Annual Report 2015-2016 CSIR-CIMAP

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Annual Report

2015-2016




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

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Annual Report
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CSIR-Central Institute of Medicinal and Aromatic Plants

(Council of Scientific and Industrial Research)

Lucknow | Bengaluru | Hyderabad | Pantnagar | Purara

Contents

निदेशक का संदेश

वर्ष 2015-16 का वार्षिक प्रतिवेदन प्रस्तुत करते हुए मुझे अत्यंत प्रसन्नता का अनुभव हो रहा है । क्योंकि इस दौरान सभी वैज्ञानिकों, तकनीकी अधिकारियों, शोधार्थियों, परियोजना सहायकों और दूसरे कर्मचारियों के समर्पित कार्य के फलस्वरूप सीएसआईआर-सीमैप विशेष योग्यता, उत्तम प्रदर्शन, प्रभाव और पहचान के साथ आगे बढ़ा है। जहां एक ओर अश्वगंधा के क्षेत्र में उत्कृष्ट कार्य हेतु सीमैप को एनबीआरआई, सीडीआरआई और आईआईसीबी, के साथ संयुक्त रूप से जीव विज्ञान के क्षेत्र में सीएसआईआर प्रौद्योगिकी पुरस्कार प्राप्त हुआ, वहीं दूसरी ओर किसानों की आय में बढ़ोत्तरी के लिए खस पर आधारित तकनीकी हस्तक्षेप हेतु सीएसआईआर ग्रामीण विकास पुरस्कार-2014 के लिए सीएसआईआर-सीमैप को चुना गया। पारम्परिक चिकित्सा पद्धति में अत्यन्त महत्वपूर्ण मानी जाने वाली पूजा तुलसी के सम्पूर्ण जीनोम सीक्वेंस का प्रकाशन सीएसआईआर-सीमैप की शोध यात्रा में एक महत्वपूर्ण मील का पत्थर रहा है। भारतवर्ष से प्रथम औषधीय पौधे का सम्पूर्ण जीनोम सीक्वेंस कर सीएसआईआर-सीमैप ने अपनी वैज्ञानिक क्षमता का परिचय दिया है। इस वर्ष हमने किसानों और उद्योगों की सेवा में ऑसिमम बेसिलकम (तुलसी), मुकुना प्रूरियन्स (केंवांच), एसपरेगस रेसीमोसस (सतावर), सेंटेला एसियाटिका (मंडूकपर्णी), विदानिया सोम्नीफेरा (अश्वगंधा), आर्टिमिसिया एनुआ (आर्टिमिसिया), सिम्बोपोगॉन फ्लेक्सिओसस (नीबूघास), साल्विया स्क्लैरिया (क्लेरीसेज) तथा वेटीवेरिया जिजैनिवाइडिस (वेटीवर) की 9 नई किस्में जारी की हैं।

मार्च 2015 में औषधीय पौधों पर अन्तर्राष्ट्रीय संगोष्ठी तथा इंडियन ओशन रिम एसोसिएशन देशों के औषधीय पौधों के फोकल प्वांइट्स की द्वितीय बैठक सफलतापूर्वक आयोजित कर सीएसआईआर-सीमैप औषधीय पौधों के क्षेत्र में एक ग्लोबल लीडर के रूप में उभरा है। सीएसआईआर-सीमैप ने छोटे किसानों के लिए औषधीय और सगंधीय फसलों की खेती के समायोजन और गुण श्रंखला के प्रबन्धन पर राष्ट्रीय कृषि विज्ञान अकादमी के अंतर्गत चर्चा सत्र का आयोजन करके इस क्षेत्र के लिए नीति निर्धारण में अपनी भूमिका अदा की है।

जापान, अमेरिका, जर्मनी, ईरान, टर्की और दूसरे देशों सहित कई उद्योगों के प्रतिनिधियों ने सीएसआईआर-सीमैप आकर यहां चल रहे अनुसंधानों के बारे में जानकारी प्राप्त की और परस्पर अनुसंधान तथा विकसित प्रौद्योगिकियों और उत्पादों में अपनी रूचि भी दर्शायी । फलस्वरूप, मेंथा की खेती की लागत में कमी लाने के लिए भारतीय मेन्था इंडस्ट्री द्वारा मेंथा की नई प्रजाति और अगैती मिन्ट टेक्नालॉजी के प्रचार के लिए जागरूकता कार्यक्रम आयोजित किये गये। कई प्रौद्योगिकियों जैसे कि आर्टीमिसिनिन निष्कर्षण, मधुमेह रोधी फार्मुलेशन (सीमैप व एनबीआरआई द्वारा संयुक्त रूप से विकसित), दर्द निवारक तेल (रिलैक्सोमैप) बनाने की विधि, इत्यादि को उद्योगों को हस्तान्तरित किया गया। विभिन्न हर्बल प्रोडक्ट्स के बड़े स्तर पर निर्माण के लिए सीएसआईआर-सीमैप द्वारा पायलट प्लांट की स्थापना की गयी ताकि समाज में उनकी उपलब्धता में सुधार लाया जा सके । यह सुविधा स्टार्टअप्स के लिए भी मददगार सिद्ध होगी।

ग्रामीण विकास कार्यक्रम के अन्तर्गत उत्तर प्रदेश के अतिरिक्त जम्मू और कश्मीर, उत्तराखण्ड, बिहार, गुजरात, महाराष्ट्र, तमिलनाडु, कर्नाटक, आंध्र प्रदेश, मिजोरम, मेघालय इत्यादि के किसानों, आदिवासियों तथा उद्यमियों में उन्नत कृषि प्रौद्योगिकी और उन्नत किस्मों के व्यापक प्रचार के लिए प्रशिक्षण कार्यक्रम तथा खेतों पर प्रदर्शन आयोजित किये गये। महिला सशक्तीकरण की दिशा में महिलाओं को स्वरोजगार की ओर प्रेरित करने के लिए फूलों से अगरबत्ती निर्माण पर प्रशिक्षण कार्यक्रम आयोजित किये गये।

सीएसआईआर-सीमैप द्वारा लखनऊ और पंतनगर में आयोजित किसान मेले बड़ी संख्या में किसानों और उद्यमियों के उत्साहजनक भागीदारी के गवाह बने, जहाँ पधार कर उन्होंने उन्नत प्रजातियों और कृषि प्रौद्योगिकियों में अपनी रूचि दिखायी और पौध सामग्री खरीदी। नई मेन्थाल मिन्ट की किस्म ''सिम-क्रान्ति'' किसानों में अत्यधिक लोकप्रिय रही।

मैं इस अवसर पर सभी वैज्ञानिकों, तकनीकी व गैर-तकनीकी तथा सहायक कर्मचारियों और शोधार्थियों को संस्थान की शोध एवं विकास की गतिविधियों को आगे बढ़ाने हेतु किये गये योगदान की सराहना करता हूँ और हृदय से धन्यवाद देता हूँ । साथ ही, मैं अपने समस्त श्रेष्ठ एवं वरिष्ठ जनों का भी उनकी निरन्तर शुभकामनाओं, सहयोग व मार्गदर्शन के लिए आभार व्यक्त करता हूँ।

अनिल कुमार त्रिपाठी

Director's Message

I feel great pleasure in presenting the Annual Report for 2015-16, during which CSIR-CIMAP marched ahead with distinction, better visibility, impact and recognitions due to the dedicated work of its scientists, technical officers, research students, project assistants and other employees. While CSIR-CIMAP was conferred with CSIR Technology Award-2015 in Life Sciences, in association with teams at CSIR-NBRI, CSIR-CDRI and CSIR-IICB, for the outstanding work done in the field of Ashwagandha (*Withania somnifera*), CSIR-CIMAP was also selected for the prestigious CSIR Award for S&T Innovation for Rural Development (CAIRD)-2014 for enhancing incomes of farm communities through Vetiver (Khus) based technological interventions. One major milestone in the strides of CSIR-CIMAP towards excellence in research was the publication of whole genome sequence of Holy basil, a plant of high importance for traditional systems of Indian medicine. Thus CSIR-CIMAP has proven its scientific capability by sequencing the whole genome of the first medicinal plant from India. This year we have released 9 new varieties of *Ocimum basilicum, Mucuna pruriens, Asparagus recemosus, Centella asiatica, Withania somnifera, Artemisia annua, Cymbopogon flexuosus, Salvia sclarea and Vetiveria zizanioides* in the service of farmers and industry.

By successfully organizing International Conference on Medicinal Plants, and Second meeting of Medicinal Plants focal points of Indian Ocean Rim Association countries in March 2015, CSIR-CIMAP has emerged as a global leader in the area of medicinal plants. CSIR-CIMAP also coordinated organization of a Brain Storming Session on Integration of Medicinal and Aromatic Crop Cultivation and Value Chain Management for Small Farmers. Representatives from industries including those from Japan, USA, Germany, Iran, Turkey and other countries visited CSIR-CIMAP to apprise themselves about the research work being done here. As a result, Indian mentha industry organized farmer awareness programs to popularize our new mint variety and "Early Mint Technology" to reduce the cost of mint cultivation. Several technologies such as extraction of Artemisinin, anti-diabetic formulation (developed jointly by CIMAP & NBRI), pain relieving oil (Relaxomap), etc. were transferred to industries. A pilot-plant facility was established for manufacturing various herbal products on large scale to improve their availability to the society. The facility will also be helpful to the start-ups.

Under our rural development programme, improved agro-technologies and plant varieties were popularised among the farmers, tribals and entrepreneurs through training programmes and crop demonstrations on farmers' fields in Jammu & Kashmir, Uttarakhand, Bihar, Gujarat, Maharashtra, Tamil Nadu, Karnataka, Andhra Pradesh, Mizoram, Meghalaya etc. besides Uttar Pradesh. Towards women empowerment, training programmes were organized for women on making of incense sticks using floral bio-resource to promote self-employment amongst them. The farmers' fairs (Kisan Mela) organised by CSIR-CIMAP at Lucknow and Pantnagar witnessed very enthusiastic participation of farmers and entrepreneurs in large numbers who showed their interest in our improved varieties and agro-technologies and purchased the planting material. The new menthol mint variety "CIM-Kranti" was a big hit among farmers this year.

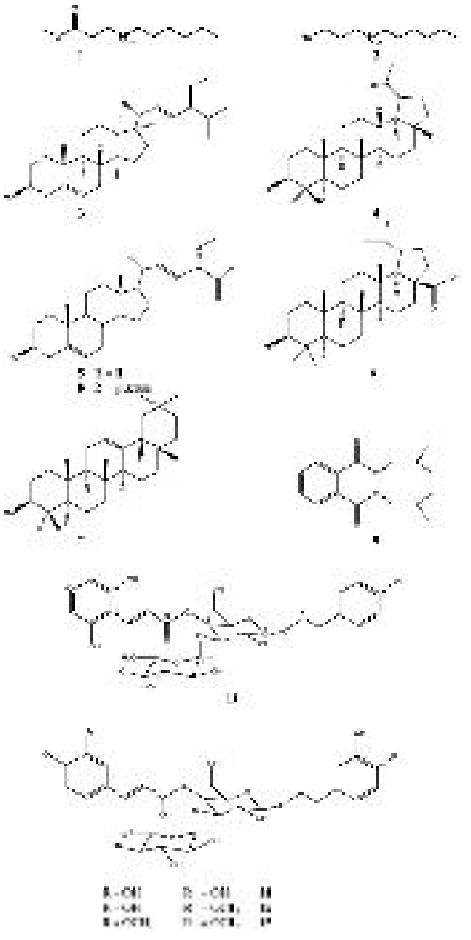
On this occasion, I convey my sincere appreciation and thanks to all the scientific, technical, non-technical, supporting staff and research scholars for taking the R&D activities of the institute forward. I also express my gratitude to all our peers and seniors for their continued good wishes, support and guidance in our endeavours.

