वार्षिक प्रतिवेदन
Annual Report

2016-2017

CSIR-Central Institute of Medicinal and Aromatic Plants
(Council of Scientific and Industrial Research)
Lucknow | India

Acknowledgments
Research Council, Management Council
Project Leaders, Scientists, Technical Staff
Research Students and Scholars
MAPs Cultivators, Growers and Processors

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Lucknow | Bengaluru | Hyderabad | Pantnagar | Purara

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निदेशक का संदेश

गत वर्ष की भांति इस वर्ष भी 2016-17 का वार्षिक प्रतिविदन करते हुए मुझे हर्ष हो रहा है क्योंकि इस दौरान हमारे संस्थान के वैज्ञानिकों ने नव ज्ञान के सृजन के साथ-साथ सामाजिक दायित्वों विशेषकर किसानों एवं उद्योगों के क्षेत्र में विशेष योगदान करते हुए अपनी एक विशिष्ट पहचान बनायी है। यह हमारे संस्थान के वैज्ञानिकों, तकनीकी अधिकारियों, शोध छात्रों तथा अन्य कर्मचारियों के समर्पित प्रयासों से ही संभव हो सका है। पिछले वर्ष सीमैप के वैज्ञानिकों ने किसानों और नवोन्मेषी उद्यमियों के लिए नयी तकनीकियाँ, उन्नत पादप प्रजातियों तथा उत्पाद विकसित किये हैं। इसी के साथ-साथ हमारे वैज्ञानिकों ने उच्च स्तर की वैज्ञानिक पत्रिकाओं में शोध पत्र प्रकाशित किये और विभिन्न पुरस्कार भी अर्जित किये है।

इस प्रतिवेदन अवधि में 95 शोध-पत्र राष्ट्रीय/अन्तर्राष्ट्रीय जर्नल्स में प्रकाशित करने के अतिरिक्त 3 राष्ट्रीय पेटेन्ट भी पंजीकृत किये गए। संस्थान द्वारा इस वर्ष औषधीय एवं सगंध फसलों की 3 नयी किस्में-सिम समृद्धि (खस), सिम पीताम्बर (हल्दी) और सिम-स्निग्धा (तुलसी) विकसित की गई। हल्दी एवं खस की किस्मों को देश के कृषकों को सीएसआईआर प्लेटिनम जयन्ती समारोह के अवसर पर प्रधानमंत्री श्री नरेन्द्र मोदी जी द्वारा समर्पित किया गया।

इसी वर्ष संस्थान के द्वारा आर्युवेद आधारित एक हर्बल कफ सीरप भी विकसित किया गया जो कि एलर्जी जन्य खाँसी नियन्त्रण में प्रभावकारी है। हमारे संस्थान को राष्ट्रीय वनस्पति अनुसंधान संस्थान के साथ सम्मिलित रूप से मधुमेह नियन्त्रक हर्बल औषधि के विकास के लिए वर्ष 2016 के सीएसआईआर तकनीकी पुरस्कार (जीव विज्ञान) से सम्मानित किया गया। इस औषधि का तकनीकी हस्तान्तरण एमिल फार्मास्युटिकल्स, नई दिल्ली को किया गया था। परिणामतः लाखों व्यक्तियों को स्वास्थ्य लाभ पहुँचा और वर्षभर की समयावधि में कम्पनी ने इस उत्पाद का लगभग 120 करोड़ रूपये का कारोबार किया। इसी वर्ष संस्थान को खस की उच्च उत्पादकता, कम समय में परिपक्व होने वाली (10-20 माह) किस्मों तथा लाभकारी कृषि के विकास के लिए सीएसआईआर ग्रामीण विकास पुरसकार से भी सम्मानित किया गया। संस्थागत पुरस्कारों के अतिरिक्त संस्थान के कई वैज्ञानिक अपने वैयक्तिक योगदान के लिए भी सम्मानित हुए।

महत्वपूर्ण शोध की दृष्टि से आर्टीमिसिया एनुआ के द्वितीयक चयापचय (secondary metabolites) चक्र में मेटोबोलिक अभियन्त्रण (metabolic engineering) के द्वारा आर्टीमिसनिन की मात्रा को बढ़ाया गया। सदाबहार में पाये जाने वाली कवकीय इण्डोफाइट्स इसमें पायी जाने वाली विन्डोलीन की मात्रा को संरचनात्मक और नियामक जीवन की सक्रियता नियन्त्रित करती है। राइजोबैक्टीरियम और डिट्जीया नैट्रोनोलिमनीया जैसे पौध वृद्धि को बढ़ाने वाले कीटाणु लवणरोधी जीन्स की सक्रियता को बढ़ाकर पौधे की लवण (salt) सहनशीलता को बढ़ाते है। डीनोवो सिक्वेंसिंग और ट्रांसक्रिप्टोम विधियों के प्रयोग से सगंध पौधों के सुगंधित तेल के जैव संश्लेषण के बारे में नवीनतम जानकारियों उपलब्ध हुई। तुलसी से प्राप्त थाउमेटिन जैसे प्रोटीन की अभिव्यक्ति द्वारा रोगकारक कवकों और अजैवीय कारकों के प्रभाव के प्रति प्रतिरोधिता प्रदर्शित की गई। थाईम के सगंध तेल एवं उसके रासायनिक अवयवों में केन्द्रीय तंत्रिका तंत्र सम्बन्धित बीमारियों जैसे अल्जाईमर और परकिन्सन के कारकों को नियन्त्रित करने की क्षमता पाई गई। प्राकृतिक यौगिकों के संश्लेषित व्युत्पन्नों (synthetic derivatives) जैसे ग्लैबरिडीन-चालकोन व डाईहाइड्रोआर्टिमिसनिन के एकल और युग्मित चालकोनबन्धित बहुलकों में मिथीसिलीनरोध स्टेफाइलोकोकस आरियस (MRSA) जीवाणु और कैंसर के प्रति जैव सक्रियता पायी गई। अन्न एवं खाद्य सामग्रियों के भण्डारणजन्य हानियों के नियन्त्रण में सगंध तेल पर आधारित फार्मुलेशन को उपयोगी पाया गया।

सुधरी हुई उन्नत कृषि तकनीकों और फसलों की किस्मों की लोकप्रियता को बढ़ाने के लिए प्रशिक्षण, जागरूकता और प्रदर्शन कार्यक्रमों का आयोजन उत्तर प्रदेश, उत्तराखण्ड, बिहार, गुजरात, महाराष्ट्र, आन्ध्र प्रदेश, कर्नाटक, तमिलनाडु, उड़ीसा और राजस्थान में आयोजित किया गया। कृषकों की आय एवं जीवन स्तर में सुधार हेतु हमारा संस्थान खस, सिट्रोनेला, नीबूघास, तुलसी, मेन्था, पचौली, जिरेनियम और पामारोजा जैसे सगंध फसलों का मिशन कार्यक्रम के रूप में कार्यान्वयित कर रहा है। संस्थान के वैज्ञानिक कृषकों की मदद के लिए आसवन और प्रसंस्करण सम्बन्धी समस्याओं का निदान उनके क्षेत्रों में जाकर सचल आसवन संयंत्रों के द्वारा प्रदान कर रहे है।

मुझे पूर्ण विश्वास है कि संस्थान की यह उपलब्धियां कृषकों का विशवास बढ़ाने और उनकी आय दुगुनी करने में सार्थक एवं प्रभावशाली सिद्ध होगी। संस्थान ने इस वर्ष उद्योगों और उद्यमियों के साथ परस्पर वार्तालाप में उल्लेखनीय प्रगति की है जोकि ऑर्गेनिक इण्डिया, अल्ट्राटेक और ए.एम. टाड जैसे बड़े उद्योग घरानों के आगमन से परिलक्षित है।

मैं संस्थान के सभी वैज्ञानिकों, सहायक कर्मचारियों और शोध-छात्रों को बधाई देता हूँ कि उनके बहुमूल्य योगदान से संस्थान की प्रासंगिता और उत्कृष्टता में निरंतर प्रगति हो रही है। संस्थान के पूर्व निदेशकों के प्रति भी आभार व्यक्ति करता हूँ जिनके योगदानों और दिशा-निर्देशों से हमारा संस्थान राष्ट्र और समाज की आकांक्षाओं को पूरा करने में सफलतापूर्वक अपना योगदान दे रहा है।

अनिल कुमार त्रिपाठी

From Director's Desk.....

I am truly delighted to present the Annual Report of CSIR-CIMAP for the year 2016-17, during which CSIR-CIMAP has marched ahead with better visibility and recognitions through its significant contributions not only towards creation of new knowledge but also through its commitment towards society including farmers and industry. This is possible only due to the dedicated efforts of our scientists, technical officers, research students/scholars and other employees. During the year, CSIR-CIMAP scientists have developed technologies, elite plant varieties and products for stakeholders including farmers and entrepreneurs, and also published their work in in high quality journals, and some have received honours for significant their contributions.

Metabolic engineering of secondary metabolic pathway in Artemisia annua has led to the modulation of artemisinin content. Fungal endophytes of Catharanthus roseus were shown to enhance vindoline content by modulating structural and regulatory genes related to terpenoid indole alkaloid biosynthesis. Plant growth promoting rhizobacterium, Dietzia natronolimnaea, was found to modulate the expression of stress-responsive genes to provide protection against salinity stress. For the first time, de Novo sequencing and analysis of lemongrass transcriptome provided insight into the essential oil biosynthesis of aromatic grasses. Ectopic expression of a thaumatin-like protein from Ocimum sanctum was shown to confer tolerance to fungal pathogen and abiotic stresses in Arabidopsis. Thyme oil and its individual components were found promising in curtailing cholinergic dysfunctions such as Alzheimer's, Parkinson's. Several derivatives of natural compounds such as, glabridin-chalcone hybrid molecules (GCHM) and novel dihydroartemisinin monomers and dimers containing chalcone linkers, were synthesized and found to have promising bioactivities against clinical isolates of methicillin-resistant Staphylococcus aureus (MRSA) and cancer, respectively. Essential oil-based formulations were developed to prevent the post-harvest food losses by enhancing the shelf-life of food commodities and their value-added product. A total of 95 research papers were published in National/International Journals of high repute, and 3 patents filed in India. This year CSIR-CIMAP released new varieties of Vetiveria zizanioides (CIM-Samriddhi), Curcuma longa (CIM-Pitamber) and Ocimum basilicum (CIM-Surabhi and CIM-Snigdha). The varieties of Turmeric and Vetiver were dedicated to the nation by our Honorable Prime Minister Shri Narendra Modi on the occasion of CSIR Platinum Jubilee Foundation Day.

CSIR-CIMAP has also developed and released an Ayurveda-based poly-herbal Cough Syrup which is found to be effective in the cough of allergic origin. In association with a team from CSIR-NBRI, CSIR-CIMAP was honoured with CSIR Technology Award-2016 in Life Sciences for the development of NBRMAP (trade name: BGR34) for developing an Ayurvedic formulation for diabetes management. This technology was transferred and licensed to AIMIL Pharmaceuticals, New Delhi, It is heartening to note that this product has already benefitted more than a million people and done a business of more than Rs. 120 crores in a short span of time. Apart from its contribution to affordable and herbal healthcare, CSIR-CIMAP was also conferred with the prestigious CSIR Award for S & T Innovation for Rural Development (CAIRD)-2016 for improving the quality of lives of farming communities through Vetiver (Khus)-based technological interventions. Besides these institutional awards, several scientists won awards and received recognitions for their significant scientific contributions.

Several improved agro-technologies were demonstrated and plant varieties popularized among the farmers, tribals and entrepreneurs through training programmes and camps organized on farmers' fields in several districts of Uttar Pradesh, Uttarakhand, Bihar, Gujarat, Maharashtra, Andhra Pradesh, Karnataka, Tamil Nadu, Odisha, Rajasthan etc. In our continuous endeavour to improve the quality of lives and income of farmers, a Mission Mode programme has been initiated in which aromatic crops such as Vetiver, Citronella, Lemon grass, Ocimum, Mentha, Patchouli, Geranium and Palmarosa are being planted and cultivated in the farmers' fields under the guidance of scientist from CSIR-CIMAP. The scientists from CSIR-CIMAP are helping and guiding farmers for further processing and on-site distillation of the essential oil by using the distillation units developed by CSIR-CIMAP. I feel confident that these achievements will have visible impact towards doubling the income of farmers for improving their confidence and quality of life. CSIR-CIMAP has increased its interaction with industry which is reflected by a continuously increasing number of visits by important industry (Organic India, UltraTech, A. M. Todd etc) and entrepreneurs.

I take this opportunity to congratulate the scientific and other supprt staff as well as research scholars who made their valuable contributions to the march of CSIR-CIMAP towards excellence with relevance. I express my sense of gratitude to all my predecessors for their immense contributions, and guidance for future direction for fulfilling the expectations of stakeholders and the nation.

Anil Kumar Tripathi

Genetic enhancement of MAPs using crop specific breeding methodologies

Genetic enhancement of *Mentha* species

Out of 41 half sib seed progenies of *Mentha piperita*, only one chemovar/genotype showed high oil yield potential (90-100kg/ha) with menthofuran content 0.1-0.7%, pulegone 1.5%, menthone 15-20% and 60-70% menthol content in its essential oil. The oil content ranged from 0.65-0.75%.

Identified menthol rich peppermint genotype with less than one percent menthofuran. Dementholized oil of this genotype is at par with American pepermint.


Input: Birendra Kumar

Identified an early maturing high yielding menthofuran rich genotype: MPS-36

Among the half sib seed progenies an early maturing (90 days), erect growth habit and flowering (on 90 days), menthofuran (30-35%), oil content (0.35-0.40%), oil yield (70-80kg/ha), Yield improvement over variety CIMAP- Patra (20-25%), Yield evaluation trial and fractionation of pure menthofuran/pulegone is under progress.


Input: Birendra Kumar

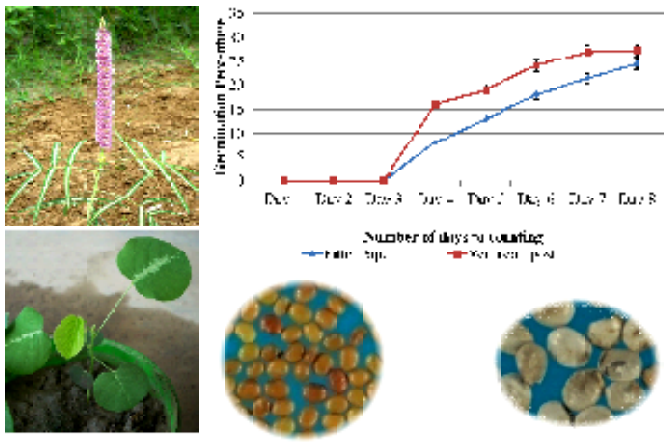
Genetic improvement for economic traits in *Andrographis paniculata*

Enahnced spectrum of variability for andrographolide (3.88-4.113%) and neo-andrographolide (0.41-0.59%) in induced M_2 progenies has exhibited 50% improvement over the parent variety CIM-Megha.

Input: Birendra Kumar

Genetic improvement for development of improved strain/genotype for high economic yield in *Uraria picta*

Forty nine half sib seed progenies of *Uraria picta* were raised for yield assessment. Out of which 20 seed progenies possesed more than 0.5% rhoifolin content in aerial part and 4 seed progenies have more than 0.5% rhoifolin content in root parts of the plant. Only two seed progenies showed more than 0.5% rhoifolin content in aerial as well as in root parts. Among substrate, vermi-compost was found optimally suitable for mean seed germination percentage (27%) followed by filter paper (24%) at constant 25°C temperature in *Uraria picta*.



Input: Birendra Kumar

Collections and Genetic Characterization of *Anacyclus pyrethrum*

A set of 20 distinct accessions of *Anacyclus pyrethrum,* an introduction from Morocco in India and naturalised, recently were collected from Haryana, Uttarakhand and Utter Pradesh from various districts and grown in randomised block design in the rabi season of 2016-2017 to evaluate the plant stature, biomass yield and ,pellitorin content and oil composition. Variability was observed in circadian rhythm, flower colour, flower size, leaf color, number of primary branching and root length. The variability is being exploited for active bio-constituent and genetic improvement.

Input: Tripta Jhang

Phenotypic diversity analysis and classification of turmeric germplasm from North-East region of India

The nature and magnitude of genetic divergence were estimated among sixty-five turmeric (*Curcuma longa L.*) genotypes using Mahalanobis D^2-statistics on thirteen agro-morphological quantitative traits. Mahalanobis's D^2 analysis revealed considerable amount of diversity among the Curcuma genotypes. The genotypes were grouped into seven clusters. Cluster I had maximum number of genotypes (37) followed by cluster II and III (9 genotypes each), IV (4), V (3), VI (2) and VII (1) in order. The genotypes falling under cluster I had the maximum divergence (430.90), which was closely followed by cluster II (332.99) and cluster IV (325.72). The highest inter-cluster distances were observed between cluster VI (959.96) and cluster VII (1020.64), suggesting that the genotypes included in these clusters may be used for future breeding programme. Traits like plant height, fresh weight of rhizome were the major contributors to genetic divergence.

Input: A.K. Gupta

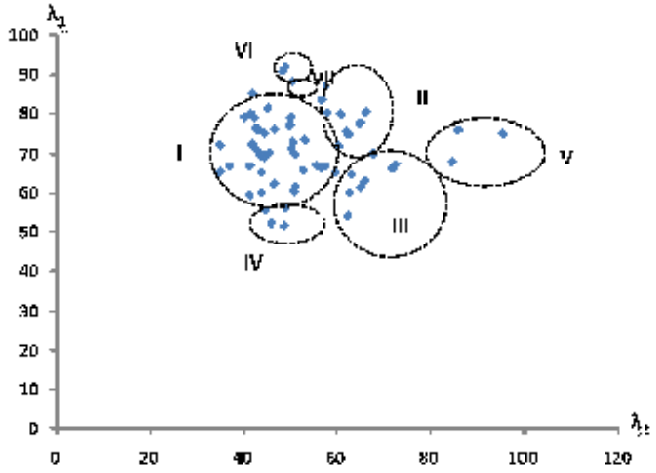


Figure 1. λ_1 – λ_2 diagram illustrating the spatial distributions of various groups formed from sixty-five genotypes of *Curcuma longa* L.

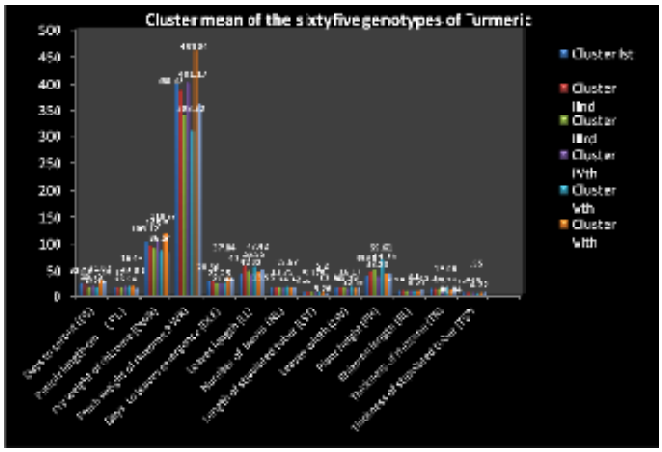
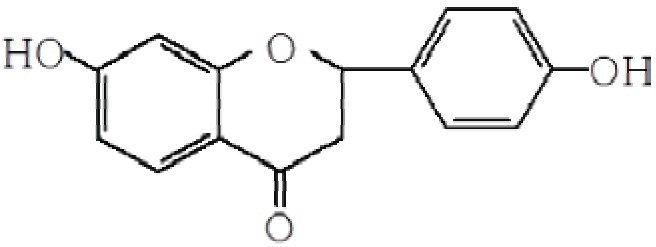


Figure 2. Cluster mean for the sixty five genotypes of turmeric

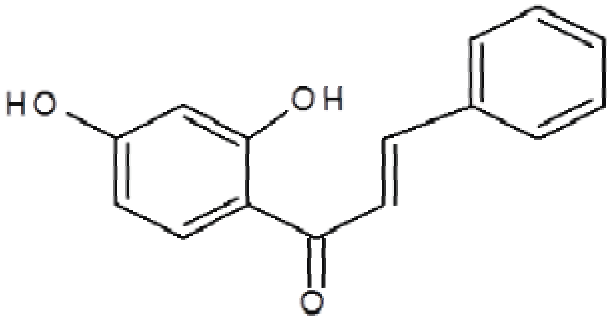
Phytochemical exploration and value addition in bioactive molecules from MAPs

Drug resistance reversal potential of isoliquiritigenin and liquiritigenin isolated from *Glycyrrhiza glabra* against methicillin resistant *Staphylococcus aureus*

Discovery of novel antimicrobial combinations for combating methicillin resistant *Staphylococcus aureus* (MRSA) infections is of vital importance in the post antibiotic era. Isoliquiritigenin (ISL) and liquiritigenin (LTG), structurally related flavonoids were isolated from the rhizomes of *Glycyrrhiza glabra*. Combination effect of LTG and ISL was explored *in vitro* and *in vivo* with βlactam antibiotics (penicillin, ampicillin and oxacillin) against *mec A*-containing strains of MRSA. MIC of LTG and ISL exhibited significant anti-MRSA activity (50–100 µg/mL) against itt clinical isolates. In the *in vitro* combination study, ISL significantly reduced MIC of βlactam antibiotics up to 16 folds (FIC, 0.312–0.5), while LTG reduced up to 8 folds (FIC 0.372–0.5). Time kill kinetics at graded MIC combinations (ISL/LTG + βlactam) indicated 3.27–9.79 fold and 2.59–3.48 fold reduction in the growth of clinical isolates of *S. aureus* respectively. In *S. aureus* infected *Swiss* albino mice model, combination of ISL with oxacillin significantly ($p < 0.05$, $p < 0.01$, $p < 0.001$) lowered the systemic microbial burden in blood, liver, kidney, lung and spleen tissues in comparison with ISL, oxacillin alone as well as untreated control. Considering its synergistic antibacterial effect, we suggest both ISL and LTG as promising compounds for the development of novel anti-staphylococcal combinations.



Liquiritigenin



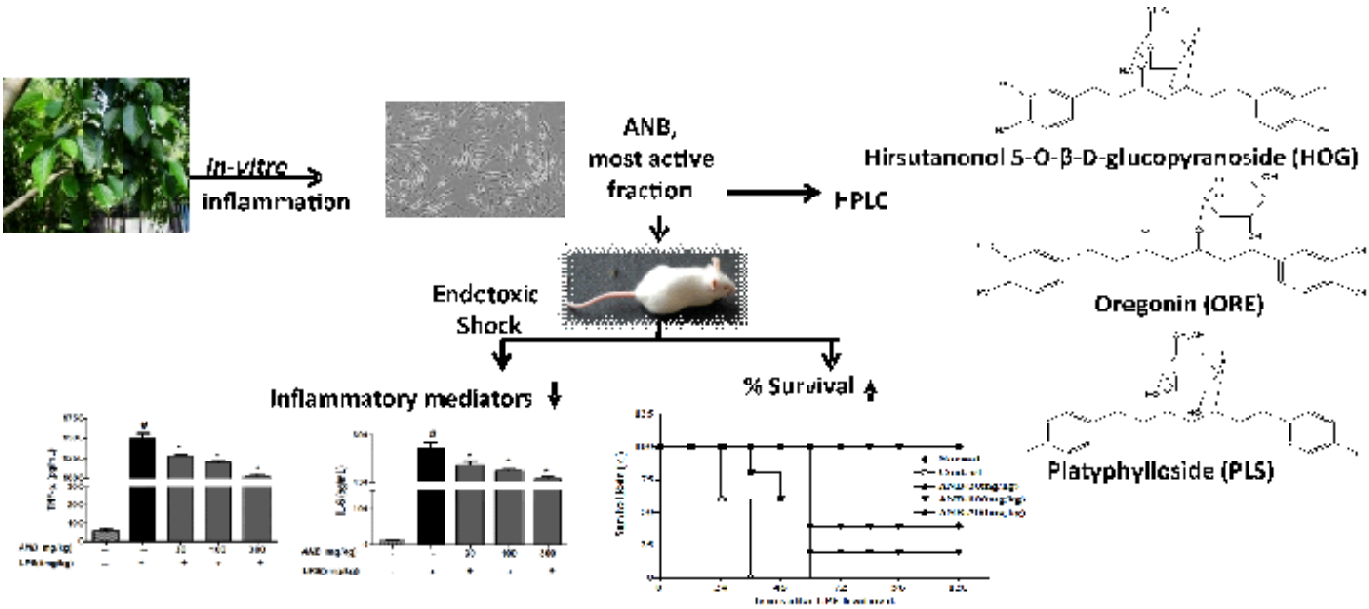
Isoliquiritigenin

Phytotherapy Research, 30: 1708–1715, 2016 (IF-2.694)
Inputs: RS Bhakuni and MP Darokar

Diarylheptanoids from *Alnus nepalensis* Attenuates LPS-Induced Inflammation in Macrophages and Endotoxic Shock in Mice

Diarylheptanoids, a group of plant secondary metabolites are increasingly recognized as potential therapeutic agents. The aim of study was to ascertain the anti-inflammatory profile of diarylheptanoids from *Alnus nepalensis* against lipopolysaccharide (LPS)-induced inflammation in macrophages and endotoxic shock in mice.

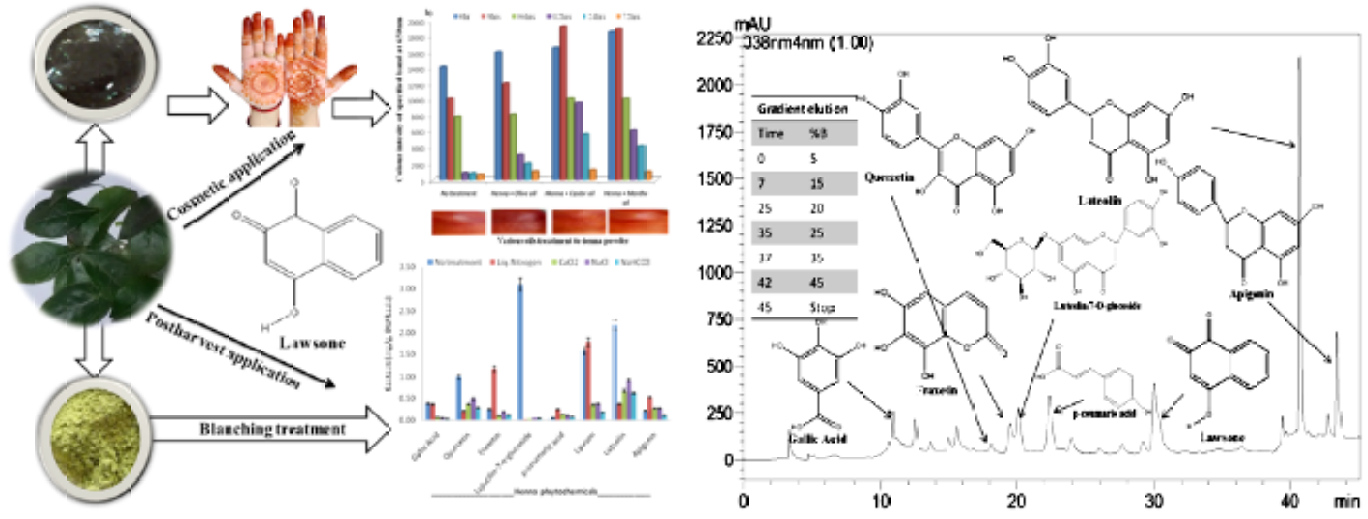
Results of the study indicated that ANB, diarylheptanoids rich fraction of A. nepalensis leaves extract as well as isolated diarylheptanoids (HOG, ORE, PLS) from ANB exert an anti-inflammatory activity by inhibiting the production of pro-inflammatory cytokines (TNF-α, and IL-6) in both in-vitro and in-vivo condition without any side effect at higher oral dose. Among the diarylheptanoids, Platyphylloside (PLS) exert the most active anti-inflammatory activity. Hence, diarylheptanoids rich fraction of *A. nepalensis* leaves extract can be regarded as a candidate for further investigation towards the management of inflammatory diseases



International Immunopharmacology 30, 129–136 (2016); (IF-2.551)
Inputs: D.U.Bawankule, M.M Gupta

Analytical method development: Validated method for quality assessment of henna (*Lawsonia inermis* L.) leaves after postharvest blanching and its cosmetic application

Henna (*Lawsonia inermis L.*, family- Lythraceae) has been used for number of cosmetic purposes, including body painting, palm colouring and dyeing of hair. In spite of huge demand for cosmetic applications, no validated analytical method is available for the quality assessment of henna. Therefore, present validated method demonstrates the simultaneous quantification of eight marker compounds. Chemical markers, namely **1**) gallic acid, **2**) quercetin, **3**) fraxetin, **4**) luteolin-7-*O*- glucoside, **5**) *p*-coumaric acid, **6**) lawsone, 7) luteolin and **8**) apigenin were chosen for the quality assessment of henna. The method was also applied to assess the effects of postharvest treatments (PHT) on the quality of henna leaves as well its derived product i.e. oil mixed paste. Both the chemical and thermal blanching treatments severely ($p < 0.5$) changed the content of targeted secondary metabolites (**1**-**8**). The contents of fraxetin and lawsone were found to increase on deep freezing, remaining six phytochemicals reduced significantly on blanching. Luteolin-7-*O*- glucoside in henna was

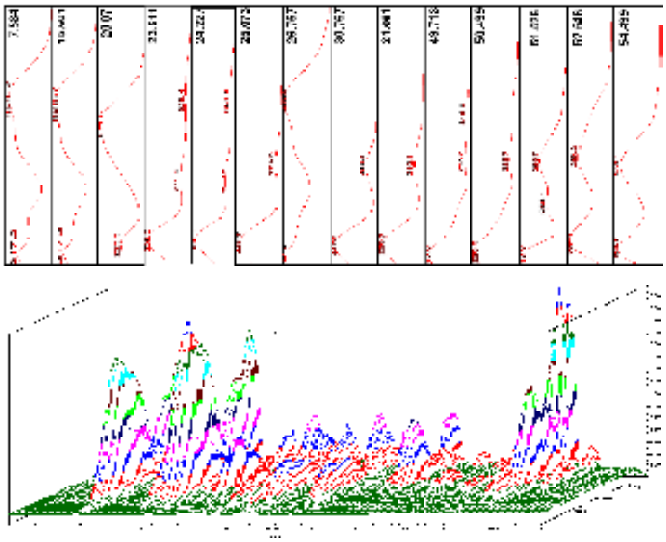


most susceptible to both salt and liquid nitrogen treatment. Additionally, the effects of mixing of oils (olive, castor and mentha oil) on modulation of chemical markers and color intensity over palm were also evaluated. We observed a significant increase in the color intensity attributed to mixing of castor >>menthol>olive oil. The apigenin content was about 2.4 times higher in olive oil mixed henna paste than control, while, fraxetin content reduced to half. Mixing of castor oil in henna paste has produced the most intense color; while the mentha oil facilitated the persistence action when applied for palm ornamentation. **Industrial Crops and Products, 95: 33–42, 2017 (IF: 3.449)**.

Inputs: Drs. Karuna Shanker & Suiab Luqman*

HPLC Fingerprinting of *Flacourtia indica* bioactive extract: A mechanism-based pharmacological evaluation of efficacy of *Flacourtia indica* in management of dyslipidemia and oxidative stress in hyperlipidemic rats

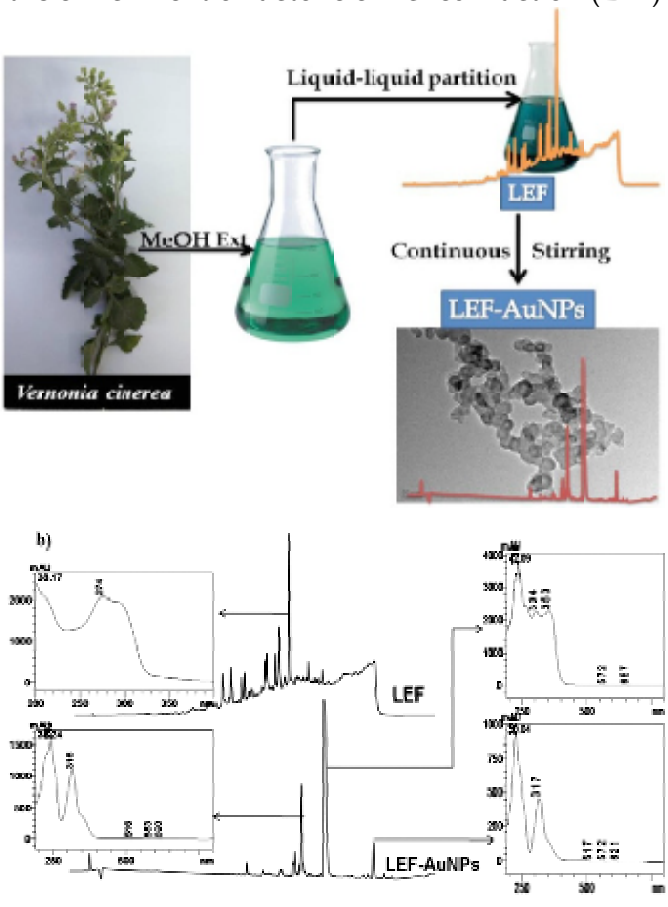
Natural products are the most promising source of effective bioactive substances in the treatment of various health ailments. The robust biological actions are ensured by chemical fingerprint. Under normal RP-HPLC gradient elution methods, the more polar compounds are generally eluted first. Thus, diglycosides precede monoglycosides, which in turn precede aglycones. The classes of flavonoids that characterize *Flacourtia indica* (flavanones, flavones, and, to a lesser extent flavonols/ flavanols) have their maximum absorption at specific wavelength ranges: flavanones (280- 290 nm), flavones (304-350 nm) and flavonols (352-385 nm). A representative 3D-PDA HPLC chromatograms (200-400nm) of *F. indica* fruit extract highlights the presence of flavanones compared to flavones with characteristic UV spectrum plot index.



Journal of Basic and Clinical Physiology and Pharmacology, 27(2):121-129, 2016 (IF: 0.759)
Input: Drs. Karuna Shanker & Anirban Pal

Synthesis and Bio-prospection: Gold mediated biocompatible nanocomposite of lactone enriched fraction from Sahadevi (*Vernonia cinerea* Lees): An assessment of antimalarial potential

Metals reduction into submicro/nano size through bhasma preparations for therapeutic use is well established in ancient traditional system of Indian medicines i.e. Ayurveda. Recently, nanotechnology has drawn the attention of researchers to develeope various size and shape nanoparicles / composite for number of applications. In this article, we report the enrichment of lactone enriched fraction (LEF)

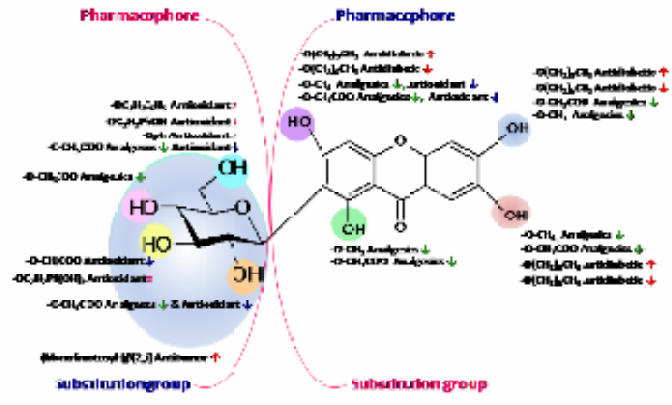


by liquid-liquid portioning of *Vernonia cinerea* metabolic extract and synthesis of mediated nano-gold composite (LEF-AuNPs) in single step process. The morphological characteristic based on transmission electron microscope (TEM) image analysis showed that LEF-AuNPs were predominantly nanopolygons and nanobots in shapes ranging from 50-200 nm in size. Abundance of phytochemicals in both LEF and LEF-AuNPs was dissimilar. In LEF, montanol- a diterpenoid, while in LEF-AuNPs, neophytadiene- a phytanes was the major compound. HPLC profile of relatively polar compounds also varied drastically. In-vitro biocompatibility, cytotoxicity [MTT (3-[4,5-dimethylthiazol-2-yl]-2,5 diphenyl tetrazolium bromide) based assay] and storage stabilitiy of LEF-AuNPs were evaluated. The moderate ability of LEF-AuNPs to restrict parasitaemia, extended mean survival time of mice infected with *Plasmodium berghei* and lack of any evident toxicity provides new opportunities for the safe delivery and applications of such nanocomposites in malaria therapy.

Current Topics in Medicinal Chemistry, 16:2043-2050, 2016 (IF: 3.402)
Input: Drs. Karuna Shanker, DU Bawankule & Anirban Pal

Mangiferin: A review of sources and interventions for biological activities

Xanthones are naturally synthesized in various biological systems such as plants, lichens and fungi and stored as by products. In addition to taxonomic significance, these are also having / therapeutic importance and used for the management of number of ailments and wellness of humans. Although numbers of pharmacological studies have proved its effectiveness as antioxidant, analgesic, anti-diabetic, anti-proliferative, chemopreventive, radioprotective, cardiotonic, immunomodulatory, and diuretic. But still mangiferin or its derived lead molecule required detailed mode of action studies to qualify for clinical trials. However uses of plants having mangiferin as one of the major components are centauries old in traditional system of medicine of India and China for numerous disease management and health benefits. In spite of resemblance with biflavones, the C-glucosyl xanthone known as

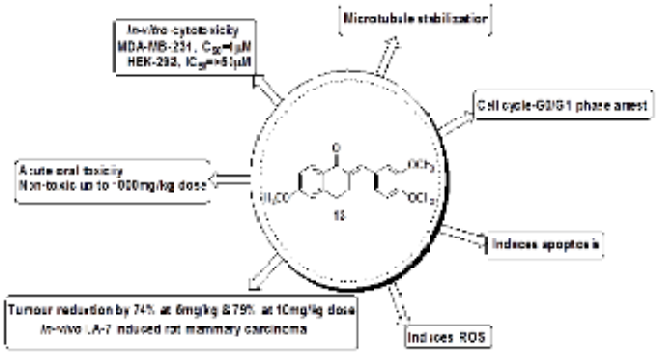


mangiferin has great nutritional and medicinal significance due to unique structural characteristics restricted to angiospermic families. Thermally stable mangiferin protects the plants against both static and dynamic stresses including admittance of pathogenic microorganisms. The C-glycoside link of mangiferin, mimicked to nucleophilic phloroglucinol substitution, facilitates its bioavailability and also responsible for antioxidant actions. Researchers have also utilized its xanthonic framework for both pharmacophoric backbone and substitution group as synthesis prospects. To date more than 500 derivatives using about 80 reactions such as lipid peroxidation, phosphorylation, glycosylation, methylation, fermentation, deglycosylation, hydrolysis, polymerization, sulfation, acylation, etherification, peroxidation etc. have been generated. Multiple studies on efficacy and safety have increased the global demand of mangiferin based food supplements formulated from *Mangifera indica* and *Irvingia gabonensis*. This review highlights the distribution of mangiferin in plants of different geographic locations, its isolation, characterization and assay methods applicable to different sample matrices, in addition to updates on various strategies and derived products intended for the designated pharmacological actions.

BioFactor, 42(5): 504-514, 2016, (IF: 4.504)
Input: Dr Karuna Shanker

Potential anticancer activity of tetralone derivative through microtubule stabilization and activation of Reactive oxygen species

Logical semi-synthetic modification of gallic acid, veratrol and piperonal yielded potential anti-breast cancer agents. The best compound **13**,

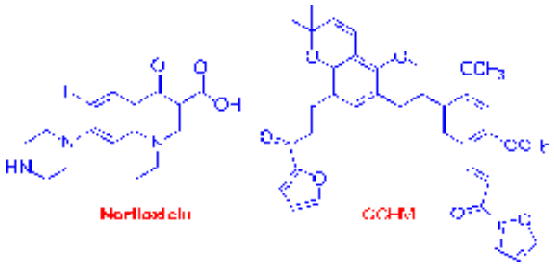


reduced 74-79% rat mammary tumour at 5-10mg/kg oral dose. Further optimization may yield a better anticancer candidate in future.

Royal Society of Chemistry Advances, 6: 33369-33379, 2016 (IF-3.289).
Inputs: Arvind Singh Negi and D. Chanda

Glabridin-Chalcone hybrid molecules: Drug resistance reversal agent against clinical isolates of Methicillin-Resistant *Staphylococcus*

A novel series of glabridin (an antibacterial constituent of *Glycyrrhiza glabra*) chalcone hybrid molecules (GCHMs) were synthesized and evaluated against clinical isolates of methicillin-resistant strain of *Staphylococcus aureus* (MRSA) alone and in combination with norfloxacin. Among all, one of the derivatives exhibited marked synergism, up to 16-fold reduction in MICs with



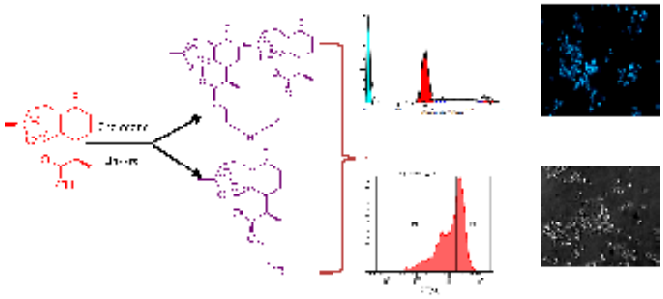
norfloxacin (FICI from 0.312 to 0.375). In a systemically infected Swiss albino mice model, the novel compound significantly ($p < 0.01$, $p < 0.05$) lowered the systemic bacterial load in blood, liver, kidney, lung and spleen tissues.

The present study reports the potential use of GCHMs in the development of economical anti-infective combinations for the treatment of infection caused by clinical MRSA isolates.

Medicinal Chemical Communications, **7:** 693–705. 2016 (IF-2.319)
Inputs: RS Bhakuni and MP Darokar

Novel dihydroartemisinin monomers and dimers containing chalcone linkers as anticancer agents

A new series of monomers and dimers of dihydroartemisinin (DHA) containing chalcones as a linker were synthesized. Upon their investigation against different human cancer cell lines HL-60, Mia PaCa-2, PC-3, LS180 and HEPG2 five new derivatives were found to be more active against HL-60 cell lines, IC50 values less than 1 µM than parent DHA, IC50, 2 µM for 48 h. The

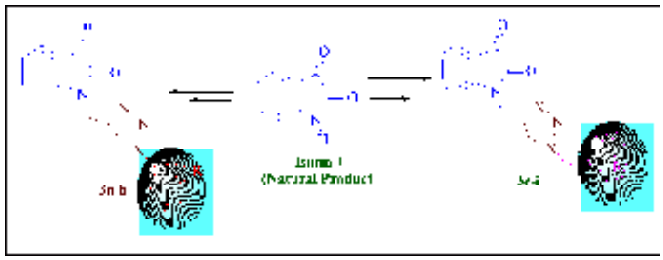


most potent compound with IC50= 0.3 µM, at par with doxorubicin (IC50= 0.3 µM) and several folds higher active than DHA was selected for further mechanistic work in the human leukemia HL-60 cells.