Anil Kumar Tripathi

Project: Phytochemical exploration and value addition in bioactive molecules from MAPs

Bioactive chemical constituents from the root of *Clerodendrum phlomidis*

Hexane and ethyl acetate extracts of *Clerodendrum phlomidis* roots show anti-tubercular activity. Bioguided fractionation of active extracts led to the isolation of a new phenylethanoid glycoside, β-(4-hydroxyphenyl)-ethyl-*O*-α-L-rhamnopyranosyl(1 → 3)-β-D-(4-*O*-22,62 dihydroxy-cinnamoyl)-glucopyranoside (phlomidoside, **10**) along with 12 known compounds. The structures of the isolated compounds were elucidated on the basis of detailed spectroscopic analysis (NMR, Mass and IR). All the compounds except **2**, **4**, and **8** have been isolated for the first time from *C. phlomidis*. Anti-tubercular activity of extracts and isolated compounds was determined by BACTEC radiometric susceptibility assay against *Mycobacterium tuberculosis* H37Rv (ATCC 27294). In addition, isolated compounds were also evaluated for their effect on lipopolysaccharide-stimulated macrophages for production of pro-inflammatory cytokines, tumor necrosis factor-α and interleukin-6. This is the first report on the anti-tubercular potential of *C. phlomidis*, indicating the underlying mechanism involved in the therapeutic application of a traditionally used plant.

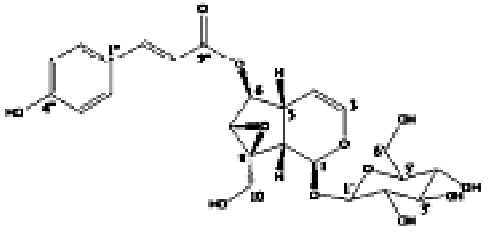


Chemical structures of compounds (1–13) isolated from *Clerodendrum phlomidis* roots

Medicinal Chemistry Research 24:1112-1118, 2015; Input: MM Gupta, Dharmendra Saikia, Anirban Pal

Specioside (6-O-coumaroylcatalpol) an iridoid glucoside isolated from the patala (*Stereospermum suaveolens*) ameliorates oxidative stress and promotes longevity in *Caenorhabditis elegans*

Specioside (6-O-coumaroyl-catalpol) is an iridoid glucoside which possesses multifunctional activities viz. analgesic, anti-dyspeptic, astringent, liver stimulating and wound healing properties. The present study for the first time delineates stress alleviating and lifespan prolonging action of specioside (SPC), isolated from *Stereospermum suaveolens* in the free



Chemical structure of specioside (6-O-coumaroylcatalpol)

living, multicellular nematode model *Caenorhabditis elegans*. A strong correlation between lifespan extension and stress modulation in adult worms was established in a dose dependent manner. The dietary intake of this phytomolecule elevated juglone induced oxidative and heat induced thermal stress tolerance in *C. elegans*. On evaluation, it was found that 25 µM dose of SPC significantly extended lifespan by 15.47% (P d" 0.0001) with reduction in stress level. Furthermore, SPC enhanced mean survival in mev-1 mutant suggesting its oxidative stress reducing potential. SPC also augmented stress modulatory enzymes superoxide dismutase (SOD) and catalase (CAT) level in *C. elegans*. Altogether, these findings broaden current perspectives concerning stress alleviating potentials of SPC and have implications in development of therapeutics for curing age related disorders.

Comparative Biochemistry and Physiology, Part C 169:25–34, 2015; Input: MM Gupta, Rakesh Pandey

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. Extracts prepared from dried leaves of *A. nepalensis* using standard solvents were tested against LPS-induced inflammation in macrophages. Among all, butanol extract (*ANB*) has shown most significant inhibition of pro-inflammatory cytokines without any cytotoxicity. HPLC analysis of *ANB* showed the presence of diarylheptanoids. The diarylheptanoids were further isolated and tested *in vitro* for anti-inflammatory activity. Treatment of isolated diarylheptanoids (*HOG*, *ORE* and *PLS*) was able to reduce the production and mRNA level of pro-inflammatory cytokines (TNF-α and IL-6). Furthermore, we demonstrated that it inhibited the expression of NF-kB protein in LPS-induced inflammation in macrophages. *In vivo* efficacy and safety profile of *ANB* revealed that oral treatment of *ANB* was able to improve the survival rate, and inhibited the production of pro-inflammatory cytokines in serum, attenuated vital organ injury in a dose dependent manner without any toxic effect at higher dose in mice. The results suggest that diarylheptanoids from *A. nepalensis* can be considered as potential therapeutic candidates for the management of inflammation related diseases.

Int. Immunopharmacology, 30: 129–136; Input: MM Gupta, DU Bawankule

Ocimum basilicum and *Premna integrifolia* modulate stress response and lifespan in *Caenorhabditis elegans*

The ever increasing popularity of herbal supplements modulating aging has shifted focus towards development of natural therapeutics for curing age related afflictions in living organisms. The progression in age is correlated with elevation in oxidative stress. The increment in oxidative stress ultimately affects human health, which led to search for new stress alleviating compounds, but very few bioactive molecules are available presently. To this end, the effect of three aqueous extract viz., *Ocimum basilicum* (OCW), *Premna integrifolia* (PSW) and mixture of both herbs (OPW) on *Caenorhabditis elegans* was evaluated. The present study delineates effect of OPW, PSW and OCW on lifespan using survival and stress assays. The maximal lifespan extension was observed in OPW (50 µg/ml) 32% ($P < 0.0001$) followed by 27.9% ($P < 0.0001$) in PSW (50 µg/ml) and 18.39% ($P < 0.0001$) in OCW (50 µg/ml). Furthermore, all the three extracts were able to modulate both the oxidative as well as thermal stress. Altogether, OPW mediates maximal lifespan extension in the worm which can be attributed to modulation of stress level to a greater extent. These results may provide insights for designing evidence-based herbal therapy in future.

Ind. Crops Prod, 76: 1086–1093, 2015;
Input: MM Gupta, Rakesh Pandey

Acacetin 7-O-α-l-rhamnopyranosyl (1–2) β-D-xylopyranoside elicits life-span extension and stress resistance in *Caenorhabditis elegans*

A novel phytomolecule acacetin 7-O-α-L-rhamnopyranosyl (1–2) β-D-xylopyranoside (ARX) from *Premna integrifolia* has been isolated and evaluated for its anti-aging effects in *Caenorhabditis elegans*. The spectral data analysis revealed the occurrence of a new compound ARX. Out of the three tested pharmacological doses of ARX, viz. 5, 25, and 50 µM, the 25-µM dose was able to extend life span in *C. elegans* by more than 39%. The present study suggests that ARX affects bacterial metabolism, which in turn leads to dietary restriction (DR)-like effects in the worms. The effect of ARX on worms with mutations (*mev-1*, *eat-2*, *sir-2.1*, *skn-1*, *daf-16*, and *hsf-1*) indicates that ARX-mediated life-span extension involves mechanisms associated with DR and maintenance of cellular redox homeostasis. This study is the first report on longevity-promoting activity of ARX in *C. elegans* mediated by stress and DR-regulating genes. This novel phytomolecule can contribute in designing therapeutics for managing aging and age-related diseases.

J Gerontol A Biol Sci Med Sci doi: 10.1093/gerona/glv173, 2015
Input: MM Gupta, Rakesh Pandey

Verminoside mediates life span extension and alleviates stress in *Caenorhabditis elegans*

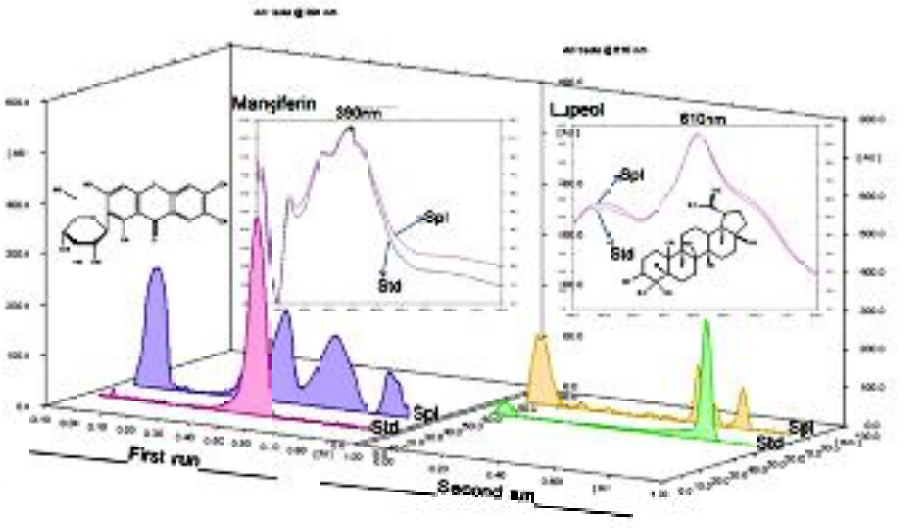
The discovery of bioactive molecules modulating aging in living organism promotes development of natural therapeutics for curing age-related afflictions. The progression in age-related disorders can be attributed to increment in intracellular reactive oxygen species (ROS) and oxidative

stress level. An iridoid verminoside (VMS) from *Stereospermum suaveolens* was isolated and evaluated for its effect on *Caenorhabditis elegans*. The present study delineates VMS-mediated alteration of intracellular ROS, oxidative stress, and life span in *C. elegans*. The different tested doses of VMS (5 µM, 25 µM, and 50 µM) were able to enhance ROS scavenging and extend mean life span in *C. elegans*. The maximal life span extension was observed in 25 µM VMS, that is, 20.79% ($P < 0.0001$) followed by 9.84% ($P < 0.0001$) in 5 µM VMS and 8.54% ($P < 0.0001$) in 50 µM VMS. VMS was able to alleviate juglone-induced oxidative stress and enhanced thermo tolerance in worms. The stress-modulating and ROS-scavenging potential of VMS was validated by increment in mean survival by 29.54% ($P < 0.0001$) in VMS-treated oxidative stress hypersensitive *mev*-1 mutant strain. Furthermore, VMS modulates expression of DAF-16 (a FoxO transcription factor) promoting stress resistance and longevity. Altogether, our results suggest that VMS attenuates intracellular ROS and stress (oxidative and thermal) level promoting longevity. The longevity and stress modulation can be attributed to VMS-mediated alterations in *daf-16* expression which regulates insulin signaling pathway. This study opens doors for development of phytomolecule-based therapeutics for prolonging life span and managing age-related severe disorders.