European Journal of Medicinal Chemistry, 122: 232-246, 2016 (IF-3.902)
Inputs: RS Bhakuni & team

Synthesis and biological evaluation of some novel Isatin-N-1, 2, 3-triazoles

Seven novel Isatin triazole derivatives were synthesized. Four anti-cancer lead compounds against HeLa and HepG2 cell lines {**3a** (IC_{50} 6.52±0.04), **3b** (IC_{50} 2.78±0.04 µM), **3d** (IC_{50} 7.09±0.037 µM) and **3h** (2.25±0.04 µM)} and One



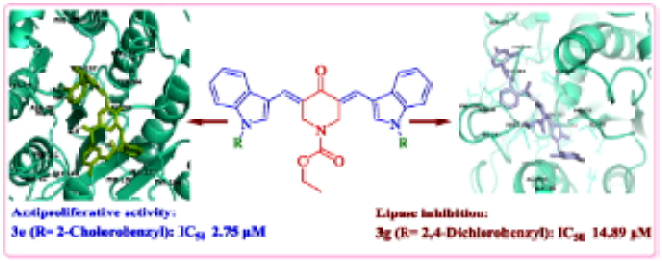
α-glucosidase inhibition (47.4%) were obtained by *in vitro* biological activity screening.

Inputs- J Kotesh Kumar

Synthesis and evaluation of anticancer and anti-obesity activity of 1-ethoxy carbonyl-3,5-bis (32 -indolyl methylene)-4-pyperidone analogs

A series of eleven novel bis indole derivatives were synthesized and screened for anticancer and anti-obesity potentials in *in vitro* mode.

Compounds **3f** significantly inhibited HepG2cell line (IC_{50} 7.33 µM), **3e** (IC_{50} 2.75 µM), **3f** (IC_{50} 4.21 µM) and **3i** (IC_{50} 15.98 µM) showed better activity against A549 cell line.



Compounds **3g** (IC_{50} 14.89 µM), **3c** (IC_{50} 56.41 µM) and **3i** (IC_{50} 30.88 µM) have potentially inhibited enzyme Lipase

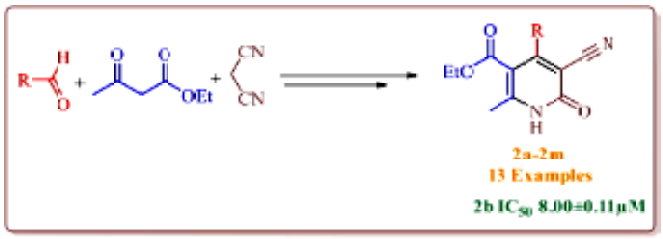
Bioorganic & Medicinal Chemistry Letters, 26 (6), 1633-1638, 2016 (IF-2.486).
Inputs- J Kotesh Kumar

Iodine catalyzed simple and efficient synthesis of anti proliferative 2-pyridones.

Developed a simple, efficient and general method for the selective synthesis of 2-pyridones from 4H-pyrans using iodine as catalyst and ethanol as solvent. The present procedure is equally effective for both hetero aromatic and aromatic ring contained pyrans and electron donating as well as electron withdrawing substituents. The compatibility with various functional groups, mild reaction conditions, high yields and application of inexpensive, readily and easily available iodine as catalyst and formation of 2-pyridones as major products are the advantages of the present procedure.

In vitro anticancer activity of the final synthesized compounds were screened for four different Human cell lines (Lung adenocarcinoma-A549, Hepatocarcinoma-HepG2, Breast carcinoma-MCF-7 and Ovarian carcinoma-SKOV3). Compounds **2b** showed better inhibition against MCF-7, HepG2 and A549 cell lines (IC_{50} 8.00±0.11, 11.93±0.01 and 15.85±0.04 µM respectively) as compared with doxorubicin and also **2e** showed moderate inhibition against MCF-7, HepG2 (IC_{50} 9.32±0.21 and 20.22±0.01 µM respectively cell lines respectively) as compared with doxorubicin.

Scheme:



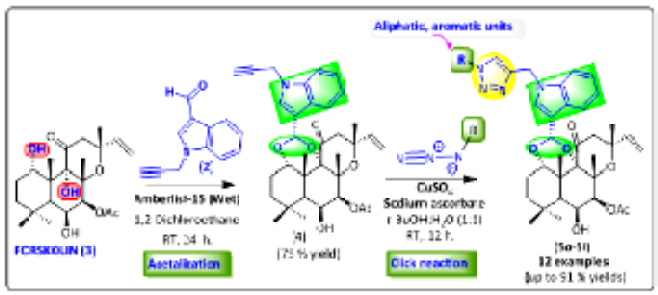
Bioorganic & Medicinal Chemistry Letters, 26, 2159-2163, 2016(IF-2.486).
Inputs- J Kotesh Kumar

Design, synthesis and biological evaluation of forskolin-indole-triazole conjugates

11 novel Forskolin-indole-triazole semisynthetic derivatives were prepared.

Compound **3*g*** was found potent in most of the tested cell lines (IC_{50} 9.6-21.66 µg/mL) except COLO-205.

Scheme:



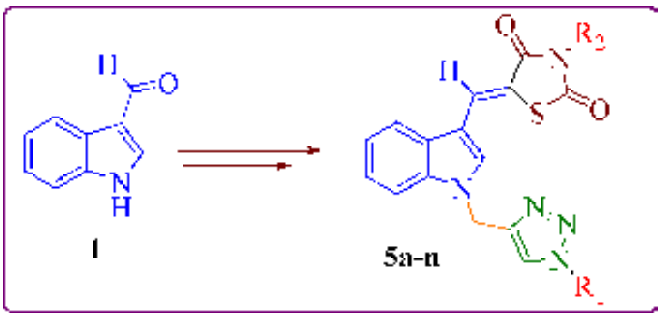
Inputs- J Kotesh Kumar

Synthesis, in *silico* molecular docking, Lipase and α-glucosidase hydrolysis inhibitory activity of novel thiazolidinedione derivatives containing triazole ring

A series of 15 novel thiazolidenedione-triazole hybrid molecules were synth*esized*.

Two compounds shown significant lipase inhibition activity.

Scheme:

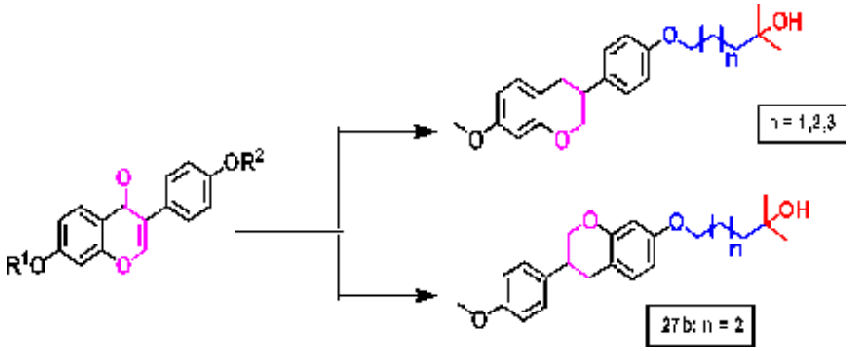


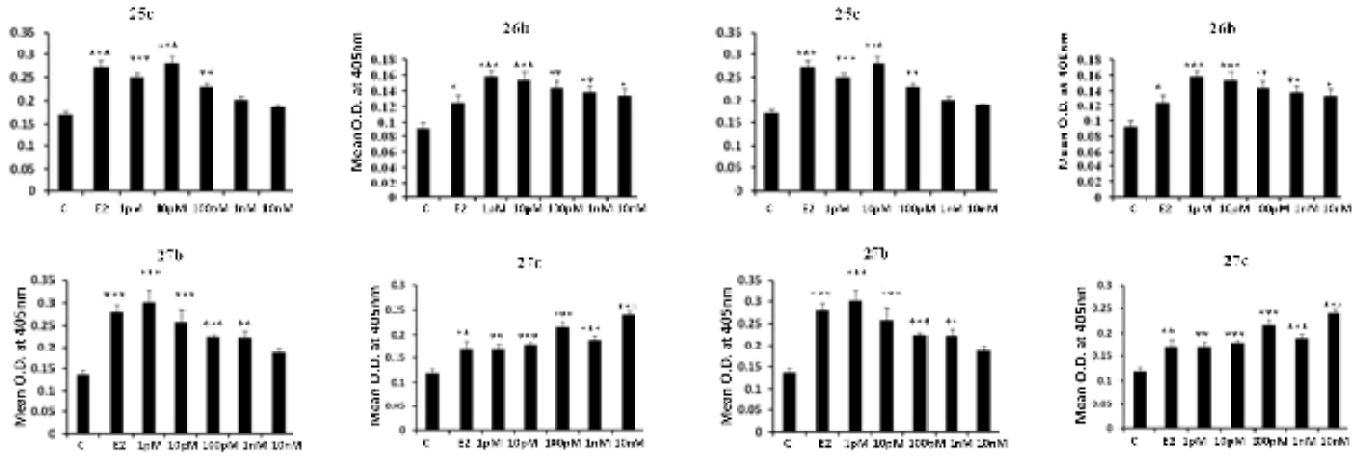
Inputs- J Kotesh Kumar

Substituted 3-arylbenzopyran based non-steroidal osteogenic agents

3-arylbenzopyran based non-steroidal osteogenic agents were explored as a structural template of estrogen and vitamin-D_3. The target molecules were studied for their osteogenic activity in osteoblast differentiation assay *in-vitro* using mouse calvarial osteoblast cells. Four compounds (**25c**, **26b**, **27b** and **27c)** effectively increased ALP activity at 1pM concentration compared to the untreated cells. The active compounds were devoid of inherent toxicity at 1pM concentration in osteoblast cells. The most active compound, **27b**, was studied for mineralization of osteoblast cells, expression of marker genes viz BMP-2 and RUNX-2 & Osx, involved in osteogenesis. Molecular docking analysis performed for **27b** showed its possible interactions with estrogen receptor-α and β (ER-α and ER-β) as well as vitamin-D receptor (VDR).

Osteoblast differentiation efficacy of test compounds: MCOs were seeded in 96 well plates and exposed to **25c**, **26b**, **27b** and **27c** at different concentrations (ranging from 1pM to 1μM) for 48h and ALP activity was determined spectrophotometrically at 405 nm. 17β-Estradiol (at 100 pM) was used as a positive control. Data shown as mean ± SEM; n=8; (*) P < 0.05, (**)P < 0.01, (***)P<0.001 compared with untreated cells taken as control.



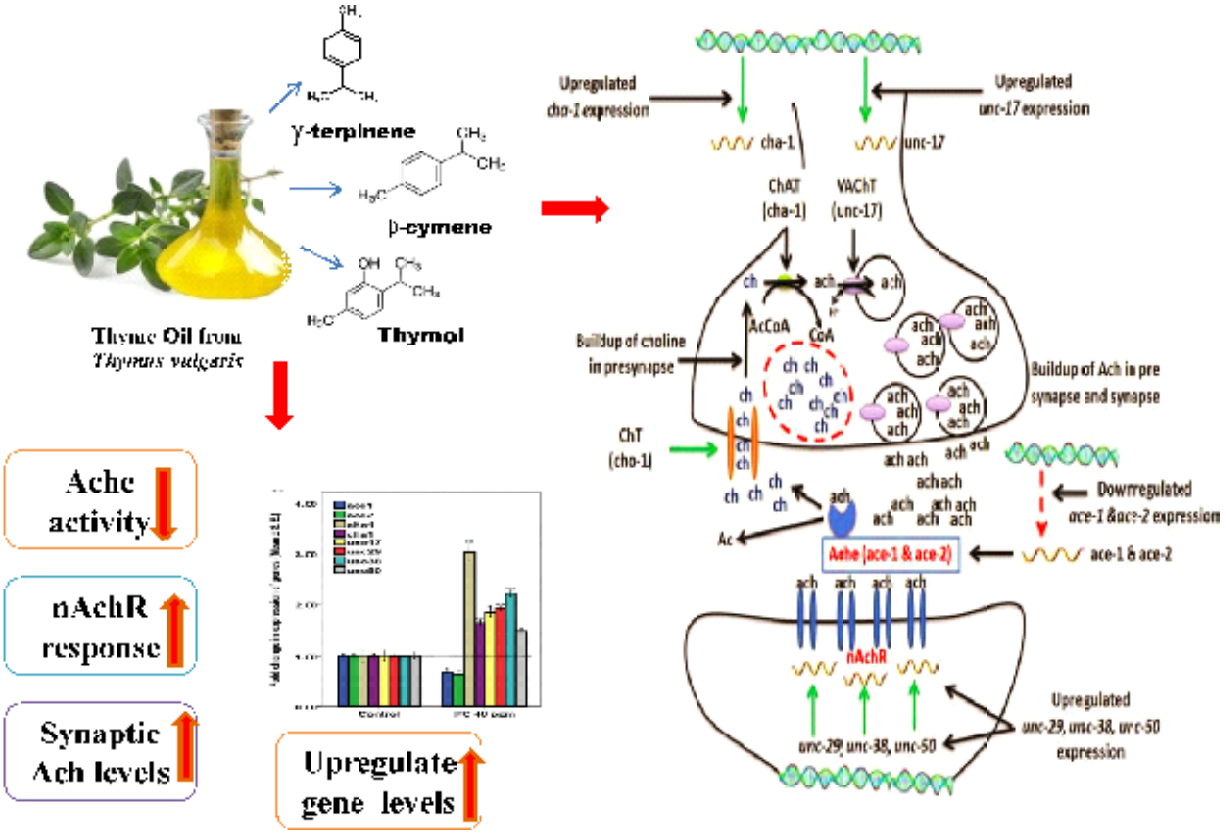


In-vitro toxicity of **25c**, **26b**, **27b** and **27c** in healthy osteoblast cells**.** Oteoblast Cells were cultured in osteoblast differentiation medium and treated with of **25c**, **26b**, **27b** and **27c** at different concentrations (ranging from 1 pM to1 µM) for 48 h, and cell viability was assessed by MTT assay. The percent of viable cells were calculated in comparison with control untreated cells. Data represent the mean ± SEM.

Med Chem Comm., 7, 2381-2394, 2016
Inputs: Atul Gupta and Ashok Sharma

1-Methyl-4-propan-2-ylbenzene from *Thymus vulgaris* attenuates cholinergic dysfunction

Cholinergic dysfunction is manifested in a plethora of neurodegenerative and psychiatric disorders such as Alzheimer's, Parkinson's, and Huntington's diseases. The extent of cholinergic affliction is maximum in Alzheimer's disease which is a progressive neurodegenerative disorder involving death of cholinergic neurons. To this date, the therapeutic management of cholinergic dysfunction is limited to provide symptomatic relief through the use of acetylcholinesterase (AChE) inhibitors only. The present study elaborates the potential of thyme oil and its individual components in curtailing cholinergic deficits. We found that thyme oil augments neurotransmission by modulating synaptic acetylcholine (ACh) levels and nicotinic acetylcholine receptor activity, being orchestrated through upregulation of genes cho-1, unc-17 and unc-50. Studies on individual components revealed para-cymene (1-methyl-4-propan-2-ylbenzene) as the active component of thyme oil, contributing its effects through upregulation of cho-1, cha-1, unc-17 and unc-50, while downregulating ace-1 and ace-2. Interestingly, thymol and gammaterpinene which although were devoid of any activity individually, exhibited significantly enhanced synaptic ACh levels and nicotinic acetylcholine receptor (nAChR) responsiveness, when administered in combination. Our findings advocate that thyme oil and its constituents as potential candidates for amelioration of cholinergic dysfunction. The study is speculated to make a way for a new line of phytomolecules-based drugs from the diverse pool of natural compounds.



Molecular Neurobiology DOI 10.1007/s12035-016-0083-0 (2016)
Inputs: Rakesh Pandey, Alok Kalra & Sudeep Tandon

Citrus hystrix-derived 3,7-dimethyloct-6-enal and 3,7-dimethyloct-6-enyl acetate ameliorate acetylcholine deficits

Cholinergic neurotransmission is an affliction in a plethora of neurodegenerative disorders such as Alzheimer's, Huntington's and Parkinson's diseases and some psychiatric disorders like schizophrenia. The current management of many of these diseases relies heavily on treatments designed to elevate neurotransmission either through curtailing AChE activity or positive modulation of Ach receptors. The present study elaborates for the first time the potential and underlying mechanism of Kaffir lime oil (KLO) and its active constituents, citronellal (3,7-dimethyloct-6-enal) and citronellyl acetate (3,7-dimethyloct-6-enyl acetate), extracted from Citrus hystrix as potential therapeutic agents in the augmentation of cholinergic response in *Caenorhabditis elegans*. We observed significant elevation of synaptic Ach levels evident through aldicarb assay, being orchestrated through mitigation of AChE activity upon treatment with KLO, recorded at genomic and biochemical levels, along with elevated genomic expression of choline transporter. The active components citronellal and citronellyl acetate were also found to lower AChE activity at biochemical and transcriptomic levels, besides also executing their function through modulation of choline transporter and choline acetyltransferase at genomic levels. Paradoxically, other constituents beta caryophellene and linalool were found to show adverse effects at lower doses. Notably, all of the components of KLO and KLO itself were devoid of any interaction-based AChE inhibitory activity as determined through in vitro assay. Our study has identified and validated KLO and active components for their significant pharmaco-medical importance, presenting novel leads and a new line of drug action compared to the conventional AChE inhibition-based therapeutic approach.

Royal Society of Chemistry Advances
6: 68870-68884 (2016)
Inputs: Rakesh Pandey & Sudeep Tandon

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

1 Technology licensing

- An agreement was signed with M/s Kolar Point Works, Kolar road, Bhopal, Madhya Pradesh for technology transfer of pain relieving oil on 11 May, 2016.
- An agreement was signed with IPCA laboratory Ratlam (MP) on 13 October, 2016 for licensing of knowhow for cultivation of *Artemisia annua* variety CIM- Sanjeevani at large scale.
- An agreement was signed with M/s Pragathi International, Bangalore-560011 on 31st January, 2017 for technology of mosquito repellent spray and mosquito repellent agarbatti.

2. Study on economics and marketing in medicinal and aromatic crops (MACs):

(a) Adoption pattern and profitability of mint cultivation in Dudhwa Tiger Reserve of Uttar Pradesh

The present study on adoption of menthol mint (*Mentha arvensis* family lamiaceae.) cultivation technology was carried out in tribal farmer's field of Dudhwa Tiger Reserve of Uttar Pradesh. The menthol mint is an essential oil bearing plant was first time introduced among the *tharu* tribes of the tiger reserve. During the study period menthol mint cultivation has been demonstrated on the farmer's field of two villages namely Dhuskia (Chandan Chowki range) and Chhedia Paschim (Bankati range) of Dudhawa under Palia tehsil of district Lakhimpur Kheri. The primary data were collected from the selected farmer's field on adoption pattern and profitability of mint cultivation. Simple analytical tools and technique has been used for data analysis and calculation of cost of cultivation. The socio-economic and resource structure was workout by analyzing the family size, literacy rate, occupation, cropping pattern, farm assets and land holding. It was observed during the study that farmers of medium holding size topped the adoption followed by farmers of larger and smaller holding size. The total cost of cultivation and gross return of menthol mint was found Rs. 37239/- and Rs. 71400/- per hectare respectively. The net return has been found Rs 34161/- per hectare. The B: C ratio has been observed 2.43 and 1.92 at cost A1 and Cost C respectively.

b. Feedback study of mentha cultivation at farmers field during June, 2016

Data collected from the farmer's field of major mint growing districts of Uttar Pradesh viz., Barabanki, Lucknow, Raebareli, Sitapur, Tanda Maharajganj, Lakhimpur, Shahjahanpur, Pilibhit, Bareilly etc. 80 farmers were interviewed randomly at farmer's field. About 23 percent farmers' informed that they are cultivating mentha variety Kosi and said this variety is having better oil production than other available in the market. About 5 percent farmers told that the cultivation of CIM-Kranti variety is better because they have harvested oil during winter season at the time of sucker production and saves the cost of nursery. Remaining about 72 percent farmers cultivating mentha were not aware about the latest improved varieties and cultivation technologies. The major problems faced by the farmer's in mint cultivation was of insect and pests attack on crop (especially white flies and green catterpiller), non-availability of planting material at sowing time, lack of knowledge about variety, improved distillation unit and basic infrastructure regulated marketing system and minimum support price were the other bottlenecks.

c. Market Survey:

Major markets of medicinal and aromatic plants were surveyed at different locations in northern part of the Uttar Pradesh. These included Faizabad, Bareilly, Barabanki and Lucknow. Major commodities traded in these markets were ashwagandha, satavar, kalmegh, serpgandha, amla, dry rose flowers among the medicinal plants while in essential oils menthol mint, lemongrass, palmarosa, vetiver and tulsi. About 20 whole sellers, retailers and buyers were contacted/ interviewed during the study.

3. Visitors:

About 4600 visitors including students, farmers, entrepreneurs, government officials, and other common people has visited CSIR-CIMAP and were apprised of different activities of the institute based on their interest.

View of student's visiting the Manav Upvan

4. Major events organized:

- **National Technology Day**

  On the occasion of National Technology Day an interactive business meeting was organized on 11 May, 2016. In which about 20 aroma industries/representatives and > 30 scientist of CSIR-CIMAP has participated.

- **CSIR-CIMAP Kisan Mela – 2017, Lucknow**

  CSIR-CIMAP organized its annual Kisan Mela on 31st Jauary, 2017 in its campus located near Kukrail Picnic Spot at Lucknow. Prof. Panjab Singh, President, NAAS and former Director General of ICAR was the Chief Guest and, Prof. Arun Tiwari, Chairman, Make in India Campaign in strategic sector of CSIR was Guest of Honour and Shri Pradeep Bhatnagar, IAS, Agriculture Production Commissioner, Govt. of UP presided over the function.

Inauguration by Chief Guest (Kisan Mela 2017)

More than 6000 farmers, entrepreneurs, representatives of industries, buyers of essential oil and herbs hailing from various states like Odisha, Bihar, West Bengal, Andhra Pradesh, Uttar Pradesh, Uttrakhand, Chhattisgarh, Rajasthan and Assam had participated in this Kisan Mela. A special CSIR pavilion was also arranged on this occasion in which several laboratories of CSIR including CDRI, NBRI, IITR, IHBT, CCMB,

Releasing of Aus Gyanya

Participants view

CMERI, CSMCRI, NEERI, NEIST and CIMAP displayed their rural technologies, products and services beneficial for farmers. Representatives from different industries viz., MCX, IPCA Lab, Jindal Drugs, Herbochem, Biotech Park, Arshi Essential oils and several buyers of medicinal and aromatic plants and FFDC Kannauj (UP) also participated in this event. An improved variety named 'CIM-Snigdha' of *Ocimum basilicum* developed by CSIR-CIMAP possessing higher amount of methyl cinnamate (about 78%) was released by the chief guest.

5. SIDBI sponsored Skill-cum-Technology Upgradation Programmes on "Cultivation and Primary Processing of economically important Medicinal and Aromatic Plants"

CSIR-CIMAP organised 04 Skill-cum-Technology Upgradation Programmes on "Cultivation and Primary Processing of economically Important Medicinal and Aromatic Plants" during the year 2016-17 at different locations of the country. 02 Programmes were organised at CSIR-CIMAP, Lucknow, 01 at CSIR-NEERI, Nagpur and 01 at CSIR-IGIB, New Delhi. In these programmes in total 328 farmers/entrepreneurs participated from different parts of the country.

SIDBI sponsored Skill-cum-Technology Upgradation Programmes on "Cultivation and Primary Processing of economically important Medicinal and Aromatic Plants"

Sr. No.	Date	Place	No. of participants
1.	15-17 June, 2016	CSIR-CIMAP, Lucknow	96
2.	07-09 July, 2016	CSIR-NEERI, Nagpur	26
3.	08-10 December, 2016	CSIR-CIMAP, Lucknow	124
4.	27-28 Feb to 1 March, 2017	CSIR-IGIB, New Delhi	82
		Total	**328**

6. Exhibition

- Participated in Destination North East, 2017 at Chandigarh. The CSIR Stall was inaugurated by Dr. Jitendra Singh, Minister, DONER, Govt. of India. DG, CSIR and Shri Naveen Verma, IAS, Secretary, DONER has also appreciated the CSIR CIMAP technologies and varieties.
- Participated in Public viewing of Mughal and other gardens of Rashtrapati Bhavan (Udyanostav, 2017) on 10.03.2017.

caption

A view of participants in SIDBI Sponsored Training programme at Lucknow

A view of participants in SIDBI Sponsored Training programme at Nagpur

7. Publication of Extension Literature/Publicity folders/Brochures

- "Aus Gyanya" published and released on the occasion of Kisan Mela-2017
- Short Video Film of Lemongrass & Turmeric crops
- Training manual of cultivation, primary processing and marketing of medicinal and aromatic plants (English)

Input: Sanjay Kumar, VKS Tomar, Alok Krishna, Ramesh Kumar Srivastava, Ram Suresh Sharma and R P Yadav

Development of pre and post harvest technologies for commercially viable medicinal and aromatic crops and their popularization

Design and Development of Multi purpose Satavar Root Digger

Satavar is a high value medicinal crop having great demand in pharmaceutical industries. The Satavari roots are being harvested manually by using traditional farm tools like Phawra (spades), Kudali etc. which causes significant root losses and huge labour input. Considering the problems being faced

Comparison of cost economics for Satavar root harvesting Rs./Hectare	
Harvesting through Satavar Digger	Manual digging
• 25 mandays for collection of harvested roots during digging with tractor @ Rs. 250 / manday = Rs. 6250 /-	250 Man days @. 250 / manday
• 15 Hour tractor operation @ 450 / hr = Rs. 6750/- **Total cost = Rs 13,000/-**	Total cost Rs 62,500/-
Comparative efficiency : Four to five times efficient than manual digging	

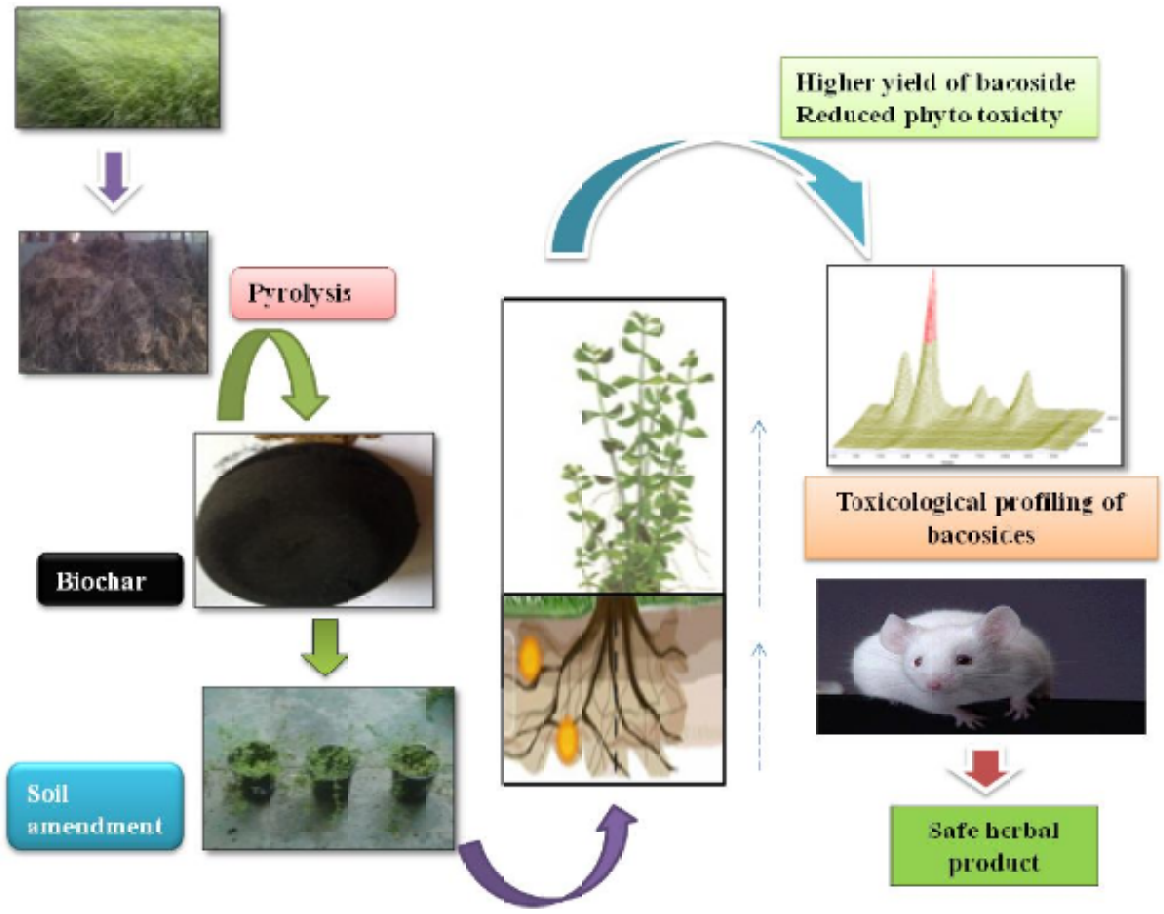
by the farmers in manual harvesting of Satavar roots, R&D work towards mechanization of this process was initiated by CSIR-CIMAP during 2015-16 and after field testing of several prototype designs. Based on the test results, finally modified design of Tractor operated Satavar root digger was successfully tested at CSIR-CIMAP research farm for its optimal performance in terms of efficiency, savings on labour input and 99% root recovery with negligible root losses/damages in comparison of manual digging process. This tractor pulled Satavar root digger reduces the digging cost by 1/5th of the manual digging cost. Developed multipurpose Satavar – Digger was released for the farmers on National Technology Day, 11th May, 2016 by Director CSIR-CIMAP, Lucknow

*** EQUIPMENT COST : APPROX RS 15,000/-**

Input : JP Tiwari

Evaluation of potentially hazardous metal (PHM) content in *Bacopa monnieri* L. grown in the acidic mine spoils

Acidic mine spoils might pose risk to the environment due to bio-accumulation of heavy metals in the food chain, which can increase the ecotoxicological risks associated with remediation of acidic mine spoils using plants. Biochar (BC) could provide the answer for this problem. In the present study, BC derived from lemongrass (*Cymbopogon flexuosus*) was investigated regarding its applicability for reducing the potentially



hazardous materials (PHM) content in the Bacopa (*Bacopa monnieri* L.) grown in the acidic mine spoil contaminated soil and associated toxicological risk. Bacopa herb powder and aqueous extracts were examined for the hazardous index and in vivo toxicity for Al, Cd, Cr, Cu, Fe and Pb. Results indicates that BC amendments increase the biomass yield of Bacopa. BC treatments were able to reduce translocation of Al (29-73%), Cr (49-83%), Cu (14-40%), Fe (66-77%) and Pb (81%) in the plant tissues significantly. Comparing with international permissible limits, lower levels of metals were recorded in the bacopa. The estimated daily intake (EDIs) of PHM for all treatments were quite lower than the tolerable limits or oral reference dose (RfD), set for daily exposure to toxic elements without any substantial health risk. In vivo toxicity also suggests that no toxic effect of bacopa extract on the albino mice. It indicates that bacopa grown in the acidic mine spoil affected area will be safer for the use.

Input : Puja Khare

The amelioration effects of biochar generated from distilled waste of *Cymbopogon flexuosus* at two temperatures on sandy loam soil and plant growth

The present study examined the effect of biochar produced from the distilled waste of *Cymbopogon flexuosus* at two pyrolysis temperatures (450 and 850°C) on the chemical and biological properties of sandy loamy soil (SLS) and its subsequent impact on plant growth performance. *Bacopa monnieri* was cultivated in SLS with biochar applied at four different rates (2%, 4%, 6% and 8% (w/w)) for 120 days. Biochar induced alterations in soil properties were evaluated by the water holding capacity (WHC), soil organic carbon contents, Cation exchange capacity (CEC), available nitrogen and phosphorus, β-glucosidases, urease and phosphatase activities. Plant response were measured by biomass yield, chlorophyll, bacoside content, antioxidant activities (DPPH, ABTS, FRAP and total antioxidants) and the total phenolic content. Biochar application, notably improved the

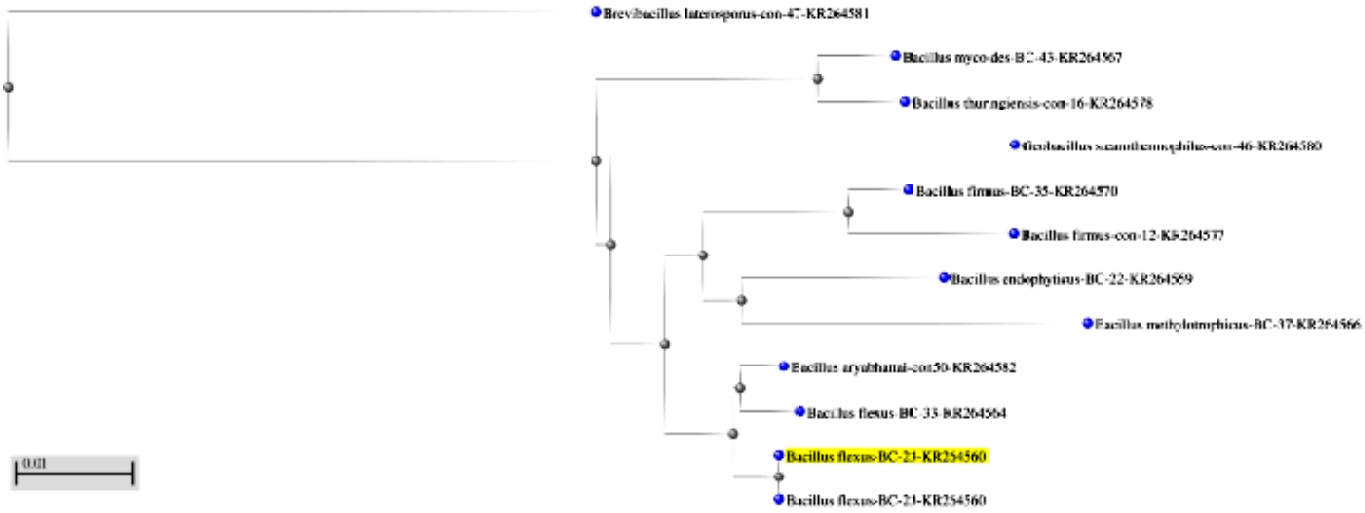


Figure Taxonomic analysis of the 16S rDNA sequence for species identification of bacteria isolated from biochar emended soils.

soil carbon content, soil cation exchange capacity and the availability of $NH4^+$ and phosphorus. Initially biochar produced at the lower temperature had more effect on the available nitrogen, phosphorus, soil enzymatic properties and plant biomass growth. After 120 days, the pyrolysis temperature had only a marginal influence on biochar-induced effects on soil pH, WHC and soil enzymatic activities. Our results suggest that *Cymbopogon flexuosus* derived biochar produced at 450°C was more effective for plant biomass production and soil characteristics improvement.

Input : Puja Khare

Effect of organic amendments and microbial application on sodic soil properties and growth of an aromatic crop

In this experiment, we studied the effects of microbial inoculation, vermicompost and sludge application on physical, chemical and microbial properties of sodic soil and growth of *Ocimum basilicum* (holy basil). Sodic soil collected from natural field was amended with two bacterial strains A and C (isolated from the same soil), vermicompost and tannery sludge @ 5 t ha”1 up to 0–15 cm soil depth of field buried cement barrels (125 cm height, 49.5 cm diameter) in such a way that nine treatments (control sodic soil (T0), vermicompost or VC (T1), VC + strain A (T2), VC + strain C (T3), VC + strain A and C (T4), tannery sludge or TS (T5), TS + strain A (T6), TS + strain C (T7), and TS + strain A and C (T8) were taken. The application of organic amendments is helpful in the reclamation of sodic soil by decreasing sodicity (EC, pH, exchangeableNa) and by increasing fertility (organic matter, status of nutrients and microbial diversity). The combination of salt tolerant bacteria together with organic amendments have comparatively high impact on physico-chemical and microbiological properties of the soil. The amendments also have a significant effect on the growth and oil yield of *Ocimum basilicum*. It can be concluded that organic amendments are helpful in improving the physico-chemical properties of sodic soil and increase crop production.

Ecological Engineering 102, 127–136, 2017.
Input : Rajesh Kumar Verma

Herbal products, formulations and process development using traditional/modern approaches

CSIR-CIMAP Cough Syrup

Over the counter, non-prescription medications are commonly used to treat acute cough (*kasa)*. Various cough syrups based on API formulations/classical literature available in markets lacks the scientifically validated proven efficacy and saftely standards. Therefore, a novel polyherbal formulation based on *Ayurvedic* therapeutic strategy, effective in cough of shorter duration and allergic origin was developed

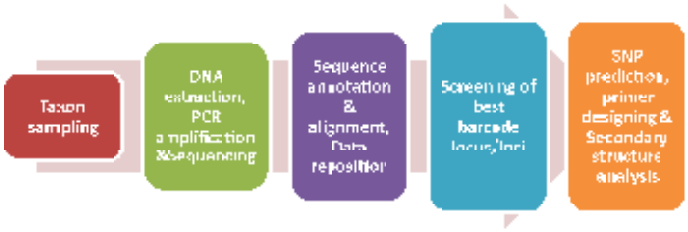
and scientifically validated with no side effects. The syrup balances the *Kaphaj-Vataj-dosha,* reduces the frequency and severity of cough, sputum quantity and suppresses the symptoms associated with allergic cough.

Input: Dr. Dayanandan Mani

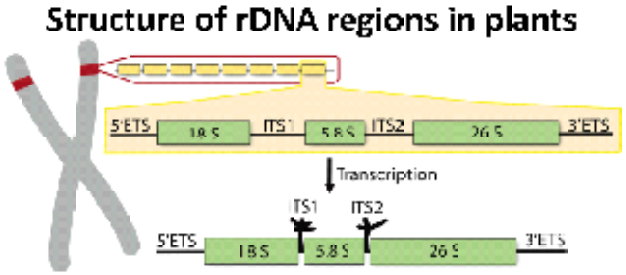
Development of DNA barcodes for selected trade in demand and CITES 11.50 medicinal plants

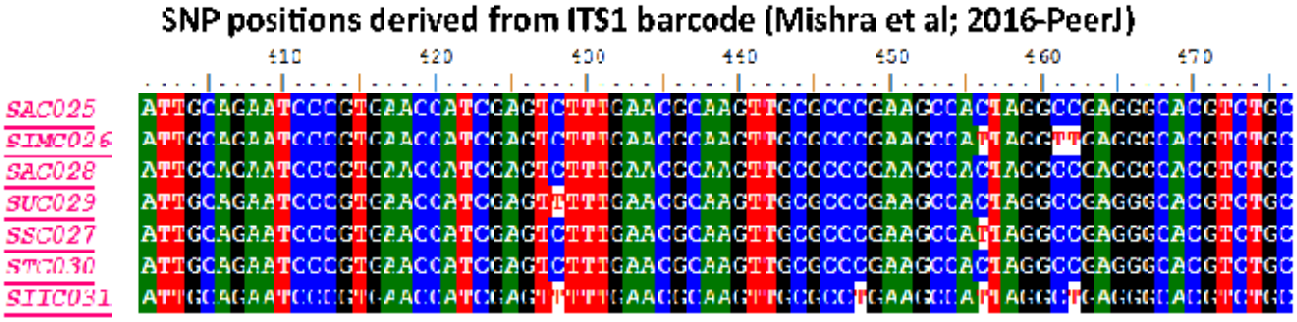
DNA barcode Secondary structure analysis & SNP Polymorphism for characterization of *Senna alexandrina* Mill.

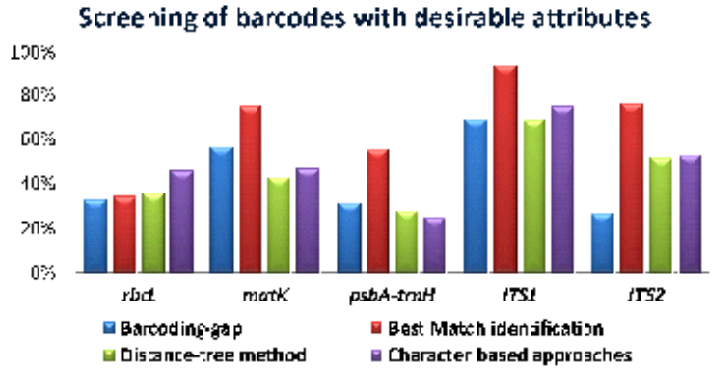
Senna alexandrina Mill. (Syn. *Cassia angustifolia* Vahl.) commonly known as Tinnevelly *Senna* or Indian *Senna* is a non-prescription laxative known for the presence of dimeric glycosides anthraquinone derivatives known as *Senna* glycosides or sennosides. The taxonomic delimitations of *Cassia angustifolia* is still debated. Tinnevelley senna is a highly valued medicinal plant that has considerable commercial importance, but is jeopardized by product substitution. We compared the secondary structure variance between ITS1 & ITS2 barcode regions correlated with the single-neucleotide polymorphism (SNP) site in ITS1 to characterize *Cassia angustifolia* from its allied species.

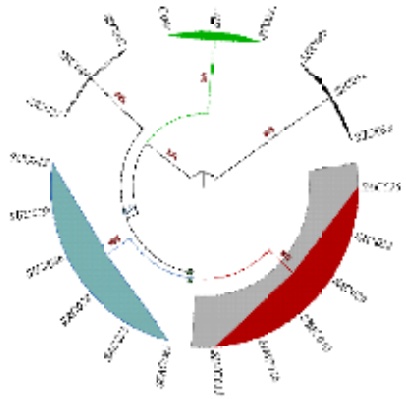


GenBank results: SAX-KY214459, SIM-KY214460, SS-KY214461, SAU-KY214462, SU-KY214463, ST-KY214464, SII-KY214465









Oligos Designed	Primer Sequence (5'-3')
SAX-C025F	GCGAGAAGCGTCAAGGAAC
SAX-C025R	CGAGGCATCTGCTCAACCA
SIM-C026F	AACCTGCGGAAAGGATCATTG
SIM-C026R	CGATGCGAGAGCCGAGATA

Species specific SNP position found between 380-470 bp region within 7 allied species of Senna were utilized to develop species specific marker. 100% grouping of SAX with SIM were further being analyzed by the secondary structure prediction analysis through RNAfold.