Free Radical Research 49: 1384-1392, 2015; Input: MM Gupta, Rakesh Pandey

Analytical method development: Uni-dimensional double development HPTLC-densitometry method for simultaneous analysis of mangiferin and lupeol content in mango (*Mangifera indica*) pulp and peel during storage

Mango (*Mangifera indica*) fruit is one of the important commercial fruit crops of India. Similar to other tropical fruits it is highly perishable in nature. During storage/ ripening, changes in its physico-chemical quality parameters viz., firmness, titrable acidity, total soluble solid content (TSSC), carotenoids content, and other biochemicals are



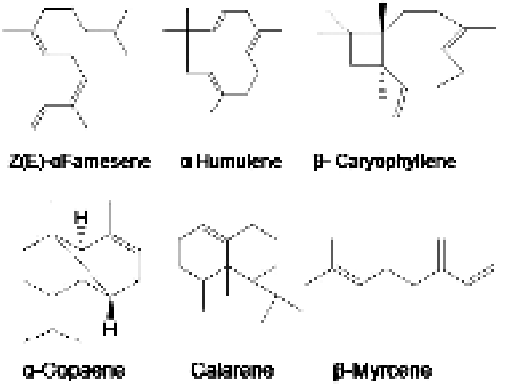
Representative densitogram of uni-directional double development HPTLC determination of mangiferin and lupeol in mango pulp

inevitable. A uni-dimensional double-development high-performance thin-layer chroma-tography (UDDD-HPTLC) method was developed for the real-time monitoring of mangiferin and lupeol in mango pulp and peel during storage. The quantitative determination of both compounds of different classes was achieved by densitometric HPTLC method. Silica gel 60F_{254} HPTLC plates and two solvent systems viz., toluene/EtOAC/MeOH and EtOAC/MeOH, respectively were used for optimum separation and selective evaluation. Densitometric quantitation of mangiferin was performed at 390nm, while lupeol at 610nm after post chromatographic derivatization. Validated method was used for real-time monitoring of mangiferin and lupeol content during storage in four Indian cultivars, e.g., Bombay green (*Bgreen*), *Dashehari*, *Langra*, and *Chausa*. Significant correlations ($p<0.05$) between of acidity and TSSC with mangiferin and lupeol in pulp and peel during storage were also observed.

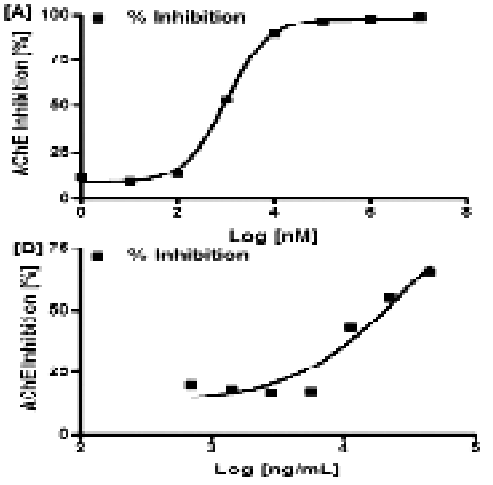
Food Chemistry 176: 91-98;
Input: Karuna Shanker

Chemical composition and acetylcholinesterase inhibitory activity of *Artemisia maderaspatana* essential oil

To date, there are no reports to validate the Indian traditional and folklore claims of *Artemisia maderaspatana* (syn. *Grangea maderaspatana*) (Asteraceae) for the treatment of Alzheimer's disease. The present study characterizes the volatile components (non-polar compounds) of *A. maderaspatana* and evaluates its acetylcholinesterase (AChE) inhibition potential. The essential oil (yield 0.06% v/w) was obtained from the fresh



Major phytoconstituents of *Artemisia maderaspatana*



Dose dependent AChE inhibition potential of (a) physostigmine-a standard drug and (b) essential oil of *A. maderaspatana*

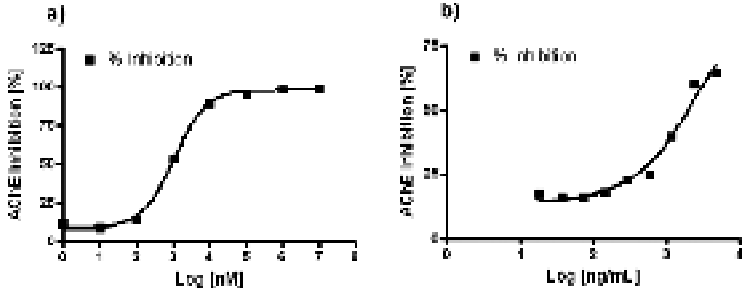
aerial part of *A. maderaspatana*. The *in vitro* AChE inhibition of the volatile organic constituents (VOC's) of *A. maderaspatana* aerial part was evaluated in varying concentration ranges (0.70-44.75 µg/mL) with the Ellman's method. The major components were α-humulene (46.3%), β-caryophyllene (9.3%), α-copaene (8.2%), β-myrcene (4.3%), Z(E)-α-farnesene (3.7%), calarene (3.5%). The experimental results

showed that diverse volatile organic constituents of *A. maderaspatana* have significant acetylcholinesterase inhibitory activity (IC_{50} value 31.33 ± 1.03 µg/mL). This is the first report on the inhibition of acetylcholinesterase properties of essential oil of *A. maderaspatana* obtained from fresh aerial part. The present study showed that essential oil of *A. maderaspatana* isolated from North region of India could inhibit AChE moderately. Therefore, possibility of novel AChE inhibitors might exist in VOCs of this plant.

Pharmaceutical Biology 53:1677-1683;
Input: Karuna Shanker, D Chanda

Chemical characterization and acetylcholinesterase inhibition potential of volatile components of aerial Parts of *Pluchea lanceolata*

Pluchea lanceolata (Rasana) is an important medicinal plant due to its usage in a number of Ayurvedic formulations. For the first time, chemical composition of essential oil from the aerial part of *P. lanceolata* was analyzed by gas chromatography-mass spectrometry (GC-MS) and NMR spectroscopy. *Ex vivo* cholinesterase inhibitory activity of the essential oil was also evaluated using mouse brain homogenate. The major components were linalool (32.2%), β-caryophyllene (8.5%), α-terpineol (8.0%), spathulenol (7.4%), linalylacetate (5.6%), naphthalene, 1,6-dimethyl-4-(1-methylethyl)- (4.3%), α-copaene (3.6%), epi-cubebol (3.6%) and trans-α- bergamontene (3.1%). The experimental results showed that hydrodistilate of *P. lanceolata* significantly inhibited acetylcho-linesterase activity (IC50 value 2.54 ± 0.03 µg/mL).

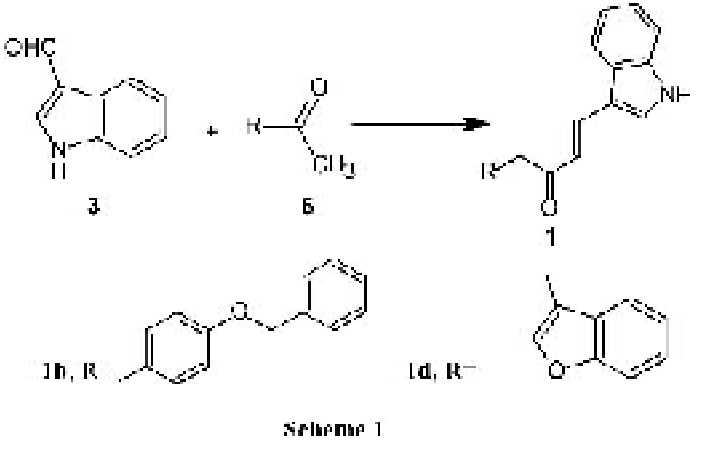


Acetylcholinesterase inhibition by (a) physostigmine and (b) non-polar fraction of *P. lanceolata*

Records of Natural Products 9: 586-591;
Input: Karuna Shanker, D. Chanda

Molecular modeling based synthesis and evaluation of *in vitro* anti-cancer activity of indolyl chalcones

A series of twenty-one chalcone derivatives having indole moiety were synthesized (Scheme 1) and evaluated against



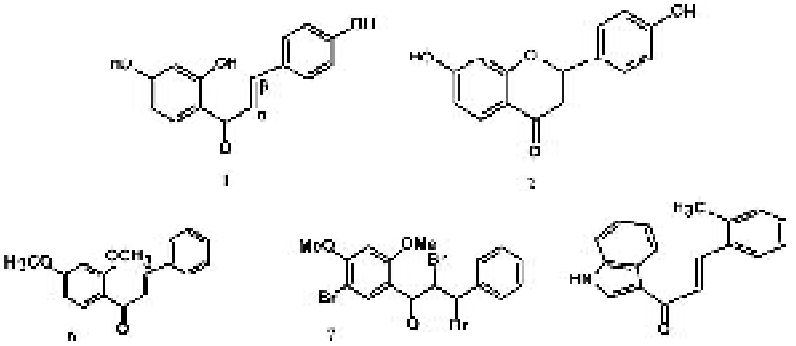
Scheme 1

four human cancer cell lines. Eleven indolyl chalcones showed significant anti-cancer activity. Chalcones **1b** and **1d** were the most active and selective anti-cancer agents with IC50 values <1µg/ml and 1.51µg/ml, against WRL-68 cell line, respectively. Molecular mechanism was explored through *in silico* docking and ADMET studies.

Curr Top Med Chem. 15: 1003-12, 2015
Input: RS Bhakuni, MP Darokar, Feroz Khan

Synthesis, anti-tubercular activity, and molecular modeling studies of analogues of isoliquiritigenin and liquiritigenin, bioactive components from *Glycyrrhiza glabra*

Isoliquiritigenin (ISL, **1**) and liquiritigenin (LTG, **2**) were isolated from the rhizomes of *Glycyrrhiza glabra*. In an attempt to develop potent and selective anti-tuberculosis agents, a series of ISL analogues were synthesized mainly via acid- and base-catalyzed Claisen–Schmidt condensation reaction for their anti-tubercular activity. Compared to ISL

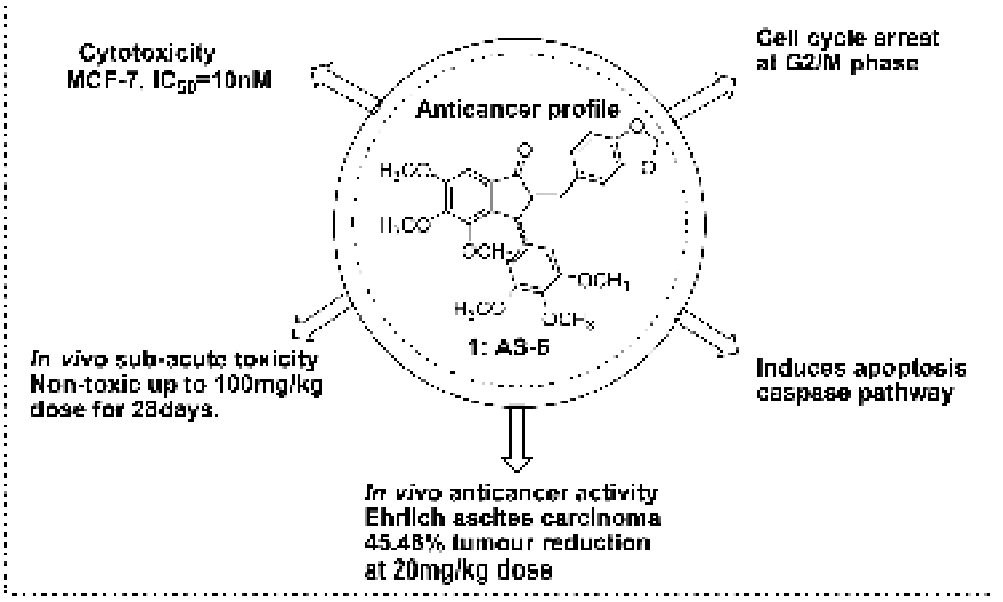


(MIC = 25 lg/mL), derivatives **6**, **7**, and **15** exhibited two fold higher activity (MIC = 12.5 lg/mL) against *Mycobacterium tuberculosis*. Among the LTG derivatives, LTG 40-acetate and LTG-oxime were found to be as active (MIC = 25 lg/ mL) as LTG. It is the first report on antimycobacterial activity of these ISL- and LTG-based derivatives. Molecular docking and *in silico* ADME studies revealed that compounds **6, 7**, and **15** are potent inhibitors of *M. tuberculosis* H37Rv alanine dehydrogenase and showed compliance with standard parameters of drug likeness.

Med Chem Res. 34: 3494-3503, 2015;
Input: RS Bhakuni, D Saikia and Feroz Khan

Anti-cancer profile of AS-6

Compound 1 is an optimized anti-cancer lead molecule obtained on modification of gallic acid, a plant phenolic acid. It exhibited potent cytotoxicities (IC_{50}=0.010-14.76µM) against various human carcinoma cells. In cell cycle analysis, benzylidene indanone **1** induced G2/M phase arrest in both MCF-7 and MDA-MB-231 cells. It also induced apoptosis in DU145 cells which was evident by cleavage of PARP. In Ehrlich ascites carcinoma, benzylidene indanone **1** showed 45.48% inhibition of tumour growth at 20mg/kg dose in Swiss albino mice. Further, in sub-acute toxicity experiment in Swiss albino mice, it was found to be non-toxic up to 100mg/kg dose for 28 days. The lead compound benzylidene indanone **1** can further be optimized for better anti-cancer activity.



Eur. J. Pharm. Sci., 76: 57-67, 2015; Input: ASNegi

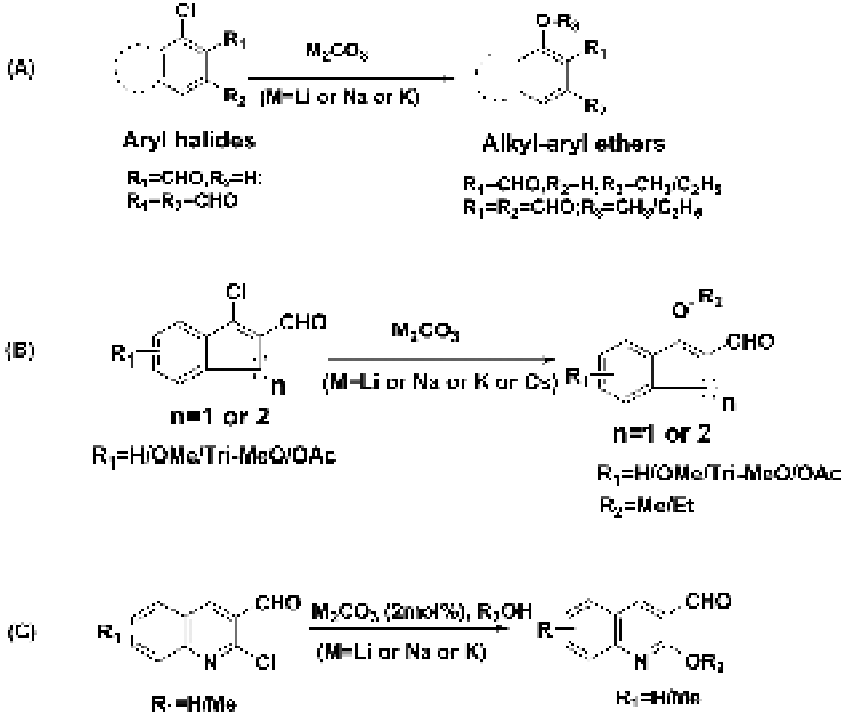
Synthesis, docking and ADMET studies of novel chalcone triazoles for anti-cancer and anti-diabetic activity

A series of novel chalcone-triazole derivatives were synthesized and screened for *in vitro* anti-cancer activity on the human cancer cell lines IMR32 (neuroblastoma), HepG2 (hepatoma) and MCF-7 (breasta denocarcinoma), DU-145 (prostate carcinoma), and A549 (lung adenocarcinoma). Among thetested compounds, 4r showed the most promising anti-cancer activity in all the cell lines whereas, compounds 4c (IC50 65.86 µM), 4e (IC50 66.28 µM), 4o (IC50 35.81 µM), 4q (IC50 50.82 µM) and 4s (IC50 48.63 µM) showed better activity than the standard doxorubicin (IC50 69.33 mM) in A549 cell line alone. Rat intestinal α-glucosidase inhibitory activity of the synthesized derivatives showed 4m (IC_{50} 67.77 µM), 4p(IC_{50} 74.94 in µM) and 4s (IC_{50} 102.10 µM) as most active compared to others. The *in silico* docking of synthesized derivatives 4a-4t with DNA topoisomerase IIa revealed the LibDock score in the range of71.2623e118.29 whereas, compounds 4h, 4m, 4p and 4s with docking target a-glucosidase were in the range of 100.372e107.784.

Input: J Kotesh Kumar

A regioselective etherification of aryl/alkyl halides

An efficient synthesis of alkyl ethers has been developed for *o*-deactivated aryl halides, and 1-halotetralenes. The method shows good regioselectivity towards *ortho* substituted halides. Alkali metal carbonates (Li_2CO_3/Na_2CO_3/K_2CO_3/Cs_2CO_3) have been used without a transition metal co-catalyst and ligand. The method is simple, straight-forward and proceeds to afford products in good isolated yields.



Etherification of arylchlorides, indenes, tetralenes and heterocyclic system in presence of metal carbonates.

Tetrahedron Letters 56: 2340-2344, 2015; Input: ASNegi

Changes in the essential oil content and composition of palmarosa (*Cymbopogon martinii*) harvestedat different stages and short intervals in two different seasons

The essential oil of palmarosa (*Cymbopogon martinii*) is one of the industrially important essential oils. Since the content and composition of essential oils is known to depend on extrinsic and intrinsic factors, including climate and season of harvest, knowledge of the optimal harvesting time is necessary for production of quality essential oil. Hence, experiments were conducted to study the variation in the essential oil composition of palmarosa harvested twelve times at short intervals during a six-month period from October to March. Chemical profiling of the essential oils was done by GC/GC–MS analysis, which revealed the presence of eleven compounds in the essential oil. The compounds are myrcene, cis-ocimene, trans-ocimene, linalool, neral, geraniol, geranial, geranylacetate, caryophyllene, geranyl isobuterate, and farnesol. A significant increase in the geraniol content and a significant

decrease in the gerany lacetate were noticed with the passage of time. Maximum and minimum temperatures exhibited significant positive correlation with geraniol and showed significant negative relation with geranylacetate. Geraniol and geranylacetate in the essential oil were inversely related. Ideal harvesting time is around 70–80 days taking in to consideration of oil content, oil yield/plant and the content of geraniol and geranylacetate in the essential oil.

Input: J Kotesh Kumar

Hairy root mediated functional derivatization of artemisinin and their bioactivity analysis

Biotransformation of artemisinin (1) with the selected hairy root clones of three medicinally important plants, i.e., *Atropa belladonna*, *Hyoscyamus muticus* and *Ocimum basilicum*, yielded two biotransformed products, which were identified as 3-hydroxy-1-deoxyartemisinin (2) and 4-hydroxy-9,10-dimethyloctahydrofuro-(3,2-i)-isochromen-11(4H)-one (3). Their structures were elucidated through spectroscopic analysis (NMR/MS) and X-ray crystallography. The relative transformation efficiencies of the tested hairy root clones differed concerning individual bioconversion reactions. Consequently, the HR clones of *H. muticus* and *A. belladonna* accomplished the highest conversion of (1) to (2) and (3) respectively, while that of *O. basilicum* imparted an intermediate response. *In silico* and *in vitro* bioactivity analysis of the derivatives revealed promising anti-plasmodial activity profile in tandem with notable TNF level lowering potential of compound (2), indicating thereby its prospective therapeutic merit in ameliorating the severity of malarial infection.

Input: J Kotesh Kumar

Composition of herb and seed oil and anti-microbial activity of the essential oil of two varieties of *Ocimum basilicum* harvested at short time intervals

An experiment was conducted to study the changes in the chemical composition of the essential oil of two varieties of *Ocimum basilicum* over a period of six months at short harvest intervals for two crop seasons. In variety Vikarsudha, GC/MS analysis revealed the presence of eighteen essential oil constituents. Linalool (23.540.1% and 22.833.7%) and methyl chavicol (25.451.9% and 40.052.7%) were the major constituents in main and ratoon crops. Similarly, in variety Kuhmohak GC/MS analysis revealed the presence of linalool (19.225.4 % and 16.131.3%) and methyl chavicol (34.753.4% and 39.459.2%) in large quantities in main and ratoon crops, respectively. Beta myrcene, limonene, 1,8 cineole, ocimene, camphor, terpinen-4-ol, bornyl acetate, eugenol, methyl eugenol, beta elemene, beta caryophyllene, alpha humulene, gamma cadinene and cadinol were present in smaller quantities. Results pertaining to the zone of inhibition in the anti-microbial activity of essential oil indicated that *Chromobacterium violaceum* is more sensitive as compared to *Staphylococcus aureus*. Among the fungal strains *Aspergillus niger* was found to be more sensitive. GC-MS analysis of the fixed oils obtained from the seeds in the ratoon crop revealed the presence of unsaturated and

saturated fatty acids. The unsaturated fatty acids averaged 89% consisting of α-linolenic (49.3%-52.4%), linoleic (23.4%-26.0%), and oleic (10.3%-12.3%) acids. The most abundant saturated fatty acids were palmitic and stearic acids.

Input: J Kotesh Kumar

Synthesis and evaluation of anti-cancer activity of novel andrographolide derivatives

A series of 3,19-O-acetal derivatives of andrographolide have been synthesized by protecting thehydroxyls at C-3 and C-19 through a novel route. All the derivatives were evaluated for *in vitro* anti-cancer activity. Among the synthesized derivatives, compounds 3, 3a, 3d, 3e, 7 and 8 showed potential cytotoxicity against human cancer cell lines A549 (lung), HeLa (cervical), ACHN (renal), B-16 (melanoma) and IEC-6 (small intestine). The binding mode conformation was evaluated through docking simulations, while bioavailability/drug-likeness was evaluated through predictive ADME screening studies. All the derivatives were characterized by spectroscopy and the stereochemistry of compounds 3a and 3e was also confirmed by X-ray analysis.