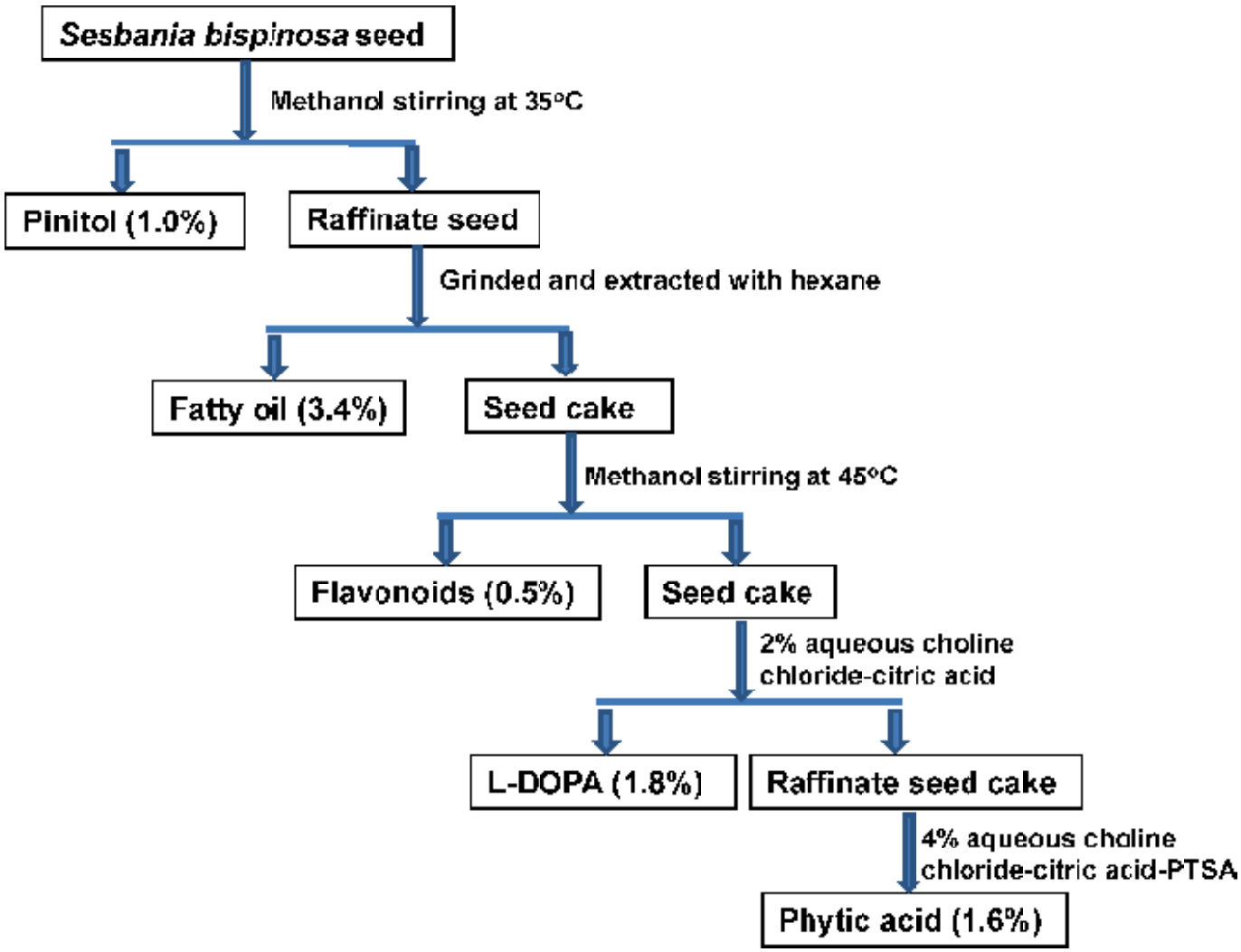
Production of bio-chemical and biofuels from spent aromatic biomass by bio/chemical processes

Process of isolation of bioactive compounds from *Sesbania bispinosa* seeds

- *Sesbania bispinosa* is cultivated for green manure purpose
- Seed contain several bioactive compounds including good quality fatty oil (unsaturated fatty acids ~75%)
- A complete flow sheet has been developed for isolation of each bioactive compounds selectively using different combination of solvent system
- Biomass is used for the isolation of cellulose (45%) as per our claimed process
- Cellulose is used for the production of glucose (60%) using *Trichoderma* culture

Chemical Engineering Science 172, 318-346, 2016 (IF: 2.75)

Input: PK Rout, AD Nannaware, A Kalra



New initiatives to boost agriculture productivity through maximizing pre-and post-harvest yields

Prevention of post harvest food losses by innovative technological strategies for enhancing shelf life of food commodities and their value added product

Our results have clearly shown that essential oil based formulations can be successfully used for stored grain protection from pests without the use of synthetic chemical insecticides. It is estimated that more than 20,000 species of field and storage pests destroy approximately one-third of the world's food production, valued annually at more than $100 billion among which the highest losses (43%) occurring in the developing world. Synthetic chemicals like phosphene and methyl bromide, apart from being toxic, are also contributing in development of resistance in insects. Essential oils therefore cannot only increase the income of rural farmers but also its formulations can promote safety and quality of food and life in general and reduce the loss of grains caused by various stored grain pests. Essential oil of *Coriandrum sativum*, 1,8-cineole and cinnamaldehyde has been identified as leads for translation into fumigant tablets. Since *C. sativum* oil is rich in linalool (58%) and geranyl acetate (14%), further theses two compounds will also be evaluated both singly and in combination which were found effective when used together. Such formulations will have huge applications not only in storage godowns but also will be useful for farmers storing the grains for their own use.

Sprouting causes increased weight loss and may impede airflow through the potato pile. Reduced airflow often leads to increased pile temperatures and an increase in problems related to rotting.

Sprouting is also associated with the conversion of starch to sugars, which is undesirable in the processing industry due to darkening of fried products. One method to delay sprout development is with cold temperature storage (38-42°F) which is quite expensive. We have identified essential oil which can regulate (promote and suppress) the sprouting of potatoes. The ones improving the sprouting were also used for enhancing sprouting of *Mentha* suckers for faster growth and higher yields and were found to be useful in improving the yields. Such essential oil based regulators of sprouting could be an economical alternate to chemical sprout inhibitor, such as chlorpropham (CIPC), the most commonly used post-harvest sprout inhibitor in the United States. CIPC, however, inhibits sprout development by interfering with cell division, and, therefore cannot be used for seed potatoes.

Essential oil based preservatives and surface sterilizing agents would be of great use and would be able to replace toxic synthetic chemicals. Essential oils from cinnamon leaf and ajwain could be successfully used in many herbal formulations for increasing the shelf life and also could reduce the microbial load on the surface of fruits and vegetables.

Bio-prospection of Plant Resources and other Natural Products

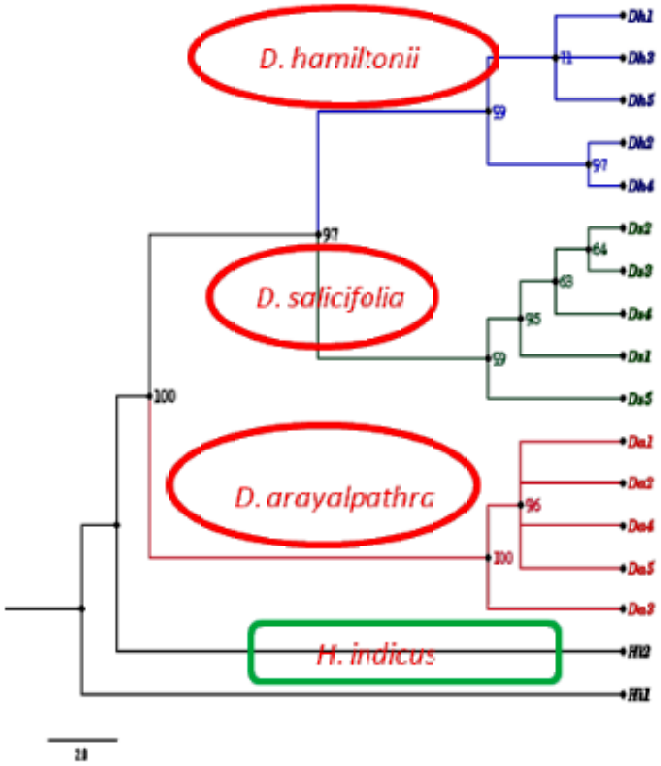
Prospecting the virtually untapped sources of plants is highly significant in view of the emerging need of novel chemotherapeutic agents. The project aims on systemic documentation, evaluation and utilization of biodiversity towards prospecting novel phytomolecules for therapeutic use in disease conditions. Briefly, the objectives of the project revolves around bioresource mapping, eco-geographic assessment, in different plant groups and bio-prospecting unexplored species for their medicinal properties.

Towards bioresource mapping, a combination of experimental data and an *in-silico* approach was performed to decipher the comparative potential of ITS datasets (ITS1, ITS2 and concatenated) in resolving the underlying morphological disparity in the highly complex genera, to assess their discriminatory power as potential barcode candidates in Cassiinae. Lab-generated sequences were compared against those available in the GenBank using BLAST and were aligned through MUSCLE 3.8.31 and analysed in PAUP 4.0 and BEAST1.8. DNA barcoding gap was realized based on the Kimura two-parameter distance model (K2P) in TaxonDNA and MEGA. The reticulated phylogenetic hypothesis using the ITS1 region mainly supported the relationship between the species of Cassiinae established by traditional morphological methods. The ITS1 region showed a higher discrimination power and desirable characteristics as compared to ITS2 and ITS1+2 there by concluding to be the locus of choice. Considering the complexity of the group and the underlying biological ambiguities, the results presented here are encouraging for developing DNA barcoding as a useful tool for resolving taxonomical challenges in corroboration with morphological framework.

In another study involving the steno-endemic species of genus *Decalepis* which is highly threatened by destructive harvesting from the wild. The medicinally important fleshy tuberous roots of *Decalepis hamiltonii* are traded as substitute to meet the international market demand of *Hemidesmus indicus*. Also, the tuberous roots of all the three species of *Decalepis* possess similar exudates and texture, which challenges the conventional techniques alone to ascertain the accurate species authentication. A study was undertaken to generate DNA barcodes for Decalepis species, which could be utilized in curtailing the illegal trade of these endangered species. The first DNA barcode reference library was developed in BOLD database with candidate barcodes *rbcL*, *matK*, *psbA-trnH*, *ITS* and *ITS2*. The individual barcodes and their multilocus combinations were tested for their efficacy with distance-based as well as different model-based machine learning methods.

The present study unequivocally demonstrates the efficiency of DNA barcoding for endemic species identification. The signature sequences of the proposed barcode rbcL+matK+ITS provided accurate signals in facilitating the molecular identity of Decalepis species in accordance with its latest taxonomic revision. The region clearly framed the entire sister species of *Decalepis* as a major cluster with its potent substitute *H. indicus* as an out-group positioning as nodal branch at the base of the tree. The species-specific assays derived on *matK* barcoding

Region	Best match			All species barcodes		
	Correct (%)	Ambiguous (%)	Incorrect (%)	Correct (%)	Ambiguous (%)	Incorrect (%)
ITS1	81.63	8.16	10.2	30.61	63.26	6.12
ITS2	75.0	0	25.0	33.33	62.5	4.16
ITS1+2	77.41	19.35	3.22	19.35	77.41	3.22



region sequences further confirm its uniqueness in providing accurate species discrimination method in CITES. The character-based approach through PAUP and BLOG successfully distinguished 100% of investigated samples rendering its accuracy and reliability as a method of choice in DNA barcoding studies. The inclusion of different conspecific populations is expected to gain insight into the conservation status of *Decalepis* species hotspots as well as emphasizing the practical application of DNA barcoding tool in biodiversity conservation of endemic and threatened plant groups.

Towards the bio-prospection of endangered species against *P. falciparum*, 18 positives (<50µg) were narrowed down. All these positives are being pursued for higher quantities of the samples so as to follow them up in the mouse model of malaria.

Structural and Functional Genomics of *Ocimum* species

Several *Ocimum* species grown in India are used in Ayurvedic and indigenous medicines. The presence of important essential oils and medicinal properties in different species of *Ocimum* makes them attractive for modern molecular studies. Therefore, sequencing of leaf transcriptomes of most prominent species popularly grown in India, including *O. sanctum, O. basilicum*, *O. gratissimum* and *O. kilimandscharicum*, and *O. africanum* were undertaken in this network project. During the past couple of years, leaf transcriptomes of *O. sanctum* (CIM-Ayu), *O. basilicum* (CIM-Saumya), *O. gratissimum* and *O. kilimandscharicum* were sequenced, analyzed. In this line, a recently developed lemon scented variety of *O. africanum* (CIM-Jyoti) was selected for sequencing of leaf transcriptome. Mature leaf tissue was harvested and subjected to deep sequencing by using illumina technology (150 bp paired end), and sequence data was generated and analyzed.

[A]. Transcriptome Sequencing of *Ocimum* species:

The total RNA was extracted from *O. africanum* leaf tissue and library was constructed for deep sequencing (**Figure 1**). The paired-end Sequencing-by-Synthesis (SBS) on Illumina platform yielded

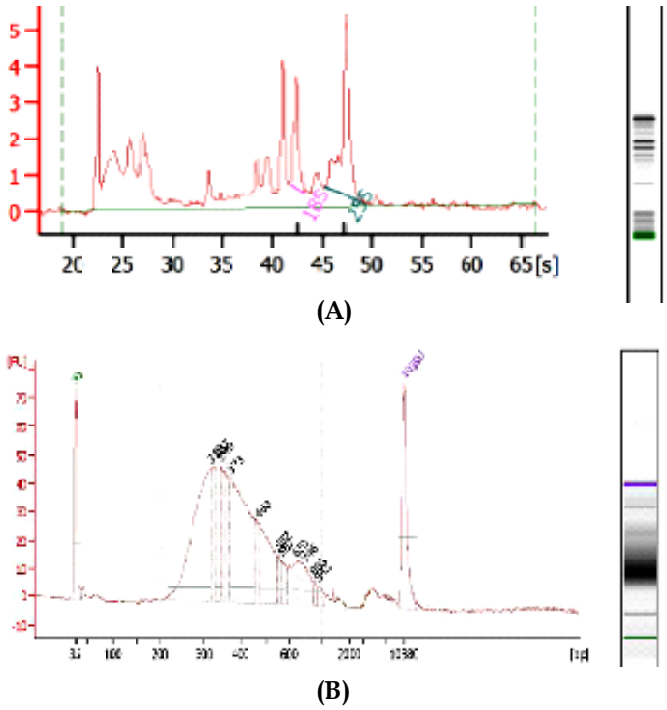


Figure 1. Bioanalyzer profile of (A) RNA, and (B) amplified product. Size range of library: 250-880, Insert size in library: 130-680 bp, Adapter size: 120 bp.

30.68 million raw reads. The reads were then processed to remove adaptor sequences which yielded 26.99 million high quality reads. These high quality reads were assembled to generate contigs which resulted in 69,191 transcripts with an average length of 817.7 ± 613.9 bp with N50 value of 1053. Around 41,013 and 18,240 transcripts

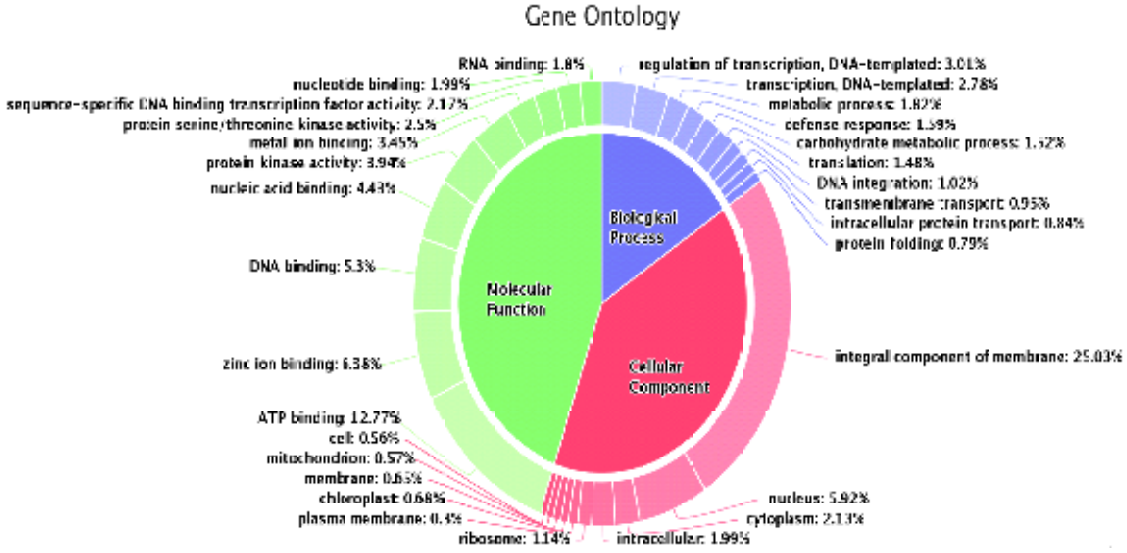


Figure 2. Gene Ontology classification of *O. africanum* leaf transcripts.

were found to be greater than 500 bp and 1.0 Kb, respectively. Functional annotation (GO: Gene Ontology) was done to assign putative functions to the transcripts that were generated after the assembly. Transcripts were clustered at 95% identity which resulted into clustered orthologous groups (COGs). COGs were annotated using NCBI BLASTx program against the non-redundant protein sequences of Viridiplantae taken from Uniprot database. The associated hits were searched for their respective GO. Based on homology, 50,323 transcripts could be annotated and categorized under three main categories: Biological Process (BP), Cellular Component (CC) and Molecular Function (MF) (**Figure 2**).

KEGG pathway analysis of *O. africanum leaf* transcriptome

Pathway analysis was done by using KAAS Server. Eudicots [*Arabidopsis thaliana* (thale cress), *Arabidopsis lyrata* (lyrate rockcress), *Brassica rapa* (field mustard), *Tarenaya hassleriana* (spider flower), *Citrus sinensis* (Valencia orange), *Theobroma cacao* (cacao), *Glycine max* (soybean), *Fragaria vesca* (woodland strawberry), *Cucumis sativus* (cucumber), *Populus trichocarpa* (black cottonwood), *Vitis vinifera* (wine grape) and *Solanum lycopersicum* (tomato)] were considered as reference organisms for pathway identification (**Figure 3**).

Simple sequence repeat (SSR) markers in the transcripts

The assembled contigs of *O. africanum* were analyzed for the presence of SSR markers by using MISA program. Out of 69,191 transcripts (contigs), 9,281 sequences contained 10,911 SSRs. Tetra-nucleotide repeats were highest in number followed by others (**Table 1** and **Figure 4**).

Table 1. Statistics of identified SSRs

Types of SSRs	*O. gratissimum*
Total number of identified SSRs:	10911
Number of SSR containing sequences:	9281
Number of sequences containing more than 1 SSR:	1373
Di-nucleotide Repeats (p2: > 6 repeats)	2629
Tri-nucleotide Repeats (p3: ≥ 5 repeats)	2073
Tetra-nucleotide Repeats (p4: ≥ 5 repeats)	3107
Penta-nucleotide Repeats (p5: > 5 repeats)	15
Hexa-nucleotide Repeats (p6: > 5 repeats)	05

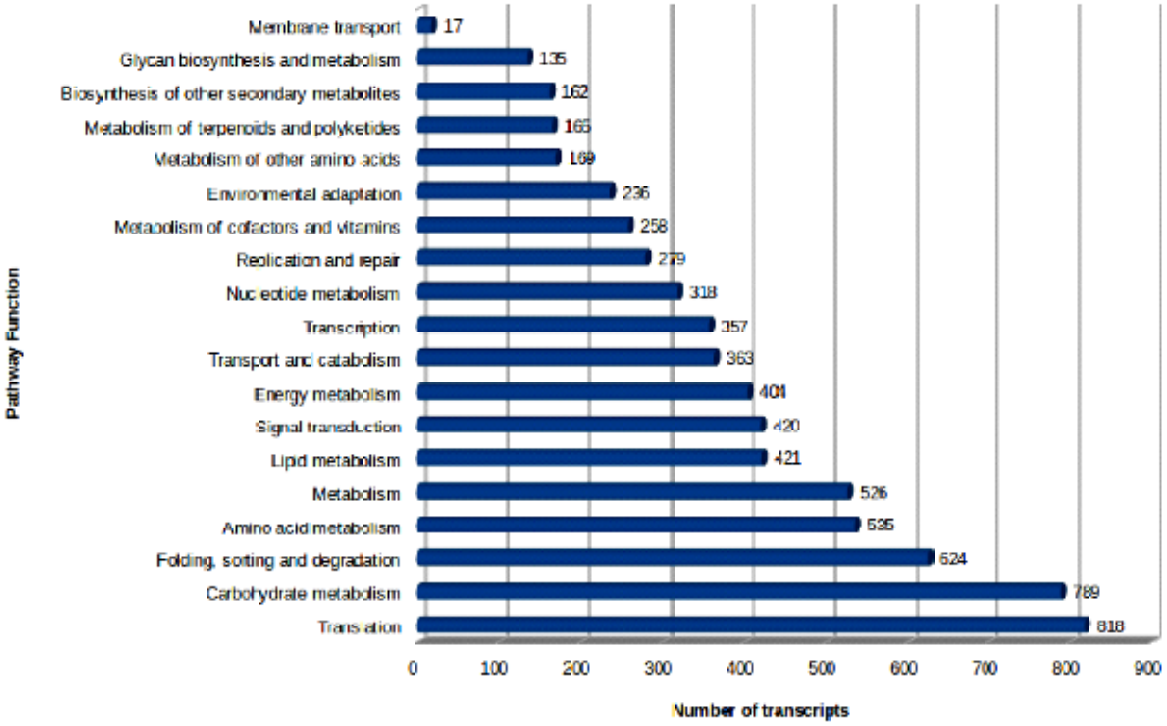


Figure 3. KEGG Pathway analysis of *O. africanum* transcripts.

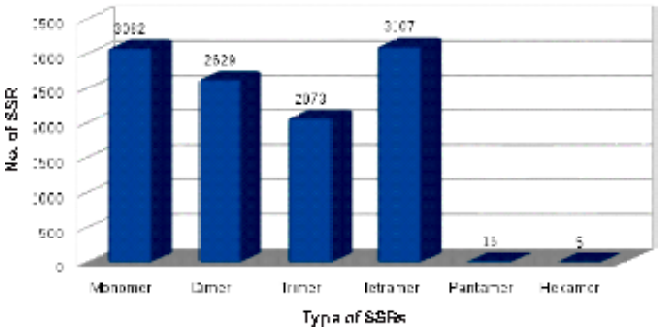


Figure 4. SSRs identified in *O. africanum* transcripts.

[B]. Characterization of a Thaumatin-like protein (ObTLP1) from *Ocimum basilicum*

Functional characterization of an *Ocimum basilicum* PR5 family member (*ObTLP1*) was completed. *ObTLP1* encodes a 226 amino acid polypeptide that showed similarities with a sweet-tasting protein thaumatin of *Thaumatococcus danielli* and also with a stress-responsive protein osmotin of *Nicotiana tabacum*. The expression of *ObTLP1* in *O. basilicum* was found to be organ-preferential under unstressed condition, and responsive to biotic and abiotic stresses, and multiple phytohormone elicitations. Bacterially-expressed recombinant ObTLP1 inhibited mycelial growth of the phytopathogenic fungi, *Sclerotinia sclerotiorum* and *Botrytis cinerea*; thereby, suggesting its antifungal activity (Figure . Ectopic expression of *ObTLP1* in Arabidopsis led to enhanced tolerance to *S. sclerotiorum* and *B. cinerea* infections, and also to dehydration and salt stress. Thus, *ObTLP1* might be useful for providing tolerance to the fungal pathogens and abiotic stresses in crops. (**Misra et al., 2016, Scientific Reports, 6:25340**).

Take Home Message

Transcriptome of *O. africanum* (CIM-Jyoti) leaf tissue was sequenced, assembled and analyzed. Several important genes/transcripts related to the biosynthesis of secondary metabolites could be identified in the transcriptome data. Apart from

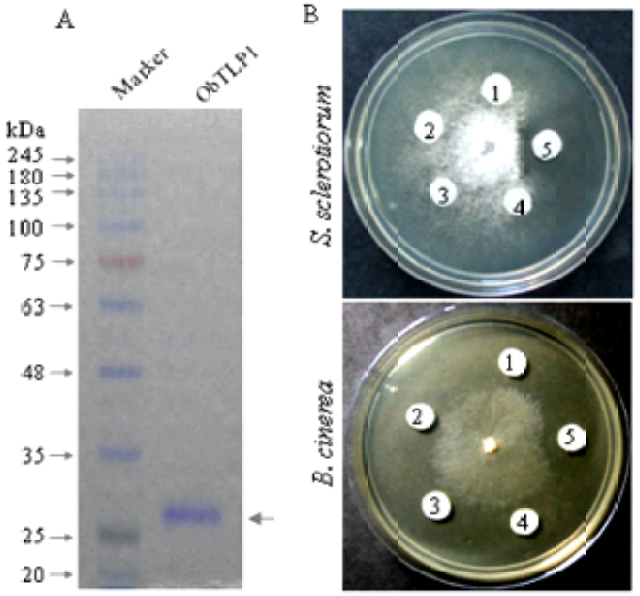


Figure 5. A dose-dependent antifungal activity of ObTLP1 against phyto-pathogenic fungi *Sclerotinia sclerotiorum* and *Botrytis cinerea* (A) Purified protein, and (B) Anti-fungal activity, 1. buffer only, 2. BSA in buffer, 3-5. 3µg, 10 µg and 30 µg purified protein.

the pathway genes, several SSR markers were also detected in the sequences. The information generated would be useful for the genetic improvement of *Ocimum* species. An *O. basilicum* PR5 family member (*ObTLP1*) was completely characterized. Recombinant ObTLP1 inhibited mycelial growth of the fungi *Sclerotinia sclerotiorum* and *Botrytis cinerea* which clearly suggested its antifungal activity. Ectopic expression of *ObTLP1* in Arabidopsis led to enhanced tolerance to *S. sclerotiorum* and *B. cinerea* infections, and also to dehydration and salt stress.

Scientific Reports 6: 25340, 2016 (IF 5.228)

Front. Physiol. (accepted: doi: 10.3389/fphys.2016.00691) (IF ~4.0).

Proceedings of the Indian National Science Academy (PINSA) 82: 1187-1208.

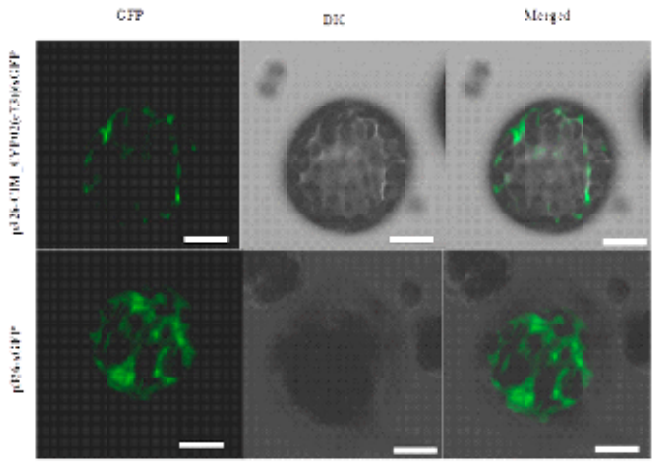
Inputs by: V. Gupta, A.K. Shasany, N.S. Sangwan, D.A. Nagegowda, S. Ghosh and R.K. Shukla

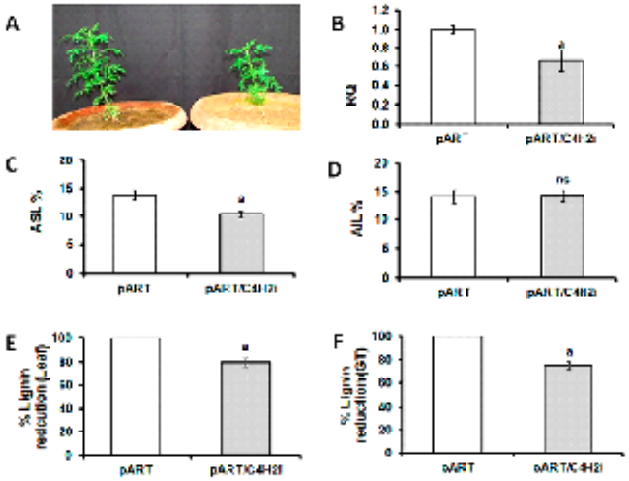
Plant Diversity: Studing adaptation biology and understanding/exploiting medicinally important plants for useful bioactives

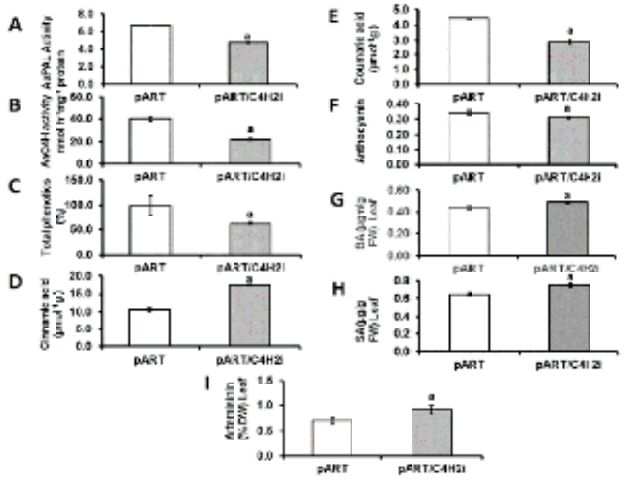
RNAi down-regulation of *cinnamate-4-hydroxylase* increases artemisinin biosynthesis in *Artemisia annua*

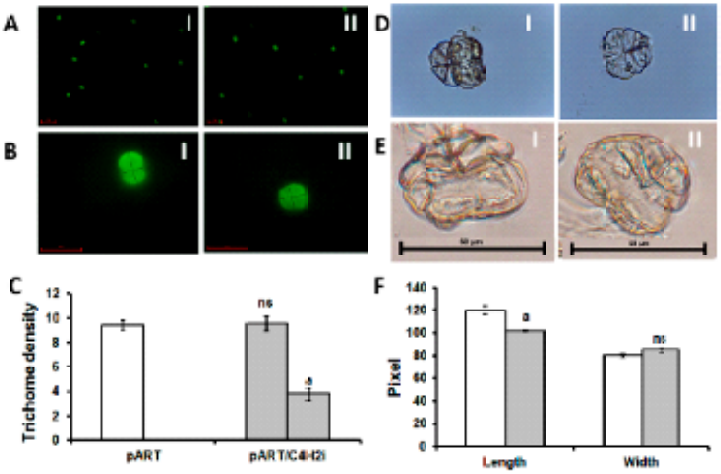
Cinnamate-4-hydroxylase (C4H) converts *trans*-cinnamic acid (CA) to *p*-coumaric acid (COA) in the phenylpropanoid/ lignin biosynthesis pathway. Earlier we reported increased expression of AaCYP71AV1 (an important gene of artemisinin biosynthesis pathway) caused by CA treatment in *Artemisia annua*. Hence, AaC4H gene was identified, cloned, characterized and silenced in A. annua with the assumption that the elevated internal CA due to knock down may increase the artemisinin yield.

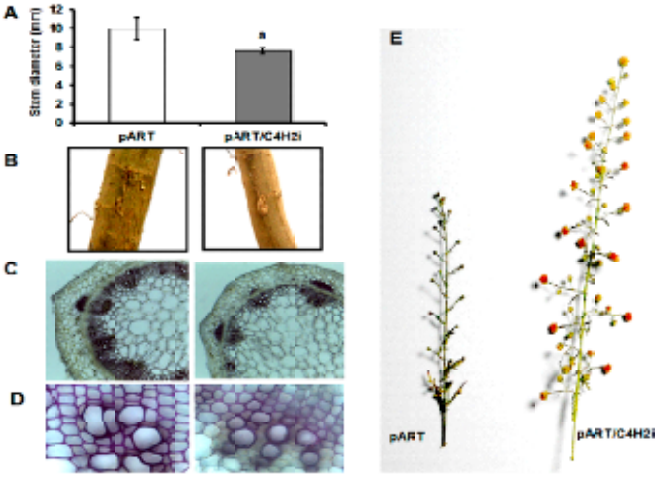
Accumulation of trans-cinnamic acid in the plant due to AaC4H knockdown was accompanied with the reduction of p-coumaric acid, total phenolics, anthocyanin, cinnamate-4-hydroxylase (C4H) and phenylalanine ammonia lyase (PAL) activities but increase in salicylic acid (SA) and artemisinin. Interestingly, feeding trans-cinnamic acid to the RNAi line increased the level of artemisinin along with benzoic (BA) and SA with no effect on the downstream metabolites p-coumaric acid, coniferylaldehyde and sinapaldehyde, whereas p-coumaric acid feeding increased the content of downstream coniferylaldehyde and sinapaldehyde with no effect on BA, SA, trans-cinnamic acid or artemisinin. SA is reported earlier to be inducing the artemisinin yield.

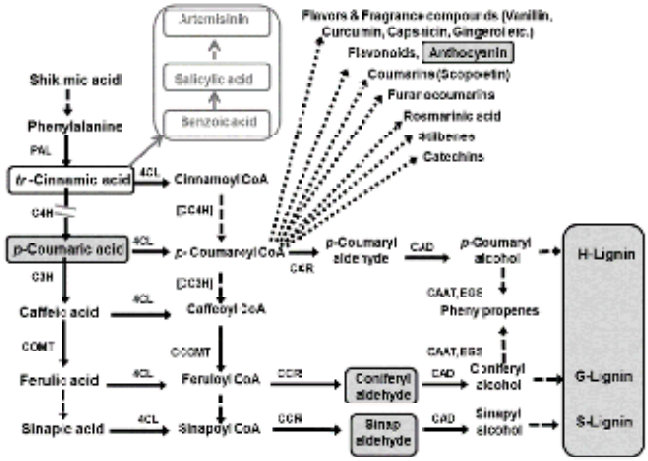












This report demonstrates the link between the phenylpropanoid/ lignin pathway with artemisinin pathway through SA, triggered by accumulation of trans-cinnamic acid because of the blockage at C4H.

Sci Rep. 2016 May 25;6:26458. doi: 10.1038/srep26458
Input By Ajit K Shasany

Introduction, domesticaltion, improvement and cultivation of economically important plants

Development of superior genotype in Palmarosa:

Under the programme number of high essential oil yielding strains of Palmarosa were developed. Among these strains the performance of the palmarosa composit-10 was evaluated in pilot scale trial over year. The composite -10 is maintaining their superiority over all four checks for herb and oil yield with better quality essential oil as in bellow table:

Table. Annual Performance over three cuttings/ year of composite-10 in pilot scale trial

S. No.	Entries	Herb yield (q/ha)	Oil yield (Kg/ ha)	Geriniol content (%)	Geranyl-formate	Linalool
1.	Composite-10	325.16	245.15	89.83	3.044	3.565
2.	CIMAP Harsh	298.52	210.00	88.08	0.041	2.593
3.	Trishna	265.35	195.35	86.11	0.050	2.517
4.	PRC-1	255.89	186.49	84.80	0.021	2.692
5.	Tripta	279.45	187.36	86.71	0.025	2.405

*In 50 kg tank hydro-distillation

Input : Dr R K Lal

Effect of Biochar on Menthol mint and Geranium:

We examined the effectiveness of biochar on the growth of *M. arvensis and geranium* due to inhibitory effects of low resilience and metal contaminated soils. Results indicate that in biochar treatments significantly increase in biomass yield and oil content. The improvement in gas exchange, photosynthetic pigment contents and uptake of essential elements (Ca, Mg and K) in the plant was observed.The addition of biochar enhanced the available phosphorus (P) (162-553%), organic carbon (OC) (146-312%), pH (1.1-1.7 unit) and cation exchange capacity (CEC) (23-72%) in soil, which is attributed to high P, OC content and CEC value of biochar. The increase in soil enzymatic activity in biochar treatments was also observed; beta-glucosidases (7-121%), Alkaline phosphatase (28-112%), Acid phosphatase (15-98%) and Urease (26-89%).

Input: Dr Puja Khare

Development of natural hair oil to control dandruff and help in hair growth.

Screening of the plants were carriedout for desired activities required for quality dandruff management hair oil. The extracts were prepared and different combinations were made. These combinations are under evaluation for anti-microbial activity. Formulation of the oil is under process and various parameters related to the final product like efficacy against dandruff, skin irritation test, GC, HPTLC fingerprinting, stability data and user feedback analysis of the formulation is to be completed.

Input: Dr Dinesh Kumar

Agro-technology for enhancing menthofuran rich Mint:

CIM-Patra: *Metha piperita* is most important commercial source of Menthofuran and CIM Patra is Menthofuran rich cultivar (47%). But herbage yield is low, so to increase its herbage yield experiments were planned in intercropping with Maize in different row pattern. Maximum growth of CIM-Patra was obtained in 3:1+1 and 4:1+1 when planting was done at ridges.

CIM-Patra was obtained in 3:1+1

CIM-Patra was obtained in 4:1+1

Input : Dr Saudan Singh

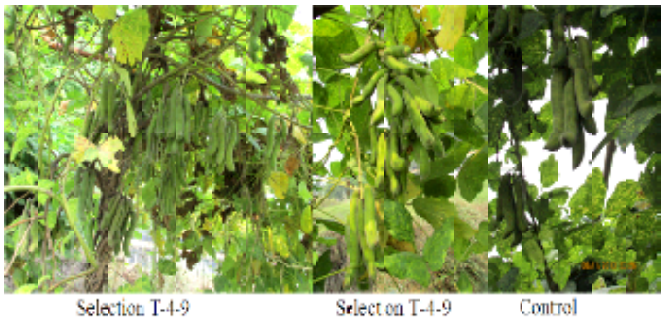
Development of functional food for lactating mothers:

Developed the standard operating procedure (SOP) for preparation of formulation in different dosage of different forms viz., Granules, Syrup, Paste *(Awaleha)* and Candy of the functional food for lactating mothers. Micro and macro nutrient element study of plant material has been completed. Heavy metal analysis of plant material has been completed. Primary evaluation of formulations has been completed. Acute safety studies of individual plant materials too were completed.

Input: Dr DN Mani

Identification of new genotype in *Mucuna pruriens* with desirable traits.

The morphological changes were observed and recorded after treatment of seeds with genotoxin (gamma irradiation), their germination and growth in field. The treated seeds after germination showed varied morphology compared to control. There were visible variations in pod characteristics as numbers of pods per cluster, length of inflorescence axis as depicted in figures.



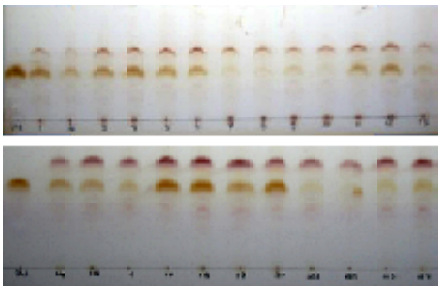
Selected variants and control.

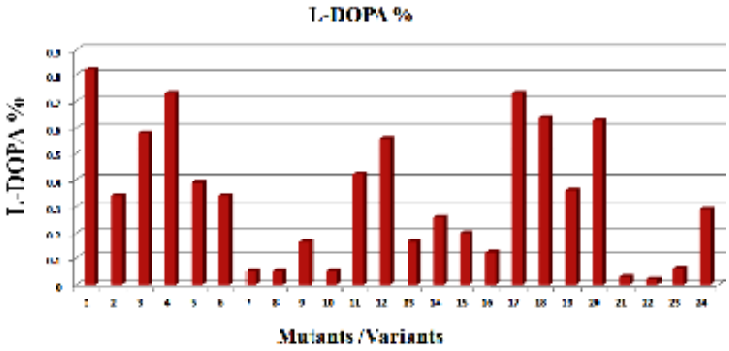
Pod characteristics of selected variants and control.

The variants were selected on the basis of high L-DOPA concentration and other elite traits in subsequent generations.

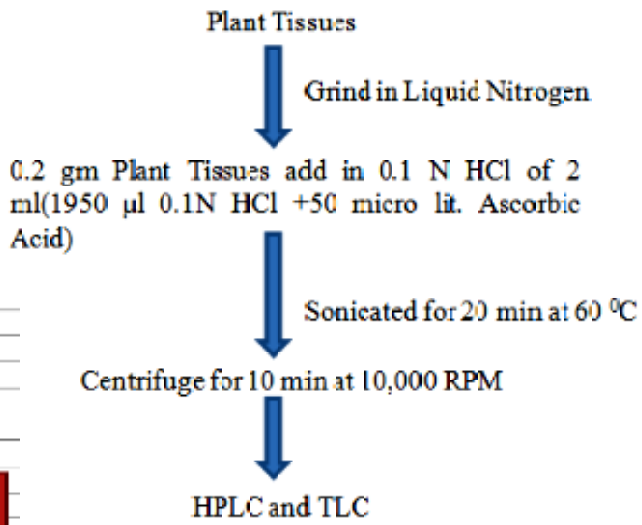
L-DOPA analysis in different mutants/variants in M_2 generation

L-DOPA percent in selected variants in TLC





Methodology



L-DOPA% in different mutants /variants and control from fresh leaves by HPLC.
Comparative variations in different variants and control for L-DOPA %

Assessment of natural mycorrhizal colonization and soil fertility status of lemongrass [(*Cymbopogon flexuosus*, Nees ex Steud) W. Watson] crop in subtropical India

The objective of this experiment was to evaluate the changes on mycorrhizal root colonization (through natural infection into the lemongrass roots), soil pH, soil organic carbon (SOC), total nitrogen, available soil nutrients and soil enzymes of lemongrass in 1st year and their subsequent crops 2nd year (1st ratoon) and 3rd year (2nd ratoon). The results showed that chemical and biological properties of the soil was significantly influenced in 1st year and subsequent ratoon crops of 2nd and 3rd year. Natural mycorrhizal root colonization was significantly observed in lemongrass crop. Maximum mycorrhizal root colonization (74%) was found in the 3rd year lemongrass crop. Soil pH significantly decreased in the 2nd and 3rd year crops as compared to the fallow soil. The maximum SOC (58%), total nitrogen (65%), available P (204%) and available K (52.9%) was build up in the 3rd year crop soil as compared to the fallow soil. Among all the crop years (1st year, 2nd year and 3rd year) $NH4^{+}$–N had higher concentration compared to $NO3^{-}$–N in lemongrass grown soil as well as fallow soil, however, the quantitative estimates of the two ionic forms of N were lower in the fallow soil compared to the lemongrass grown soil. The soil enzymes activity in lemongrass field was significantly higher as compared to fallow soil.