Input: J Kotesh Kumar

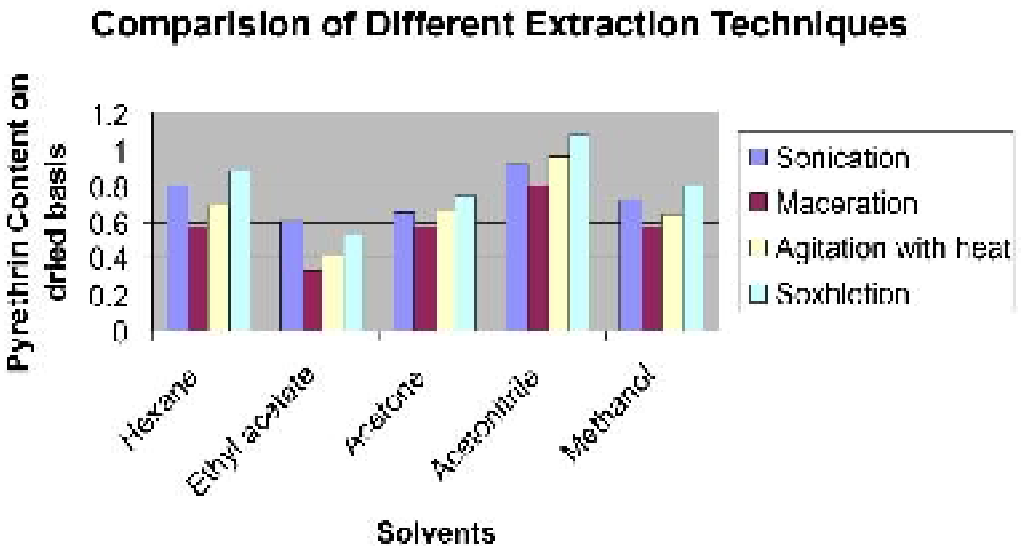
Highly selective one pot synthesis and biological evaluation of novel 3-(allyloxy)-propylidene acetalsof some natural terpenoids

A series of 3-(allyloxy)-propylidene acetals 1a to 6a of some natural terpenoids like andrographolides 1,2, forskolins **3–5** and arjunolic acid 6 were developed by a novel one pot synthetic strategy using cericammonium nitrate as a catalyst. The method is bothchemo and regioselective towards 1,3-acetalformation without affecting other poly functional groups of terpenoids. O-Allylation is an important functional group transformation for alcohols and the resulting end allylic double bond may participate in a number of synthetically useful transformations like olefin metathesis. Acetal of andrographolide 1a was further converted into 1b, 1c and 1d by dimerization, acetylation and epoxidation respectively. All the synthesized compounds were screened for in vitro anti-proliferative activity against four cancer cell linesB16F10, THP-1, PC-3 and SKOV3. Derivatives of andrographolide 1a, 1b, 1c and 2a, forskolin 4a andarjunolic acid 6a have shown promising cytotoxicity (IC50 < 10 μg/ml) in most of the tested cell lines. Also compounds 1b (IC50 0.83 μg/ml) and 5a (IC50 3.43 μg/ml) showed significant a-glucosidase inhibition in an *in vitro* assay. Structures of all the synthesized compounds were confirmed by NMR, mass and IR spectral data. A single crystal X-ray analysis of 5a also confirmed the 3-(allyloxy)-propylidene acetal formation.

Input: J Kotesh Kumar

Studies on the comparative extraction and enrichment techniques for pyrethrins from flowers of *Chrysanthemum cinerariaefolium*

Comparative extraction efficiencies and enrichment methods for natural insecticidal compounds pyrethrins from the dried flowers of *Chrysanthemum cinerariaefolium* using different techniques and solvent



systems have been studied. Four different extraction techniques viz., maceration, agitation with heat, sonication and soxhlet using five different solvent systems hexane, ethyl acetate, acetone, acetonitrile and methanol were evaluated. The successive and maximum enrichment of the total pyrethrins was achieved by solid-matrix partitioning of the extract using acetonitrile as extracting solvent followed by treatment with activated charcoal, subsequent chilling & filtration by which enrichment of total pyrethrins up to 60% content has been obtained.

Input: Sudeep Tandon, Ateeque Ahmad

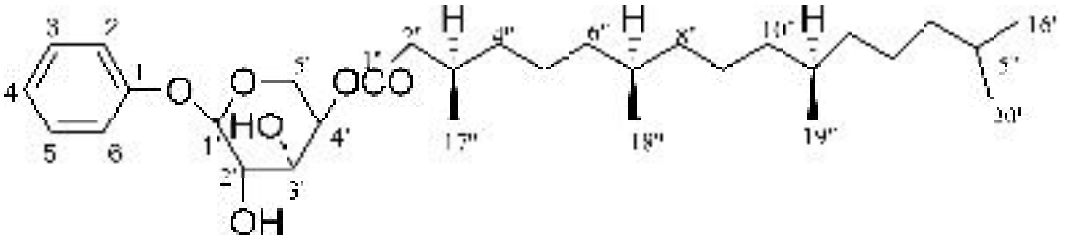
In silico docking studies on natural anti-tubulin agents for revealing importance of 3,4,5-trimethoxy phenyl fragment

Microtubules are polar cytoskeletal filaments assembled from head-to-tail and comprised of lateral associations of α/β-tubulin heterodimers that play key role in various cellular processes. Because of their vital role in mitosis and various other cellular processes, microtubules have been attractive targets for several disease conditions and especially for cancer. Anti-tubulin is the most successful class of anti-mitotic agents in cancer chemotherapeutics. The target recognition of anti-mitotic agents as a ligand is not much explored so far. However, 3,4,5-trimethoxyphenyl fragment has been much highlighted and discussed in such type of interactions. In this review, some of the most important naturally occurring anti-mitotic agents and their interactions with microtubules are discussed with a special emphasis on the role of 3,4,5-trimethoxyphenyl unit. At last, some emerging naturally occurring anti-mitotic agents have also been tabulated.

Bioorg Med Chem. 23:373-89, 2015;
Input: Feroz Khan, ASNegi

Chemical constituents from the fruits of *Zanthoxylum armatum*

Chemical investigations on the fruits of *Zanthoxylum aramatum* (Rutaceae) led to the isolation of one new compound characterized as phenol-*O*-β-D-arabinopyranosyl-4'-(3″, 7″, 11″, 15″-tetramethyl)-hexadecan-1″-oate (1) along



Chemical structure of new compound (phenol-*O*-β-D-arabinopyranosyl-4'-(3″, 7″, 11″, 15″-tetramethyl)-hexadecan-1″-oate)

with nine known compounds *m*-methoxy palmityloxy benzene, tambulin, prudomestin, obmuin, 3,4,5, 3',4',5'-hexahydroxydiphenyl ether, acetyl phenyl acetate, *m*-hydroxyphenoxy benzene, linoleiyl-*O*-*α*-D-xylopyranoside and palmitic acid from the hexane extract. The chemical structures were established with the help of physical, chemical and spectroscopic methods.

Input: Sudeep Tandon, Ateeque Ahmad

In silico structure-activity relationship studies on gymnemic acid analogues for anti-diabetic activity targeting PPARã

Diabetes accounts for high mortality rate worldwide affecting million of lives annually. Global prevalence of diabetes and its rising frequency makes it a key area of research in drug discovery programs. The work studies the development of quantitative structure activity relationship model against PPARã, a promising drug target for diabetes. Multiple linear regression approach was adopted for statistical model development and the QSAR relationship suggested the regression coefficient (r2) of 0.84 and the cross validation coefficient (rCV2) of 0.77. Further, the study suggested that chemical descriptors viz., dipole moment, electron affinity, dielectric energy, secondary amine group count and LogP correlated well with the activity. The docking studies showed that most active gymnemic acid analogues viz., gymnemasin D and gymnemic acid VII possess higher binding affinity to PPARã. QSAR and ADMET studies based other predicted active gymnemc acid analogues were gymnemic acid I, gymnemic acid II, gymnemic acid III, gymnemic acid VIII, gymnemic acid X, gymnemic acid XII, gymnemic acid XIV, gymnemic acid XVIII and gymnemoside W2. Predicted

activity results of three query compounds were found comparable to experimental *in vivo* data. Oral bioavailability of these active analogues is still a limiting factor and therefore further lead optimization required. Also, such study would be of great help in active pharmacophore discovery and lead optimization, and offering new insights into therapeutics for diabetes mellitus.

Curr Comput Aided Drug Des. 11:57-71, 2015; Input: Feroz Khan, NS Sangwan

In silico exploration of synergistic effect mechanism of (+)-pinitol from *Saraca asoca* with β-lactam antibiotics

Saraca asoca bark has been used in the Ayurvedic system of medicine for female urino-genital disorders. We have recently reported the isolation and characterization of several compounds as markers to develop HPLC profiling of its methanol and aqueous methanol extracts. Now, a HPLC-PDA inactive compound, (+)-pinitol has been isolated and characterized from the bark of this medicinally important tree. Pinitol is a well known bioactive compound for a variety of biological activities, including hypoglycemic and anti-inflammatory activities. A process for the isolation of relatively good concentration of (+)-pinitol from *S. asoca* bark has been developed and its *in vitro* anti TNF-α and anti-inflammatory activities against carragenan-induced edema confirmed. While conducting experiments on the possible agonistic activity, it was found that (+)-pinitol showed up to eight fold reduction in the doses of β-lactam antibiotics. The mechanism of its agonistic activity was studied by docking experiments which showed that different conformations of (+)-pinitol and antibiotics were actually in the same binding site with no significant change in the binding energy. These docking simulations, thus predict the possible binding mode of studied compounds and probable reason behind the synergistic effect of (+)-pinitol along with β-lactam antibiotics.

J Asian Nat Prod Res. 2:1-12, 2015; Input: Feroz Khan, LN Mishra

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

CIM-Harit an early maturing and high yielding variety of clarysage

Clarysage (*Salvia sclarea*), an important aromatic crop is cultivated for essential oil used in fragrance and pharmaceutical industries. The pale-green bracteates variety "CIM-Harit" is an early maturing (20 days earlier) and produces about 22% higher essential oil over the variety CIM-Chandni.

Single branch of var. CIM-Harit

Description of the clarysage variety CIM-Harit

Growth habit	Erect
Appearance	Light green
Shape of canopy	Symmetrical
Plant height	160 – 180 cm
Spike length	75 – 85 cm
Flower	Light pale green bracteates
Flower spike yield (q/ha)	200 – 225
Essential oil content (%)	0.12 – 0.13 (on the basis of Clevenger) 0.08 – 0.10 (commercial recovery)
Essential oil yield (kg/ha)	20 –25 (experimental) 16 – 18 (commercial)

Field view of var. CIM-Harit

Input: Mohd. Yaseen, Dasha Ram

Clarysage seed oil rich in omega -3 fatty acid

For the first time in India edible oil extracted from the clarysage seeds yielding 28-30% oil that is rich in ALA type of Omega-3 fatty acid (45-50%). ALA type of omega 3 is precursor to marine omega 3 (EPA and DHA), thus it is the source of all three types (ALA, EPA and DHA) of fatty acids. It is a dual purpose crop both grown for essential oil as well as fatty oil which can be used in the health care products as an antioxidant and for lowering the cholesterol levels. The compound present in seed oil of clarysage are palmatic acid 7.6%, stearic acid 2.7%, oleic acid 25.7%, linileic acid 16.4%, linolenic acid (**ω-6**) 0.30% and linolenic acid (**ω-3**) 45.7%.

Input: Mohd. Yaseen, Sukhmal Chand, PK Rout

Intercropping of MAPS with food grain crops

Due to ever increasing demand of food crops on account of increasing population, it is not economically feasible to spare good agricultural land for the cultivation

Pigeon pea+ kalmegh

Pigeon pea+ sweet basil

of medicinal and aromatic plants (MAPs). Pigeon pea and maize are wider row spaced, erect and slow growing crops, we have tried to utilize the inter row space through inter cropping of short statured kalmegh and sweet basil for sustainable production. Intercropping of two rows of kalmegh / sweet basil in between two pair rows of pigeon pea grown at 90:30 x 20 cm spacing gave maximum land use efficiency (152%), monitory equivalent ratio (1.21) and 21% higher net return as compared to sole crop of pigeon pea.

Input: M. Yaseen, Dasha Ram, Man Singh

Optimization of harvesting time for vetiver planted in different seasons

A field experiment was conducted to workout the optimum harvesting time for vetiver planted in different seasons. Planting of vetiver in mid July and harvested in January (18 months after planting) gave maximum oil yield.

Input: Man Singh, Mohd. Yaseen, Dasha Ram

Optimization of plant population and harvesting time for satavar

A field experiment consisting of four plant population and four harvesting time was conducted during July 2012 to June 2014 to workout optimum

6 months

12 months

18 months

24 months

plant population and harvesting time for sataver. Maximum dry tuber yield (56 q ha^{-1}) of satavar was obtained by maintaining plant population of 55,500 plants ha^{-1} (60 x 30 cm) and harvested at 18 months after transplanting.

Input: Man Singh, M. Yaseen, Dasha Ram

Effect of biochar and *Bacopa monneri* on enzymatic resilience properties of mine waste

The combined effect of biochar and *B. monneri* on acidic mine overburden (OB) contaminated soil was assessed using the resistance and resilience of soil enzyme activities involved in phosphorus, nitrogen, sulphur and carbon cycling. Addition of biochar enhanced the enzyme resistance and resilience of OB contaminated soil. *In silico* study indicates that biochar–Fe complex play a significant role in the enzymatic activities. Results indicated a significant influence of *B. monneri* and biochar addition on soil enzymatic activity that is extremely resistant to OB. The major species associated with the soil microbial activities were *B. firmus, B. thurengesis, Geobacillus stearothermophilus, Brevibacillus laterosporus, Bacillus sphaericus B. mycoides* and *B. aryabhatti* (Fig. 1).

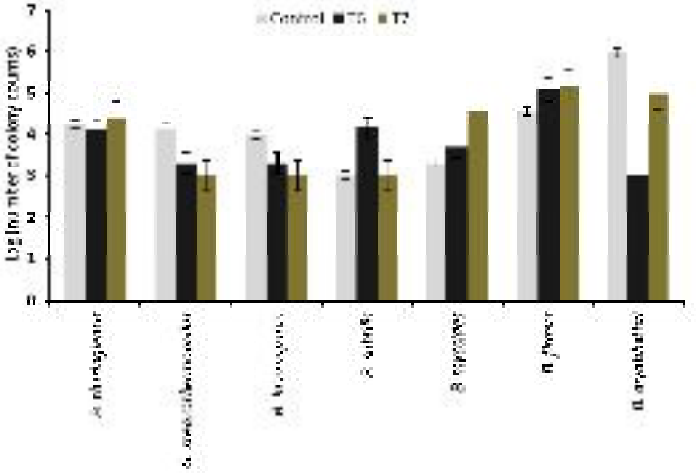


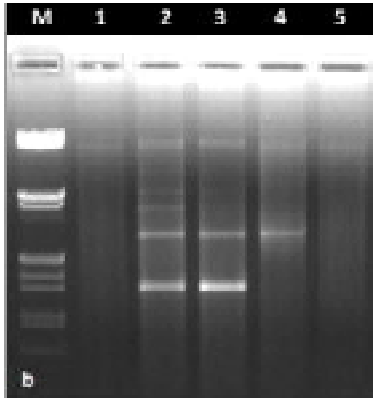
Fig. 1. Taxonomic analysis of the 16S rDNA sequences for species identification of soil bacteria and their colony count in control, mine spoil (T6) and mine spoil biochar (T7) treatments

Input: Puja Khare

RCA based molecular detection of a new strain of begomovirus infecting *Andrographis paniculata*

In a recent field survey, a new strain of begomovirus infecting *A. paniculata* was discovered and full genome analysis revealed it to be different from the two isolates of begomoviruses reported earlier in this plant. The infected plants were infested with whiteflies (*Bemicia tabaci*), which is the known vector of begomoviruses. The disease incidence was recorded to be 15–20%. The RCA product of the sample generated ~ 2.7 and 1.3 kb fragments corresponding to the viral DNA and betasatellite molecule, with *Bam*HI and *Hinc*II.

Begomovirus infected *A. paniculata* plant

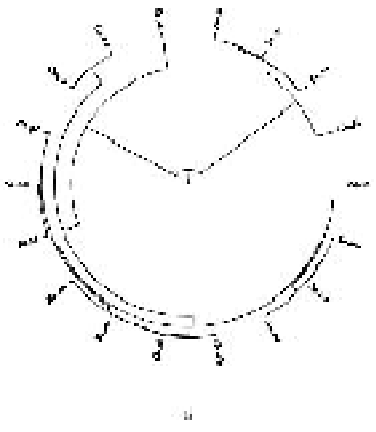


Restricted RCA product of the sample

Input: Abdul Samad

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

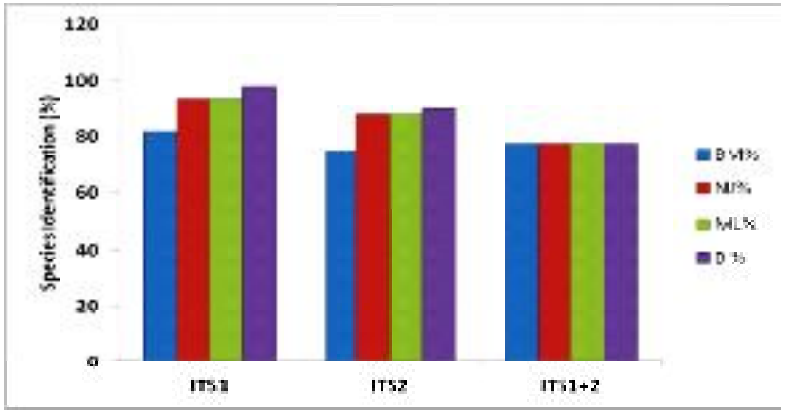
Testing the feasibility of nuclear ribosomal region ITS1 over ITS2 in barcoding taxonomically challenging genera of subtribe Cassiinae



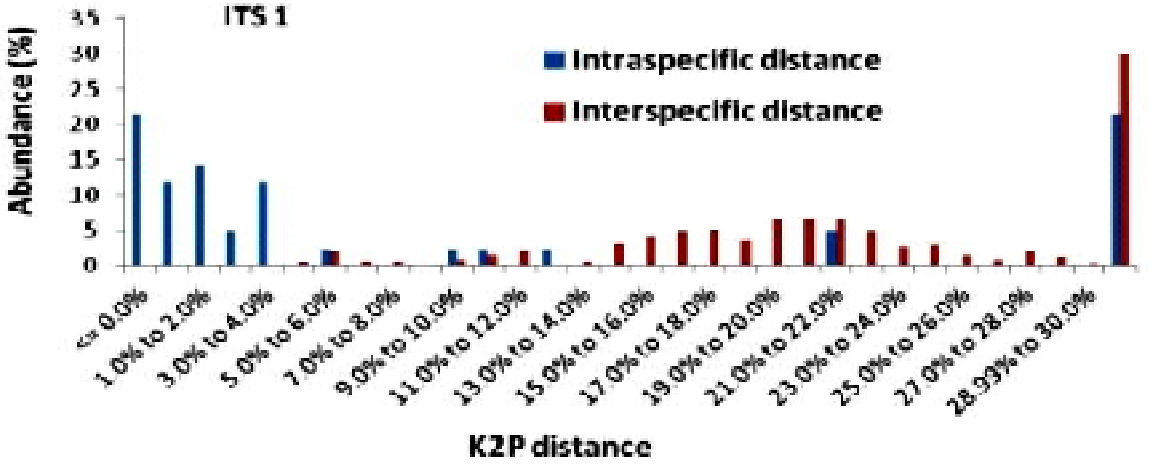
Genera *Cassia, Senna* and *Chamaecrista* are highly complex with more than 600 species of high medicinal, commercial and ornamental value. Tinnevelley *Senna* contributes significantly among the largest exported bulk herb drug traded in the range of 5000 metric tons per year as commercial products. Sequences corresponding to 18 different species representing three different genera of *Cassiinae* were evaluated based on the nuclear ribosomal internal transcribed spacer regions to assess their discriminatory power as candidate barcodes.

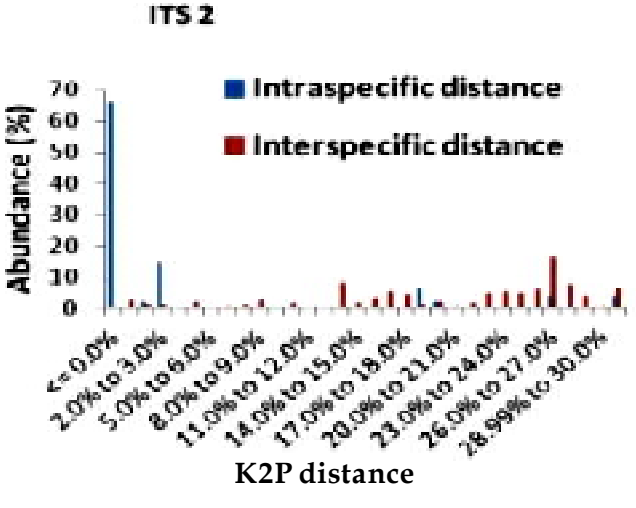
Sequence characteristics of the candidate barcode