Journal of Applied Research on Medicinal and Aromatic Plants, 2016
Input: Rajesh Kumar Verma

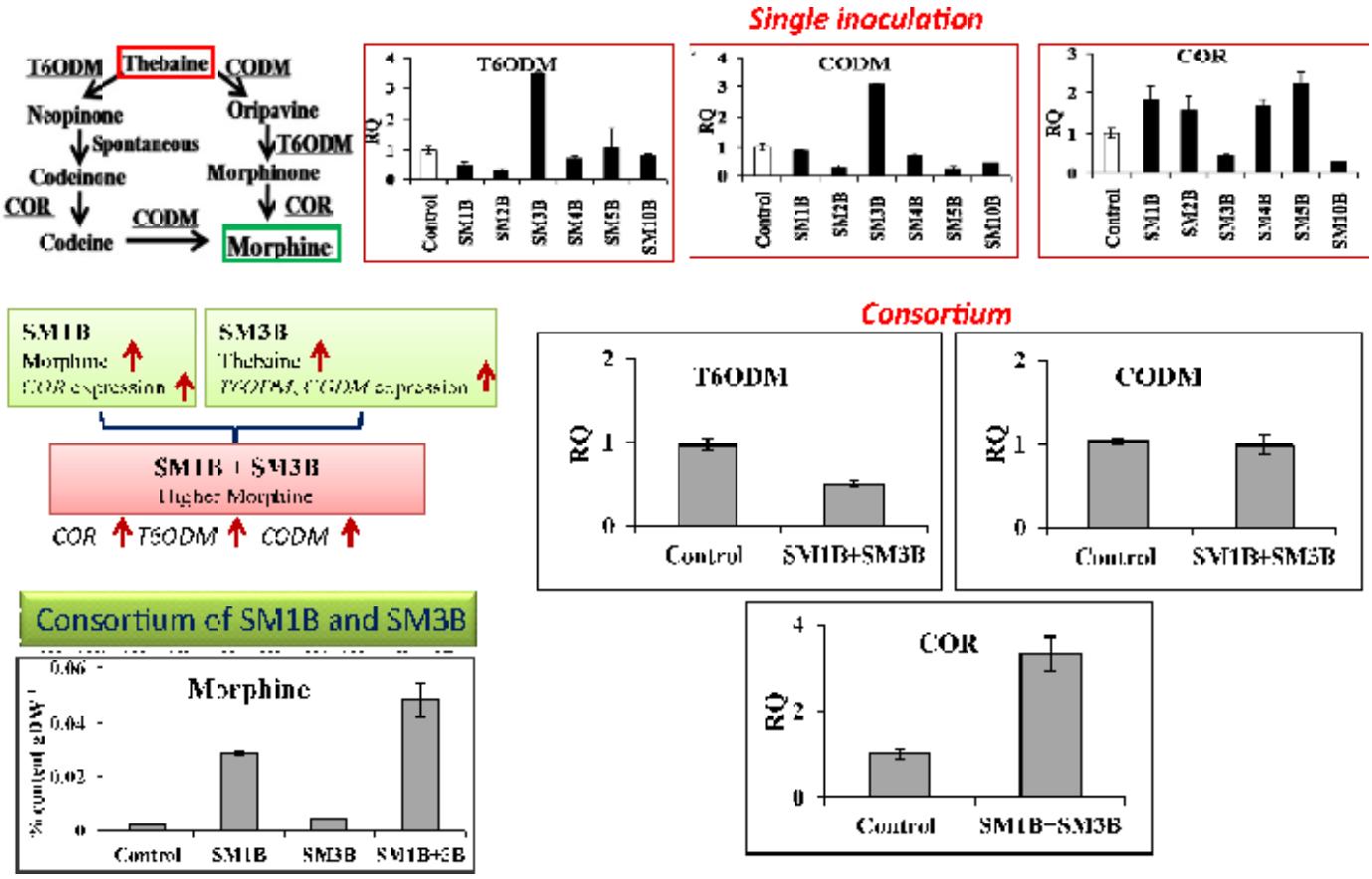
Metal absorption properties of Mentha spicata grown under tannery sludge amended soil-its effect on antioxidant system and oil quality

An experiment was conducted to investigate the metal absorption properties of *Mentha spicata* grown under different levels of TS amended soil (soil: sludge in 100:0, 75:25, 50:50, 25:75 and 0:100 ratio) and its effect on the antioxidant system and oil quality. At 75:25 ratio of sludge and soil, metal translocation factor was $\geq$ 0.5 for Cr, Cd, and Co and for Ni and for Pb $\geq$ 1. Carvone, limonene, dihydrocarvone and other oil constituents along with biomass were maximum in 75:25 ratio of sludge and soil. Superoxide dismutase (SOD), CAT (Catalases), POD (Peroxidases), MDA (Malondialdehyde) and proline play a major role in detoxification of reactive oxygen species generated due to TS (heavy metal stress). Antioxidant (SOD, CAT and POD), MDA and proline showed an increasing trend as the concentration of TS increased with the treatments. To test the relationship between 23 character principal component analysis (PCA) was performed. PC-I contributed 56% of total variance while PC-II contributed 37% of total variance. The results concluded that M. spicata performed well in terms of oil yield and multiple metal translocations in 75:25 sludge and soil ratio.

Chemosphere., 2016 147:67-73.
Input: Rajesh Kumar Verma

Plant-Microbe and Soil Interactions

Plant-endophyte interactions responsible for enhancing yields of selected therapeutically useful secondary metabolites in opium poppy



Inoculation of consortium of endophytes (SM1B+SM3B) performed better than single inoculation for *in planta* morphine production by upregulating the expression of *COR* (3.3 fold) which is a key regulatory gene of BIA biosynthesis resulted enhanced morphine production in opium poppy

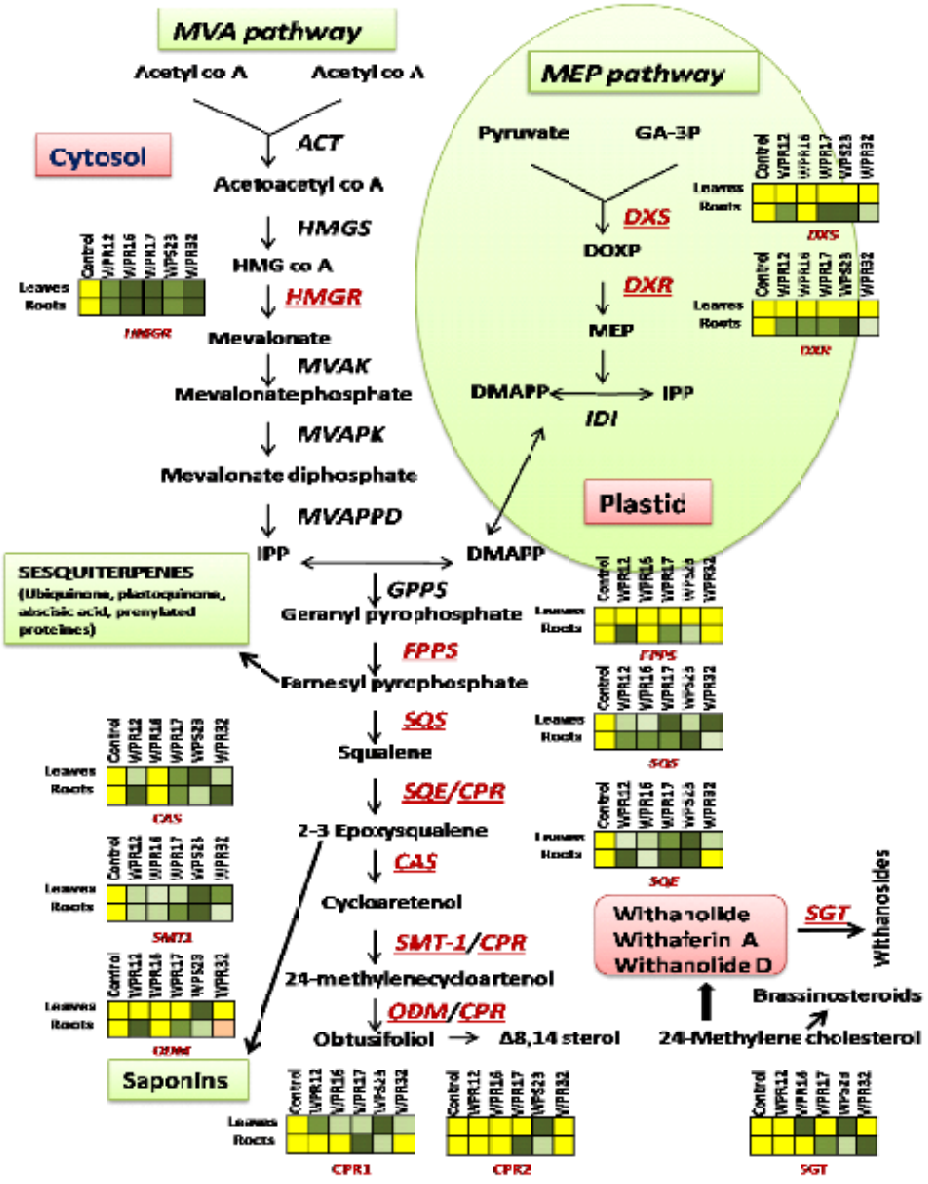
Plant-endophyte interactions responsible for enhancing yields of selected therapeutically useful secondary metabolites

Differential modulation of withanolide biosynthesis by different endophytes

- Endophytes modulated the expression of most of the genes of withanolide biosynthesis in both leaf and root tissue.
- Most of the selected endophyte-inoculation upregulated the expression of *SQS*, *SQE*, *CAS* and *SMT* that could enhance the production of withanolides in leaf and root of *W. somnifera* plants.

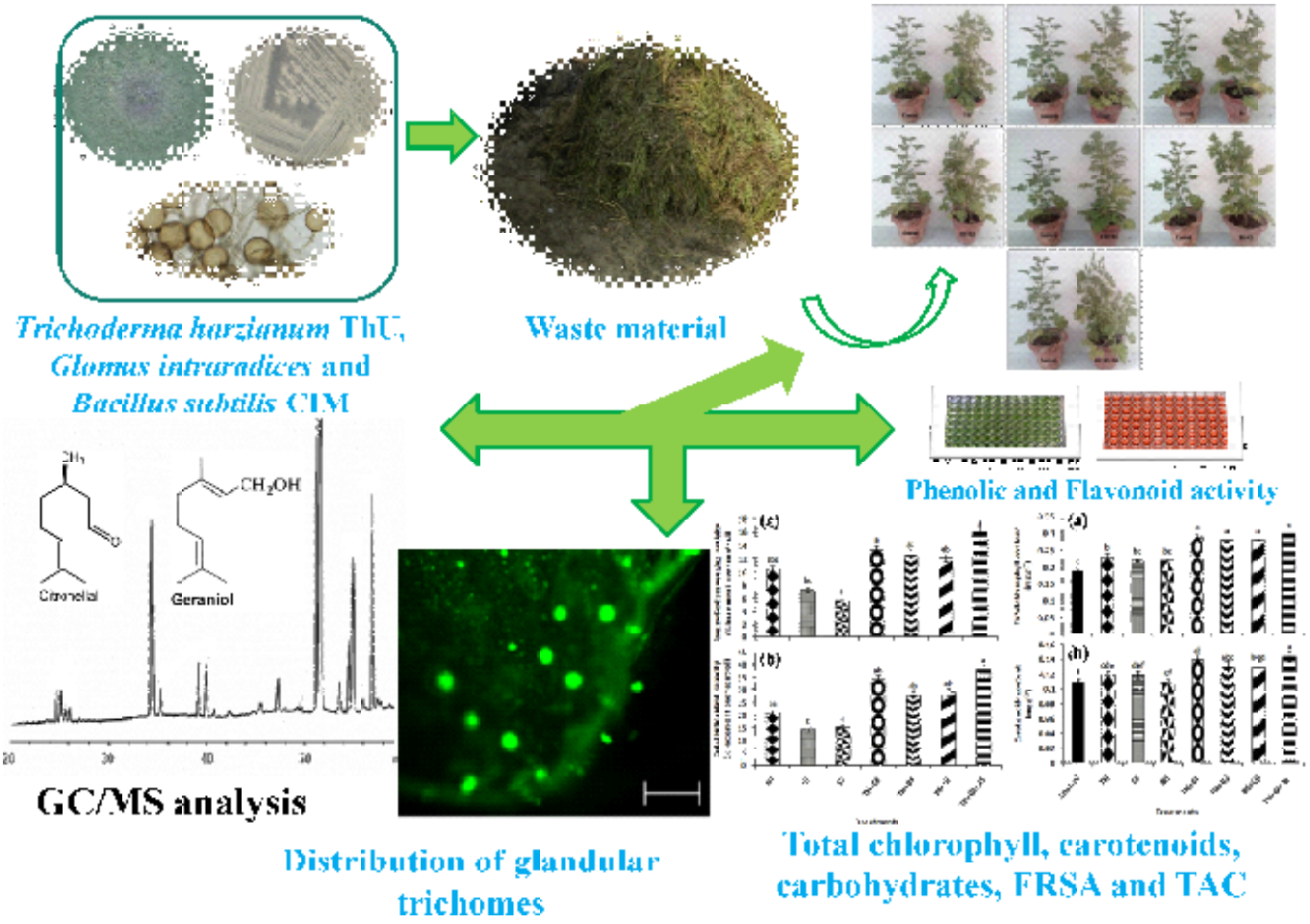
Expression of different genes was presented in square boxes. Green colour of boxes indicate upregulated expression (intensity of green colour shows the level of expression i.e. more green more expression and vice versa), yellow colour shows the level of expression in non-inoculated endophyte free control plants and orange colour shows downregulated expression.

Enzyme abbreviations: HMGR, 3-hydroxy-3-methylglutaryl-coenzyme A reductase; DXS, 1-Deoxy-D-xylulose-5-phosphate synthase; *DXR*, 1-deoxy-D-xylulose-5-phosphate reductase; *FPPS*, farnesyl diphosphate synthase; *SQS*, squalene synthase; *SQE*, squalene epoxidase; *CAS*, cycloartenol synthase; CPRs (1,2), cytochrome P450 reductase; *SMT*, sterol methyl transferase; *ODM*, obtusifoliol-14 - demethylase,



Microbes enhanced glandular trichomes, secondary metabolites and antioxidants in Geraniu

Despite the vast exploration of microbes for plant health, there is a lack of knowledge about the synergistic effects of specificmicroorganisms insustainable agriculture, especially in medicinalplants such as*Pelargoniumgraveolens* L'Hér.The aim of this study was to evaluate how synergistic microbes *Trichoderma harzianum* ThU, *Glomus intraradices* and *Bacillus subtilis* CIM affected crop productivity, secondary metabolites and glandular trichome number in *P. graveolens*. The results demonstrated a significant ($P < 0.05$) increase in plant growth, secondary metabolites, total chlorophyll, carotenoids, carbohydrates, total phenolics, total flavonoids, free radical-scavenging activity and total antioxidant capacity of *P.*

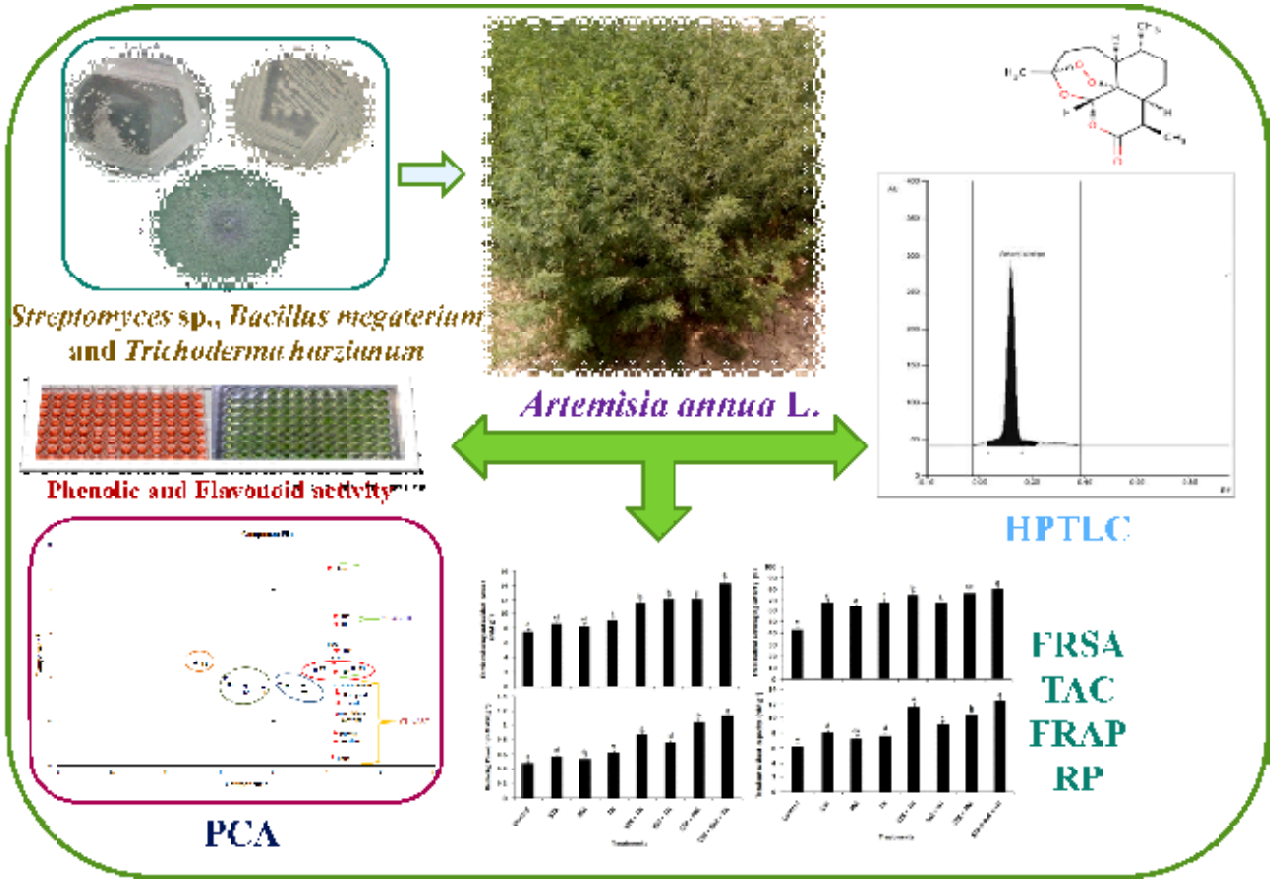


graveolens treated with synergistic bioinoculants as compared with the control. Most interestingly, an increase in essential oil by 32% in the treatment with all three microbes was observed. Furthermore, the principal aroma compounds citronellol and geraniol also increased in the same treatment. A positive and direct correlation was observed between essential oil content and number of glandular trichomes in all treatments. The present study highlights an explicit amalgamation of prospective microbes showing potential for synergism that act as biostimulants in enhancing plant production and improving the antioxidant and aroma profile of *P. graveolens*.

Journal of Food Science and Agriculture. **96**: 4151–4159DOI 10.1002/jsfa.7617, 2016
Input: Gupta, R., Singh, A. and **Pandey, R.**

Utilization of microbes on growth, antioxidant and artemisinin content in Artemisia annua under organic field conditions

Artemisia annua L. is mostly known for a bioactive metabolite, artemisinin, an effective sesquiterpene lactone used against malaria without any reputed cases of resistance. In this experiment, bioinoculants viz., *Streptomyces* sp. MTN14, *Bacillus megaterium* MTN2RP and *Trichoderma harzianum* Thu were applied as growth promoting substances to exploit full genetic potential of crops in terms of growth, yield, nutrient uptake and particularly artemisinin content. Further, multi-use of the bioinoculants singly and in combinations for the enhancement of antioxidant potential and therapeutic value was also undertaken which to our knowledge has never been investigated in context with microbial application. The results demonstrated that a significant ($P<0.05$) increase in growth, nutrient uptake, total phenolic, flavonoid, free radical scavenging activity, ferric reducing antioxidant power, reducing power and total antioxidant capacity were observed in the *A. annua* treated with a combination of bioinoculants in comparison to control. Most importantly, an increase in artemisinin content and yield by 34 and 72 % respectively in the treatment having all the three microbes was observed. These results were further authenticated by the PCA analysis which showed positive correlation between plant macronutrients and antioxidant content with plant growth and artemisinin yield of *A. annua*.

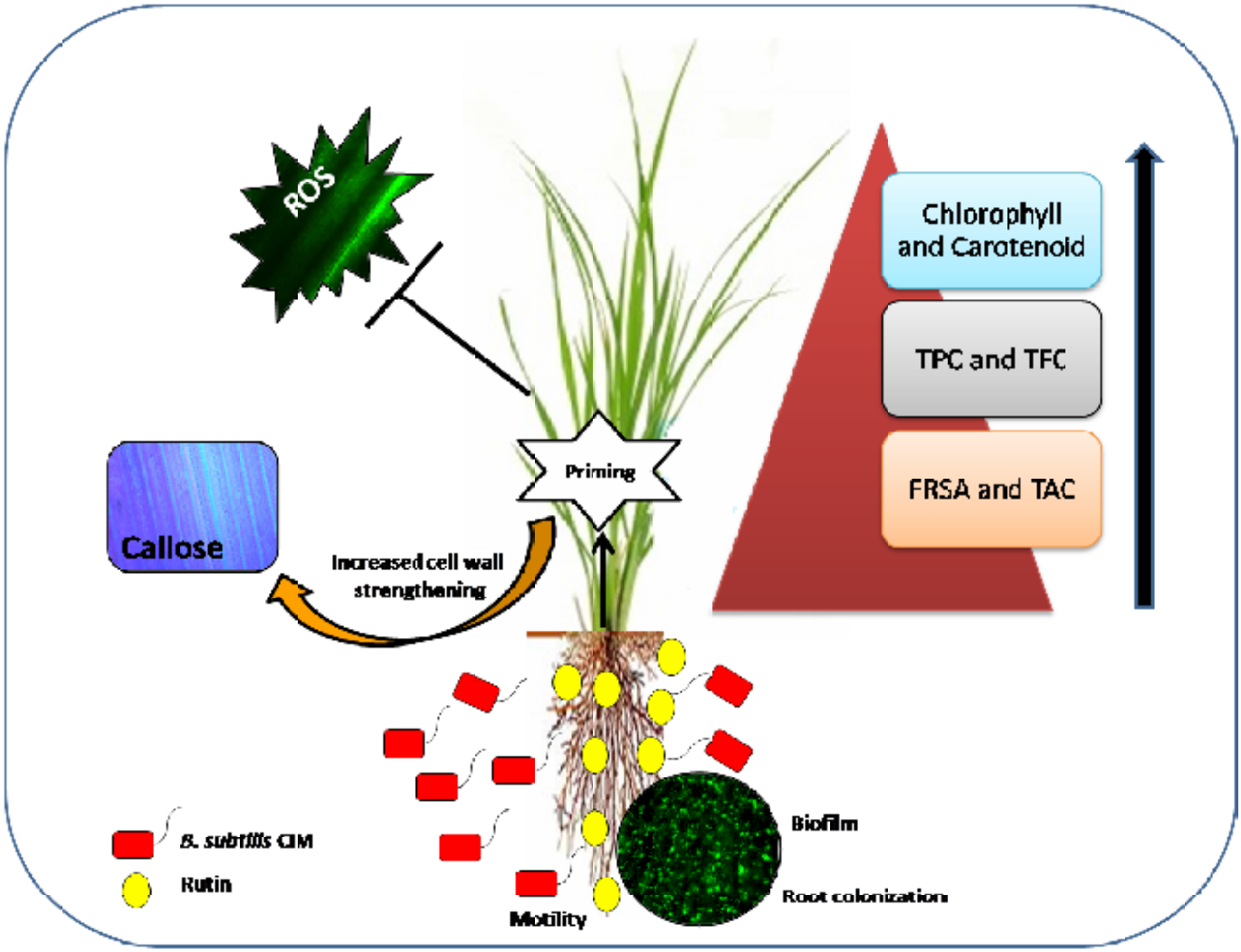


The present study thus highlights a possible new application of compatible bioinoculants for enhancing the growth along with antioxidant and therapeutic value of *A. annua*.

World Journal of Microbiology and Biotechnology, *32*(10), 167, 2016
Input: Gupta, R., Singh, A., Gupta, M. M., & Pandey, R.

Rice Seed Priming with Picomolar Rutin Enhances Rhizospheric *Bacillus subtilis* CIM-BS Colonization and Plant Growth

The effect of rutin, a bioflavonoid on the growth and biofilm formation of *Bacillus subtilis* strain CIM-BS was investigated. In addition to swimming, swarming, and twitching potentials of *B. subtilis* CIM-BS, one picomolar (1 pM) of rutin was also observed to boost the biofilm forming ability of the bacterium. Bio-priming of rice seeds with BS and rutin not only augmented root and shoot lengths but also the photosynthetic pigments like chlorophyll and carotenoid. Similarly, high accumulation of phenolic and flavonoid contents was observed in the leaves. Fluorescent microscopic images revealed that BS plus rutin enhanced Callose deposition in the leaves. It was also established that the least formation of reactive

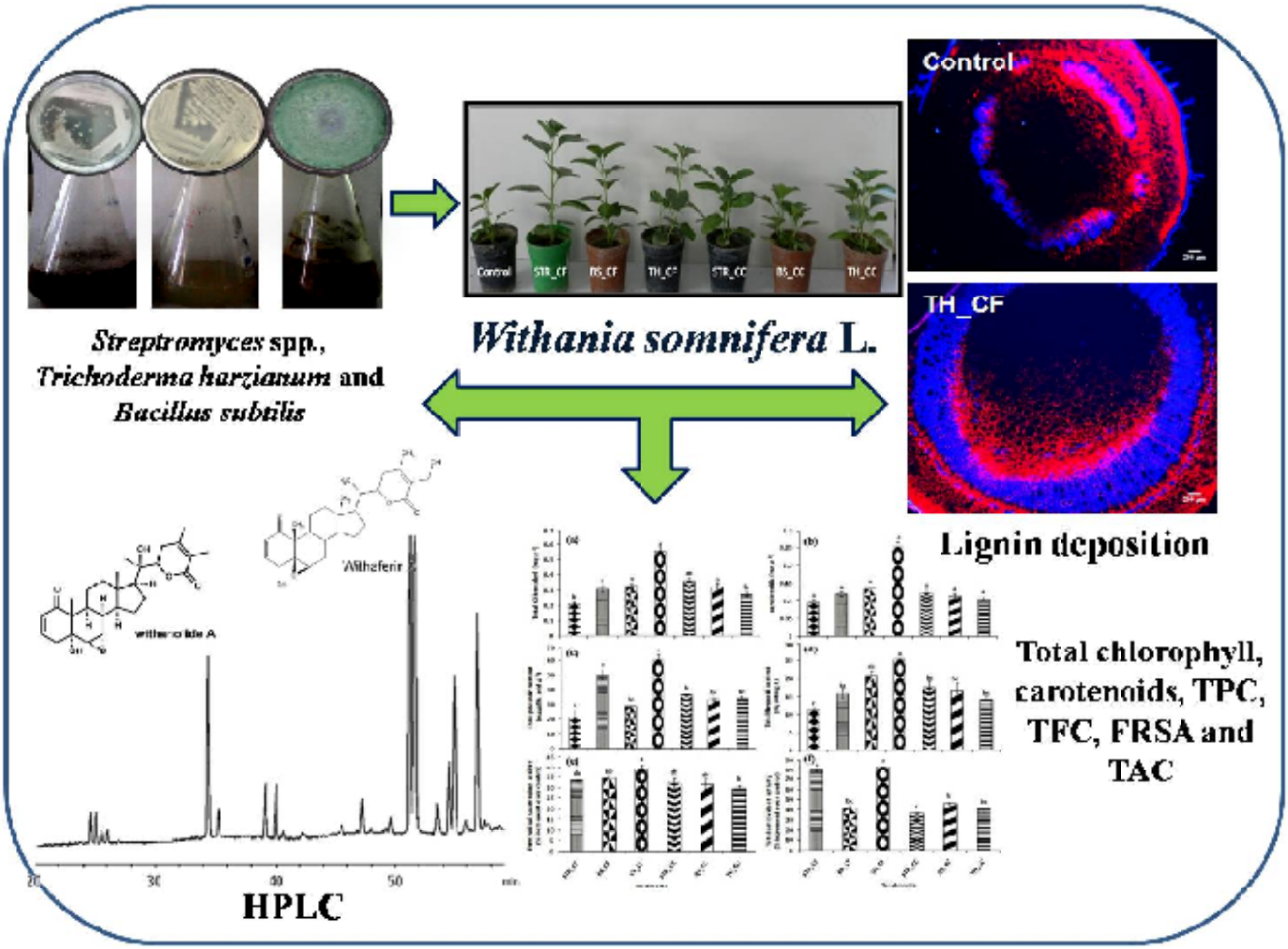


oxygen species in BS plus rutin treated rice plants was due to higher free radicals scavenging activity and total antioxidant potential. The results highlight chemo attractant nature of BS towards rutin, which by enhancing biofilm formation and root colonization indirectly strengthened the plants' defence mechanism.

PLoS ONE 11(1):e0146013, 2016
Input: Singh, A., Gupta R. and **Pandey. R.**

Microbial secondary metabolites ameliorate growth, *in planta* contents and lignification in *Withania somnifera* (L.) Dunal

In the present investigation, metabolites of Streptomyces sp. MTN14 and *Trichoderma harzianum* ThU significantly enhanced biomass yield (3.58 and 3.48 fold respectively) in comparison to the control plants. The metabolites treatments also showed significant augmentation (0.75–2.25 fold) in withanolide A, a plant secondary metabolite. Lignin deposition, total phenolic and flavonoid content in *W. somnifera* were maximally induced in treatment having T. harzianum metabolites. Also, *Trichoderma* and *Streptomyces* metabolites were found much better in invoking in planta contents and antioxidants



compared with their live culture treatments. Therefore, identification of new molecular effectors from metabolites of efficient microbes may be used as biopesticide and biofertilizer for commercial production of *W. somnifera* globally.

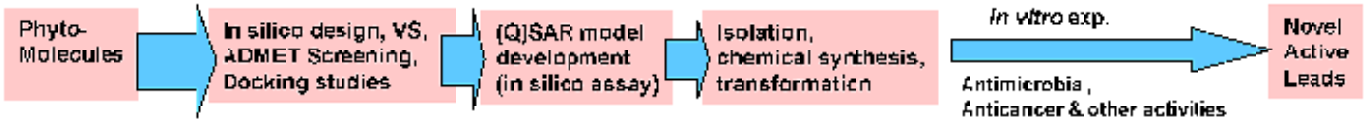
Physiology and Molecular Biology of Plants, 22(2), 253-260, 2016
Input : Singh, A., Gupta, R., Srivastava, M., Gupta, M. M., and **Pandey, R.**

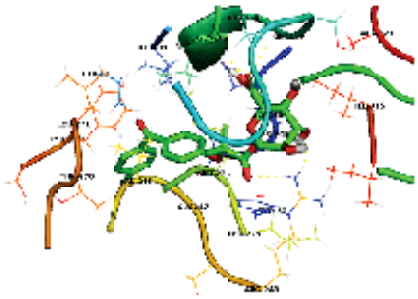
Optimization of active phytomolecules derivatives as lead against Cancer & drug resistant bacterial pathogens.

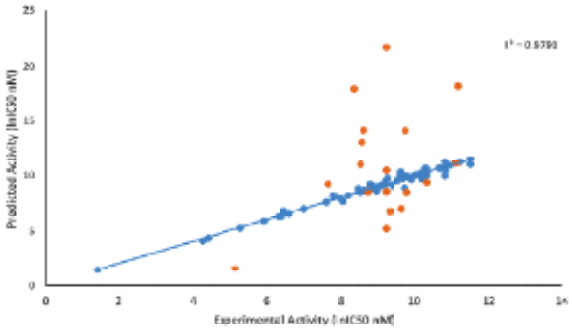
Objective: Development of *in silico/in vitro* screening methods & identification of anticancer & antibacterial leads.

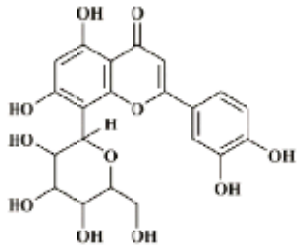
Diethyl-4,4'-dihydroxy-8,3'-neolign-7,7'-dien-9,9'-dionate exhibits antihypertensive activity in rats through increase in intracellular cGMP level and blockade of calcium channels

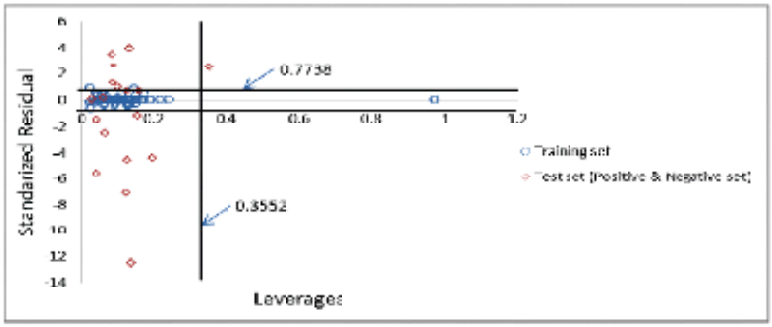
(22β,25R)- 3β-Hydroxy-spirost-5-en-7-iminoxy-heptanoic acid exhibits anti-prostate cancer activity through caspase pathway.











Steroids 110:9-34. 2016. (IF:2.513)
Bioorg Med Chem Lett. 26(21):5322-5327, 2016. (IF:2.486)
Comb Chem High Throughput Screen. 19(8):656-666, 2016. (IF: 1.041)
Bioorg Med Chem Lett. 26(6):1633-8. 2016. (IF:2.486)
Chem Biol Interact. 245:12-9. 2016. (IF:2.618)
Eur J Pharmacol. pii: S0014-2999(17)30054-7. 2017. (IF:2.73)
Steroids 119:43-52. 2017. (IF:2.513)
Chem Biol Drug Des. 88(5):625-631. 2016. (IF: 2.802)

Outcome:

Synthesis of 3,5-dihydroxy-7,8-dimethoxy-2-(4-methoxyphenyl)benzopyran-4-one derivatives as anticancer agents.

SAR studies on *O. sanctum L.* based flavonoid Orientin and its analog for cytotoxic activity in HepG2 cancer cell line.

Synthesis and evaluation of anticancer and antiobesity activity of 1-ethoxy carbonyl-3,5-bis (3'-indolyl methylene)-4-pyperidone analogs

Anticancer activity of gallic acid template based benzylidene indanone derivative as microtubule destabilizer

Conclusion:

Natural anti-cancer & anti-obesity agents were identified through chemical synthesis/lead optimization guided by *in-vitro* activity evaluation and *in-silico* QSAR, docking & ADMET studies.

Input by: SK Srivastava, AS Negi, A Gupta, MP Darokar, DU Bawankule, S Luqman, D Chanda

S & T Interventions to combat malnutrition in women and children

The beneficiaries were divided into three categories viz, males 6-19 years, females 6-19 years and females 20 – 45 years age group. The herbal nutraceutical products CIMAP-*Paushak*, CIMAP-*Phal* se, IHBT-Nutri bar and NBRI-Nutri jam were distributed to the identified beneficiaries during visits at the villages at regular intervals. The products were provided by CSIR-CIMAP, CSIR-IHBT and CSIR-NBRI for distribution

S. no	Village	Beneficiaries	Product Distributed
1.	Gangapur, Pantnagar & Purara, Bageshwar (Uttarakhand)	133	CIMAP-Paushak (approx. 300 kg) & CIMAP-Phal se (approx. 100 kg)
2.	Ahmadpur, Raibareilly, Uttar Pradesh	60	IHBT-Nutri bar
3.	Tulsipur, Amethi	70	CIMAP-Paushak (approx. 60 kg)
3	Daun, Unnao, Uttar Pradesh	40	NBRI-Nutri jam

CSIR-CIMAP was entrusted the responsibility for distribution of these products and also recording the various observations (height, weight, MUAC, head circumference, diet and energy level) that had been finalized for the labs CSIR-CIMAP, CSIR-IHBT and CSIR-NBRI

1. CIMAP Village : Gangapur Patia, Uttarakhand

The CSIR-CIMAP products CIMAP-Paushak and CIMAP-Phalse was provided to the identified beneficiaries in the age group 6 – 19 years and age group 20 – 45 years after every 30 days interval.

A significant improvement in weight, height and mid upper arm circumference physical parameters were observed. It was also observed that various other factors like improvement in daily diet and energy level after consumption of the distributed products. The volunteers also shared that there was reduction in the various ailments like lethargy, abdominal pain, joint pain, gastritis and,

headache.

2. CIMAP Village : Purara, Bageshwar, Uttarakhand

The CSIR-CIMAP products CIMAP Paushak was provided to the identified beneficiaries in the age group 6 – 19 years and CIMAP – Phalse was provided to the identified beneficiaries in the age group 20 – 45 years after every 30 day interval.

There was a significant improvement in weight, height and mid upper arm circumference physical parameters. It was also observed that various other factors like improvement in daily diet and energy level and other minor ailments after consumption of the distributed products.

3. CIMAP Biovillage: Ahmadpur, Raebarelly (UP)

CSIR-IHBT product Nutribar was provided to the identified beneficiaries in the age group 6 – 19 years and age group 20 – 45 years after every 30 day interval.

It was observed that in the age group male 6-19 years and in the age group 6-19 years female, there

was improvement in weight, height and mid upper arm circumference physical parameters. The volunteers also shared that there was minor reduction in the various ailments like lethargy, abdominal pain, joint pain, gastritis and, headache.

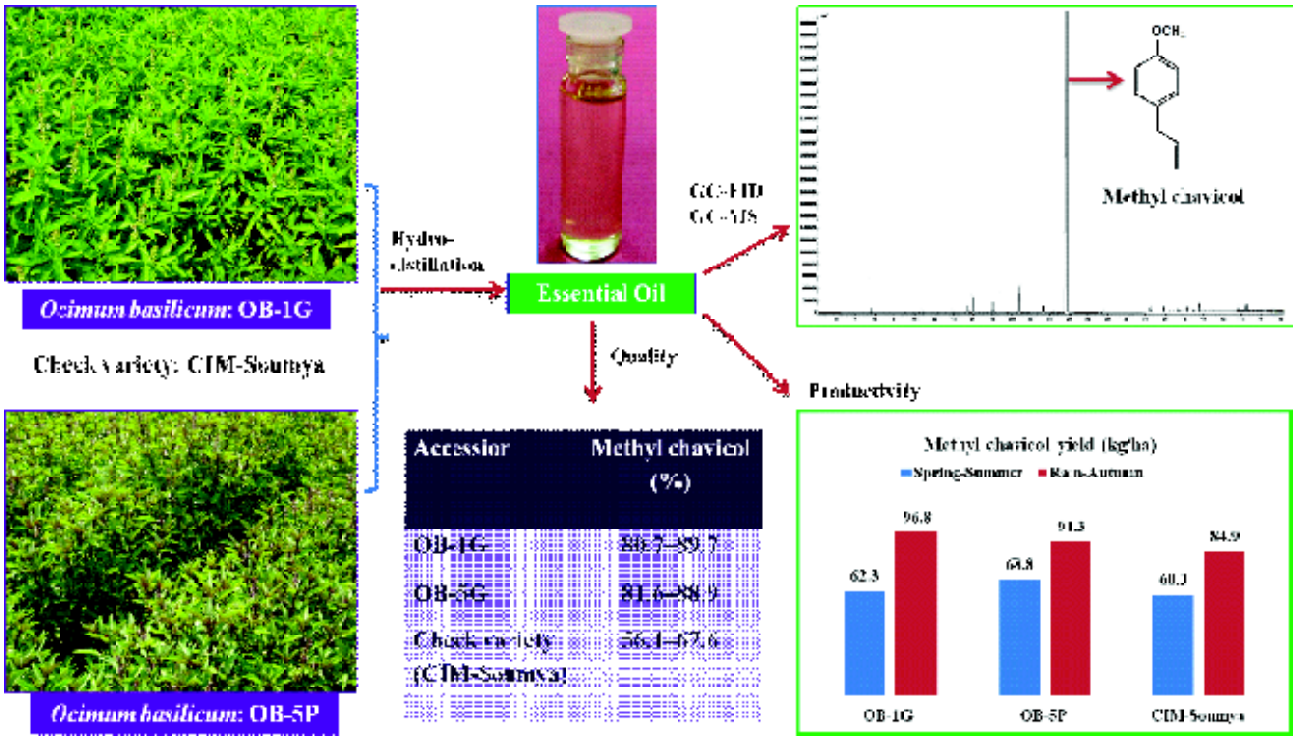
4. CIMAP Biovillage: Tulsipur, Amethi (UP)

The CSIR-CIMAP products CIMAP Paushak and CIMAP – Phalse was provided to the identified beneficiaries in the age group 6 – 19 years and age group 20 – 45 years after every 30 day interval and significant improvements in the health parameters were noticed.

Chemical biology of Ocimum and other aromatic plants

Productivity and essential oil quality assessment of promising accessions of *Ocimum basilicum* L. from north India

The productivity and essential oil quality of two accessions of *O. basilicum* (OB-1G and OB-5P) were assessed compared to a existing prevalent variety of *O. basilicum* (CIM-Soumya) in different harvesting stages (half bloom, full bloom, and seed setting stages) of two cropping seasons (spring-summer and rain-autumn). Significant variations were noticed in essential oil content, herb and essential oil yield,

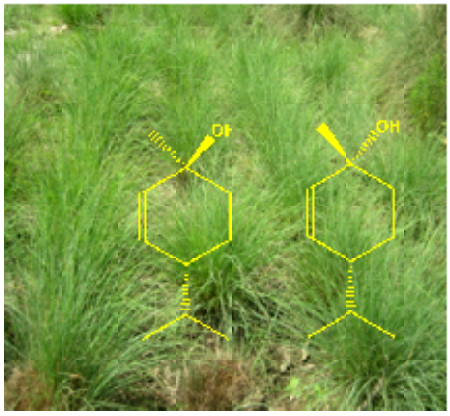


and methyl chavicol yield of the investigated *O. basilicum* taxa. The essential oils of *O. basilicum* accessions possessed significantly higher content of methyl chavicol (OB-1G: 80.7-89.7%; OB-5P: 81.6-88.9%) compared to CIM-Soumya (56.1-67.6%). Significantly higher methyl chavicol yield (96.8 kg ha^{-1}) was found in OB-1G, followed by 91.3 kg ha^{-1} in OB-5P; with lowest (84.9 kg ha^{-1}) in check variety. The accessions, OB-1G and OB-5P produced 14.0% and 7.5% more methyl chavicol, respectively as compared with the check variety.

Input: R.C. Padalia

Variability in yield and composition of p-Menthenols chemotype of *Cymbopogon distans* from India and antimicrobial potential of its essential oil against pathogens

Cymbopogon distans (Nees. ex. Steud.) W. Watson (family: Poaceae) is a perennial aromatic grass widely distributed in tropical and subtropical zones of North-Western Himalaya. The essential oil of *C. distans* has industrial potential for aromatherapy, fragrances and for natural aroma isolates. The present study aimed for assessing the variability in essential oil quality of *C. distans* harvested in different seasons during annual growth and to evaluate the antimicrobial potential of its essential oil against pathogenic bacterial and fungal strains. The major constituents identified in essential oil of *C. distans* were *cis*-p-menth-2-en-1-ol (24.5-26.7%), δ-2-carene (19.9-28.2%), *cis*-piperitol (10.9-23.6%), *trans*-p-menth-2-en-1-ol (8.4-13.3%), and *trans*-piperitol (5.4-7.3%). The essential oil showed good antibacterial activity against *Bacillus subtilis*, *Salmonella typhimurium*, *Escherichia coli*, *Staphylococcus epidermidis*, *Staphylococcus aureus* strains. Moreover, the essential oil also showed good antifungal activity against *Candida albicans*



Compounds	Content (%)				
	Spring	Summer	Rainy	Autumn	Winter
d-2-Carene	23.1	22.4	28.2	19.9	22.1
cis-p-Menth-2-en-1-ol	25.2	26.7	24.5	26.1	24.6
trans-p-Menth-2-en-1-ol	8.4	3.3	11.7	11.3	10.4
cis-Piperitol	23.6	11.3	10.9	15.2	12.1
trans-Piperitol	5.4	7.3	6.6	7.3	6.4
Essential oil yield (%)	0.58	0.53	0.52	0.50	0.54

and *Candida kefyr* strains. Results revealed that the essential oil of *C. distans* possessed >50.0% of p-menthenols viz., *cis*-p-menth-2-en-1-ol, *trans*-p-menth-2-en-1-ol, *cis*-piperitol and *trans*-piperitol as major constituents and possesses antimicrobial potential for pathogenic microbial strains.

Input: R.C. Padalia

Chemical composition and antibacterial activity of *Melaleuca bracteata* essential oil from India: A natural source of methyl eugenol

Melaleuca bracteata is an important member of Myrtaceae family. Chemical composition and antibacterial activity of the essential oil of *M. bracteata* grown in foothills of north India was evaluated. The essential oils of *M. bracteata* in spring, summer, rainy, autumn and winter seasons were analyzed using GC-FID and GC-MS. Methyl eugenol (87.2-89.5%) and (*E*)-methyl cinnamate (2.8-5.4%) were the major constituents. The antibacterial efficacy of the essential oil was evaluated against nine pathogenic bacterial strains. Results showed that the essential oil of *M. bracteata* from Indian origin possessed good activity

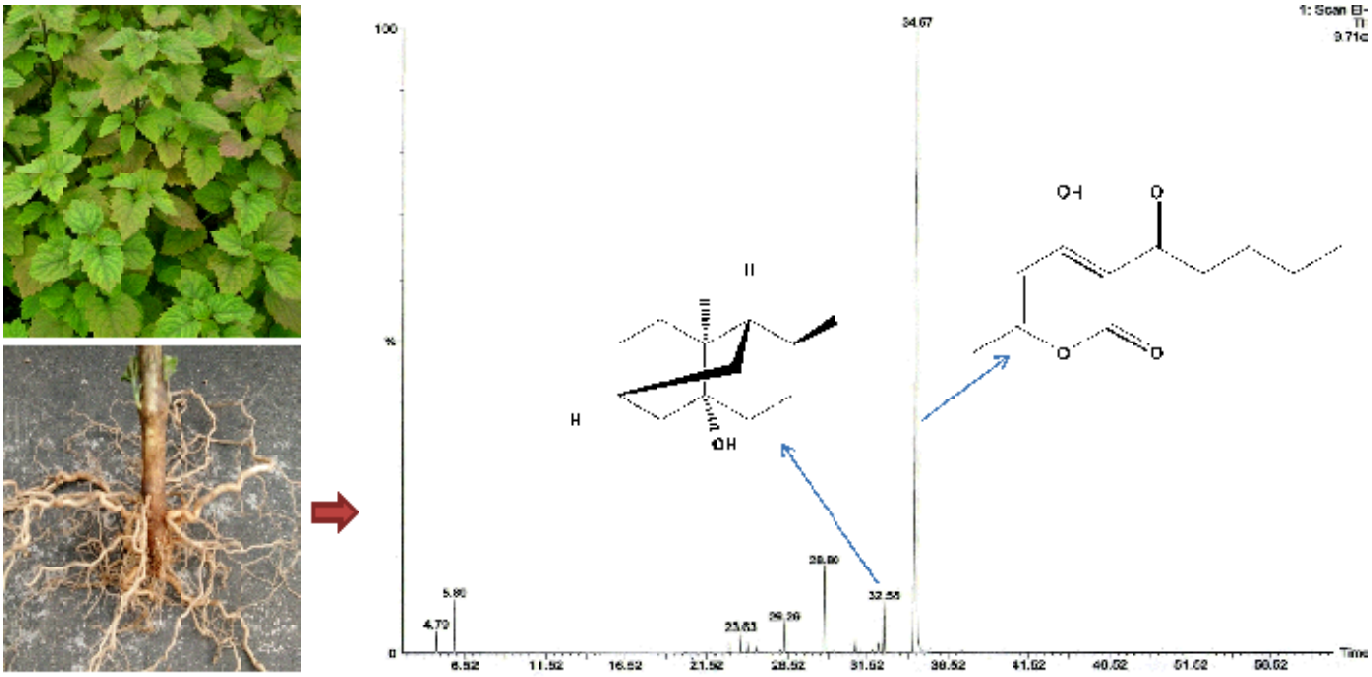
Compounds	Content (%)				
	Spring	Summer	Rainy	Autumn	Winter
(*E*)-Methyl cinnamate	5.4	4.6	2.9	4.9	2.8
Methyl eugenol	87.2	88.1	89.5	87.3	88.8
EOs content	1.00	0.95	0.90	0.95	0.85

against *Salmonella typhimurium, Staphylococcus epidermidis,* and moderate activity against *Bacillus subtilis, Staphylococcus aureus*, *Klebsiella pneumonia*, *and Streptococcus mutans*. *M. bracteata* grown in foothills of Uttarakhand, India could be classified as seasonally stable 'methyl eugenol' chemotype (>85.0%), hence may be considered as a novel natural resource for methyl eugenol rich essential oil for flavor, fragrance and pharmaceutical applications.

Input: R.C. Padalia

Roots of patchouli [*Pogostemon cablin* (Blanco) Benth.]: a natural source of pogostone

Patchouli [*Pogostemon cablin* (Blanco) Benth.] is a natural source of an important essential oil, which finds extensive application in the perfumery industry. In this study, essential oils extracted from the roots and aerial-parts of patchouli (variety CIM-Samarth) were analysed and compared using GC-FID and GC-MS. A total of twenty-two constituents, representing 95.3% of the root and thirty constituents, representing 96.9% of the aerial-parts oil compositions were identified. The root oil was characterized by higher amount of pogostone (70.2%), norpatchoulenol (5.3%) and β-pinene (4.5%). However, the oil of aerial-parts was dominated by patchouli alcohol (55.7%), α-guaiene (13.1%), α-bulnesene (11.1%),



seychellene (3.7%) and (*E*)-caryophyllene (3.1%). Pogostone is an important natural molecule responsible for the intense aromatic odor and known to possess remarkable antibacterial, antifungal pesticidal, antiinflamatory activities.

Input : R.S. Verma

Prunus persica (L.) Batsch.: A novel source of natural Benzaldehyde

Based on consumption, benzaldehyde is the second most important molecule, after vanillin, for flavor and fragrance industries It is widely used in food flavour, beverage, and fragrance industries. Presently, most of its industrial requirement is met through synthetic route. However, a small quantity of natural benzaldehyde is obtained from the kernels of apricots, peaches, prunes and bitter almonds by enzymatic process, which also produce undesirable toxic side product. In this research, a novel source of natural benzaldehyde has been explored from India. *Prunus persica* (Rosaceae) is a deciduous tree, commercially cultivated in many countries for its nutritive fruits. The leaf essential oil of the plant extracted in different seasons was analyzed using GC-FID, GC-MS, and NMR (^{1}H & ^{13}C) techniques. The oils from spring, summer, rainy and autumn seasons were solely composed of benzaldehyde (96.68–98.31%). In conclusions, the leaf essential oil of *P. persica* could be a potential natural source of benzaldehyde for industrial use. Moreover, after fruiting phase harvesting of leaves for essential oil production could add value to the peach cultivation.

Input : R.S. Verma

A report of volatile oil composition of patchouli (*Pogostemon cablin*) during a rare incidence of flowering

A rare incidence of flowering in patchouli [*Pogostemon cablin* (Blanco) Benth.] was observed in north India during spring season (2016 & 2017). The essential oils extracted from the leaves and inflorescence of patchouli during this rare phenomenon was analysed and compared using GC-FID and GC-MS. A total of thirty-one constituents, representing 97.4–97.7% of the total oil compositions were identified. Principal constituents of the leaf and inflorescence essential oils were patchouli alcohol (57.7% and 45.6%), α-bulnesene (10.4% and 15.2%), α-guaiene (13.2% and 17.9%), seychellene (3.8% and 6.9%) and (*E*)-caryophyllene (3.2% and 3.6%). Sesquiterpene hydrocarbons (α-bulnesene, α-guaiene, seychellene, (*E*)-caryophyllene, β-patchoulene, cycloseychellene, β-elemene, β-selinene, aciphyllene and γ-patchoulene) were accumulated higher inflorescence, while sesquiterpene alcohols (patchouli alcohol and norpatchoulenol) were higher in the leaves. Moreover, due to absence of flowering and seed set, it is very difficult to create genetic variability in patchouli, which is important for genetic improvement. Thus, the flowering in patchouli in north India could be a ray of hope for genetic improvement of patchouli.

Input : R.S. Verma

Elucidation of essential oil biosynthesis in aromatic grasses (*Cymbopogon* sp.)

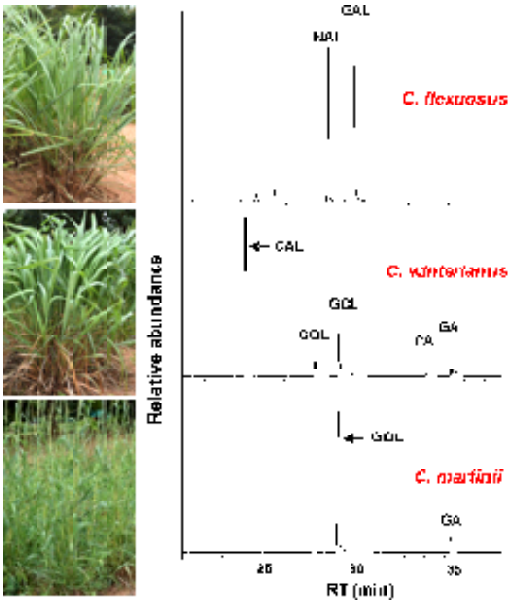


Fig 1. Relative abundance of essential oil components in *Cymbopogon*. Abbreviations: CA, citronellyl acetate; CAL, citronellal; COL, citronellol; GA, geranyl acetate; GAL, geranial; GOL, geraniol; NAL, neral.

Summary of RNA-Seq of *C. flexuosus*	
Total Number of HQ Reads	26936556 (26.93 Mb)
Number of paired-end reads after trimming	23793466 (23.79 Mb)
Mean read quality (Phred score)	33.85
Number of bases (MB)	2720.59
Number of bases (GB) after trimming	1.89
Mean read length (bases)	101
kmer size	31
Number of assembled transcripts	107,363
Number of transcripts with length ≥ 150 bases	92,937
Maximum transcript length (bases)	47,050
Average transcript length (bases)	635
N50 value	968
Mean GC % of transcripts	49.89
Number of transcripts with FPKM ≥ 1.0	92,139

Fig 2. RNA sequencing summary of *C. flexuosus* leaf transcriptome

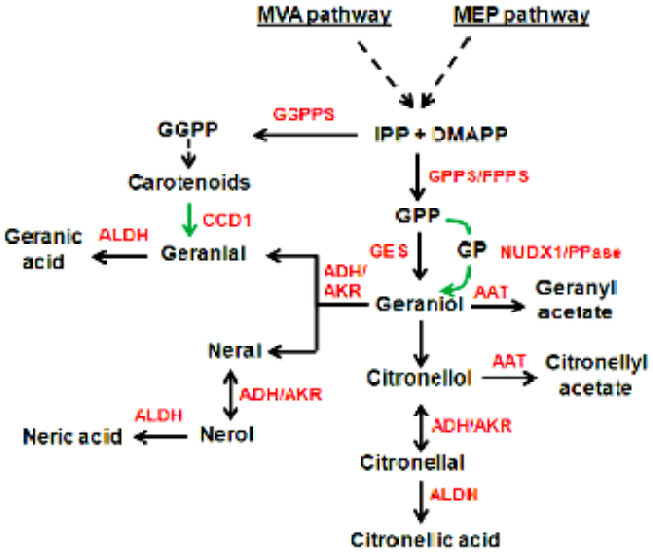


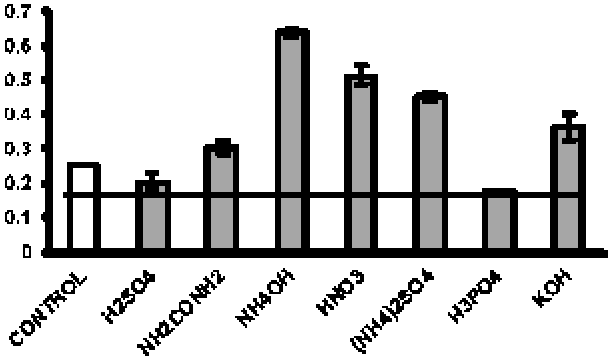
Fig 3. Proposed pathway steps of essential oil biosynthesis in aromatic grasses. AAT, alcohol acetyl transeferase; ADH, alcohol dehydrogenase; AKR, aldoketo reductase; ALDH, aldehyde dehydrogenase; CCD, carotenoid cleavage deoxygenase; FPPS, farnesyl diphosphate synthase; GES, genraniol synthase; GPPS, geranylgeranyl diphosphate synthase GPPS, geranyl diphosphate synthase; NUDX, Nudix hydroxylase; PPase: pyrophosphatase

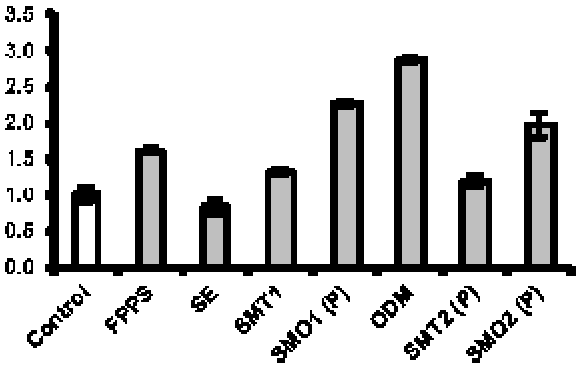
Transcriptome analysis combined with phylogenetics and comparative expression and metabolite analysis unveiled potential candidate genes involved in essential oil biosynthesis of aromatic grasses.

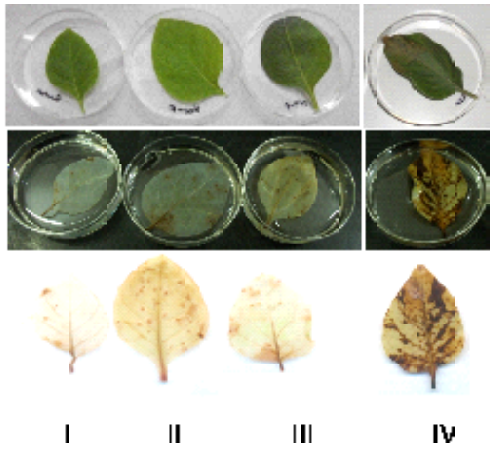
Frontiers in Plant Science, 7:1129, 2016
Input: Nagegowda DA, Rao DKV and Shasany AK

Nitrogen treatment enhances sterols and withaferin A through transcriptional activation of jasmonate pathway, WRKY transcription factors and biosynthesis genes in *Withania somnifera* (L.) Dunal

Use of elicitors like salicylic acid, methyl jasmonate, fungal extracts and even mechanical wounding have been attempted earlier with limited results to increase withanolides in *W. somnifera*, where the commercial viability and logistics of application are debatable. In this investigation, we chanced upon simple nitrogeneous fertilizers, enhancing the biosynthesis of withaferin A.

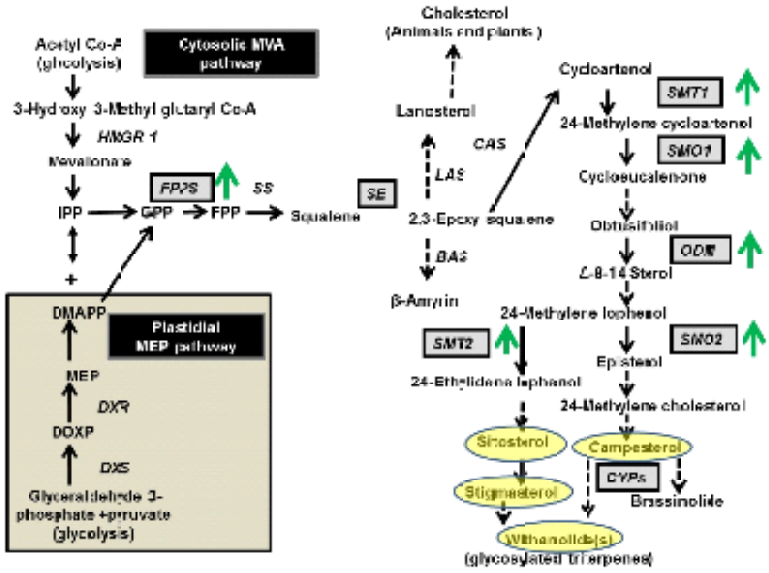






Application of ammonium sulphate enhanced the sterols required for the withanolide biosynthesis and was related to higher expression of pathway genes like FPPS, SMT1, SMT2, SMO1, SMO2 and ODM. Increased expression of a cytochrome P450 gene homologous allene oxide cyclase, crucial in jasmonic acid biosynthetic pathway, suggested the involvement of jasmonate signaling. High levels of WRKY gene transcripts indicated transcriptional regulation of the pathway genes.

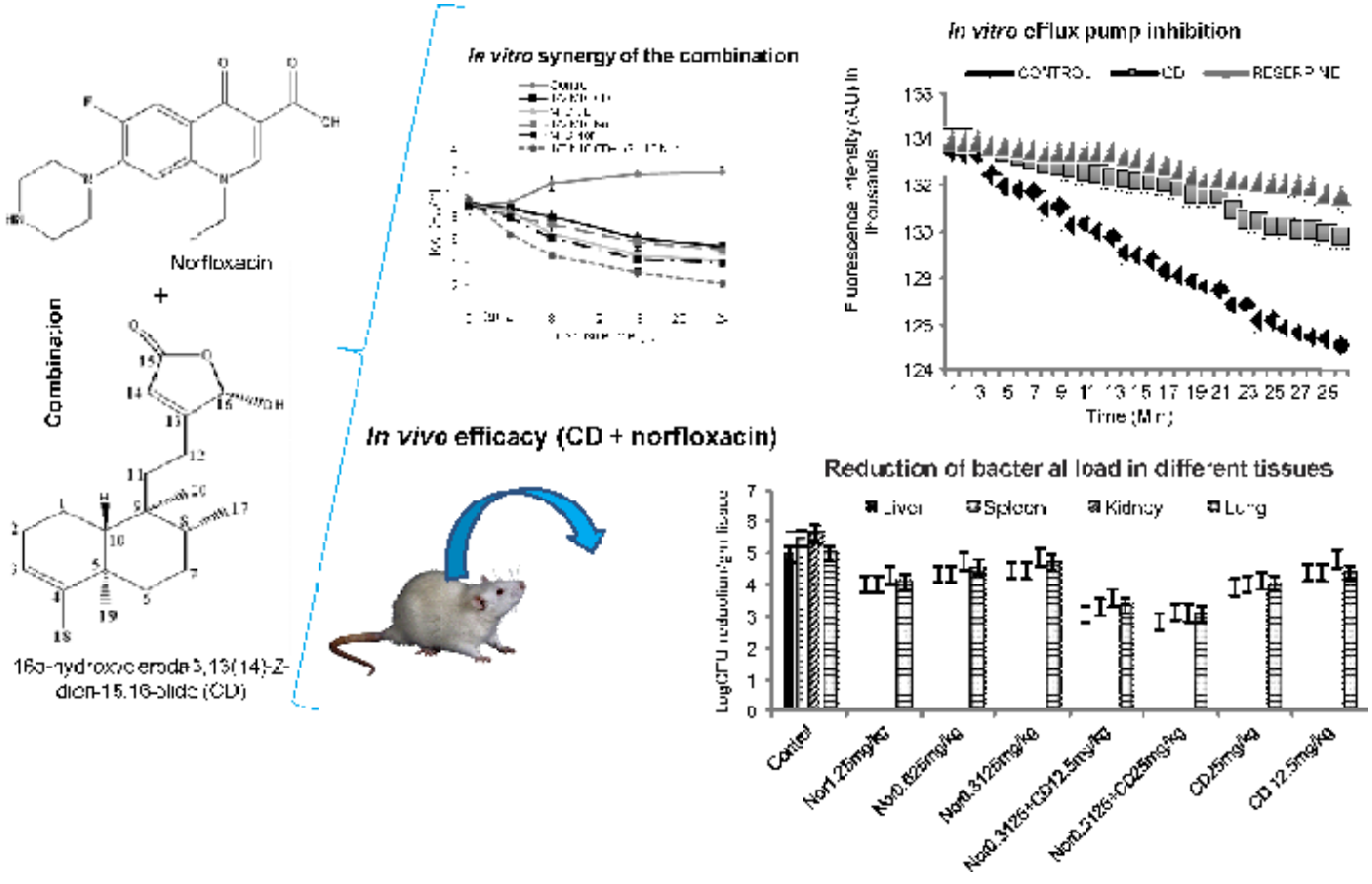
These results implicated simple physiological management of nitrogen fertilizer signal to improve the yield of secondary metabolite through the involvement of



jasmonate signal and WRKY transcription factor for the first time, in *W. somnifera* besides improving the foliage.

Protoplasma. 254(1):389-399, 2017
Input: Ajit K Shasany & M M Gupta

A clerodane diterpene from *Polyalthia longifolia* as a modifying agent of the resistance of methicillin resistant *Staphylococcus aureus*.

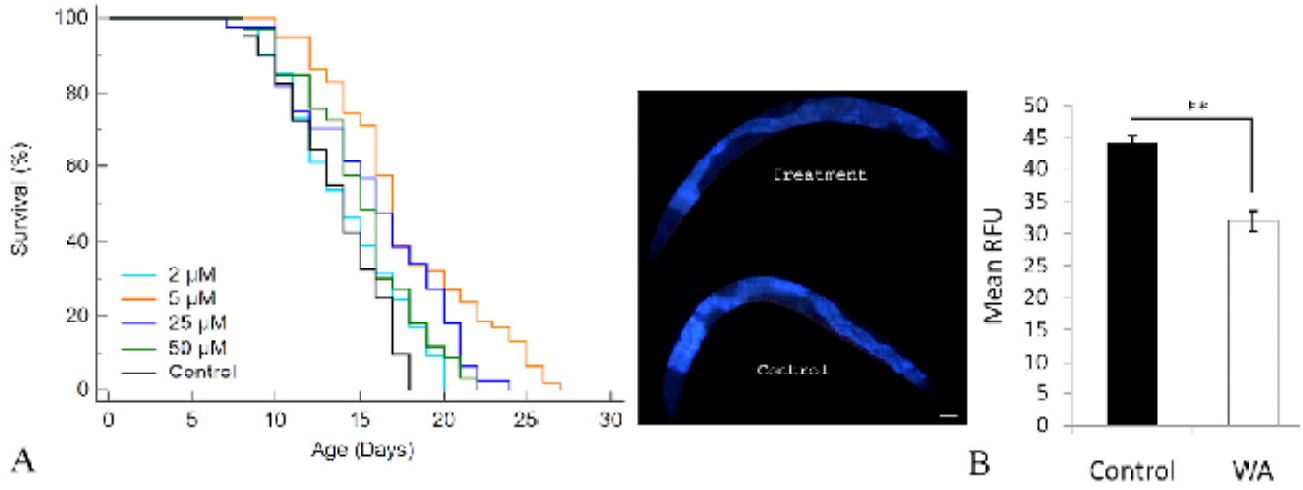


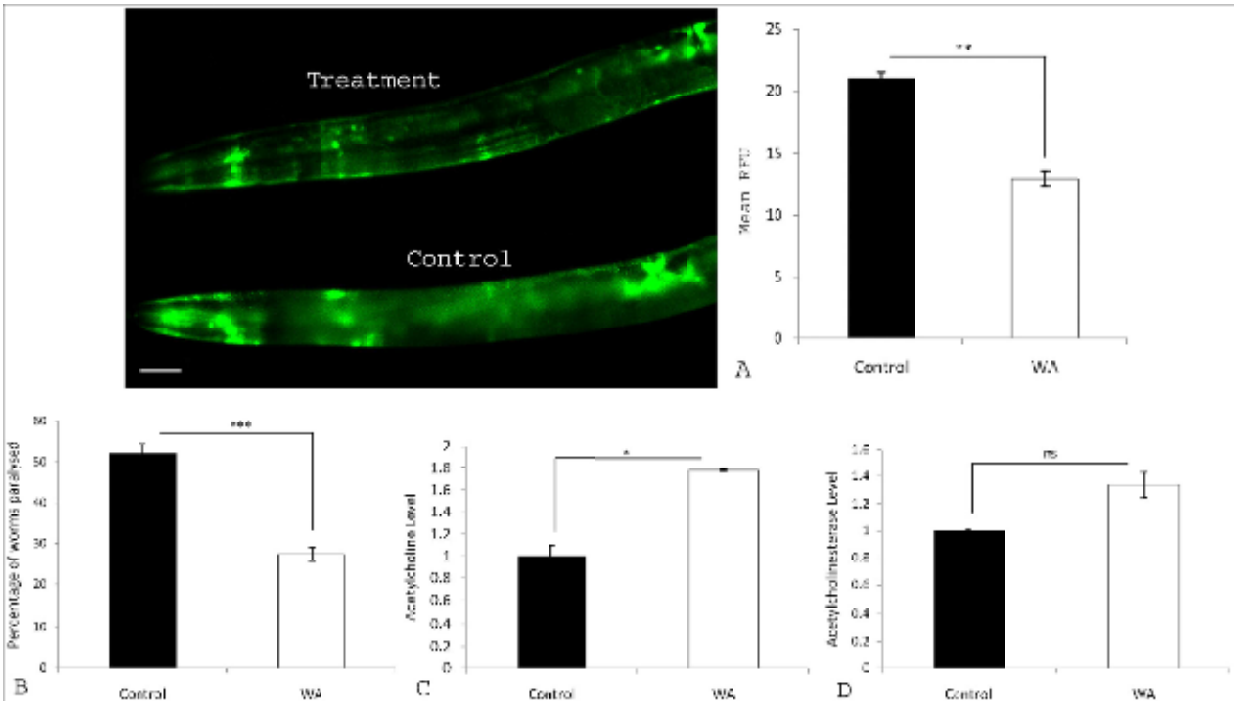
Phytomedicine 23, 654-661, 2016 (IF=2.937)
Input: MP Darokar, Anirban Pal, & SK Srivastava

Withanolide A offers neuroprotection, ameliorates stress resistance and prolongs the life expectancy of *Caenorhabditis elegans*

Withanolide A (steroidal lactone) forms the major constituent of the most popular herbal drug in Ayurvedic medicine, Ashwagandha. It has been used since ancient times as an alternative medicine for the treatment of a variety of age related disorders. Here the present experiment provide multiple lines of evidence indicating that Withanolide A improves healthspan, delays age-associated physiological changes and also extends the lifespan of *Caenorhabditis elegans*. Several neuroprotective benefits of this natural product, including its antiamyloidogenic effects, alleviation of α-synuclein aggregation and neuroprotection through modulation of neural mediators like acetylcholine. We observed that Withanolide A mediates lifespan extension and promotes stress resistance via insulin/insulin-like growth factor signaling pathway. Such findings could be helpful to develop a therapeutic medicine from this natural product for the prevention or reversal of age-related ailments and to improve the survival of patients suffering from Alzheimer's or Parkinson's disease.

Withanolide A (WA) extends *C. elegans* lifespan. (A) Dose–response Kaplan–Meier survival curves ofwild-type (N2) populations exposed to 0 µM (control), 2, 5, 25 and 50 µM WA at 20 °C.

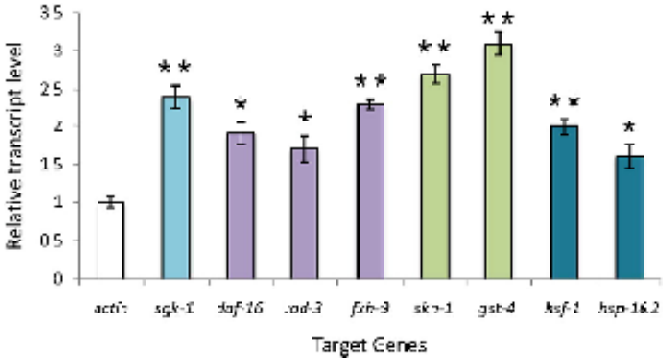




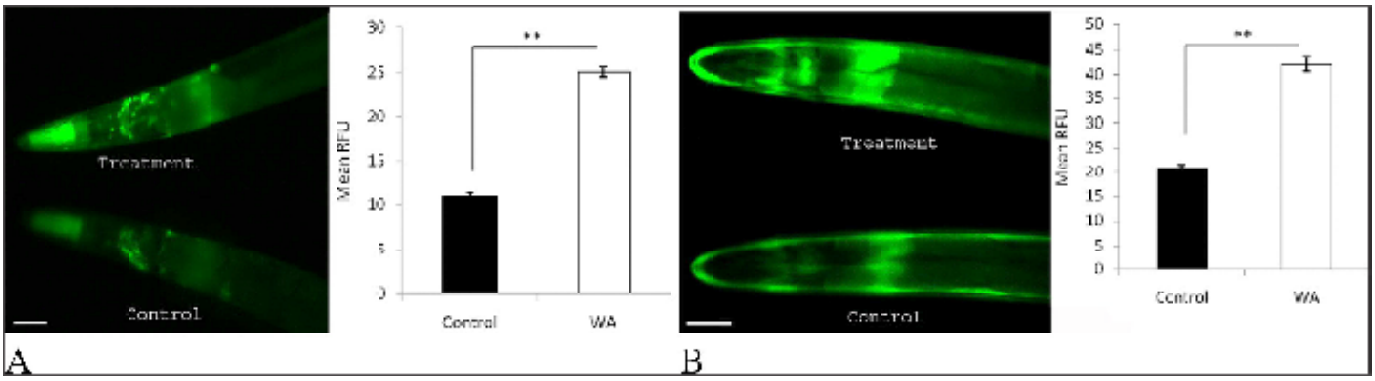
Treatment with 5 µM, 25 µM and 50 µMWA significantly ($P < 0.0001$) extended the mean lifespan of worms, whereas treatment with 2 µM WA did not cause a significant increase in lifespan. The maximum mean and median lifespan extension by 29% and 21% respectively was seen in worms treated with 5 µM WA. (B) WA delays the progression of aging. Higher accumulation of lipofuscin was seen in control worms compared with their respective 5 µM WA treated animals. Representative images show intestinal lipofuscin autofluorescence of untreated (Control) and WA-treated (5 µM) day 10 N2 animals (n = 20). Images were quantified using the Image J software. Scale bar, 30 µm.

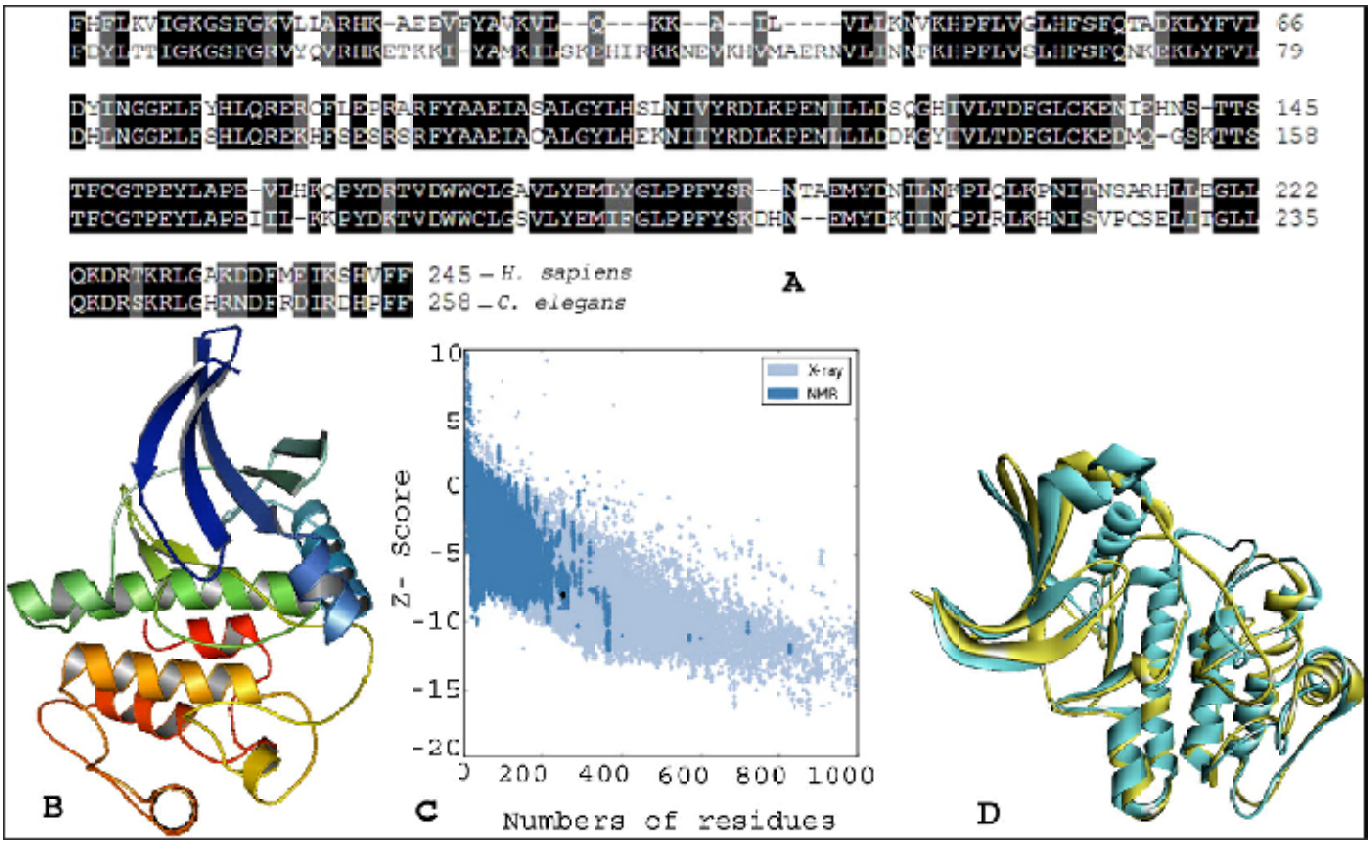
WA shows multifunctional neuroprotective roles in C. elegans. (A) α synuclein levels in NL5901 worms. A substantial decrease in alphasynuclein level was seen in WA treated worms, compared to control. Fluorescence intensity was quantified by ImageJ software. (B) Graphical representation of Aβ-induced toxicity in CL4176 worms. The worms were cultivated at 15 °C for 48 h. At the 48 h time point, the temperature was up-shifted to 25 °C. The worms were scored at 18 h after the initiation of upshift and the scoring was continued in 1 h increments until all worms were paralyzed. WA significantly reduces the percentage of CL4176 worms paralyzed as a result of Aβ toxicity. (C, D) Effect of WA on neurotransmitter acetylcholine and acetylcholinesterase in wild-type worms. WA elevates both ACh (C) and AChE (D) levels however the acetylcholinesterase increase was found insignificant. ***$P < 0.001$, **$P < 0.01$, *$P < 0.05$, ns not significant. Scale bar, 30 µm.

WA up-regulates stress-responsive genes in C. elegans. Fluorescent photomicrographs of (A) SOD-3::GFP in CF1553 and (B) GST-4:GFP transgene in the CL2166 strains. GFP expression inWA-treated worms is higher than that in control worms. Quantification of images was performed by ImageJ software. **$P < 0.01$. Scale bar, 30 µm.



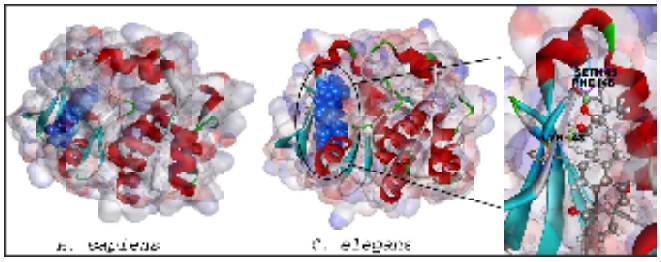
WA augments the expression level of stress and longevity promoting genes. The housekeeping gene β-actin (act-1) was used as an endogenous control and the calculations were performed using Ct (ΔΔCt) method. *$P > 0.05$, **$P > 0.01$.





Modeling of Serum/glucocorticoid-regulated kinase 1 in *C. elegans*. (A) A kinase domain sequence alignment of SGKs fromhuman and *C. elegans*. The conserved (identical and similar amino acid residues) are highlighted in black and gray colors. (B) 3D structure of the modeled kinase domain of SGK-1 protein in *C. elegans*. (C) Investigation of the modeled SGK-1 structure using the ProSA-web service. The z-score of this model is "8.02, a value too close to the experimentally resolved structures. (D) Structural overlay of the homology model of SGK-1 protein of *C. elegans* (yellow) with the SGK of *H. sapiens* (cyan) (PDB ID: 2R5T

Docked conformation ofWA with SGK of C. elegans and H. sapiens.WA is indicated in CPK,

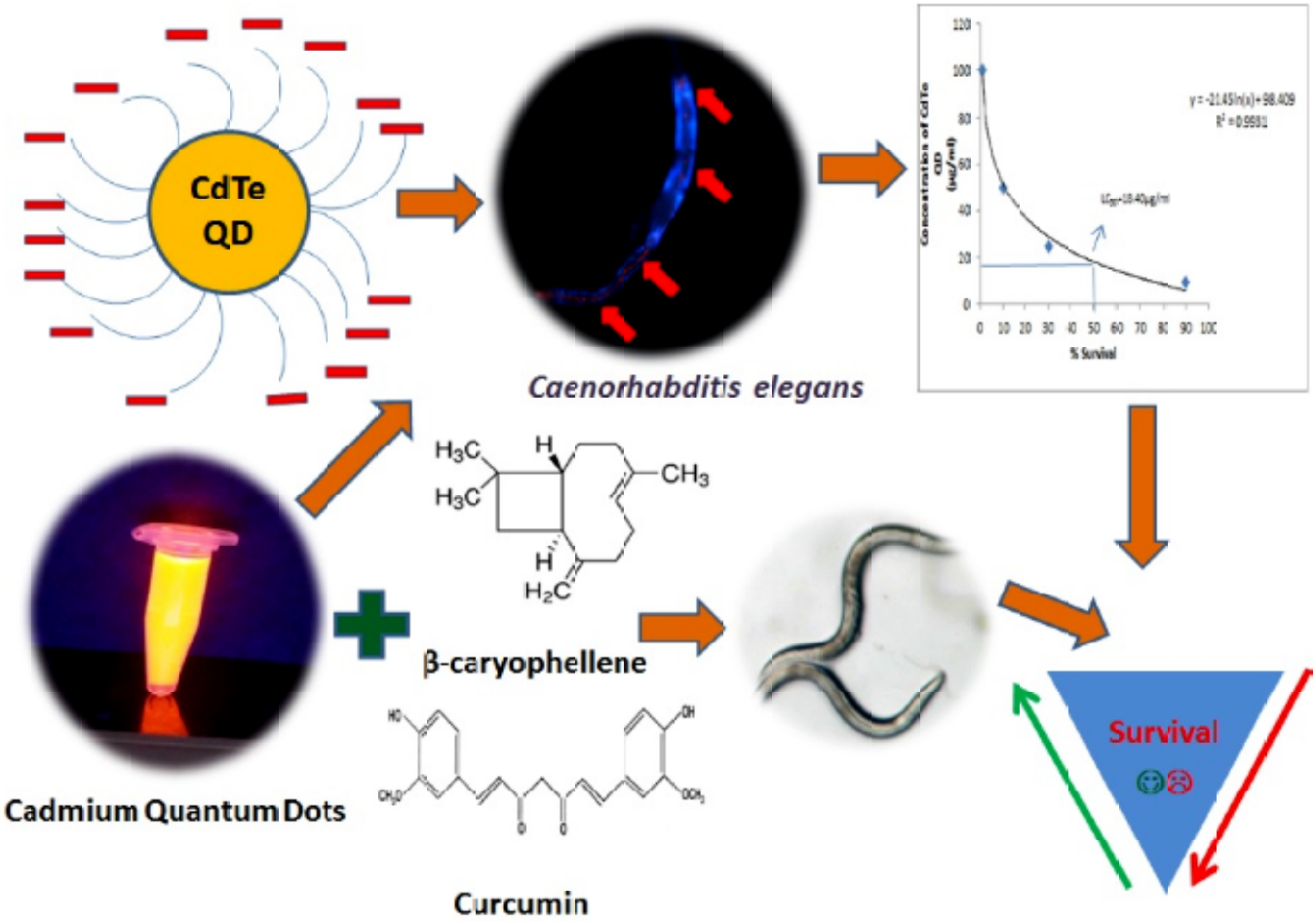


blue colored. The putative interacting residues of *C. elegans* SGK-1 forming hydrogen bonds with WA are labeled and shown as sticks.

Experimental Gerontology 78: 47-56, 2016
Input: Rakesh Pandey

Curcumin and β-caryophellene attenuate cadmium quantum dots induced oxidative stress and lethality in *Caenorhabditis elegans*

Curcumin (CUR) and beta-caryophellene (BCP) are well known bioactive phytomolecules which are knownto reduce oxidative stress in living organisms. Therefore, the present study was envisaged to explore the possible effects of CUR and BCP in suppression of cadmium quantum dots (CdTe QDs) induced toxicity in *Caenorhabditis elegans*. CdTe QD are luminescent nanoparticles extensively exploited for in vivo imaging,but long term bioaccumulation confer deleterious effects on living organisms. The 24-h LC50and LC100ofCdTe QD were found to be 18.40 µg/ml and 100µg/ml respectively. The CdTe QD exposure elevated HSP-16.2 expression mediating induction of the stress response. The CdTe QD lethality was due to



increment in ROS and decline in SOD and GST expression. The present study demonstrates improved survival in BCP(50 µM) and CUR (20µM) treated worms by over 60% ($P < 0.01$) and 50% ($P < 0.029$) in CdTe QD (100 _g/ml) exposed worms. Furthermore, BCP and CUR attenuate oxidative stress triggered by QD. The present study for the first time demonstrates CdTe QD toxicity remediation via BCP and CUR. The future investigationscan unravel underlying protective effects of phytomolceules for remediating cyotoxicolgical effects ofQDs

Environmental Toxicology and Pharmacology 42: 55-62, 2016
Input: Srivastava, S., Pant A., Trivedi, S. and Pandey, R.

Jammu Aroma Arogya Gram

Farmers' awareness -training-cum-demonstration programmes on aromatic plants production technology under JAAG Project (RSP-4001)

Six training-cum-awareness programmes were organised under Jammu Aroma Arogya Gram project (JAAG:RSP-4001) during 2016-17 for the farmers, entrepreneurs of Jammu & Kashmir region to educate them about the production and primary processing technology of economically important aromatic plants for income enhancement of poor farmers besides utilization of stressed soils, etc. From these programmes, more than 461 participants benefitted hailing from different districts of Jammu & Kashmir.

Table:4. Farmers' awareness/ training-cum-demonstration programmes on aromatic plants production technology under JAAG Project

Sr. No.	Date	Place	No. of participants
1.	14.07.2016	KVK Kathua	120
2.	15.07.2016	Advance Center for Dry Land Rainfed Agriculture, Samba	46
3.	16.07.2016	KVK RS Pura, Jammu	85
4.	18.07.2016	KVK Reasi	65
5.	10.01.2017	RS Pura, Jammu	62
6.	12.01.2017	Bagta, Reasi	83
		Total	**461**

A view of awareness programme at KVK RS Pura, Jammu (J&K)

Field view of Lemongrass at Jammu (J&K)

Development and Deployment of improved Agrotechnologies and processing technology of economically important medicinal and aromatic crops for income enhancement and employment generation.

Farmers' awareness, training-cum- demonstration programmes on medicinal and aromatic plants production technology under Rural Development Project (RSP-4004)

35 awareness/training-cum- programmes were organised at different parts of the country under the project during 2016-17 to educate farmers and entrepreneurs for production and primary processing technology of economically important medicinal and aromatic plants for income enhancement of farmers besides utilization of underutilized and marginal land etc. From these programmes, more than 3072 participants were benefitted in different parts of the country.