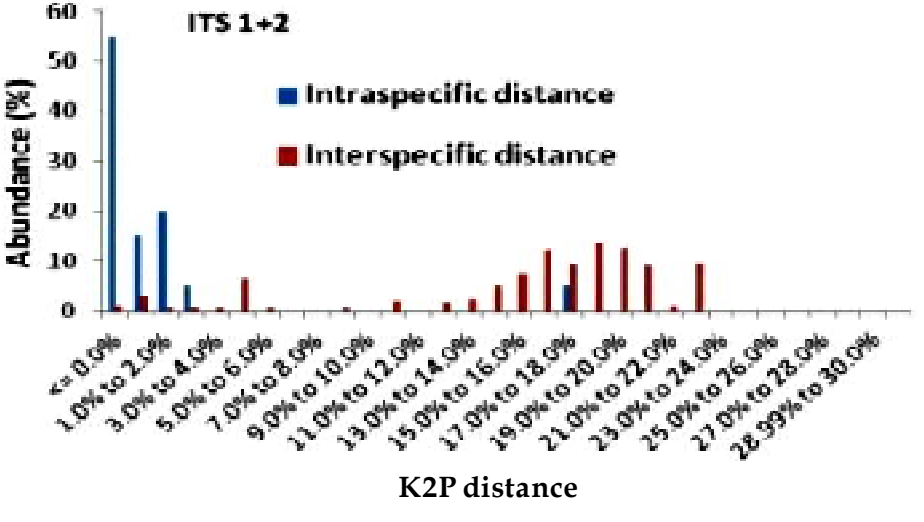
	ITS1	ITS2	ITS1+2
Aligned length (bp)	315	244	559
Average intra-distance	0.01%	0.03%	0.01%
Average inter-distance	0.24%	0.25%	0.17%
Average theta (e)	0.27%	0.26%	0.18%
Coalescent depth	0.02%	0.38%	0.17%
Proportion of variable sites	66.66%	60.24%	46.53%
Proportion of parsimony sites	65.39%	47.54%	43.64%



Conclusion: Nuclear region ITS1 and ITS2 present all the desired characteristics of a DNA barcode in *Cassiinae* group examined in the present study. High rate of PCR ampliûcation and sequencing success with potential rate of correctly assigned species among the genera *Cassia, Senna* and *Chamaecrista* concludes the ability of nuclear region ITS. However, till date there have been no ideal barcode for plants. The previously advocated plastids regions have successfully been used in many barcoding studies. And many of them have also indicated the potentiality of species discrimination based on the combination of ITS and plastid loci or ITS2 alone in different plant groups. Through our study, we concluded that ITS1 region should be used as a


ITS 1
Intraspecific distance
Interspecific distance
Abundance (%)
35
30
25
20
15
10
5
0
<= 0.0%
1.0% to 2.0%
3.0% to 4.0%
5.0% to 6.0%
7.0% to 8.0%
9.0% to 10.0%
11.0% to 12.0%
13.0% to 14.0%
15.0% to 16.0%
17.0% to 18.0%
19.0% to 20.0%
21.0% to 22.0%
23.0% to 24.0%
25.0% to 26.0%
27.0% to 28.0%
28.99% to 30.0%
K2P distance


ITS 2
Intraspecific distance
Interspecific distance
Abundance (%)
70
60
50
40
30
20
10
0
<= 0.0%
2.0% to 3.0%
5.0% to 6.0%
8.0% to 9.0%
11.0% to 12.0%
14.0% to 15.0%
17.0% to 18.0%
20.0% to 21.0%
23.0% to 24.0%
26.0% to 27.0%
28.99% to 30.0%
K2P distance


ITS 1+2
Intraspecific distance
Interspecific distance
Abundance (%)
60
50
40
30
20
10
0
<= 0.0%
1.0% to 2.0%
3.0% to 4.0%
5.0% to 6.0%
7.0% to 8.0%
9.0% to 10.0%
11.0% to 12.0%
13.0% to 14.0%
15.0% to 16.0%
17.0% to 18.0%
19.0% to 20.0%
21.0% to 22.0%
23.0% to 24.0%
25.0% to 26.0%
27.0% to 28.0%
28.99% to 30.0%
K2P distance

Species	Individuals
Chamaecrista absus	03
Senna uniflora	04
Chamaecrista nigricans	02
Senna italica	05
Senna hirsuta	05
Senna alata	03
Senna sulfurea	03
Senna siamea	03
Senna obtusifolia	02
Senna occidentalis	05
Cassia javanica	04
Cassia fistula	04
Senna pallida	02
Senna auriculata	04
Senna alexandrina	03
Senna tora	03
Cassia roxburghii	02
Senna surattensis	04

starting point to assign correct identification in the highly divergent genera *Cassia, Senna* and *Chamaecrista*. More over the choice of ITS1 over ITS2 have been suggested recently in the studied taxonomic group.

Input: V. Sundaresan

Project : Conservation of rare/endangered/elite germplasm of important MAPs under *in vitro* bank

Panax quinquefolius

A 3.5 fold increase in the ginsenoside yield was achieved in *Panax quinquefolius* with use of culture filtrate of *Trichoderma actiniviridae*, with simultaneous ginsenoside leaching in cell media. The process is cost effective at the industrial level due to easier retrieval and downstream processing. Further, *P. sikkimensis* cell suspensions respond to *T. harzianum* CF (3.8 fold increase). In addition to quantity, the quality enhancement is also a priority with a better proportion of more bioavalaible and potent ginsenosides.

Centella asiatica

Identified and molecularly characterized (AFLP) the elite accessions of *Centella* suitable for Northern plains – Lucknow and Bengaluru. As far as their biomass and centelloside production is concerned as this particular accession A, can grow throughout the year irrespective of seasonal variation with high herb yield and asiaticoside/centelloside content. The developed method has potential to address industry's demand for clean and good quality *Centella* herb for the herbal formulations for domestic and overseas markets. Based on the results, a cold tolerant variety of *Centella asiatica* named as CIM-Medha was released on 26 September 2015.

Input: Archana Mathur

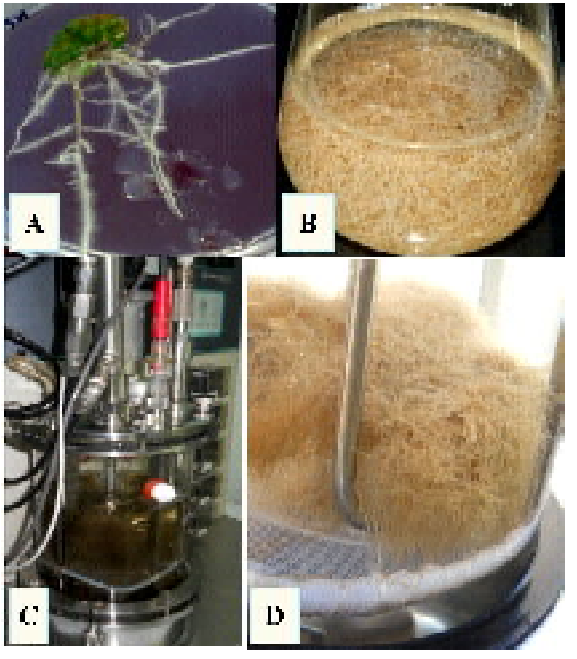
Project : Induction, up-scaling, chemical and bioactivity profiling of hairy root cultures of *Boerhaavia diffusa* - a traditional medicinal herb bearing advance therapeutic potentials

The roots of *Boerhaavia diffusa* L. (Nyctaginaceae) are used in the Ayurveda and Unnani systems of medicines. The latest discoveries of potential anti-cancer, immunomodulatory and cardio-protective activities have increased its market demand. *B. diffusa* is rich in secondary metabolites, including flavonoides, alkaloids and triterpenoids. Boeravinone B and eupalitin gained present in the plant has gained global attention owing to their proven anti-cancer activities. The demand of the *B. diffusa* is mostly fulfilled by the mass scale collection of the plant from natural habitats leading to its depletion and adulteration.

Biotechnological intervention in the form of *Agrobacterium rhizogenes* mediated hairy root (HR) culture has been taken up for round the year supply of plant material independent of seasonal fluctuations and environmental / pathological constraints.

The bacterial strain specificity and the underlying competence of the induced HR clones for their biosynthetic (i.e., Boeravinone B and Eupalitin) and bioactivity potentials have been evaluated. RP-HPLC analysis of the targeted metabolites production in the HR clone revealed a higher accumulation of eupalitin (1.44 times) over the control roots, while the later showed higher boeravinone B content as compared to the former. Up scaling in 10L"stirred-tank" reactor facilitated higher root biomass yield with 6.1 fold and 1.15 fold yield increment of the boeravinone B and eupalitin respectively compared to shake-flask cultures. As compared to the control roots, the established hairy root clone revealed improved anti-inflammatory potential with analogous antioxidant / anti-bacterial activities against pathogenic gram positive and gram-negative bacteria.

The overall findings first time indicated equivalent biosynthetic and bioactivity potentials of the HR clones with 15.21 fold time saving compared to the field grown plants' roots, suggesting its potentials benefit in future drug development process.

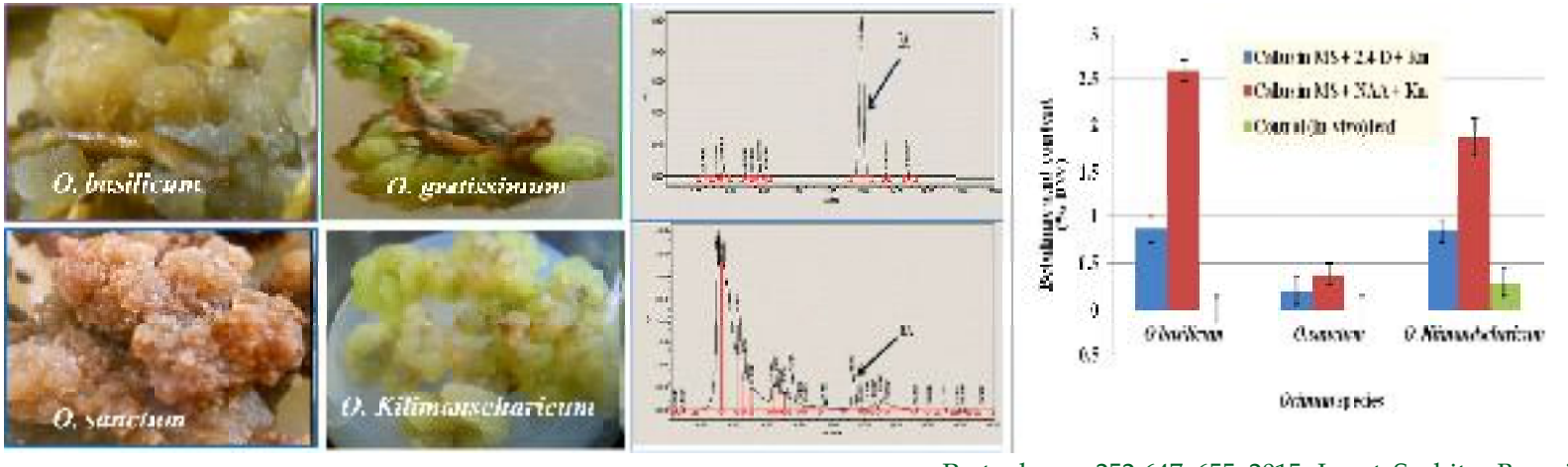


Input: S Banerjee, S Luqman, DU Bawankule; Protoplasma DOI 10.1007/s00709-015-0875-5

Production of anti-cancer triterpene (betulinic acid) from callus cultures of different *Ocimum* species and its elicitation

The betulinic acid (BA) possess selective cytotoxicity towards different kinds of human cancer cells, including brain and ovarian carcinomas, neuroblastomas and leukemia, making it as one of the most promising anti-cancer agents. However, low content of BA in the natural sources makes its commercially unviable.