Awareness/training cum demonstration programmes on medicinal and aromatic crops in rural development project

Sr. No.	Date	Place	No. of participants
1.	11.04.2016	Devipur, Gorakhpur, UP	188
2.	13.04.2016	Subudhiya, Kusinagar, UP	152
3.	14.04.2016	Pipralala, Maharajganj, UP	183
4.	27.05.2016	Saidnagar, Distt. Jalaun,UP	152
5.	28.06.2016	Rath, Distt. Hamirpur, UP	123
6.	29.06.2016	Chhilolar, Distt. Banda, UP	34
7.	06.07.2016	Deolapar, Nagpur, Maharashtra	80
8.	07.07.2016	KVK Anta, Rajasthan	109
9.	08.07.2016	KVK Jhalawar, Rajasthan	100
10.	09.07.2016	Srichattarpura, Rajasthan	43
11.	11.07.2016	Gundla, Distt. Kutch, Gujarat	140
12.	12.07.2016	Rapar, Distt. Kutch, Gujarat	190
13.	09.08.2016	Bhojdeeh, Ranchi, Jharkhand	100
14.	11.08.2016	Gabhadeeh, Ranchi, Jharkhand	50
15.	14.08.201	Saroul, Anand, Gujarat	62
16.	19.08.2016	Navada, Bihar	71
17.	08.09.2016	Masauli, Barabanki, UP	48
18.	09.09.2016	Ahmadpur, Satawan, Raibareily	62
19.	22.09.2016	Singhpur, Fazilka, Punjab	23
20.	11.10.2016	Guntala, Kutch, Gujarat	40
21.	12.10.2016	Rapar, Kutch, Gujarat	80
22.	14.10.2016	Saroul, Anand, Gujarat	62
23.	15.10.2016	Jaspur, Baroda, Gujarat	88
24.	18.10.2016	Kamrrop, Assam	42
25.	06.11.2016	Mahmoodabad, Sitapur, UP	19
26.	17.12.2016	Gendikhata, Haridwar, Uttrakhand	102
27.	23.12.2016	Masauli, Barabanki, UP	79

28.	28.12.2016	Chauri Chaura, Distt. Gorakhpur,UP	118
29.	29.12.2016	Rudrapur, Distt. Deoria, UP	112
30.	11.01.2017	Deurbut, Bastar, Chattisgarh	50
31.	14.01.2017	FFDC Kannauj	12
32.	15.01.2017	CIMAP, Lucknow for SBI Officers	15
33.	18.01.2017	Neelgaon, Sidhauli, Distt. Sitapur	161
34	18.01.2017	Masauli, Barabanki	62
35.	20.01.2017	Fatehpur, Barabanki	120
Total			**3072**

View of palmarosa field near Mandvi, Kutch, Gujarat

Interaction with farmers in Guntala, Kutch, Gujarat

View of Lemon field tribal village of Ranchi, Jharkhand

View of Palmarosa harvesting in Guntala, Kutch Gujarat

A view of participants in Awareness Programme at Kamroop district of Assam

Distribution of planting material of Lemongrass by Honb'le Minister of MSME at Navada, Bihar


View of farmers field lemongrass and vetiver crops in Bihar

Entrepreneurial training to women on making of incense sticks using floral bio-resource

A step towards making self-sustainable to unemployed and poor women through making of incense sticks using discarded or used flowers for self-employment activity, CSIR-CIMAP organised 4 training courses during the year benefitting 184 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 30% women who took part in these trainings have started making of incense sticks and selling in the local market.


Group of trainees and view of training programme CIMAP-WETF, Chandrika Devi, Baksi Ka Talab, Lucknow

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

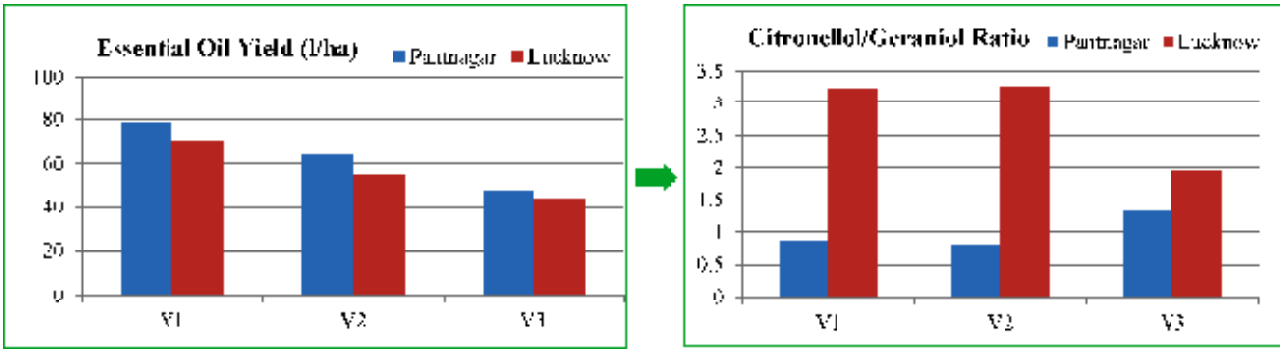
Sr. No.	Date	Place	No. of participants
1.	30.07.2016	Chandrika Devi Temple, Lucknow	25
2.	28.08.2016	CSIR-CIMAP, Lucknow	12
3.	31.01.2017	CSIR-CIMAP, Lucknow	82
4.	16.02.2017	Samodha, Dalelnagar, Hardoi, UP	65
		Total	**184**

Research Centre, Pant Nagar

Productivity and quality assessment of a promising variety CIMAP Bio-G-171 of rose-scented geranium (*Pelargonium graveolens* L' Herit. ex Aiton.) in two agroclimatic conditions of North India

Productivity and quality of the essential oil of a newly developed rose-scented geranium (*Pelargonium graveolens* L' Herit. ex Aiton.) var. CIMAP Bio-G-171 was assessed and compared with that of existing prevalent varieties (CIM-Pawan and Bourbon) in two locations of North India. The fresh leaf yield and essential oil yield of CIMAP Bio-G-171 was significantly higher (173.6–174.2 q h^{1} and 69.93–79.05 l h^{1}) than CIM-Pawan (158.8–160.6 q h^{-1} and 55.57–64.46 l h^{-1}) and Bourbon (133.3–139.3 q h^{-1} and 44.19–48.38 l h^{-1}). Chemical composition of the essential oils were analysed and compared using GC-FID and GC-MS techniques. Major constituents of the oils were citronellol (20.9–39.5%), geraniol (10.9–26.5%), linalool (2.9–14.2%), isomenthone (7.4–9.4%), citronellyl formate (5.5–9.1%) and 10-epi-ã-eudesmol (5.2–9.0%). In conclusion, the essential oil yield and chemical composition were substantially influenced by variety and location of growing. Moreover, var. CIMAP Bio-G-171 showed improvement up to 58.2–63.4% and 22.6–25.8% in essential oil productivity over existing varieties, Bourbon and CIM-Pawan, respectively.

Variety CIMAP-Bio-G-171



V1: CIMAP-Bio-G-171; V2: CIM-Pawan; V3: Bourbon

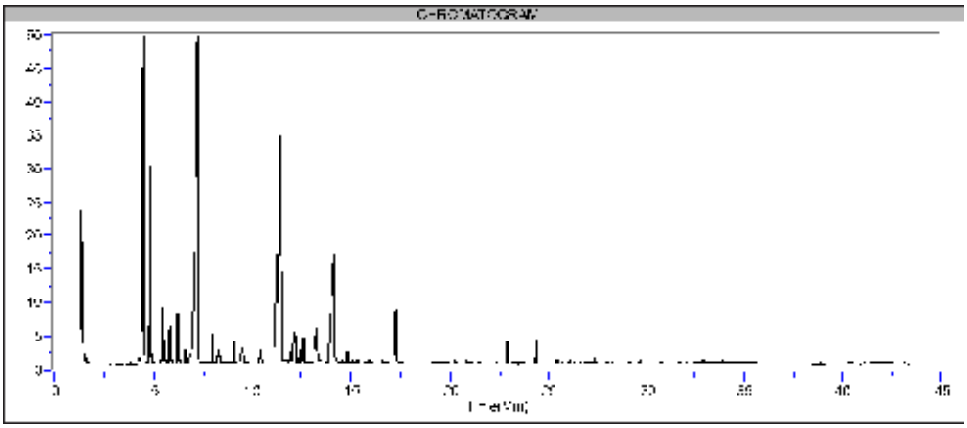
Input : V.R. Singh

Evaluation of essential oil yield and quality of rosemary (*Rosmarinus officinalis*) grown as a seasonal crop in the subtropical conditions of north India

The essential oil yield and chemical composition of rosemary (*Rosmarinus officinalis* var. *CIM Hariyali*) was evaluated under the subtropical climatic conditions of Uttarakhand. The crop was planted in mid November and harvested on six different dates, viz. 15 April, 1 May, 15 May, 1 June, 15 June, and 1 July. The crop harvested on 1 July yielded 88.03 liter/ha essential oil, which was non-significantly higher than the essential oil yield obtained from 15 June harvest (83.34 liter/ha). The essential oils optained were analysed using GC-FID and GC-MS. Major constituents of the oils were camphor (23.9-35.8%), 1,8 cineole (20.1-26.7%), α-pinene (4.5-14.4%) verbenone (6.5-12.4%), and camphene (2.5-6.9%).

Input : R.S. Verma

Harvesting time	Essential oil yield (l/ha)
15 April	10.28
1 May	23.26
15 May	30.59
1 June	50.14
15 June	83.34
01 July	88.03
SEm (0.05)	6.77
CD (0.05)	21.36



Essential oil composition of African marigold (*Tagetes minuta* L.) harvested at different growth stages in foothills agroclimatic conditions of North India

Tagetes minuta L., commonly known as African marigold, is reputed as a source of 'Tagetes oil' of trade that finds an extensive use in food, flavoring, pharmaceutical, perfumery and cosmetic industry. Variation in the essential oil yield and quality of *T. minuta* grown in foot hills agroclimatic conditions of northern India were assessed in different harvesting stage (flower initiation, full flowering, late flowering and seed setting) of the winter crop. Altogether, 28 constituents, comprising 81.2-93.9% of the oil compositions were identified using gas chromatographic retention index (RI) and mass spectral data. The essential oil composition was mainly represented by (*E*)-ocimenone (31.8-42.2%), (*Z*)-â-ocimene (22.9-32.7%), (*Z*)-

Compounds	Content (%)			
	Flower initiation	Full flowering	Late flowering	Seed setting
Limonene	1.2±0.05	1.5±0.11	1.3±0.92	1.0±0.10
(*Z*)-β-Ocimene	25.6±0.26	26.5±0.90	32.7±2.02	22.9±0.20
Dihydrotagetone	3.7±0.20	1.7±0.29	2.8±0.40	3.1±0.40
(*E*)-Tagetone	1.8±0.15	2.5±0.83	1.2±1.10	1.0±0.25
(*Z*)-Tagetone	11.0±0.51	8.9±0.30	10.0±0.57	8.0±1.0
(*Z*)-Ocimenone	6.0±0.76	7.5±1.01	6.9±2.45	10.3±0.80
(*E*)-Ocimenone	42.2±1.41	39.5±0.90	34.3±1.86	31.8±0.35
Total identified	93.9	90.1	91.8	81.2
Essential oil content	0.52±0.03	0.66±0.03	0.72±0.02	0.78±0.03

tagetone (8.0-11.0%), and (*Z*)-ocimenone (6.0-10.3%), dihydrotagetone (1.7-3.7%), (*E*)-tagetone (1.0-2.5%) and limonene (1.0-1.5%). The essential oil of *T. minuta* from foothills of northern India consist the constituents in entirely different quantitative composition.

Input: R.C. Padalia

Precision Farming: A new agro-technology to boost-up yield attributes and oil yield of Chamomile

The results revealed that different fertilizer application methods, the T4 (100:60:40 Kg NPK ha-1 incorporated in surrounding soil of the plant: 1/3rd N and full dose of P2O5 and K2O as basal, and 1/3rd N each at 25-30 DAT and 40-45 DAT) recorded significantly highest attributes like; plant height (63cm), dry flower yield (4.11Mg ha-1), oil content (0.91%), and oil yield (37.32kg ha-1) as compared to T3, and T2; and the lowest value of plant height (44cm), dry flower yield (2.15Mg ha-1), oil content (0.70%), and oil yield (15.05kg ha-1) were recorded in control (no fertilizer).

Treatment	Plant height (cm)	Dry flower yield (Mg ha^{-1})	Oil content (%)	Oil yield (kg ha^{-1})
T_1	44.0	2.15	0.70	15.05
T_2	53.0	2.57	0.75	19.37
T_3	56.0	3.48	0.75	26.09
T_4	63.0	4.11	0.91	37.32
$SEm_{\pm}$	1.67	0.11	0.01	0.78
$LSD_{(0.05)}$	5.80	0.39	0.04	2.70

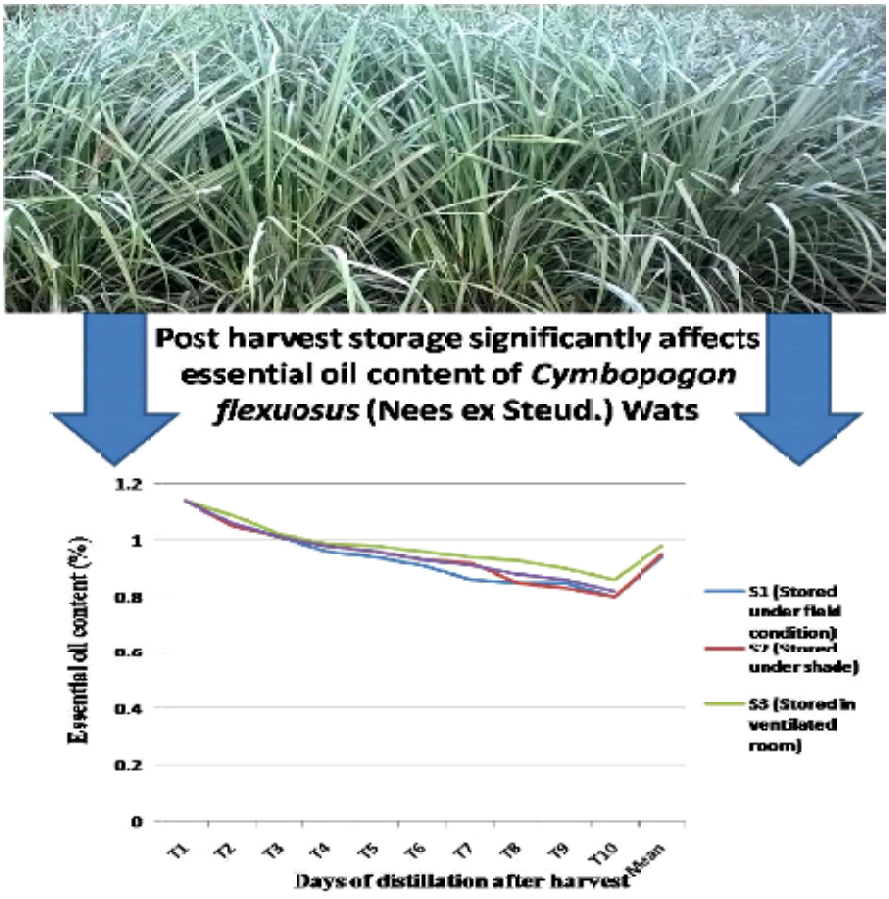
T_{-1}- Control; T_{-2}- 100:60:40 Kg NPK ha^{-1} top dressed: 1/3rd N and full dose of P_2O_5 and K_2O as basal, and 1/3rd N each at 25-30 DAT and 40-45 DAT; T_{-3}- 100:60:40 Kg NPK ha^{-1} applied on surrounding soil of the plant: 1/3rd N and full dose of P_2O_5 and K_2O as basal, and 1/3rd N each at 25-30 DAT and 40-45 DAT; T_{-4}- 100:60:40 Kg NPK ha^{-1} incorporated in surrounding soil of the plant: 1/3rd N and full dose of P_2O_5 and K_2O as basal, and 1/3rd N each at 25-30 DAT and 40-45 DAT.

Input: R.K. Upadhyay

Development of post harvest management practices for quality essential oil production of *Cymbopogon flexuosus* (Nees ex Steud.) Wats

The results obtained showed that *C. flexuosus* recorded significantly highest essential oil content (1.14%) at the same day or first day of harvest as compared to other treatments. Thus, it was concluded that *C. flexuosus* should preferably be distilled as fresh or same day of harvest to get higher yield of quality essential oil.

Input: R.K. Upadhyay



Genetic improvement in *Cymbopogon martinii var. motia, Mentha spicata, Mentha citrata and Origanum vulgare*

- About 150 superior plants were selected in *Cymbopogon martinii var. motia* based on internodal length, leaf length, leaf width, inflorescence size, inflorescence length and inflorescence compactness. The essential oil yield was estimated in some of the selected plants and seeds were harvested individually from all the selected 150 plants of palmarosa. These selected lines were evaluated in future for qualitative and quantitative traits for palmarosa crop improvement.
- Seeds were collected from open pollinated commercial *Mentha citrata* and *Mentha spicata* fields and seed progenies were planted in field and these progenies are under evaluation for qualitative and quantitative traits.
- Fourteen *Origanum vulgare* germplasms were collected from different locations of Uttarakhand. All the fourteen germplasms were successfully acclimatized to north Indian planes (Pantnagar) and under further evaluation.

Input: Venkatesha KT

Seed germination studies in *Rauvolfia serpentina* variety CIM-Sheel

T1: Cocopit; T2: Cocopit and Farm yard manure (50:50); T3: Farm yard manure; T4: Soil; T5: Soil and Farm yard manure (50:50) and T6: Soil and cocopit (50:50). D1: 25 DAS; D2: 30 DAS; D3: 45 DAS; D4: 60 DAS; D5: 75DAS; D6: 90 DAS

Germination medium	Germination Period						Mean
	D_1	D_2	D_3	D_4	D_5	D_6	
T_1	23.00	28.00	32.33	34.00	34.67	35.00	31.17
T_2	31.00	32.67	37.00	37.67	37.67	37.67	35.61
T_3	41.33	41.33	42.00	42.00	42.00	42.00	41.78
T_4	0.33	0.33	0.67	0.67	0.67	0.67	0.56
T_5	0.00	0.00	0.00	0.00	0.00	0.00	0.00
T_6	0.00	0.00	0.33	0.33	0.33	0.67	0.28
Mean	15.94	17.05	18.72	19.11	19.22	19.33	
	D		T		D*T		
SEM	0.26		0.43		1.29		
CD	0.73		1.22		NS		

- The propagation of *R. serpentina* through seeds is difficult due to less viability and very low germination percentage (<20.0%). The present study was conducted in the month of February to determine the influence of different germination medium & duration on seed germination of *R. serpentina.*
- Highest germination (41.0%) was found in in Treatment T3 (FYM) at 25 days after sowing which was significantly superior over other treatments.

Input: Amit Chauhan & Amit Tiwari

Sowing time : Last week of August

Post harvest storage effect on essential oil content and composition of *Cymbopogon distans* (Nees ex Steud.) Wats.

The lemon-scented chemotype of *C. distans*, domesticated in foothills was studied for post harvest storage under shade and open field conditions.

The results revealed that there were no losses in essential oil content up to 15 days of storage (0.46%) under shade conditions. However, in field conditions a loss of 6.52% and 10.87% of essential oil was observed over a fresh herb after 7 days and 15 days of storage, respectively.

- Major constituents of the essential oil were geranial (20.3-25.9%), neral (13.2-17.5%), geraniol (15.3-18.6%), and geranyl acetate (17.2-23.0%).
- In conclusion, *C. distans* should preferably be distilled a fresh or it may be stored in shade conditions up to 15 days without any loss of essential oil.

Input: Amit Chauhan

Kisan Mela at CIMAP Research Center Pantnagar

One-day farmer's fair was organized at CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP) Research Center, Pantnagar on 11th February 2017. Over 800 participants (including farmers, entrepreneurs, academicians, Scientists, industry representatives etc.) from different states viz. Uttarakhand, Uttar Pradesh, Bihar, Delhi, Madhya Pradesh participated in this farmer fair. The Kissan Mela was inaugurated and addressed by Dr. Alok Kalra, Chief Scientist, CIMAP, Lucknow, Dr. V.K.S. Tomar, Consultant, CIMAP, Lucknow, and Prof. C.S. Mathela, Retd. Professor and Head, Chemistry Department, D.S.B. Campus, Kumaun University, Nainital. A Kisan Gosthi was organized comprising of famers, Scientists, Academicians and industry representatives. Demostaration of agrotechnologies of MAPs, distillations processes, Rose water technology, and early mint technology, hands on training for Agarbattis/Incense sticks production was carried out in the

farmer fair. Various stalls displayed different activities pertaining to MAPs technologies, herbal products, agro-advisory, industrial herbal products, and CIMAP publications. Moreover, the quality planting material of menthol-mint suckers also sold to the farmers during Kisan Mela. The Kisan Gosthi, represented by the farmers, Scientists of CIMAP (Lucknow and Pantnagar), G.B. Pant University of Agriculture and technology-Pantnagar, Krishi Vigyan Kendra, Jeolikot and industry representatives, covered various aspects of MAPs cultivation, processing, marketing, and recent advances in MAPs.

Participation in 100th All India Farmer's Fair & Agro-Industrial Exhibition-2016 at GBPUA&T Pantnagar

CSIR-Central Institute of Medicinal Aromatic Plants (CIMAP) Research Center, Pantnagar participated in the 100th All India Farmer's Fair & Agro-Industrial Exhibition-2016 held at G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand during 17th-20th October 2016. More than 2000 visitors (Farmers/


G.B. Pant University of Agriculture & Technology
Pantnagar (U.S. Nagar), Uttarakhand

100th ALL INDIA FARMERS' FAIR
AND
AGRO-INDUSTRIAL EXHIBITION-2016

Certified that CIMAP, Pantnagar participated in the Agro-Industrial Exhibition held at this University from October 17-20, 2016. The display was greatly appreciated by the visitors of the Exhibition and Farmers' Fair. Their stall was adjudged Special in Government Group.

Director Extension Education

Vice-Chancellor

grower, students, entrepreneurs, academicians, industry representatives) from different states visited CSIR-CIMAP Stall. Team CSIR-CIMAP enthusiastically displayed various activities of CSIR-CIMAP viz. MAPs technologies (varieties of Mints, Lemongrass, Citronella, Palmarosa, Rose, Vetiver, Geranium, Rosemary, Acorus, Withania, Asparagus etc. and their agro and processing technologies), agro-advisory, herbal products and CIMAP publications. The herbal products and CIMAP publications were sold to popularize the technologies of CSIR-CIMAP during the Kissan Mela. Moreover, Dr. R.K. Upadhaya participated in Kisan Gosthi and delivered a lecture on 'Agrotechnology and Marketing Aspects of MAPs'. CSIR-CIMAP stall got a special prize for its outstanding exhibition of various activities on MAPs during the Agro-Industrial Exhibition at G.B. Pant University of Agriculture and Technology, Pantnagar, Uttarakhand.

Visit of the foreign Delegation at CRC, Pantnagar

An industrial delegation from China and Indonesia visited at CSIR-Central Institute of Medicinal & Aromatic Plants, Research Center, Pantnagar, with Sh. Ramakant Harlalka of Nishant Aromas, Mumbai on 30.04.2016. Delegation includes 17 members of aroma industry from China, Vietnam, and Indian representative. The delegation was apprised about CSIR-CIMAP research & development activities especially aromatic plants and essential oils. An interactive meeting was held between the foreign industry delegation and CRC Pantnagar R&D staff (Drs .V.R. Singh, R.C.

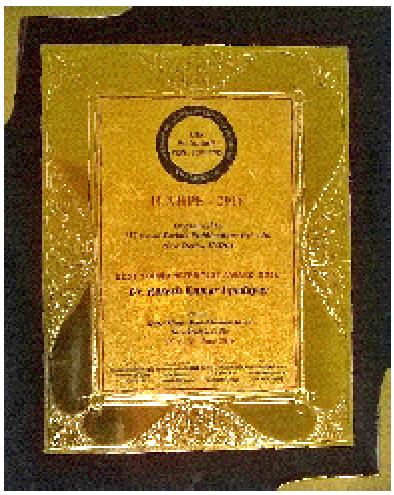
Padalia, R.S. Verma, R.K. Upadhyay, Amit Chauhan) & Dr. Sanjay Kumar from CIMAP Lucknow. The major discussion was held on the development and dissemination of aromatic plant varieties including Mint spp., Geranium, Lemongrass, Citronella, Vetiver, Rosemary, Rose,

Palmarosa, and Patchouli, etc. A visit of research farm was also organized to show the field demonstration of aromatic crops improved varieties and agrotechnologies. The delegation has shown keen interest in the CSIR-CIMAP developed improved varieties, agrotechnologies, and their dissemination on farmer's field. They were also shown the distillation and post harvest processing technologies developed by CSIR-CIMAP, herbal products and publications. The delegation appreciates the efforts of the institute in the area of aromatic crops and shown interest for future collaboration with CSIR-CIMAP.

Awards

Dr. R.K. Upadhyay received "Best Young Scientist Award-2016" IJTA 3rd International Conference on Agriculture, Horticulture & Plant Sciences, held by IJTA & Serials Publications Pvt. Ltd., New Delhi from June 25-26, 2016 at Hans Hotel, Barakhamba Road, New Delhi.

Input: R.K. Upadhyay



A Golden Journey of STUP Supported by SIDBI

CSIR-CIMAP started SIDBI sponsored Skill-cum-Technology Upgradation Programme on cultivation and primary processing of economically important medicinal and aromatic plants with the corpus found of Rs. 23 lakhs in the year of 1994-95 to achieve the following objectives:

i. To improve the performance of existing SSI units by developing/strengthening the entrepreneurial and managerial skills and capabilities of the entrepreneurs and senior executives of the small enterprises.

ii. The underlying intention is to enable the participant entrepreneurs/senior executive to assess his/her existing performance level and determine ways to enhance performance.

iii. It is also aimed at creating awareness amongst the SSI units on process improvements, technological developments etc. and to introduce the units to upgrade their technological levels.

The journey of SIDBI sponsored Skill-cum-Technology Up-gradation Programme on cultivation and primary processing of economically Important Medical and Aromatic Plants were quiet successful and produced 4440 skilled manpower from 114 trainings conducted at more than 51 location of 20 states of India. Out of 4440 odd participants, about 3000 participants were new and about 1440 participants were already doing the cultivation, processing trading, manufacturing of medicinal and aromatic plant s related products etc. . The support from SIDBI is acting as a catalyst in CSIR-CIMAP's on going effort besides boosting up the moral of the participants. The information provided by SIDBI representatives in each programme has also illuminated the hope in the trainees for financial support in their further expansions of the business. The journey of the 23 years of CSIR-CIMAP SIDBI has been memorable one and had visible impact on the medicinal and aromatic plants sector besides generating employment opportunities for the thousands of the farmers and entrepreneurs over the year will be remembered in the future.

Team CSIR-CIMAP acknowledges the golden contribution of SIDBI which has gone a long way in over all progress in the areas of medicinal and aromatic plants.

Awards & Recognition

CSIR Technology Award for "Development of Herbal Composition (NBRMAP-DB, Trade Name BGR-34) for the Management of Diabetes Type II". CSIR Technology Award for Development of Herbal Composition (NBRMAP-DB, Trade Name BGR-34) for the Management of Diabetes TypeII.

CSIR-CIMAP, Lucknow and CSIR-NBRI, Lucknow jointly developed NBRMAP-DB a scientifically validated herbal formulation for Type II Diabetes management. AIMIL Pharmaceuticals (India) Limited, New Delhi – the licensee of the formulation has launched the drug under trade name of BGR-34. The drug has evoked a tremendous response in market and in a short span of less than one year benefitted more than one million diabetic patients with an approximate sale worth Rs.60 crores. The award was presented by Dr. Harsh Vardhan, Minister of Science and Technology and Earth Sciences and Vice President CSIR on the occasion of Platinum Jubilee of CSIR Foundation Day Function held at Vigyan Bhawan, New Delhi on 26th September, 2016.

CSIR Award for Scientific and Technological Innovations for Rural Development (CAIRD-2014) for "Enhancing incomes of farm communities through Vetiver based Technological Interventions".CSIR Award for Scientific and Technological Innovations for Rural Development (CAIRD-2014) for Enhancing incomes of farm communities through Vetiver based Technological Interventions.

CSIR-CIMAP has enhanced the incomes of farming communities through Vetiver based technological interventions viz. new high yielding varieties ready to harvest with 10-12 months with high and stable oil content of >1%, intercropping of vetiver with conventional as well as other aromatic crops which led to the increase in average net profit per unit area and time. The award was presented by Dr. Harsh Vardhan, Minister of Science and Technology and Earth Sciences and Vice President CSIR on the occasion of Platinum Jubilee of CSIR Foundation Day Function held at Vigyan Bhawan, New Delhi on 26th September, 2016.

CSIR-CIMAP was awarded by the Essential Oil Association of India for the improved variety "CIM-Kranti" during the Asian Aroma Ingredients Congress & Expo 2016.

- Dr. Neelam S. Sangwan has been elected as a fellow of Indian National Science academy (INSA) in 2016, and attended member delegation "Women Leaders in Crop Science" at Cambridge University, UK under DBT co-ordinated Newton Bhabha programme-2016.
- Dr. Suaib Luqman has been awarded DHR long term fellowship for pursuing advanced training at Kings College, London, UK, by Ministry of Health and Family Welfare, Govt. of India.
- Dr Feroz Khan has been awarded DHR long term fellowship and pursuing research at Skaggs School of Pharmacy & Pharmaceutical Sciences, University of California San Diego, La Jolla, CA, USA.
- Dr. Dinesh A. Nagegowda has been awarded Raman research fellowship (2016-17).
- Dr. D. K. Venkata Rao was awarded a short term fellowship by Department of Health to pursue training at University of California, USA.
- Dr. Sumit Ghosh has got selected for deputation abroad during 2017 under bilateral exchange programme between Indian National Science Academy (INSA) and German Research Foundation (DFG).

Seminar organized

INSA-JIGYASA-2017: 22-23 February, 2017

In association with INSA Lucknow Chapter, the students of CSIR-CIMAP organized a 2-day symposium "INSA-JIGYASA-2017" on "Recent Exciting Developments in MAPS". Dr. P. K. Seth, formerly CEO, Biotech Park, Lucknow delivered an inaugural lecture. A total of 28 lectures including 3 plenary lectures by leading scientists were presented during the 2-day symposium. All the students, scientists and technical staff of CSIR-CIMAP participated in the event.

New medicinal and aromatic crop varieties

Two new improved crop varieties, one each of turmeric and khus, has been developed by CSIR-CIMAP. These varieties were released by Honorable Prime Minister of India Shri Narendra Modi on the occasion of 75th Foundation Day and beginning of Platinum Jubilee celebration at Vigyan Bhawan New Delhi on 26th September, 2016. The crop wise special characteristics are detailed below. The MAP farmers can obtain the planting material of these varieties from CSIR-CIMAP Lucknow for commercial cultivation.

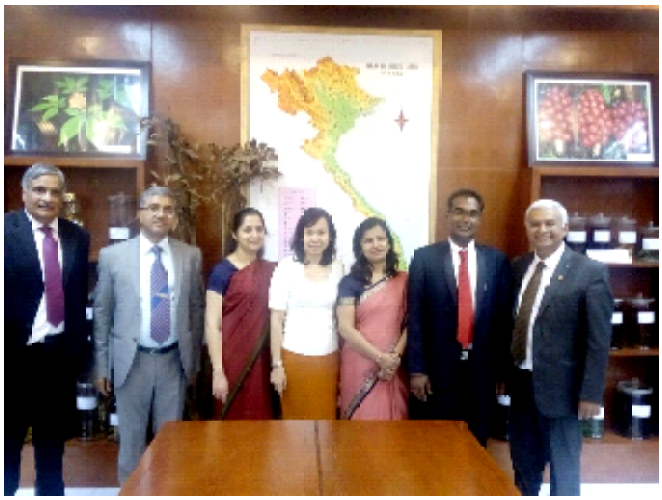
CIM-Peetambar: A high yielding variety of turmeric with rhizome yield potential of 60-65 ton/ha containing 12.5% Curcuminoids in a relatively short duration of 180-190 days. This variety would provide additional income of Rs. 20,000/ha to the farmers. The higher curcuminoid content would minimize the processing cost of pharmaceutical industry.

CIM-Samriddhi: The khushilal rich (31%) variety CIM-Samriddhi produces 35 kg of essential oil/ha which is 20% higher than other existing varieties. This variety has broad dark green leaves and yellow green inflorescence.

CIM-Snigddha: It is a methyl cinnamate-rich (78.7%) high essential oil yielding variety of *O. basilicum*. The potential herb yield of this new variety is 221 q/ha and oil yield of 190 Kg/ha.

Visits of Delegations and Dignitries

CSIR Delegation to National Institute of Medicinal Materials, Hanoi, Vietnam (10-14 April, 2016)



A delegation from CSIR, India visited NIMM, Hanoi to attend a workshop on Science Technology and Innovation policies with a view for enhancing globalization and trade liberalization.

Visit of Organic India to CIMAP (20 October , 2016)

A delegation from Organic India visited CSIR-CIMAP to discuss future collaboration on organic cultivation of Ocimum genotypes for commercial utilization.

Visit of Hon'able Minister Giriraj Singh (23 November, 2016)

Honorable minister of State for MSME visited CSIR-CIMAP to learn about the recent developments in the field of MAPs and discussed the possibility of involving the farmer entrepreneurs through MSME.

Visit of DG CSIR to CSIR-CIMAP (10 December, 2016)

Director General of CSIR, Dr. Girish Sahni visited CSIR-CIMAP on 10th December,2016 and addressed the staff members and students with encouraging remarks. He also separately interacted with the scientists of four CSIR labs to understand the frontier areas of research and advised to work in a team and utilize the common facilities.

Visit of Philippines Delegation to CSIR-CIMAP (16 December, 2016)

Important Events of the year

National Technology Day (May, 2016)

Chief guests were Prof. Manoranjan Sahu and Prof. Pralay Maiti who gave lecture on wound healing through Ayurvedic traditional method of Pancha balkal on clinical cases. Healing of piles or fistula through the traditional method of Char Sutra were also discussed

16-22 September 2016 (Hindi Week)

Hindi week was observed from 16-22 September,2016 during which various competitions were held for the students and staff members of the Institute to encourage the application of the hindi language in day to day official work.

International Yoga Day (21 June-2016)

International Yoga day was observed on 21st June,2016. A lecture on benefits of various asanas was deliberated by Dr. VK Agarwal in the forenoon while a demonstration was organized for the staff members in the evening.

Foundation Day celebration (21 October, 2016)

CSIR foundation day was celebrated on 21st October, 2016. On this occasion Prof. Lalji Singh delivered a lecture on "Reconstructing Indian population history". He emphasized that allele frequency differences between groups in India are larger than in Europe, reflecting strong founder effects whose signatures have been maintained for thousands of years owing to endogamy. He also predicted that there will be an excess of recessive diseases in India, which should be possible to screen and map genetically.

India International Science Festival 7-11 December, 2016

CSIR-CIMAP actively participated in the India International Science Festival 2016 at National Physical Laboratory, Delhi from 7th-11th December to spread scientific temper amongst young generation.
An open day was also observed on 8th November to celebrate the IISF-2016 at CSIR-CIMAP. Students from relevant post graduate institutions were invited to refresh their awareness towards newer technologies in medicinal and aromatic plants sciences.

National Science Day-2017

A lecture by Dr. Shiv Shankar Tripathi

48th Shanti Swaroop Bhatnagar Tournament (Indoor): March 3-5, 2017

CSIR Platinum Jubilee celebration:

CSIR Foundation Day celebration was organised in Nochikkadu village, Cuddalore Dist., Tamil Nadu on 26 September 2016 to mark the Platinum Jubilee celebration of CSIR Foundation Day. An interact live telecast with the Hon'ble Prime Minister, Shri Narendra Modi and distribution of new variety of vetiver (CIM-Samriddhi) to the farmers of Tsunami affected village Nochikkadu, Cuddalore District, Tamil Nadu was arranged. Hon'ble Prime Minister interacted with Shri P. Dhanraj, vetiver grower in Cuddalore Dist. regarding the cultivation and economics of vetiver.

About 500 farmers and officials from different departments attended the function. 180 farmers from surrounding villages of Cuddalore and other districts registered for the programme out of which 165 were men and 15 women participants. A brochure on cultivation aspects of vetiver in local language, Tamil was distributed to the registered participants. The farmers are very much interested to cultivate our improved varieties of vetiver.

Distribution of CIM-Samriddhi vetiver slips

Interaction with Hon'ble Prime Minister by farmers

Participation in Exhibitions/Seminars etc.:

CSIR-CIMAP Research Centre, Bengaluru participated in the following events where aromatic and medicinal plants, seeds of medicinal and aromatic plants and aromatic oils were displayed at the stall. The herbal products of CSIR-CIMAP were also displayed. The visitors were explained the agrotechnologies and distillation process of medicinal and aromatic plants. Brochures on medicinal and aromatic plants such as Lemongrass, Palmarosa, Vetiver, *Eucalyptus citriodora*, Senna, *Ocimum sanctum*, Ashwagandha and Kalmegh were distributed to interested visitors.

Totagarike Show – Interaction with Vice Chancellor, University of Horticultural Sciences, Bagalkot

Totagarike Show – Interaction with visitors

1. Totagarike Mela (Horticulture show) from 17-19 December 2016 at University of Horticultural Sciences, Bagalkot, Karnataka
2. 104th Indian Science Congress at S.V. University, Tirupati, Andhra Pradesh from 3-7 January 2017
3. 2nd International Exhibition & Conference on Pharmaceutical Industry at Bangalore International Exhibition Centre at Bengaluru from 11-13 Feb. 2017

104th Indian Science Congress – Interaction University of Horticultural Sciences, Bagalkot with Chief Minister of Andhra Pradesh

Patents granted

SN	Title	Inventors	Country/filing date
1	A single step process for the production of Ethylp-methoxycinnamate from *Kaempferia galangal* Linn.	Karuna Shanker Nupur Sirvastava Puja Khare Anju Kumari Yadav Jyotshna Sonali Mishra	India 21.7.2016
2	A novel composite catalyst system for eco-friendly synthesis of menthol from citronellal rich essential oil.	CS Chanotiya PK Rout Anju Yadav AK Shasany	India 21.7.2016
3	Thymol and Carvacrol analogues as inticancer agents and their process for preparation.	Dushyant Singh Raghuvanshi Suaib Luqman Sudeep Tandon Narsingh Verma Shilpi Singh Kaneez Fatima	India 10.11.2016

New staff memebrs who joint in this year (From 01-04-2016 to 31-03-2017)

Sl. No.	Name	Designation	DOJ	Remarks
1.	Pradipto Mukhopadhyay	Sr. Scientist	11-05-2016 (A/N)	CIMAP, Lucknow
2.	Rakesh Kumar	Scientist	04-05-2016 (F/N)	CIMAP RC, Pantnagar
3.	Yogendra N.D.	Scientist	17-05-2016 (F/N)	CIMAP RC, Bangalore
4.	Kishore B Bandomaravuri	Sr Scientist	23-05-2016 (F/N)	CIMAP, Lucknow
5.	Narendra Kumar	Scientist	23-05-2016 (F/N)	CIMAP, Lucknow
6.	Jnaesha A.C.	Scientist	01-06-2016 (F/N)	CIMAP RC, Hyderabad
7.	G.D. Kiran Babu	Principal Scientist	06-06-2016 (F/N)	CIMAP RC, Hyderabad
8.	Channayya Hiremath	Scientist	06-06-2016 (F/N)	CIMAP RC, Bangalore
9.	Venkatesha K.T.	Scientist	07-06-2016 (A/N)	CIMAP RC, Pantnagar
10.	Ramesh Kumar Srivastava	Sr. Scientist	07-06-2016 (F/N)	CIMAP, Lucknow
11.	Mukhti Nath Mishra	Sr. Scientist	14-10-2016 (F/N)	CIMAP, Lucknow
12.	Suchita Gupta	Senior Steno	31-10-2016 (F/N)	CIMAP, Lucknow
13.	Pratibha Maurya	Assistant (G) III	11-11-2016 (F/N)	CIMAP, Lucknow
14.	Ravi Prakash Mishra	Assistant (G) III	11-11-2016 (F/N)	CIMAP, Lucknow
15.	Bhaskar Jyoti Deuri	COA	19-12-2016 (F/N)	CIMAP, Lucknow
16.	B. Mallikamba	AO	30-01-2017 (F/N)	CIMAP RC, Hyderabad
17.	Anil Kumar Tewari	Technical Officer	01-02-2017 (F/N)	CIMAP, Lucknow

Externally funded projects

SN	Funding Agency	GAP No.	Project Title	PI	Start date	Total Project Cost	End date
1	NMPB	GAP-334	Economics of cultivation of important medicinal plants grown at farmers' field	Dr Sanjay Kumar	13.05.2016	32,34,000	12.05.2019
2	Telangana State Medicinal Plants Board	GAP-336	Establishment of medicinal plants processing facility at CIMAP, Research Centre, Hyderabad in Collabaration with TSMPB	Dr. J Kotesh Kumar	11.03.2016	50,00,000	10.03.2017
3	NABARD	GAP-337	Agriculture empowerment of farmers through creation of vetiver oil production hub under problematic soils and rain-fed conditoins in Hamirpur district of UP	Dr Alok Krishna	22.03.2016	9,89,000	21.03.2017
4	SERB, DST	GAP-338	Molecular studies to prospect UV-B-mediated epigenetic dynamics in *Withania somnifera* and its association with the secondary metabolism	Dr Neha Pandey	18.04.2016	19,20,000	17.04.2018
5	CSIR	P-81 (EMR)	Engineering plant triterpene biosynthesis in heterologous host	Dr Sumit Ghosh	02.05.2016	25,00,000	01.05.2021
6	DST	GAP-339	In silico & in vitro bioactivity evaluation studies of plants derived tri-terpenoids and their derivatives through QSAR approach	Ms. Aparna Shukla	17.05.2016	15,68,000	16.05.2018
7	NMPB	GAP-340	Identification of Swertia chirayita genotype (s)/strain (s) performing well under lower Himalayan altitute of Uttarakhand	Dr Birendra Kumar	19.07.2016	27,45,000	18.07.2019
8	SERB, DST	GAP-341	Evaluation of phytomolecules for their effects on aging via modulating DAF-2/DAF-16 insulin like signaling pathway: studies employing model system *Caenorhabditis elegans*	Dr Pooja Shukla	01.04.2016	19,20,000	31.03.2018
9	SERB, DST	GAP-342	Study on individual and combinatorial effects of phytomolecules on alpha synuclein and dopamine related pathologies in Parkinson's disease	Dr Supinder Kaur	01.04.2016	19,20,000	31.03.2018
10	INSA	GAP-343	Establishment of the virus induced gene silencing assay for functional characterization of the genes involved in medicinal diterpene biosynthesis in Kalmegh	Dr Sumit Ghosh	10.06.2016	1,500,000	09.06.2019

11	SERB, DST	GAP-344	Elucidation of Pyrethrin production pathway under changing climate scenario: a potential natural source for malaria vector control	Dr Farah Deeba	14.03.2016	1,920,000	13.03.2018
12	NMPB	GAP-345	Development of high yeidling pellitorin rich Akarkara (*Anacylcus pyrethrum*) variety and its region specific field trial in farmers field.	Dr. Tripta Jhang	11.08.2016	3,102,000	10.08.2019
13	**NGO PANI-** People's Action for National Integration	CNP-346	Consultancy project for survey of sites, training and guidance in menthe cultivation by intervention of the early mint technology with special reference to water conservation for PANI (People's Action for national Integration) Faizabad, Uttar Pradesh.	Dr. Saudan Singh	01.08.2016	1,497,000	31.12.2017
14	SERB, DST	GAP-347	Enhancement of primary and secondary metabolite production in Withania somnifera by application of nanoparticles (NPs)	Dr Ruchi Singh	01.04.2016	1,920,000	31.03.2018
15	DHR	GAP-348	Development of plant based novel alpha2 adrenergic receptor antagonists as anti-parkinsonian agents	Dr. Vineeta Gupta	15.08.2016	4,800,000	15.08.2019
16	SERB, DST	GAP-349	Ameliorating effect of Trichoderma sp. inoculation on Arsenic induced physiological and biochemical stress in some important medicinal plants commonly grown in Arsenic contaminated sites	Dr Pratibha Tripathi	11.07.2016	1,920,000	10.07.2018
17	Centre of Innovative and Applied Bioprocessing (CIAB)	CNP-350	Providing consultancy for designing, fabrication and setting up of stainless steel directly fired type field distillation unit of 250 kg capacity for essential oils based on CSIR-CIMAP knowhow & design	Er. Sudeep Tandon	12.09.2016	316,825	11.09.2017
18	IPCA Laboratories Limited	CNP-351	Technology transfer of Artemisia to IPCA Laboratories Ltd.	Dr Sanjay Kumar	17.10.2016	1,150,000	16.10.2017
19	Telangana State Medicinal Plants Board	GAP-352	Development of model nursery for production and supply of quality planting material/seed of commercially important medicinal crops in Telangana	Dr. J Kotesh Kumar	24.10.2016	2,000,000	23.10.2018

20	SERB, DST	GAP-353	Distribution mapping guided genetic diversity and reproductive ecology of Utleria salicifolia Bedd. ex Hook. F., an endemic and endangered medicinal plant from Western Ghats	Dr. Gokul S.	01.08.2016	1,920,000	31.07.2018
21	SERB, DST	GAP-354	Ameliorating effect of Trichoderma sp. inoculation on Arsenic induced physiological and biochemical stress in some important medicinal plants commonly grown in Arsenic contaminated sites	Dr. Navendu Vinayak Page	16.08.2016	1,920,000	15.08.2018
22	SERB, DST	GAP-355	Development of multiplex diagnostic assay for detection and quantification of mycotoxigenic fungi in post harvest medicinal plant materials used for herbal medicines in India	Dr. Anu Sharma	15.11.2016	3,100,000	14.02.2019
23	NMPB	GAP-356	Conservation and genetic improvement of Prishnparni (*Uraria picta*)- a critically endangered Dashmool drug	Dr. Birendra Kumar	15.12.2016	2,795,400	14.12.2019
24	SERB, DST	GAP-357	Exploring anticancer potential of 3-{3-[3-Oxo-3-(3,4,5-trimethyl-phenyl)-propenyl]-phenyl}-3H-quinazolin-2-one (a novel quinazolinone chalcone derivative) in search of safer anticancer agents	Dr. Zahoor Ahmad Wani	01.09.2016	1,920,000	31.08.2018
25	SERB, DST	GAP-358	Screening and evaluation of anticancer activity of phytomolecules in lever cancer	Dr. Ajeet Kumar Verma	03.08.2016	1,920,000	02.08.2018
26	Kankor ingredients Limited	CNP-359	Consultancy project for conducting demonstrations, awareness programme and technical guidance related to Early Mint Technology (EMT) to farmers for improved Mentha cultivation and distillation technique in Bareilly district of Uttar Pradesh for Kankor ingredients Limited, Cochin, Kerala	Dr. Saudan Singh	18.01.2017	432,000	17.01.2018
27	Indian Council of Agriculture Research	GAP-360	Chemotyping and molecular profiling of bioactive metabolites in *Hemidesmus indicus* and *Costus specious*, adapted to different phytogeographical zones and identification of candidate genes related to metabolic pathways	Dr V Sundaresan	27.01.2017	35.3514	31.12.2019

28	ICMR	GAP-361	Optimization of anti-tubercular and antifilarial leads using modern drug designing techniques	Dr Santosh Kumar Srivastava	21.06.2016	1,370,000	20.06.2018
29	SERB, DST	GAP-362	Molecular expression studies on Ca^{2+} pumps/channels in lung cancer cell and its modulation through plant natural products	Dr Abha Meena	15.03.2017	3,996,000	14.03.2021
30	SERB, DST	GAP-363	Vindoline enhancing strategies and relevant gene prospecting in important medicinal plant *Catharanthus roseus*	Dr Ashutosh Kumar Shukla	17.03.2017	4,020,840	16.03.2020
31	NASI	GAP-365	Metabolic engineering through hairy root cultures of *Atropa belladonna*-an endangered medicinal plant, for therapeutically distinctive alkaloid production alternatives and targeted derivatization of phytomolecules for value addition	Dr. Suchitra Banerjee	01.02.2017	1,380,000	31.01.2020

Staff superannuated this year (From 01-04-2016 to 31-03-2017)

Sl. No.	Name	Designation	DOJ	Remarks
1.	Suchitra Banerjee	Chief Scientist	03-04-1956	30-04-2016
2.	A.K. Srivastava	Record Keeper	22-05-1956	31-05-2016
3.	A.K. Mathur	Chief Scientist	22-06-1956	30-06-2016
4.	S.K. Kushwaha	Sr Supt. Engineer	16-06-1956	30-06-2016
5.	M.M. Gupta	Chief Scientist	01-07-1956	30-06-2016
6.	Pawan Prasad	Elect. Gr II(4)	01-07-1956	30-06-2016
7.	C.S. Pant	Junior S Assistant	01-07-1956	30-06-2016
8.	A.K. Tripathi	Chief Scientist	02-07-1956	31-07-2016
9.	O.P. Singh	Assistant (F&A) I	10-08-1956	31-08-2016
10.	J.P. Singh	Gr. II(4)	08-10-1956	31-10-2016
11.	B.D. Vashisth	COA	10-10-1956	31-10-2016
12.	S.M. Kushwaha	PS	07-10-1956	31-10-2016
13.	Archna Mathur	Chief Scientist	12-11-1956	30-11-2016
14.	A.K. Chauhan	SO (F&A)	21-11-1956	31-11-2016
15.	R.K. Lal	Chief Scientist	01-01-1957	31-12-2016
16.	VKS Tomar	Chief Scientist	24-12-1956	31-12-2016
17.	Samudra Devi	Mali	01-01-1957	31-12-2016
18.	Mohd Yaseen	Chief Scientist	04-01-1957	31-01-2017
19.	O.P. Dhawan	Chief Scientist	14-02-1957	28-02-2017
20.	Man Singh	PTO	15-02-1957	28-02-2017
21.	K.S. Ali	Assistant (F&A) I (MACP)	12-02-1957	28-02-2017
22.	Phool Chandra	Sr. Tech (2)	01-03-1957	28-02-2017
23.	R.D. Ram	Sr. Tech (2)	01-04-1957	31-03-2017

Scientific contributions of some of the scientists superannuated this year

Dr. MM Gupta

Dr. MM Gupta (PhD, Chemistry) started his journey in CSIR-CIMAP/CIMPO on 15 March, 1977 and served the organization for 39 years till his superannuation as Chief Scientist on 30 June, 2016. He successfully guided nine PhD students under his mentorship. His PhD students are well placed in reputed positions in government and private sectors. He is a great contributor in natural product and analytical chemistry, which is reflected from his achievements during 39 years of his professional expertise. He has published 214 research papers in SCI journals [Citations-3837; h-index-32; i10-index-105], 66 in papers in Symposium, and 08 Book/ book chapter, Additionally, he has also contributed to produce 24 National patents, 09 International patents, 14 plant varieties, and 03 process technologies. The research contribution of Dr Gupta were recognized by number of awards viz. most cited paper award 2005-2008 by Elsevier, 2007 & 2008; CSIR-CIMAP Annual day awards; Dr. P D Sethi Annual Awards (2008, 2010 & 2013); Neena Saxena award-2007; CSIR-technologies award for Artemisia-2012; CSIR technologies award for Withania-2015. His significant scientific contribution to IP-2007 has been appreciated by Indian Pharmacopeia Commission, Govt. of India. He is the life member of Indian Chemical Society, Indian Parasitological Society and The National Academy of Sciences India (NASI). He left indelible footprints of his dedication towards research to follow, which is quite incredible.

Email: guptammg@rediffmail.com/ guptammg@gmail.com; Mobile: 9415927850

Dr Ajay Kumar Mathur

Born on 26th June 1956, Dr AK Mathur joined CSIR-CIMAP in February 1983 after completing his Ph. D in Botany (Plant Morphogenesis) from University of Delhi. His Ph. D thesis research laid down the foundation of developing salt tolerant crops through in vitro mutagenesis and cell line selection approaches in plants. He initiated his journey at CIMAP as a post doctoral fellow in the division of plant tissue culture, became research aAssociate in 1984 and was inducted in faculty as Scientist-B on 21st Nov., 1985. He along with Late Dr AK Kukreja and late Dr PS Ahuja, played a defining role in establishing one of the best equipped and advancing cell, tissue and protoplast culture laboratory in the country. His initial efforts towards successful micro-cloning of elite selections of *Dioscorea floribunda* and *Duboisia myporoides* on one hand and somaclonal breeding in aromatic grasses (particularly citronella) on the other hand immediately marked the arrival of CIMAP on the world map of MAPs biotechnology research. The citronella variety CIMAP/Bio-13 developed by this team was the FIRST tissue culture raised and improved plant variety that reached the farmers' field in the country. Globally, it was the 13th plant variety to do so. This variety still covers about 3/4th of citronella cultivation in India and even after >25 years of its release it is the first choice of citronella farmers and essential oil industry. The focus of Dr Mathur's interests was subsequently spread to the areas of Tissue Banking, Cell culture interventions in Metabolic Pathways Engineering, Synthetic Seed Technology and Cell Fusions. He has extensively worked on crops like *Catharanthus roseus, Papaver somniferum, Centella asiatica, Artemisia annua, Hypericum perforatum, Bacopa monnieri* and *Cymbopogons.* He guided three Ph. D thesis and mentored 27 M. Sc project dissertations.

Dr Mathur is recipient of prestigious memberships of several national and international societies including the National Academy of Sciences (India), Phytochemical Society of Europe, Asian Network of Biological Sciences and Plant Tissue Culture Association of India to name a few. He has published more than 82 research papers in Peer reviewed International journals such as J Pl Physiology; Phytochemistry; Plant Breeding, Phytochemical Reviews; Protoplasma, Planta Medica, Plant Cell, Tissue and Organ Culture, Plant Science, In Vitro Cellular and Developmental

Biology, Plant Cell Reports, Industrial Crop Research, Plant Growth Regulators; Applied Microbiology and Biotechnology; Current Science etc. He has edited four conference proceedings, contributed 12 book chapters and has four patents to his credit. He is also in the project reviewers' board of several international and national funding agencies and scientific periodicals. In addition to his research capabilities, Dr Mathur has always been an important flag-ship name in CIMAP's policy making team. He has always strived to take CSIR-CIMAP to a new pedestal in MAPs research and business. Working in unison with the visions of his peers, he organized and coordinated several National Interactive Meets and Brian Storming Discussions to encourage the requisite value chain alignments in MAPs sector. As a senior faculty, Dr Mathur has regularly served the institute on all administrative issues and decisions. His is profusely respected by his younger colleagues in CSIR-CIMAP as a source of guidance and advice.

Dr Mathur has superannuated as Chief-Scientist on 30th June 2016 and is presently serving as a consultant to CSIR-CIMAP. His present contact details are as follows: Email – akmcath@gmail.com; Cell – 09415419061; Phone (R) - 05224104958.

Dr Archana Mathur

Dr Archana Mathur had her entire education at Delhi and did her B.Sc honors in Botany from Miranda House, Delhi University and completed her M.Sc and M.Phil from Depatment of Botany, University of Delhi. She did her Ph.D in Botany in 1984 from this University under the supervision of Prof. KR Shivanna who is known as Father of Pollen-Pistil interactions in the country. Her Ph.D work on Control of Parasitic Weeds through induction of precautious germination is still considered as a pioneer classical piece of research in experimental Seed Biology. Publication of three papers in a very prestigious journal **Annals of Botany** out of her work was a testimony of this worthy recognition.

Mrs Mathur has been a throughout top rankers and was recipient of **NCERT National Science Talent Fellowship** from her Higher Secondary to Ph.D courses. She was awarded with CSIR Research Associateship in 1984 and moved to CIMAP with this fellowship in 1985. She was subsequently appointed as **First Lady Scientist of CIMAP** in June 1988 as Scientist-B in the Division of Plant Tissue Culture. Her major research interests at CIMAP has been in vitro secondary metabolite production particularly the plant saponins and anthocyanins.

Mrs Mathur's major research focus and interests have been in the area of developing cell and tissue culture based alternate production platforms for plants saponins and anthocyanins that are required by the traditional and modern pharmaceutical industries. Her original contributions in the area of tissue culturing of Ginsengs (*Panax* spp.) has been internationally acclaimed. She was invited by International Foundation for Science (IFS), Sweden to participate in an International Co-ordinated project on Plant Saponins for Food and Health. She steered this project at CIMAP and was sponsored by IFS to present her findings in the Phytochemical Society of Europe's Annual Meeting at London and Poland in 1996 and 1999, respectively. She also attended review meetings of this international collaboration initiative at Vietnam and London.

Mrs Mathur was actively engaged in Tissue and Pollen Banking activities of CIMAP National Gene Bank besides her continued commitment in the area of in vitro secondary metabolism profiling under biotic and abiotic elicitations I plants such as Ginseng, Centella, Ocimums and Gymnema.

Dr Archana has an illustrious publication record with more than 75 high impact research papers in journals like Annals of Botany, Journal of Experimental Botany, Phytochemistry, Planta Medica, Seed Science and Technology Reviews, Phytochemical Review, Biotechnology Letters, In vitro Celluar & Developmental Biology, Plant Cell Tissue Organ Culture, Protoplasma, Plant Science, J Natural Medicines and others. She has written 10 Book Chapters and has three patents to her credit. She teamed up with Dr RK Lal in developing recently released variety of Centella CIM-Medha from CIMAP. She has guided three Ph.D thesis and 38 M.Sc and 4 M.Tech project

dissertations, one student is currently writing her Ph.D thesis under her mentorship.

Being the First Lady Scientist of CIMAP, Mrs Mathur has always taken a lead in championing the dignity and honor of all women staff and girl students of the institute. Creation of a children crèche for young wards of working ladies and a mess facility for hostellers in the colony were outcome of her efforts. She has always been respected as a motherly figure and local guardian for all her students.

Dr. R.K. Lal

Dr. R.K. Lal born on 1.1.1957 did his B.Sc. Ag (Hons.) 1977 and M.Sc. Ag (Genetic & Plant Breeding) 1979 from CSA Azad University of Agriculture & Technology Kanpur with 3rd and 1st position respectively in University. Entered in CIMAP on 28.11.1981 as JSA with 4 increments and superannuated as Chief Scientist on 31.12.2016. Conventional breeder by training, during his 35 years of tenure as breeder Dr. Lal has contributed enormously viz. 63 varieties of MAPs of which 33 as principal breeder, 21 patents of which 6 as principal investigator, research reports, Edited Book 1, 9 Book Chapter, 2 review papers, 10 Farm bulletins and 56 papers/posters in national and international conferences. To his credit Dr. Lal has received Dr. Sadgopal Memorial Award of 1983 for his significant work in aromatic grasses, ICV-5 Vetiver Award for significant contribution in developing vetiver varieties. Besides these many more awards were conferred upon him by various bodies. Two students of Dr. Lal had been awarded Ph.D. while four more are in process.

Publications*

Ahmad I, Raghuvanshi DS, Singh S, John AA, Prakash R, Nainawat KS, Singh D, Tripathi S, Sharma A, Gupta A. 2016. Design and synthesis of 3-arylbenzopyran based non-steroidal vitamin-D3 mimics as osteogenic agents. *Medicina Chemistry Communications* **7**:2381-2394 [IF=2.319]

Asthana J, Mishra BN, Pandey R. 2016. Acacetin promotes healthy aging by altering stress response in Caenorhabditis elegans. *Free Radical Research* **8**:861-874 [IF=2.970]

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Adviser & Scientist G
Department of Biotechnology
New Dehli

DG's Nominee

Dr Ramesh V. Sonti
Chief Scientist
CSIR-Centre for Cellular and Molecular Biology
Hyderabad

Sister Laboratory

Prof. Alok Dhawan
Director
CSIR-Indian Institute of Toxicology Research
Lucknow

Cluster Director

Dr Ram Vishwakarma
Director
CSIR-Indian Institute of Integrative Medicine
Jammu

Director

Prof. A.K. Tripathi
Director
CSIR-Central Institute of Medicinal and Aromatic Plants
Lucknow

Permanent Invitee

Head
Planning & Performance Division
CSIR, New Delhi

Member - Secretary

Dr. Alok Kalra
Chief Scientist
CSIR-Central Institute of Medicinal and Aromatic Plants
Lucknow

Management Council

Chairperson

Dr AK Tripathi
Director
CSIR-CIMAP, Lucknow

Members

Dr Madhu Dixit
Director CSIR-CDRI, Lucknow

Dr Sanjay Kumar
Director CSIR-IHBT, Palampur

Dr Ashok Sharma, Chief Scientist
CSIR-CIMAP, Lucknow

Dr M.P. Darokar, Senior Principal Scientist
CSIR-CIMAP, Lucknow

Dr Dharmendra Saikia, Principal Scientist
CSIR-CIMAP, Lucknow

Dr Abha Meena, Scientist
CSIR-CIMAP, Lucknow

Dr. V.K. Agarwal
Medical Officer
CSIR-CIMAP, Lucknow

Mr. O.P. Dhawan, Chief Scientist
PME, CSIR-CIMAP, Lucknow

Controllor of Finance & Account
CSIR-CIMAP, Lucknow

Controllor of Administration
CSIR-CIMAP, Lucknow

Budget at a glance*

	Allocation	Expenditure
Pay and allowances	2313.00	2275.414
Contingency	291.00	291.541
HRD	2.40	2
Lab maintenance	145.00	160.132
Staff qtr. maintenance	32.00	29.223
Chemicals / consumables	245.00	329.429
Works and services	310.00	74.246
Apparatus and equipment	370.00	61.308
Office equipment	0	0
Furniture and fitting	50.00	48.378
Library books	0	0
Library journal	0	0
Staff qtrs. (construction)	55.00	25.40
CSIR network projects	1141.587	847.810
Total	5089.837	4258.958
Pension	1470.00	1661.680
External Budgetary Resources		
Lab Reserve Fund (LRF)	170.63	
External Cash Flow (ECF)	583.00	

*as on 11 March 2016

Staff Members (as on 31 March 2017)

Director

Prof. Anil Kumar Tripathi

Chief Scientist

Dr. Ashok Sharma
Shri Anil Kumar
Dr. RS Sangwan
Dr. Alok Kalra
Dr. Abdul Samad
Shri Rakesh Tiwari
Shri PV Ajaya Kumar
Shri JP Tewari

Senior Principal Scientist

Dr. (Mrs) Neelam Singh Sangwan
Dr. AK Shasany
Dr. Saudan Singh
Dr. Alok Kumar Krishna
Dr. Ved Ram Singh
Dr. RS Bhakuni
Shri Sudeep Tandon
Dr. MP Darokar
Dr. Arvind Singh Negi
Dr. Birendra Kumar
Dr. AK Gupta

Principal Scientist

Dr. Laiq-Ur-Rahman
Dr. Dharmendra Saikia
Dr. Vikrant Gupta
Dr. Rakesh Pandey
Dr. Anirban Pal
Dr. Dinesh A. Nagegowda
Dr. J Kotesh Kumar
Er. G. D. Kiranbabu
Dr. (Mrs) Sunita Singh Dhawan

Sr. Scientist

Dr. Dayanandan Mani
Dr. Rajesh Kumar Verma
Dr. Karuna Shanker
Dr. Sanjay Kumar
Mr. Manoj Semwal
Dr. Dnyaneshwar Umrao Bawankule
Shri Feroz Khan
Dr. Venkata Rao D.K.
Dr. CS Vivek Babu
Dr. Sumit Ghosh
Dr. (Mrs) Prema G. Vasudev
Dr. Narayan Prasad Yadav
Dr. Suaib Luqman
Dr. V. Sunderesan
Mr. Ram Swaroop Verma
Dr. Ashutosh Kumar Shukla
Mr. KVN. Satya Srinivas
Dr. Ramesh Kumar Srivastava
Dr. Kishore Babu Bandamaravuri
Dr. Pradipto Mukhopadhyay
Dr. Rajendra Chandra Padalia
Smt. Puja Khare
Dr. Chandan Singh Chanotiya
Dr. Debabrata Chanda
Dr. Prasanta Kumar Rout
Dr. Mukti Nath Mishra

Scientist

Miss Abha Meena
Dr. Rakesh K. Shukla
Dr. (Ms.) Tripta Jhang
Dr. Atul Gupta
Dr. Preeti Srivastava
Mr. Bhasker Shukla
Dr. Rakesh Kumar Upadhyay
Dr. Ram Suresh
Shri Ashween D. Nannaware
Dr. Narendra Kumar
Dr. Rakesh Kumar
Dr. Yogendra N.D.
Dr. Channayya Hiremath
Dr. Venkatesha K.T.
Dr. Jnanesha A.C.

Group-III

Principal Technical Officer

Name of Employee
Dr VK Agarwal
Dr HP Singh
Dr. Mohd Zaim
Dr. Dinesh Kumar
Shri Kundan Singh

Sr. Technical Officer (3)

Shri Am Khan
Shri Prem Singh
Dr DK Rajput
Dr. Sukhmal Chand
Dr. Dasha Ram

Sr. Technical Officer (2)

Shri K Bhaskaran
Dr Ateeque Ahmad
Mrs. Sudha Agarwal
Shri Govind Ram

Sr. Technical Officer (1)

Smt Anju Kumari Yadav
Shri Shiv Prakash
Dr. (Mrs.) Manju Singh

Technical Officer (Gr. III (3))

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

Technical Assistant

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

Group-II

Sr. Technician (3)

Shri Sk Sharma

Sr. Technician (2)

Shri S. Selveraj
Shri Rd Ram
Shri Shyam Behari
Shri Ar Kidwai
Smt IV Rautela
Shri Ram Chandra
Shri Y Shiva Rao
Shri Salim Baig
Dr Abdul Khaliq
Shri SK Pandey
Shri Raghubind Kumar
Shri Gopal Ram
Shri E Bhaskar
Smt S Sharda
Shri PN Gautam
Shri Joseph M Massey
Shri Ram Lakhan
Shri PK Tiwari
Shri Vinod Kumar
Shri Siva Kumar DC

Sr. Technician (1)

Smt Raj Kumari
Shri Dharam Pal Singh Meena

Technician (2)

Shri V.K. Shukla
Shri Pankaj Kumar Shukla
Shri Kundan Narayan Wasnik
Shri Yalla VVS Swamy

Technician (1)

Shri Basant Kumar Dubey
Shri Vijay Kumar Verma
Shri Harendra Nath Pathak
Shri Hemraj Sharma
Shri Jitendra Kumar Verma
Shri Pramod Kumar

Group-I

Lab Assistant

Shri Mahesh Prasad
Shri VK Singh
Shri Abdul Mabood
Shri Ram Ujagir
Shri Subhash Kumar
Shri Bharat Singh Bisht
Shri Man Mohan
Shri Qasim Ali
Shri Sabhajit
Shri Mohd. Navi
Shri Munawar Ali
Shri Hari Pal
Shri Nurul Huda
Shri Surendra Nath
Shri Lal Chand Prasad

Lab Attendant (2)

Smt Pushpa Semwal
Shri Manish Arya
Shri TP Suresh

Administrative Staff

Group-A

Sh. M.S. Mehra
Sh. B.L. Meena
Sh. Baljeet Singh
Sh. Bhasker Jyoti Deuri
Smt. Mallikamba

Group-B (Gazetted)

Shri Hare Ram
Shri Ankeshwar Mishra
Shri Vikash Chand Mishra
Shri Sanjay Kumar Ram
Shri Girija Shankar Verma
Shri Shailendra Pratap Singh

Group-B (Non-Gazetted)

Smt Sufia Kirmani
Shri Muneshwar Prasad
Shri Sant Lal
Shri Parvez Nasir
Shri P Srinivas
Shri Rajesh Kumar
Shri Kaushal Kishore
Shri Siddharth Shukla
Shri Ravi Prakash
Shri Kg Thomas
Ms. Sanyogita Sainger

Asstt (F&A)

Smt Nisha Sharma
Harish Chandra
Shri Shiv Kumar
Shri Suneel Kumar
Shri Al Sahoo
Shri Ayush Singhal
Shri Kanhaiya Lal

Asstt (S&P)

Shri Pankaj Kumar
Shri Shamiullah Khan
Shri Anees Ahmad
Shri Sa Warsi

Senior Stenographer

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

Isolated Posts (Group-B)

Shri Yograj Singh
Shri Rohit Khanna
Smt Sangeeta Tanwar

Group-C Posts Asstt (S&P)

Shri Ajeet Verma

(Asstt Gen Grade-II)

Shri PK Chaturvedi
Shri Manoj Swaroop Shukla
Mrs. Sheela Yadav
Shri Vijay Kumar Bhartey
Mrs. Preeti Gangwar

Asstt (F&A) Grade-II

Smt Kc Nagarathnamma
Shri Pradeep Kumar
Smt Farzana Hafeez

Jr. Stenographer

Asstt (Gen.) Grade-III

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

Asstt (S&P) Grade-III

Asstt (F&A) Grade-III

Group C (Non –Tech)

Drivers PB-1

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

Canteen Staff

Shri Victor Mukerjee

Multi Tasking Staff

Shri Mata Prasad
Shri Kailash Chandra
Shri Tula Singh
Shri Ashok Kr. Pathak
Shri Kishan Lal
Shri P Bhikshapathi
Shri Ajay Kumar
Smt Nirmala Verma
Smt Tara Devi
Smt. Nargis Sufia Ansari
Smt Sunita Devi
Shri Santosh Kumar
Shri Sant Ram

PB-1

Shri Sudhir Kumar Bhattacharya
Shri Harihar
Shri Raja Ram
Shri Praveen Kumar
Shri Kishan Ram
Smt. Zarina Bano
Shri Ram Karan
Shri Dharam Pal Balmiki
Shri Abdul Nadir Khan
Shri Arvind Kumar
Smt. Raj Mati
Shri Harpal Valmiki
Sh. Kripa Ram
Sh. Mohd. Shameem
Mohd. Moseen

Dr OP Dhawan

Genetic and molecular studies of downy mildew resistance and flower organ identity genes in opium poppy.Development of plant varieties of MAPs and their DUS testing for registration with PPV&FRA.Projectand intellectual property management.

1 Dubey, M.K.; Shasany, A.K.; Dhawan, O.P.; Shukla, A.K. and Khanuja, S.P.S. 2009. Genetic variation revealed in the chloroplast-encoded RNA polymerase B' subunit of downy mildew-resistant genotype of opium poppy. J Hered, **100**: 76-85.

2. Singh, S.K.; Shukla, A.K.; Dhawan, O.P. and Shasany, A.K. 2014. Recessive loci *Pps-1* and *OM* differentially regulate *PISTILLATA-1* and *APETALA3-1* expression for sepal and petal development in *Papaver somniferum*. PLoS ONE 9(6): e 101272. doi: 10.137/journal. pone.0101272.

Dr. V. R. Singh

Genetic improvement of medicinal and aromatic crops through classical and conventional plant breeding approaches for the development of varieties, germplasm collection, evaluations and their maintenance.

1. Patra, N.K.; Tanveer, H; Khanuja, S.P.S.; Shasany, A.K.; Singh, H.P.; Singh, V.R. and Kumar, S., 2001. A unique interspecific spearmint hybrid having growth habit from *mentha arvensis* and essential oil quality from *Mentha spicata*. Theor. Appl. Gen., 102:471-476.

2. Upadhyay, R.K.; Singh, V.R.; and Tewari, S.K. 2016. New agro-technology to increase productivity of chamomile (*Matricaria chamomilla* L.). Industrial Crops & Products: **89**: 10-13.

Dr R. K. Lal

Genetic improvement of medicinal and aromatic Plants by utilizing Plant Breeding and Genetics, Mutation Breeding techniques and Biometrical/ statistical analysis.

1. Lal, R.K; Gupta Pankhuri and Dubey, Basant Kumar. (2017). Genetic variability and associations in the accessions of Manduk parni (*Centella asiatica* (L)). Industrial Crops and Products. 96: 173-177.

2. Patel, R.P.; Singh, R; Rao, BRR; Singh, RR; Srivastava A., Lal R. K. 2016. Differential response of Genotype × Environment on phenology, essential oil yield and quality of natural aroma chemicals of five *Ocimum* species. Industrial Crop and Products.

Dr. Birendra Kumar

Genetic improvement through classical plant breeding approaches viz. hybridization, mutation and introgression breeding, selection, quantitative genetics, and standardization and establishment of seed quality parameters in medicinal and aromatic plants.

Fellow of Indian Society of Spices Calicut, Kerla India.w.e.f. Fellow of Society for applied Biotechnology w.e.f. Nov. 2014. Society for Applied Biotechnology Tamil Nadu, India.

1. Kumar, B. and Patra NK. 2010. Genetical analysis of capsule and its associated economic traits in opium poppy (*Papaver somniferum* L.). Journal of Heredity **105** (5): 657-660.

2. Kumar, B.; Shukla AK and Samad A. 2014. Development and characterization of menthofuran-rich inter-specific hybrid peppermint variety CIMAP Patra. Molecular Breeding **34**(2): 717-724.

Dr. Anil Kumar Gupta

The major area of work is the development of improved varieties of MAP's through classical breeding approach. So far developed total 6 varieties which includes the "CIM Jeevan" of *Phyllanthus amarus*; "CIM Sheel" of *Rauwolfia serpentine*; "CIM Sheetal" of *Aloe vera*; "CIM Arogya" and "CIMSanjeevani" of *Artemisia annua*; "CIM SIL 9" of *Silybum marianum*" and "CIM Pitamber" of Turmeric.

1. Gupta, AK; Mishra, R.; Singh, A.K.; Srivastava, A. and Lal, RK. 2017. Genetic variability and correlations of essential oil yield with agro-economic traits in *Mentha* species and identification of promising cultivars. Industrial Crops and Products **95**: 726-732.

Dr. Channayya Hiremath

Non-coventional breeding approaches viz. induced variability through physical as well chemical mutagens in various aromatic and medicinal plants and study thereof.

1. The Indian Journal of Genetics and Plant Breeding, **75**(4): 514-517, 2015.
2. Electronic Journal of Plant Breeding: **1**(4): 414-419, 2010.

Dr. Tripta Jhang

Metabolite targeted breeding, plant genetic stature improvement and basic genetic studies in *Withania* , *Anacyclus* and Catharanthus. Quantitative genetics of secondary plant metabolism and their co-evolution. Molecular Marker Development and their application in marker assisted breeding

1. Kulkarni, R., Baskaran, K., and Jhang, T. 2016. Breeding medicinal plant, periwinkle [*Catharanthus roseus* (L) G. Don]: A review. Plant Genetic Resources, 14(4), 283-302. doi:10.1017/S1479262116000150
2. Jhang, T.; Kaur, M; Kalia, P; Gautam, N.; Singh, N.K. and Sharma T.R. 2010. Efficiency of different marker systems for molecular characterization of subtropical carrot breeding material. Journal Of Agricultural Science, **148**: 171-181. Cambridge University Press.

K.T. Venketash

Genetic enhancement of oil yield and geraniol content in palmarosa (*Cymbopogon martini)* through mutation breeding. Development of high yielding varieties / chemo-types suitable for commercial cultivation in Oregano (*Origanum vulgare*) and thyme (*Thymus linearis*).

1. Venkatesha, K.T., Asif, M., Vijay Kumar, K.V. and Shivanna, H. Physiological and morphological response of maize (Zea mays L.) inbred lines under drought condition. Int. J. Plant Sci., **8**(1): 131-133
2. Venkatesha, K.T., Shivanna, H., Vijaya Kumar, K.V. and Panurange Gowda, K.T. Identification of superior general and specific combiners for drought tolerance based on SCMR, SLA, ASI and " C_{13} in maize (*Zea mays L.*). Crop Res., **44**(3):394-399.

Dr. R.S. Bhakuni

Basic and applied research of MAPs Medicinal / Process Chemistry-artemisinin antimalarials, anticancer artemisinin dimers, antidiabetic / antibacterial formulations.

1. Gaur R, Pathani AS, Malik FA, Bhakuni RS, Verma RK. 2016. Synthesis of a series of novel dihydroartemisinin monomers and dimers containing chalcone as a linker and their anticancer activity. Eur J Med Chem, **22**: 232-246.
2. Goswami S, Bhakuni RS, Chinniah A, Pal A, Kar SK and Das PK. 2012. Anti. Helicobacter pylori potential of artemisinin and its derivatives. Antimicrob Agents Chemother, **56**: 4594-4607.

Er. Sudeep Tandon

Development, designing and up scaling of improved technologies for processing of medicinal and aromatic plants for herbal extracts, essential oil and downstream processing, isolation, fractionation and chemical transformation of oils, their isolates, aroma chemicals and phytochemicals for value added products and bioactive molecules. Designing and erection of plants for steam distillation, solvent extraction, fractionation and synthetics conversions for the production of essential oils, their isolates as aroma chemicals, medicinal plants herbal extracts, phyto pharmaceuticals, nutraceuticals, drug development etc. for small scale cultivators, farmers, distillers, entrepreneurs and industries.

1. Sudeep Tandon, Arnab Chatterjee, S.K. Chattopadhyay, Ranjeet Kaur, A.K.Gupta. 2010. Pilot scale processing technology for extraction of Cliv-92: A combination of three coumarinolignoids cleomiscosins A, B and C from Cleome viscosa", Industrial Crops and Products 31: 335–343
2. Abhishek Nagar, Arnab Chatterjee, Laiq Ur Rehman, Ateeque Ahmad, Sudeep Tandon. 2015. Comparative extraction and enrichment techniques for pyrethrins from flowers of *Chrysanthemum cinerariaefolium*. Industrial Crops and Products **76**: 955–960

Dr. P.V. Ajayakumar

Area of interest covers Biological Electron Microscopy and Non-invasive analysis of Bio-molecules for both qualitative and quantitative analysis and diagnostics purposes.

1. *In silico* and *in vitro* studies on begomovirus induced andrographolide biosynthesis pathway in *Andrographis paniculata* for combating inflammation and cancer 2016. Molecular Informatics, **35**: 253–261.
2. Chitinolytic microbes confer Meloidogyne incognita resistance and augment secondary metabolites in *Bacopa monnieri* (L.) Pennell 2017. Archives of Phytopathology and Plant Protection, **50**: 178-196.

Dr. Arvind Singh Negi

Working as a medicinal chemist in the area of development of cancer chemotherapeutics through microtubule destabilization using fragment based drug discovery approach.

1. Parihar, S.; Kumar, A.; Chaturvedi, A.K.; Sachan, N.K.; Luqman, S.; Changkija, B.; Manohar, M.; Om, Prakash; Chanda, D.; Khan, F.; Chanotiya, C.S.; Shanker, K.; Dwivedi, A.; Konwar, R. and Negi*, A.S. 2013. Synthesis of combretastatin A4 analogues on steroidal framework and their anti-breast cancer activity. J. Steroid Biochem. Molecular Biol., **137**: 332– 344.
2. Gautam, Y.; Dwivedi, S.; Srivastava, A.; Hamidullah; Singh, A.; Chanda, D.; Singh, J.; Rai, S.; Konwar, R.; Negi A.S. 2016. 2-(3´, 4´-dimethoxybenzylidene) tetralone induces anti-breast cancer activity through microtubule stabilization and activation of reactive oxygen species. RSC Advances, **6**: 33369-33379.

Dr. J. Kotesh Kumar

Qualitative and quantitative analysis of MAPs by HPLC and GC. Involved in promotion of cultivation of MAP's in both Andhra Pradesh, Telangana and other neighbouring states. Cultivation and distillation of aromatic grasses is being promoted in the tribal areas of Visakhapatnam in AP with funding support from Seed division of DST. Similarly, cultivation of Aswagandha is being promoted in Kurnool and Ananthapur districts by supplying quality seed material at subsidized rates with funding support from AP and TS MPB's.

1. Priyanka, Misra, K.; Sisodia, B.; Faridi, U.; Srivastava, S.; Luqman, S.; Darokar, M.P.; Negi, A.S.; Gupta, M.M.; Singh, S.C. and Kumar J.K. 2009 A promising anticancer and antimalarial component from the leaves of *Bidens pilosa* L. Planta Medica, **75**: 59-61.
2. Ponnam, D.; Singh, S.; KVNS, S.; Luqman, S.; Prakash, Om; Amtul, Z.; Arigari, NK; Jonnala, KK; Siddiqui, L.; Dubey, V.; Tiwari, A.K.; Balasubramanian, S.; Khan, F. 2014. Synthesis of cyclic 1,9-acetal derivatives of Forskolin and their bioactivity evaluation. European Journal of Medicinal Chemistry. **87**: 735-744.

R.C. Padalia

Exploration and chemosystematics of Himalayan aromatic plants. Essential oil profiling and characterization of aroma principles to explore their potential for high value fragrance chemicals and industrial use. Isolation and characterization/ Identification of aroma compounds by chromatographic and spectroscopic techniques. Chemical variability evaluation of potential aromatic plants in varied season and growth stages for harvest management for high oil yield and quality essential oils

1. Padalia, R.C.; Verma, R.S.; Upadhyay, R.K.; Chauhan, A.; Singh V.R. 2017. Productivity and essential oil quality assessment of promising accessions of *Ocimum basilicum* L. from north India. Industrial Crop and Products, **97**: 79-86.
2. Padalia, R.C.; Verma, R.S. and Chauhan A. 2015. The essential oil composition of *Melaleuca leucadendra* L. grown in India: A novel source of (*E*)-nerolidol. Industrial Crop and Products, **69**: 224-227.

Dr Karua Shanker

Our research is focused on: Natural products chemistry: Isolation, characterization, of secondary metabolites as marker (bioactive/ chemotaxonomic) chemical from medicinal plants; Standardization and QC/QA of crude drugs and herb-based preparations; Development of analytical and bio-analytical methods-chromatographic hyphenated in-vitro assay, pharmacokinetic studies of bioactive(s).

1. Shanker K, Gupta MM, Srivastava SK, Bawankule DU, Pal A and Khanuja SPS 2007. Determination of bioactive nitrile glycoside (s) in drumstick (*Moringa oleifera*) by reverse phase HPLC. Food Chemistry. **105**(1): 376-382.
2. Srivastava P, Ajayakumar PV, Shanker K 2014. Box–Behnken Design for Optimum Extraction of Biogenetic Chemicals from P. lanceolata with an Energy Audit (Thermal× Microwave× Acoustic): A Case Study of HPTLC Determination with Additional Specificity Using On line/Off line Coupling with DAD/NIR/ESI MS. Phytochemical Analysis. **25**(6):551-560.

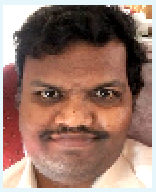
Mr. KVN Satya Srinivas

Isolation & Characterization of bioactive molecules from Medicinal & Aromatic plants; Semi-synthesis of natural bioactive molecules; Development of novel synthetic methodologies & Synthesis of bioactive molecules; Analysis of medicinal & aromatic plants by HPLC and GC.

CSIR Technologies Award for Life Sciences 2015 Team Member.

1. Devendar, P.; Niranjana A.K., Bethu, M.S.; Zehra, A.; Pamanji, R.; Rao, J.V.; Tiwari, A.K.; Sridhar, B.; Srinivas, K.V.N.S. and Kumar, J.K. 2015. Highly selective one pot synthesis and biological evaluation of novel 3-(allyloxy)-propylidene acetals of some natural terpenoids. RSC Advances. **5**: 93122–93130.
2. Komuraiah, B.; Srinivas, C.; Kumar, A.N.; Grover, P.; Srinivas, K.V.N.S.; Kumar, J.K. 2016 Iodine catalyzed simple and efficient synthesis of antiproliferative 2-pyridones. Bioorganic & Medicinal Chemistry Letters. **26**: 2159–2163.

Shri GD Kiran Babu



Process and equipment design in the field of medicinal, aromatic, nutraceutical and colour/dye-bearing plants, process up-scaling, standardization, consultancy on setting up of processing facilities for aromatic plants, supercritical carbon dioxide extraction of MAPs, quality evaluation of essential oils, skill development.

1. Kumar D, Sukapaka M, Babu GDK and Padwad Y. 2015. Chemical Composition and *In Vitro* Cytotoxicity of Essential Oils from Leaves and Flowers of *Callistemon citrinus* from Western Himalayas. PLoS ONE **10**(8): e0133823. doi:10.1371/journal.pone.0133823.
2. Robin Joshi, G.D. Kiran Babu, Ashu Gulati. 2013. Effect of decaffeination conditions on quality parameters of Kangra orthodox black tea. Food Research International, **53:** 693-703. http://dx.doi.org/10.1016/j.foodres.2012.12.050

Dr. RS Verma

Extraction, isolation and characterization of natural essential oils and aroma chemicals for industrial uses. Assessment of variability in the essential oil profile of aromatic crops due to various intrinsic and extrinsic factors. Characterization of aqueous distillate (hydrosol) aroma of Aromatic Crops

1. Verma RS, Padalia RC, Chauhan A, Thul ST. 2013. Exploring compositional diversity in the essential oils of 34 *Ocimum* taxa from Indian flora. *Industrial Crops and Products,* **45**: 7-19.
2. Verma RS, Padalia RC, Goswami P, Upadhyay RK, Singh VR, Chauhan A, Tiwari AK. 2016. Assessing productivity and essential oil quality of Himalayan thyme (*Thymus linearis* Benth.) in the subtropical region of north India. Industrial Crops and Products, **94**: 557-561.

Dr. PK Rout

Synthesis and characterization of heterogeneous catalyst for carrying out the green chemical reactions. Catalytic modification of low value essential oil to chiral selective commodity products. Valorization of after distilled aromatic biomass using green catalytic process. Chemical characterization and value addition of lipids.

1. Rout PK, Nannaware AD, Prakash O, Kalra A, Rajasekharan R. 2016. Synthesis of hydroxy-methylfurfural from cellulose using green processes: A promising biochemical and biofuel feedstocks, Chem. Eng. Sci, **142**: 318-346.
2. Prakash O, Rout PK, Chanotiya CS, Misra LN. 2012. Composition of essential oil, concrete, absolute and SPME analysis of *Tagetes patula* Capitula, Industrial Crops and Products **37**(1): 195-199.

Dr. CS Chanotiya

Chemistry of Natural Products (aromatic plants). Essential oils and their separation in one dimensional Gas Chromatography system hyphenated with mass spectrometer. Enantioselective separations of enantiomeric pairs of terpenoids and aroma chemicals. Solid-Phase Microextraction (SPME) based studies for identification of flower volatiles.

1. Pragadheesh VS, Saroj Arvind, Yadav Anju, Chanotiya CS and Samad A. 2013. Compositions, enantiomer characterization and antifungal activity of two Ocimum essential oils. Industrial Crops and Products, **50**: 333-337.
2. Pragadheesh VS, Yadav Anju and Chanotiya CS. 2015. Role of Substituents in Cyclodextrin Derivatives for Enantioselective Gas Chromatographic Separation of Chiral Terpenoids in the Essential Oils of *Mentha spicata* J Chromatogr B, **1002**: 30-41.

Dr. Atul Gupta

Research activities involve identification and development of new bioactive molecules through value addition of natural products and synthesis of designed molecules. These molecules are evaluated for estrogen receptor mediated anticancer and osteogenic activities. Additionally, group is also involved in establishing novel protocols for chemical transformations.

1. Gupta A., Ahmad I., Kureel J., Hasanain M., Pandey P., Singh S., John A.A., Sarkar J., Singh D. 2016. Induction of targeted osteogenesis with 3-aryl-2*H*-benzopyrans and 3-aryl-3*H*-benzopyrans: Novel osteogenic agents; Journal of Steroid Biochemistry and Molecular Biology, **158**: 63-75.
2. Maurya, H.K; Hasanain, M.; Singh, S.; Sarkar, J.; Dubey, V.; Shukla, A.; Luqman, S.; Khan, F.; Gupta, A. 2016. Synthesis of 4-phenyl-5, 6-dihydrobenzo[h] quinazolines and their evaluation as growth inhibitors of carcinoma cells; RSC Advances 6, **22**: 18607-18618;.

Dr. Alok Krishna

Extension of economically viable medicinal and aromatic plants, varieties, agrotech-nologies and outreach programmes for income enhancement of Indian farmers communities including technology dissemination & rural development.

1. Krishna A., Kumar V., Singh S., Singh P. and Yadav RP. 2014. Production and Trade related issues of Opium poppy cultivation with special reference to Barabanki District. U.P. Acta. Hort. **1036**: 111-118.
2. Krishna A., Kumar V. and Yadav R.P. Impact Assessment of aromatic crop distillation technology by the Indian cultivation: A case study. Int. J. Curr. Sci. **12**(E) : 45-54.

Ashween Deepak Nannaware

Current interest: Designing of solar distillation unit for essential oil extraction; Valorization of spent distilled biomass for value added biochemical production

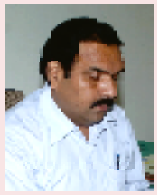
1. Rout PK, Nannaware AD, Prakash O., Kalra A., Rajasekharan R. 2016. Synthesis of hydroxymethylfurfural from cellulose using green processes: A promising biochemical and biofuel feedstocks, Chem. Eng. Sci, **142**: 318-346.
2. Rout PK, Nannaware AD, Prakesh O., Rajasekharan R. 2014. Depolymerization of cellulose and synthesis of hexitols from cellulosc using Heterogeneous catalysts, Chembioengg Rev, Vol1, Issue **3**: 96-116.

Patents

US 20140350271 A1: "A process for chemical conversion of cellulose isolated from aromatic spent biomass to hydroxymethyl furfural". PK. Rout, **Ashween Deepak Nannaware**, R. Rajasekharan

WO/2016/088139: "An eco-friendly process for the isolation of biopolymers from agricultural residues". PK. Rout, Ashween Deepak Nannaware, Om Prakesh, R. Rajasekharan

Dr. Sanjay Kumar



Business Development, Industrial liaison, MAPs Economics, Extension and Rural development

CSIR award for Rural Development CARD – 2008

CSIR award for Rural Development CARD – 2015

Prestigious Khorana Technology transfer course fellowship organized by Indo-US Science Technology Forum at University of Wisconsin at Madison, USA During – July – August – 2013.

1. Sanjay Kumar., Suresh R., Singh V.,and Singh A.K. 2011. " Economic Analysis of Menthol mint Cultivation in Uttar Pradesh: A Case Study of Barabanki District" Agricultural Economics Research Review, **24**: 345 – 350.
2. Sanjay Kumar., Suresh R., Verma D.K., Dangesh A. and Tomar V.K.S. 2015. "Public-Private-Partnership towards rural development: a case study of *Artemisia annua* in Uttar Pradesh" Current Science, 109(07): 1237-1239.

Dr. Ramesh Kumar Srivastava

Working on skill development of farmers and entrepreneurs, extension activities cultivation and processing of medicinal and aromatic plants.

1. Srivastava RK, Singh AK, Kalra A, Bansal RP, Tomar VKS, Patra DD, Naqvi AA, Chand S, Sharma S and Kumar S. Characteristics of menthol mint *Mentha arvensis* L. crop cultivated on industrial scale in the Indo- Gangetic plains., Industrial Crops and Products, USA **15**:189-198.
2. Singh AK, Srivastava RK, Kalra A, Bansal RP, Tomar VKS and Kumar S. New Practices in Cultivation of the Mint, *Mentha arvensis* in the Indo-Gangetic plains., Experimental Agriculture. **39**: 199-207.

Dr. V.K.S. Tomar

Current area of interest is rural development i.e. enhancing the income of rural masses deploying the CSIR-CIMAP technologies through onsite demonstration, training and awareness. Generation of additional mandays employment and business opportunites in rural areas through MAPs cultivation, processing and trading.

CSIR award for Rural Development CARD – 2008

CSIR award for Rural Development CARD – 2015

1. Sanjay Kumar., Suresh R., Verma D.K., Dangesh A. and Tomar V.K.S. (2015) "Public-Private-Partnership towards rural development: a case study of *Artemisia annua* in Uttar Pradesh" Current Science, **109**(07): 1237-1239.

Dr. Ram Suresh Sharma

Economic analysis of medicinal and aromatic crops (MACs), technology dissemination/ extension activities of the institute and to help in the business development activities.

1. Suresh R., Sanjay K., Singh V. Pravesh R., Tomar VKS and Singh A.K. 2012. "Economics of Production to Marketing of Aromatic Crops in Uttar Pradesh: A Case Study" Agricultural Economics Research Review. **25**: 155-158.
2. Suresh R., Kumar S., Gangwar S.P., Shanker H., Tomar V.K.S., Bansal R.P. and Singh A.K. 2014 Economic Analysis of Palmarosa Cultivation in India: Indian journal of Agricultural Research, **48**(6): 480-483.

Er. J.P. Tiwari

Design and development of agricultural tools and implements for efficient and economic cultivation practices in MAPs towards significant saving in labour input and minimizing the cost of cultivation. Successfully developed and released CIM-Krishak sathi (2005), Khus-digger (2013), Sataver-digger (2015) for the farmers use.

1. Tewari JP. 2011. Low cost, high tech implement for khus root harvesting P-28; 78-79 Souvenir, The fifth international conference on vetiver at CIMAP Lucknow.
2. Tewari J.P. 2014. Engineering intervention to mechanize the process of Khus Root Harvesting; Journal of Agricultural Engineering (ISAE) Agricultural Engineering Today, CIAE, Bhopal. **38**(3).

Dr. Saudan Singh

Development and deployment of cost effective agro-technologies aimed at reduction in inputs especially irrigartion demand with enhanced productivity , quality and economic output through cropping systems approach. Popularization of CSIR-CIMAP technologies through different means of communication and demonstrations.

CSIR, Technology prize-1999 (Biological Sciences & Technology); FICCI award 2005 in the area of rural development; CSIR award for Rural Development CARD – 2008; CSIR-Technology award for life sciences-2015. Ukraine: May 26, 2013 to June 06, 2013

1. Saudan Singh, M. Ram, S Sharma and D. V. Singh 1997. Water requirement and productivity of palmarosa on sandy loam soils under sub tropical climate. Agricultural Water Management **35**: 1-10.
2. Saudan Singh, Man Singh, Anil Kumar Singh, Alok Kalra, Anju Yadav, D.D. Patra. 2010. Enhancing productivity of Indian basil (*Ocimum basilcum* L.) though harvest management under rainfed conditions of subtropical north Indian plains. Industrial crops and Products. **32**: 601-606.

Dr Puja Khare

Assessment of contaminant levels in medicinal plants and development of agrotechnology for reduction of these contaminant in raw materials required for herbal drug preparation. Integrated approach of agromining through aromatic crops and enhancement in the fertility of soil in carbon negative manner.

1. Jain Shilpi, Mishra Disha, Khare Puja, Yadav Vineet, Deshmukh Y., Meena Abha. 2016. Impact of biochar amendment on enzymatic resilience properties of mine spoils. Science of the Total Environment **544**: 410–421.
2. Deshmukha Yogita, Yadava Vineet, Nigam Nidhi, Yadavb Anju, Khare Puja. 2015. Quality of bio-oil by pyrolysis of distilled spent of Cymbopogonflexuosus. Journal of Analytical and Applied Pyrolysis **115**: 43–50.

Rajesh Kumar Verma

Soil fertility & crop management in abiotic stress soils; soil carbon sequestration; recycling of organic wastes for improving soil health. Science and Technology intervention in rural development, Agrotechnology, Natural Resource Management, Crop/Plant Production, Environmental Agrotechnology, Crop Diversification.

1. Pragya Trivedi, Kripal Singh, Umesh Pankaj, Sanjeet Kumar Verma, Rajesh Kumar Verma, D.D. Patra 2016. Effect of organic amendments and microbial application on sodic soil properties and growth of an aromatic crop. Ecological Engineering **102**: 127–136.
2. Rajesh Kumar Verma, Ram Swaroop Verma, Laiq-Ur Rahman, Alok Kalra, Dharani Dhar Patra. 2016. Integrated nutrient management on biomass, oil yields and essential oil composition of peppermint (*Mentha piperita* L.) and residual fertility in a hilly soil. TEOP **19**(3): 582 – 591.

Dr. N.D. Yogendra

Utilization of seaweed liquid extract in medicinal and aromatic crops and Soil fertility management in medicinal and aromatic crops

1. African Journal of Agricultural Research 2014. **9**(9): 831-840,
2. Indian Journal of Dryland Agricultural Research & Development 2014. **29**(1): 63-69,

Dr. AC Jnanesha

Agro technology development for economically important, export oriented medicinal and aromatic crops. Essential oil profiles analysis of cultivated and wild growing aromatic plants. Technology dissemination and technology transfer.

Dr. Rakesh Kumar

Natural resource management and agrotechnology of medicinal and aromatic plants.

1. Rakesh Kumar, U.P.Singh and Gaurav Mahajan, 2017. Residue and weed management practices in zero-till wheat (*Triticum aestivum* L..) under rice-wheat cropping system International Journal of Agriculture Sciences, **9**(4): 3708-3712.
2. Neetu and Rakesh Kumar, 2016. Effect of GA3 on growth, flowering and corm production of gladiolus cultivars The Bioscan **11**(4):2219-2222.

Dr. Rakesh Kumar Upadhyay

Development of new agro-technologies for quality cultivation of medicinal and aromatic plants to increase the crop productivity as well as farmers income in sustainable manner at wider scale.

1. Upadhyay, R.K.; Singh, V.R.; and Tewari, S.K. 2016. New agro-technology to increase productivity of chamomile (*Matricaria chamomilla* L.). Industrial Crops & Products, **89**: 10-13.
2. Bajeli, J; Tripathi, S.; Kumar, A.; Tripathi, A. and Upadhyay, R.K. 2016. Organic manures a convincing source for quality production of Japanese mint (*Mentha arvensis* L.). Industrial Crops & Products, **83**: 603-606.

Alok Kalra

We have established the importance of microbial diversity rich in different plant growth promoting traits and identified microbes, both rhizospheric and endophytic, enhancing tolerance of plants to multiple stresses, improving secondary metabolite content, promoting build up of beneficial microbes and preventing major shifts in indigenous microbial community under stress conditions.

1. Awasthi A, Singh M, Soni SK, Singh R, Kalra A. 2014. Biodiversity acts as insurance of productivity of bacterial communities under abiotic perturbations. The ISME journal; **8**(12): 2445-2452.
2. Bharti N, Pandey SS, Barnawal D, Patel VK, Kalra A. 2016. Plant growth promoting rhizobacteria *Dietzia natronolimnaea* modulates the expression of stress responsive genes providing protection of wheat from salinity stress. Scientific Reports; **6**: 34768; doi: 10.1038/srep34768.

Dr. Rakesh Pandey

Mainly working on Plant-Microbe interactions, development of microbial based consortia for crop yield enhancement and curtailment of inorganic fertilizers. Isolated and identified a novel *Bacillus megaterium* that besides remediating the carcinogenic Chromium-VI to Cr-III prevalent in tannery effluent sites, also facilitates plant growth and phyto-nematode management in agri-crops. Other **path-breaking contributions** are- (a) strategic utilization of *Caenorhabditis elegans* model: (a) as biosensor for monitoring environmental toxicities, and (b) identification of several novel phytomolecules for anti-ageing, anti-alzheimer and anti-parkinson activities.

1. Asthana, J., Yadav, D., Pant, A., Yadav, AK, Gupta, M.M. and Pandey R. 2016. Acacetin 7-O-á-l-rhamnopyranosyl (1–2) â-Dxylopyranoside elicits life-span extension and stress resistance in *Caenorhabditis elegans*. Journals of Gerontology: Biological Sciences. **71**(9): 1160-1168.
2. Srivastava, S., Pant A., Trivedi, S. and Pandey, R. 2016. Curcumin and â-caryophellene attenuate cadmium quantum dots induced oxidative stress and lethality in *Caenorhabditis elegans* model system. Environmental Toxicology and Pharmacology **42**: 55-62

Dr. Kishore B. Bandamaravuri

Study of host-pathogen interactions through genomics and transcriptomics. DNA barcoding and molecular diagnostic tools for detection of plant pathogenic fungi. Development of integrated disease management strategies for fungal pathogens of MAPs through Organic Farming.

Abdul Samad

Research interests include studies on fungal, phytoplasma and viral diseases of economically important medicinal-, essential oil-, alkaloid- and dye-bearing plants. Also, interested in plant disease management through development of diagnostic kits and utilization of beneficial microbes towards development of biofertilizers and biopesticides.

1. Khan, A., Luqman S., Masood N., Singh D.K., Saeed S.T., Samad A. 2016. *Ecliptayellow vein virus* enhances chlorophyll destruction, singlet oxygen production and alters endogenous redox status in *Andrographis paniculata*. Plant Physiology and Biochemistry **104**: 165-173.
2. Saeed S.T. and Samad A. 2016. First Detection of a Monopartite *Tomato leaf curl Patna virus* Infecting *Mentha piperita* in India. Plant Disease **100** (11): 2340.

Dr. C.S. Vivek Babu

Probiotic endophytes for cultivation of medicinal and aromatic plants, Bioprospection of Plant actives for multi-drug resistant (MDR) Gram negative bacteria and development of novel biorationals for crop protection.

1. Planta 2016. **243**(5):1097-114 (IF 3.376).
2. Scientific Reports 2016. **6**: 26583 (IF 5.578).

Dr. Mukti Nath Mishra

We are using synthetic biology approach to engineer the metabolic pathways of a non-photosynthetic carotenoid producing bacteria which can provide a system with high flux dispensable carotenoid pathway that can be exploited for synthesis of Artemisinin and other mono- or sesquiterpenes.

1. AK Rai, AP Dubey, S Kumar, D Datta, Mukti N. Mishra, BN Singh, AK Tripathi. 2016. Carotenoid biosynthetic pathways are regulated by a network of multiple cascades of alternative sigma factors in *Azospirillum brasilense* Sp7. Journal of Bacteriology, **198**: 2955-2964.
2. Mukti N Mishra, Vangara KK and Palakurthi S. 2014. Transcriptional targeting of human liver carboxylesterase (hCE1m6) and simultaneous expression of anti-BCRP shRNA enhances sensitivity of breast cancer cells to CPT-11. Anticancer Research. **34**:6345-51.

Dr Neelam Sangwan

I have accumulated extensive knowledge resource on basic science of Ashwagandha (*Withania somnifera*). I am engaged in understanding of withanolide/withanamide/alkaloid biosynthetic pathways through identifying genes/proteins, specific transcriptomes, role and cross talk of MVA/DOXP in the withanolide biosynthesis. Her group established efficient genetic transformation of ashwagandha as homologous expression system for establishing functional genomics aspects of the secondary metabolic pathways in ashwagandha. Her metabolic diversity findings have led to the development of novel, chemo-typically and pharmacologically defined varieties of Ashwagandha.

Electrical Fellow, Indian National Science Academy, INSA, New Delhi 2016; Elected Fellow, National Academy of Agricultural Sciences (NAAS), New Delhi 2009; CSIR-Technology Award-Life Sciences 2015; Women Leader in Crop Science. Visit Cambridge; University, U/C under Newton-Bhabha Programme 2016; Managing Editor, Plant Growth Regnlation (Springer) 2016

Ashok Sharma

Current research interests include bioinformatics and computational biology of medicinal and aromatic plants, molecular interaction studies of phytomolecules, metabolic pathway elucidation and networking analysis, analysis of regulatory elements, gene expression studies under abiotic stress response.

Bioinformatics Incentive award for publications by DBT-New Delhi to Sub-DIC CIMAP for the years 2014, 2015 and 2016.

1. Tripathi, Shubhandra, Gaurava Srivastava, and Ashok Sharma. 2016. "Molecular dynamics simulation and free energy landscape methods in probing L215H, L217R and L225M âI-tubulin mutations causing paclitaxel resistance in cancer cells." Biochemical and biophysical research communications **476**(4): 273-279
2. Kahlon, Amandeep Kaur, Arvind S. Negi, Ruma Kumari, Kishore K. Srivastava, Shiv Kumar, Mahendra P. Darokar, and Ashok Sharma. 2014. "Identification of 1-chloro-2-formyl indenes and tetralenes as novel antistaphylococcal agents exhibiting sortase A inhibition." Applied microbiology and biotechnology **98**(5): 2041-2051.

Dr. Ajit Kumar Shasany

Working on Aroma genomics and biology by identifying aroma related genes and pathways in Mentha species, Ocimum species, *Pelargonium graveolens*. Involved in plant improvement through genetic intervention.

1. Kumar R, Vashisth D, Misra A, Akhtar MQ, Jalil SU, Shanker K, Gupta MM, Rout PK, Gupta AK, and Shasany AK 2016. RNAi down-regulation of cinnamate-4-hydroxylase increases artemisinin biosynthesis in Artemisia annua. Scientific Reports. **25**(6): 26458.
2. Pal S., Yadav A.K., Singh A.K., Rastogi S., Gupta M.M., Verma R.K., Nagegowda D.A., Pal A., and Shasany A.K. 2016. Nitrogen treatment enhances sterols and withaferin A through transcriptional activation of jasmonate pathway, WRKY transcription factors and biosynthesis genes in *Withania somnifera* (L.) Duna. Protoplasma DOI: 10.1007/s00709-016-0959-x.

Dr. Vikrant Gupta

Present focus is on the studies on regulation of secondary metabolism in important medicinal plants specially *Artemisia annua* and *Catharanthus roseus*. Molecular studies on the development of glandular / non-glandular trichomes in plants. Structural genomics of selected medicinal and aromatic plants.

1. Singh A., Jindal S., Longchar B., Khan F. and Gupta V*. 2015. Overexpression of *Artemisia annua* sterol C-4 methyl oxidase gene, *AaSMO1*, enhances total sterols and improves tolerance to dehydration stress in tobacco. Plant Cell Tiss Organ Cult **121**: 167-181.
2. Prakash P., Ghosliya D., Gupta V*. 2015. Identification of conserved and novel microRNAs in *Catharanthus roseus* by deep sequencing and computational prediction of their potential targets. Gene **554**(2): 181-195.

Dr Archana Mathur

Tissue Banking for biodiversity management, In vitro secondary metabolites production, Cell culture elicitations and hydroponic cultivation

1. Biswas T., Mathur A.K. and Mathur A. 2017. A literature update elucidating production of *Panax* ginsenosides with a special focus on strategies enriching the anti-neoplastic minor ginsenosides in ginseng preparations. Appl Microbiol Biotechnol. **101**:4009–4032.
2. Biswas T., Kalra A., Mathur A.K., Lal R.K., Singh M. and Mathur A. 2016. Elicitors' influenced differential ginsenoside production and exudation into medium with concurrent Rg3/ Rh2 panaxadiol induction in *Panax quinquefolius* cell suspensions. Appl Microbiol Biotechnol. **100** (11): 4909-4922.

Dr. (Mrs.) Sunita Singh Dhawan

To understand the biosynthesis of secondary metabolites and development of genetically distinct promising genotypes in medicinal and aromatic plants. To unveil the regulatory hierarchy of secondary metabolism and to develop a rational approach for metabolic engineering of secondary metabolite production using genomic technologies, leading towards development of high yielder superior elite genotypes adaptable to various environmental stresses with enhanced tolerance.

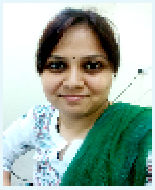
1. Mishra A., Lal R.K., Chanotiya C.S. and Dhawan S.S. 2016. Genetic elaborations of glandular and non-glandular trichomes in *Mentha arvensis* genotypes: assessing genotypic and phenotypic correlations along with gene expressions. Protoplasma; doi:10.1007/s00709-016-1011-x.
2. Singh S.K., Yadav D., Lal R.K., Gupta M.M. and Dhawan S.S. 2016. Inducing mutations through gamma-irradiation in seeds of *Mucuna pruriens* for developing high L-DOPA-yielding genotypes, International Journal of Radiation Biology, DOI: 10.1080/09553002.2016.1254832

Dr. Ajay Kumar Mathur

Metabolic pathway engineering, Somaclonal breeding, Cell fusions, Bioreactor up-scaling and Policy formualtion

1. Sharma A, Verma N, Verma P, Verma RK, Mathur A and Mathur AK 2017. Optimization of a *Bacopa monnieri*-based genetic transformation model for testing the expression efficiency of pathway gene constructs of medicinal crops. In Vitro Cell. Dev. Biol.—Plant **53**:22–32.
2. Prasad A, Prakash O, Mehrotra S, Khan F, Mathur AK and Mathur A. 2016. Artificial Neural Network-based model for the prediction of optimal growth and culture conditions for maximum biomass accumulation in multiple shoot cultures of *Centella asiatica*. Protoplasma **254**: 335-341.

Dr. Abha Meena



Area of interest is to understand the Ca^{2+} signalling pathways in Cancer and Cardiovascular diseases using cell lines and animal model. We are exploring the plant-derived molecules and their analogues to be used as the potential lead in such conditions. In addition toxicity analysis and *insilico*, drug-receptor interactions are subsidiary areas.

U.K. Common wealth overseas trust scholarship for pursuing Ph.D. (2010-2013) at university of Cambridge.

1. Meena A, Tovey SC, Taylor CW. 2015. Sustained signalling by PTH modulates IP_3 accumulation and IP_3 receptors through cyclic AMP junctions. J Cell Sci. **128**(2):408-20.
2. Thurley K, Tovey SC, Moenke G, Prince VL, Meena A, Thomas AP, Skupin A, Taylor CW, Falcke M. 2014. Reliable encoding of stimulus intensities within random sequences of intracellular Ca^{2+} spikes. Science Signalling. Jun **24**: 7(331).

Dr. Rakesh Kumar Shukla

To understand the transcriptional regulation of secondary metabolism in medicinal plants for human health benefits. To understand the structure and function relationship of AP2/ERF and WRKY transcription factors from medicinal plants under stress and other developmental conditions to improve the crop plants.

1. Mishra S, Phukan UJ, Tripathi V, Singh DK, Luqman S, Shukla RK 2015. PsAP2 an AP2/ERF family transcription factor from *Papaver somniferum* enhances abiotic and biotic stress tolerance in transgenic tobacco. Plant Mol Biol. **89**(1-2):173-86.
2. Upadhyay S, Phukan UJ, Mishra S, Shukla RK 2014. De novo leaf and root transcriptome analysis identified novel genes involved in steroidal sapogenin biosynthesis in *Asparagus racemosus*. BMC Genomics. **30**: 15:746.

Dr. Feroz khan

My research interest lies in the area of Bioinformatics and Cheminformatics (Pattern identification/matching, clustering, molecular modeling, structure-activity relationship, database & tool development). The goal is to explore complete understanding of how structures & functions are coded in sequences & how functions are regulated in a cell.

Long term Training in Foreign country Fellowship 2016-17, HRD, DHR, ICMR (Govt. of India) New Skagys School of Pharmacy & Pharamacentical Sciences, University of Calfornia San Diego (UCSD) La Jolla, San Diego 7-11-2016 to 6-11-2018 (12 months ongoing tenure on deputation).

1. Prakash O, Ahmad A, Tripathi VK, Tandon S, Pant AB, Khan F. 2014. In silico assay development for screening of tetracyclic triterpenoids as anticancer agents against human breast cancer cell line MCF7. PLoS One. **9**(11):e111049.
2. Yadav DK, Kalani K, Singh AK, Khan F, Srivastava SK, Pant AB. 2014. Design, synthesis and in vitro evaluation of 18â-glycyrrhetinic acid derivatives for anticancer activity against human breast cancer cell line MCF-7. Curr Med Chem. **21**(9): 1160-70.

Dr. Dinesh A. Nagegowda

Molecular plant biology and functional genomics for identification of pathway steps and regulators of plant specialized metabolism with an aim to improve the production of therapeutically and commercially important metabolites by metabolic engineering or synthetic biology approaches.

1. Singh AK, Dwivedi V, Rai A, Pal S, Reddy SEG, Rao DVC, Shasanv AK, and Nagcgowdd 2015. Venus induced gene iselenang of Withania Sommifera squalene synthase negativity regulates sterel and defence related genes resulting in reduced withanoldes and biotic stress tolerance. Plant Biotechnology Journal **13**(9): 1287-1299.
2. Rai A, Smita SS, Singh AK, Shanker Kand, Nagegaioda DA 2013. Heleromeric and homomeric general diphosphate synthase from catharanthus roseus and their role in monoterpene indofe alkaloid biosynthese. Molecular Plant **6**:1531-49, 2013 (IF – 6.6).

Dr. D.K. Venkata Rao

Development of yeast expression systems to produce high value plant terpenes. In this system, recombinant yeast cells engineered for the production of desirable terpenes in a relatively pure form. Also, interested in developing yeast-based models (such as luciferase-tagged or GFP-tagged specific genes) to screen phytochemicals to understand their medicinal importance.

1. Plant physiology **160**(2): 667, 2012 (IF 6.2).
2. Biochim Biophys Acta **1801**(4): 455, 2010 (IF 4.77). (Before joining)

Dr. Ashutosh K. Shukla

Prospecting genes in medicinal and aromatic plants towards better understanding of secondary metabolic pathways with a focus on alkaloid biosynthesis. Molecular studies for characterization of contrasting organs and / or genotypes of alkaloid-producing plant species like *Catharanthus roseus* and *Papaver somniferum*. Use of transcriptomic approach for exploring the molecular basis for *dosha*-balancing property-based classification of plants in *Ayurveda*: Validation of traditional knowledge using modern molecular biology tools. DNA fingerprinting of important medicinal and aromatic plant species.

Indo-US Research Fellowship 2012 (Sept 12-Sept 2013) by (IUSSTF) of USA and DST of India. At the Donald Danforth Plant Science Centre, St Louis Missouri, USA.

1. Shukla A.K., Shasany A.K., Gupta M.M., Khanuja S.P.S. 2006. Transcriptome analysis in *Catharanthus roseus* leaves and roots for comparative terpenoid indole alkaloid profiles. Journal of Experimental Botany **57**: 3921-3932.
2. Augustin M.M., Ruzicka D.R., Shukla A.K., Augustin J.M., Starks C.M., Mark O'Neil-Johnson, M.R. McKain, B.S. Evans, Barrett M.D., Smithson Ann, Gane Ka-Shu Wong, Michael K. Deyholos, Patrick P. Edger, J. Chris Pires, James H. Leebens-Mack, David A. Mann, Toni M. Kutchan, 2015. Elucidating steroid alkaloid biosynthesis in *Veratrum californicum*: production of verazine in Sf9 cells. The Plant Journal **82**: 991-1003.

Dr. Pradipto Mukhopadhyay

My research area is related to physiology and molecular biology of medicinal and aromatic plants (MAPs). Presently, the focus of my lab is towards the assessing the effect of various physiological factors and developmental stages on the abundances active metabolites in MAPs.

Dr. Prema G. Vasudev

X-ray crystallography based structural biology of plant proteins, peptide conformational analysis, plant peptidomics. My research focuses on the crystallization and structure determination of important enzymes involved in the plant secondary metabolite pathways, structural and functional characterization of biologically active plant peptides. Conformational tuning of peptides using unusual amino acids so as to direct molecular assemblies facilitating the design of functional peptide materials is another current research endeavour.

Dr. Sumit Ghosh

I am investigating the biosynthetic pathway components that determine spatio-temporal accumulation of medicinally important specialized metabolites in plants that are widely exploited in traditional medicine. My current research includes understanding the biosynthesis and spatio-temporal accumulation of pentacyclic triterpenes and labdane-related diterpenes in medicinal plants.

INSA-Deutsche Forschungsgemeinschoft (DGF) Biolateral Exchange Programme in 2017. Young Scientist-Award. CSIR. 2015. INSA Medal for Young Scientist 2015. Innovative Young Biotechnologist Award (IYBA 2014) of DBT; Young Scientist Platinum Jubilee Award 2014 from the NSSP.

1. RC Misra, S Sharma, Sandeep, Garg A, Chanotiya CS and Ghosh S 2017. Two CYP716A subfamily cytochrome P450 monooxygenases of sweet basil play similar but nonredundant roles in ursane- and oleanane-type pentacyclic triterpene biosynthesis. New Phytologist, doi: 10.1111/nph.14412.
2. Misra RC, Maiti P, Chanotiya CS, Shanker K and Ghosh S 2014. Methyl jasmonate-elicited transcriptional responses and pentacyclic triterpene biosynthesis in sweet basil. Plant Physiology, **164**:1028-1044.

Dr. S Luqman

Research in my laboratory is focused on molecular and cell target based discovery of biologically active compounds/molecules for their cancer chemopreventive and/or chemotherapeutic activity using *in vitro*, *in vivo* and *in silico* approaches. Role of ion channels in metabolic disorder, microbial infections and pain are ancillary and exploratory area of our interest.

DHR Long Term Fellowship in Foregin Institute from Ministry of Health and Welfare, Govt. of India for pursuing advance training at King's College London, United Kingdom (2016-2017).

1. Dubey V, Luqman S. 2017. Cathepsin D as a promising target for the discovery of novel anticancer agents. Current Cancer Drug Targets; **17** (1): 1-19.
2. Masood N, Luqman S. 2014. A method for measuring difference in activity of phenolic and non- phenolic groups through 2,2‘ azino-bis-(3-ethyl-benzothiazoline-6- sulphonate) radical cation. Combinatorial Chemistry & High Throughput Screening; **17**(8): 718-22.

Dr. Mahendra P. Darokar

The focus of current research activities are in the area of infectious diseases for identifying plant derived bioactive products having therapeutic potential in combination for combating multidrug resistant infections caused by human pathogenic bacteria *Escherichia coli* and *Staphylococcus aureus* including MRSA/VISA/VRSA using holistic approach covering traditional wisdom to modern scientific knowledge base for the activity assaying through *in vitro*, *in vivo* bioassays and target based bioevaluation through modern biology tools.

1. Singh V., Pal A. and Darokar M.P. 2015. A polyphenolic flavonoid Glabridin: oxidative stress response in multidrug resistant *Staphylococcus aureus*. Free Rad Bio Med. **87**: 48-57.
2. Dwivedi G.R., Tiwari N., Singh A., Kumar A., Roy S., Negi A.S., Pal A., Chanda D., Sharma A., and Darokar M.P. 2016. Gallic acid based indanone derivative interacts synergistically with tetracycline by inhibiting efflux pump in multidrug resistant *E. coli*. Appl Microbiol Biotechnol **100**(5): 2311-2325.

Dr. Anirban Pal

The clinical emergence of co-infection of *Plasmodium* and *Salmonella* has provoked my inquisitiveness to develop mice model harbouring malaria and typhoid. My expérience of standardizing infectious models for drug discovery and modulation of innate immune mechanisms by plant bioactives is driving me towards prospecting medicinal plants towards the disease condition.

1. Gupta VK, Tiwari N, Gupta P, Verma S, Pal A, Srivastava SK, Darokar MP. 2016. A clerodane diterpene from Polyalthia longifolia as a modifying agent of the resistance of methicillin resistant *Staphylococcus aureus*. Phytomedicine **23**(6): 654-661.
2. Tiwari N, Gupta VK, Pandey P, Patel DK, Banerjee S, Darokar MP, Pal A. 2017. Adjuvant effect of Asparagus racemosus Willd. derived saponins in antibody production, allergic response and pro-inflammatory cytokine modulation. Biomedicine & Pharmacotherapy **86**: 555-561.

Dr. D. Saikia

Exploration for novel antitubercular bioactive entity from indigenous medicinal and aromatic plants , or their semi-synthetic derivatives. Safety Assessment of bioactive molecules or formulations for their mutagenic, genotoxic, etc. potential.

1. Tiwari N., Thakur J.P., Saikia D. and Gupta M.M. 2013. Antitubercular diterpenoids from Vitex trifolia. Phytomedicine, **20**: 605– 610.
2. Saikia D., Parveen S., Gupta V.K. and Luqman S. 2012. Antituberculosis activity of Indian Khus grass (Vetiveria zizanioides L. Nash) Complementary Therapies in Medicine **20**(6): 434-436.

Dr. Debabrata Chanda

We use ex-vivo, in-vivo and in-vitro models to study the potential of medicinal plant derived leads for cardiovascular potential. We explore the role of intracellular second messenger molecules like cGMP, cAMP, Ca^{++}, modulation of protein kinases like PKA, PKG, PKC, tyrosine kinase, calmoduline kinases etc. as well as contribution of EDRF, EDHF, potassium channels and calcium channels etc. to study the mode of action. The identified potent bioactives are then evaluated for efficacy for anti-hypertensive activity, vascular hyporeactivity etc. in experimental animal models.

Attended Post doctoral training at School fo Medicine, King's College, London from 21.9.12 to 14.9.2013 sponsured by DBT-CREST fellowship 2011-2012.

1. Chanda D., Prieto-Lloret J., Singh A., Iqbal H., Yadav P., Snetkov V., Aaronson P.I. 2016. Glabridin-induced vasorelaxation: Evidence for a role of BKCa channels and cyclic GMP. Life Sci., **165**: 26–34. doi: 10.1016/j.lfs.2016.09.018.
2. Singh A, Kumar BS, Alam S, Iqbal H, Shafiq M, Khan F, Negi AS, Hanif K, Chanda D. 2017. Diethyl-4,4'-dihydroxy-8,3'-neolign-7,7'-dien-9,9'-dionate exhibits antihypertensive activity in rats through increase in intracellular cGMP level and blockade of calcium channels. Eur J Pharmacol. **15**: 799:84-93. doi: 10.1016/j.ejphar.2017.01.044.

Dr. Dnyaneshwar Umrao Bawankule

My laboratory focus is on *in-vitro* (Mammalian cell culture) and *in-vivo* (Small Animal Model) bioassays with special emphasis on inflammatory pathway involved in metabolic and infectious diseases in the area of experimental pharmacology with the objectives, Molecular Mechanism(s) of action of potential plant-derived leads and Scientific validation of Traditional System of Medicine of plant origin.

1. Singh M, Hamid AA, Maurya AK, Prakash O, Khan F, Kumar A, Aiyelaagbe OO, Negi AS, Bawankule DU. 2014. Synthesis of diosgenin analogues as potential anti-inflammatory agents. Journal of Steroid Biochemistry and Molecular Biology. **143**C:323-333
2. Bawankule DU, Trivedi P, Pal A, Shanker K, Singh M, Sharma P, Khan F, Maurya AK, Verma RK, Gupta MM. 2014. Protective Mechanism of Lignans From Phyllanthus Amarus Against Galactosamine/ Lipopolysaccharide-Induced Hepatitis: An *In-Vivo* And *In-Silico* Studies. Current Topic in Medicinal Chemistry. **14**(8):1045-1055

Dr. N.P. Yadav

Dr. N. P. Yadav is a Senior Scientist in CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow (U.P.) India. He has done Ph. D. in Pharmaceutical Sciences and Post Doc in Drug Delivery/Nanomedicine from Northeastern University, Boston MA (USA). He is working in the area of Phytopharmacology and Herbal formulation development from last 15 years and developed some herbal formulations which have been licensed to Industry. His current areas of research are diabetes, psoriasis, hepatoprotection and skin hygiene.

HRD international fellowship for one year awarded by Department of Health Research, New Delhi. During 2015-16 deputed at North eastern university Boston (USA) in area of Drug Delivery/Nano Medicine.

Dr. Daya N. Mani

Reverse pharmacology using modern drug development method. Herbal nutraceuticals (formulations and supplements for disease prevention). Standardization and scientific validation of classical formulations.

1. Mishra P., Kkumar A., Nagireddy A., Mani D.N., Shukla A.K., Rrakesh T., Sundresan V. 2016. DNA barcoding : an efficient tool to overcome authentication challenges in the herbal market. Plant, Biotecnology Journal. **14**: 8-21
2. Chanda D, Shanker K, Pal A, Luqman S, Bawankule DU, Mani D, Darokar MP. 2009. Safety evaluation of *Trikatu*, a generic Ayurvedic medicine in Charles Foster rats. J. Toxicological Sci. **34**(1):99-108.

Er. Bhaskar Shukla

Area of Interest

- Enterprise Resource Planning (onecsir)
- Software Design Patterns
- Software Matrix
- Database management system (DBMS)
- Web Application Development

Er. Manoj Semwal

Working on the use of remote sensing and information technologies for acreage estimation, crop advisory and documentation of medicinal and aromatic crops in India. Developed extensive knowledge resource on use of advanced RS-GIS technologies coupled with crop modelling on climate change studies for MAPs.

1. Pankaj U., Verma S., Semwal M. and Verma R. 2016. Assessment of natural mycorrhizal colonization and soil fertility status of lemongrass [(Cymbopogon flexuosus, Nees ex Steud) W. Watson] crop in subtropical India. Journal of Applied Research on Medicinal and Aromatic Plants. DOI: 10.1016/j.jarmap.
2. Shukla, V., Patel DK., Bajpai, R., Semwal M., and Upreti, D. K. 2015. Ecological implication of variation in the secondary metabolites in Parmelioid lichens with respect to altitude. Environmental Science and Pollution Research **23**(2): DOI: 10.1007/s11356-015-5311-z

Dr. V. Sundaresan

Multi dynamic approach on MAPs starting from wild exploration to bio or chemo prospection, conservation, genetic improvement and development of specific markers, DNA Barcodes for taxonomical as well as drug authentication.

1. Mishra P., Kumar A., Nagireddy A., Mani D.N., Shukla A.K., Tiwari R., Sunderesan V. 2015. DNA barcoding : an efficient tool to over come authentication challenges in herbal market. Plant Biotechnology Journal DOI: 10.1111/pbi.12419.
2. Kumar A., Mishra P. Baskaran K., Shukla A.K., Shasany A.K. and Sunderesan V. 2016. Higher efficiency of ISSR maskers over plashid psba-tonH region in resolving taxonomical status of Ocimum L. Ecology and Evolution **6**: 7671-7682.

Dr. Narendra Kumar

Pharmacongostic evaluation of important medicinal and aromatic plants and developed markers for identification of crude drugs. Pharmacopoeial standards development of important crude drugs.Taxonomic and molecular characterization of important medicinal and aromatic plants and maintenance and strengthen of genetic resource pool of rare, endemic, threatened (RET) and commercially important medicinal and aromatic plants.

Rakesh Tiwari

Knowledge Management; Information packaging / repackaging; Research planning, project and IT management; Digitization of traditional medicinal knowledge of Indian System of Medicine (Ayurveda, Unani, Siddha, Sowa-rig-Pa, oral TK, panchmarmas, ancient manuscripts, etc.); international collaborations and agreements

1. Tiwari Rakesh. 2009. The trade in commercially important Cymbopogon oils, in Essential Oil Bearing Grasses: Genus Cymbopogon (series on Medicinal and Aromatic Plants – Industrial Profiles), CRC Press, Taylor and Francis Group, London, pp. 151-165.
2. Mishra P, Kumar A, Nagireddy A, Mani DN, Shukla AK, Tiwari Rakesh, Sundaresan V. 2016. DNA barcoding: an efficient tool to overcome authentication challenges in the herbal market. Plant Biotechnol J. **14**: 8-21. (IF 6.09)

Dr. Laiqur Rahman

Working in the area of genetic manipulations for production of plants with desirable characters. Presently involved in rerouting of phenyl propanoid pathway for production of vanillin from Ocimum sps, transgenic production of Tagetes erecta with High pyrethrin content an biotic and abiotic resistant plants of geranium by transferring bacterial gene.Recently elected as a Member of the Plant Tissue Culture Association in the 37th Annual General Meeting held at CSIR-NBRI,Lucknow.

1. Sana Khan, Swati Upadhyay, Feroz Khan, Sudeep Tandon, Rakesh Kumar Shukla, Sumit Ghosh, Vikrant Gupta, Suchitra Banerjee and Laiq ur Rahman. 2017. Comparative transcriptome analysis reveals candidate genes for the biosynthesis of natural insecticide in *Tanacetum cinerariifolium* BMC Genomics **18**: 54 DOI 10.1186/s12864-016-3409-4
2. Sana Khana, Shiv Shanker Pandey, Jyotshnac, Karuna Shanker, Feroz Khan and Laiq ur Rahman. 2017. Cloning and functional characterization of quinolinic acid phosphoribosyl transferase (QPT) gene of *Nicotiana tabacum* Physiologia Plantarum doi: 10.1111/ppl.12559.

Dr. Preeti Srivastava

Genetic enhancement of Vetiver through population improvement using plant breeding approaches.

Cytological analysis of some economically important MAPs.

Project and Intellectual Property Management of CSIR-CIMAP.

Glimpses from the history

Central Indian Medicinal Plants Organisation (CIMPO) (which was later renamed as Central Institute of Medicinal and Aromatic Plants – CIMAP) was established with following objectives*:

'To co-ordinate and channelise 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 plant 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 principle content.'

***Scope and Functions**

- To pursue developmental, promotional and related work on cultivation, production, processing, utilisation and marketing of medicinal and aromatic plants with specific reference to their practical application and utility
- To cultivate medicinal and aromatic plants, either in its own farms or through other agencies, and to process wherever necessary, the plant materials for obtaining their end products
- To carry out, in collaboration with other agencies, introduction, acclimatization (including measures for prevention and control of pests and diseases) of exotic-species and also production of authentic high-yielding seeds, leaves and other propagating materials of medicinal and aromatic plants of economic importance
- To encourage cultivation of medicinal and aromatic plants in suitable regions of the country by giving grants-in-aid or loans and other incentives, wherever necessary
- To carry out surveys of resources of medicinal and aromatic plants and to maintain economic statistics of the raw materials as well as the finished products
- To set up and maintain a specialized herbarium and museum of medicinal and aromatic plants of economic importance as well as of products derived therefrom
- To undertake research and to encourage the same in established research institutions, e.g. university laboratories, technological institutions, national laboratories, etc. for schemes relating to improvement, processing and utilization of medicinal and aromatic plants
- To act as a 'clearing house' for collecting techno-economic data relating to medicinal and aromatic plants and products derived therefrom, by scientific ledgering and documentation and to disseminate information through publications of monographs, brochures, books and all other effective means.

*cited from the 1977 brochure of the Central Indian Medicinal Plants Organisation (CIMPO)

CSIR-CIMAP

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