The present the potential of *Ocimum* callus cultures as an alternative production source of BA has been revealed for the first time. The species tested were *O. basilicum*, *O. kilimandscharicum* and *O. sanctum*. The synthesis of BA in the *O. basilicum* calli could be increased almost two times through elicitation with the MeJ after 48 h of exposure on NAA-supplemented medium.



Protoplasma 252:647–655, 2015; Input: Suchitra Banerji

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

- A novel process has been developed for the isolation of cellulose, hemicellulose and lignin from the spent *Mentha* and *Ocimum* biomass.
- A novel process has been developed for the selective isolation of anti-diabetic pinitol and fatty oils form *Sesbania bispinosa* seeds.

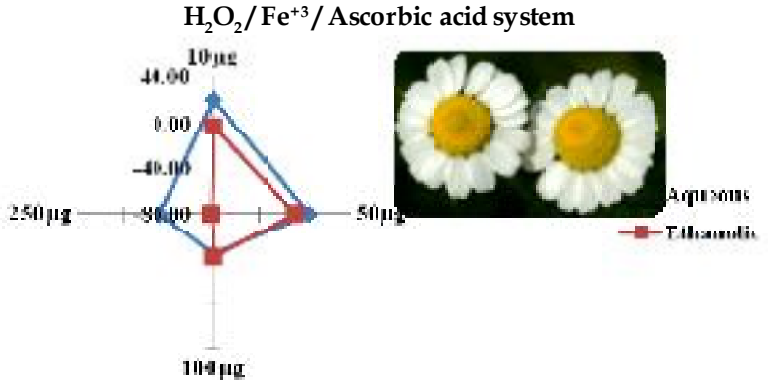
Input: PK Rout, AD Nannaware

Project: Target based validation of identified MAP leads

Anti-oxidative and pro-oxidative property of *Matricaria chamomilla* flower for the variants of deoxyribose degradation

In traditional system of medicine, chamomile tea has been used for its anti-oxidative and ROS scavenging property.

We have examined the interaction of flower extracts with the auto-oxidation of ascorbate and also determined the auto-oxidative property of the extracts by modifying the deoxyribose degradation assay.



Concentration-dependent hydroxyl radical scavenging effect of *M. chamomilla* flower extracts

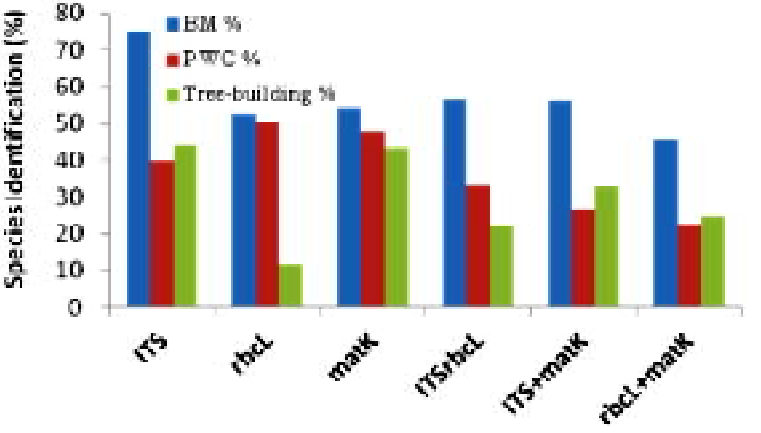
At low concentration (10-50 µg/ml), both the ethanolic and aqueous extracts protected the hydroxyl radical formation, while at high concentration (100-250 µg/ml) ethanolic extract augmented the generation of hydroxyl radical.

Annals of Phytomedicine 4 : 52-58, 2015; Input: Suaib Luqman

Project : Bioprospection of plant resources and other natural products

Evaluation of DNA barcodes in genus *Terminalia*

The genus *Terminalia* is distributed in the tropical and subtropical regions of the world. The genus is quite diverse in the forest of eastern, central and southern India. In order to overcome the morphological disparity, three plastid regions (*rbcL*, *matK* and *trnH-psbA*) and one nuclear marker (ITS) from 134 individuals representing 16 *Terminalia* species were evaluated to assess their discriminatory power as the candidates for DNA barcoding. The various approaches (tree-based, best match and PWG distance-based) employed, provided different species identification power



Species discrimination rates of main barcodes in *Terminalia species* based on different methods

Discrimination success

Region	Best match (%)			All species barcodes (%)		
	Correct	Ambi-guous	Incorrect	Correct	Ambi-guous	Incorrect
ITS	75.0	8.33	16.66	20.83	70.83	2.08
rbcL	42.55	36.17	21.27	21.27	72.34	4.25
matK	53.84	28.2	17.94	7.69	79.48	12.82
ITS+rbcL	56.84	22.1	21.05	3.15	96.84	0.0
ITS+matK	56.32	16.09	27.58	3.44	94.25	2.29
rbcL+matK	45.34	34.88	19.76	0.00	97.67	3.2

Sequence characteristics	ITS	*rbcL*	*matK*	ITS+ *rbcL*	ITS+ *matK*	*rbcL*+ *matK*
Aligned length (bp)	446	360	524	806	970	884
Average intra-distance	0.06%	0.10%	0.22%	0.58%	0.60%	0.53%
Average inter-distance	0.10%	0.14%	0.25%	0.57%	0.66%	0.52%
Average theta (e)	0.05%	0.09%	0.10%	0.52%	0.53%	0.48%
Coalescent depth	0.41%	0.53%	0.48%	0.68%	0.86%	0.85%
Variable sites	50.53%	49.84%	46.18%	65.52%	69.75%	65.25%
Parsimony sites	45.06%	29.92%	34.1%	63.29%	63.85%	55.58%
Ability to discriminate (NJ)	44.19%	11.53%	43.33%	22.07%	32.5%	24.61%

with the best match method of Taxon DNA found to be performing best.

Conclusion: ITS performed best among all the tested regions along with the best node support. ITS+*rbcL* provided the maximum variation in interspecific divergence as compared to intraspecific distances. Except for ITS, all the other regions showed overlapping, thereby concluding the negligible barcoding gap. Further exploration of *psbA-trnH* with different primer pairs and its combination with other successful regions might result for better barcoding success in genus *Terminalia*. Among all the three methods employed, sequence analysis using TaxonDNA method gave the highest species resolution based on the BM and BCM model. Species discrimination for the genus *Terminalia* was low with the tested barcodes, might be due to natural hybridization and gene introgression.

Locus	Direction	Sequence
ITS5a	Forward	5'-CCTTATCATTTAGAGGAAGGA-3'
ITS4	Reverse	5'-TCCTCCGCTTATTGATATGC-3'
matK 2.1a	Forward	5′ATCCATCTGGAAATCTTAGTTC-3′
*matK*3.2r	Reverse	5'-ATCTATCGATAATATCAGAAT-3'
*rbcL*1F	Forward	5'-ATGTCACCACAAACAGAAAC-3′
	Forward	5′-ATGTCACCACAAACAG-3′
*rbcL*724r	Reverse	5'-TCGCATGTACCTGCAGTAGC-3′
	Reverse	5′-ATGTACCTGCAGTAGC-3′

Species	Individuals
T.arjuna	21
T. Chebula	13
T. Bellirica	15
T. Catappa	10
T. muelleri	09
T. paniculata	06
T. brachystemma	07
T. phanerophlebia	07
T. sambesiaca	07
T. prunioides	87
T. Sericea	07
T. Myriocarpa	07
T. Trichopoda	06
T. Mollis	07

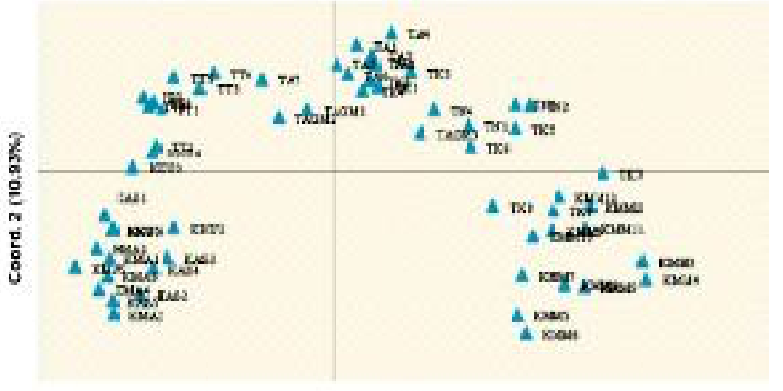
Input: V. Sundaresan

Population dynamics and conservation implications of *Decalepis arayalpathra*

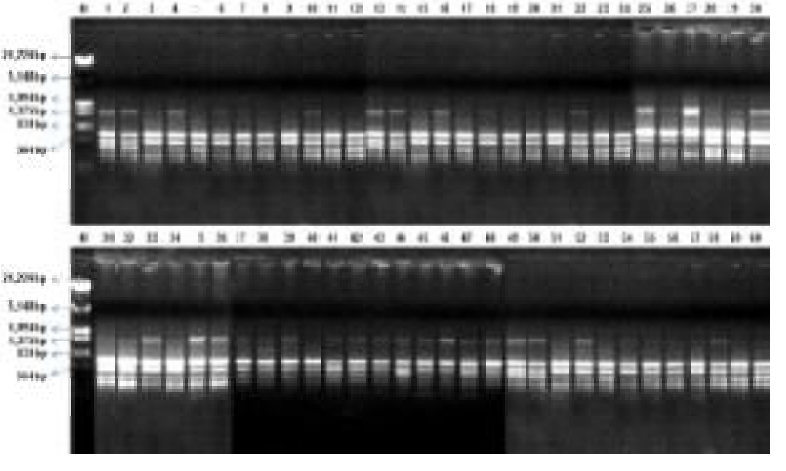
Decalepis arayalpathra, a critically endangered plant species, has a restricted and fragmented population in the Southern Western Ghats of India. This study is a first attempt to evaluate genetic diversity and population structure in the nine wild populations of *D. arayalpathra* based on molecular pattern realized through the marker assays.

Conclusion: Principal coordinate analysis (PCoA) and Nei's unweighted pair-group method with arithmetic average (UPGMA)-based hierarchical clustering of both the marker assays suggest strong genetic clustering between the individuals corresponding to their geographical ranges. In summary, the genetic diversity was remarkably low both at the species and population levels, and that the genetic differentiation between populations was considerably high. AMOVA allocated the higher proportions of genetic

Pop.	Location	District	Sample size
TA	Amman Kovilmottai	Tirunelveli	8 (1-8)
TN	Vistharmottai	Tirunelveli	4 (9-12)
TK	Kuthuraikattimottai	Tirunelveli	9 (13-21)
TAGM	Adupukalmottai	Tirunelveli	3 (22-24)
KMM	Maramalai	Kanyakumari	12 (25-36)
TT	Nadukandanparai	Tirunelveli	8 (37-44)
KKU	Pallvarakadavu	Kanyakumari	5 (45-49)
KAS	Yanaisethaoddaimadai	Kanyakumari	5 (50-54)
KMA	Asambu	Kanyakumari	6 (55-60)

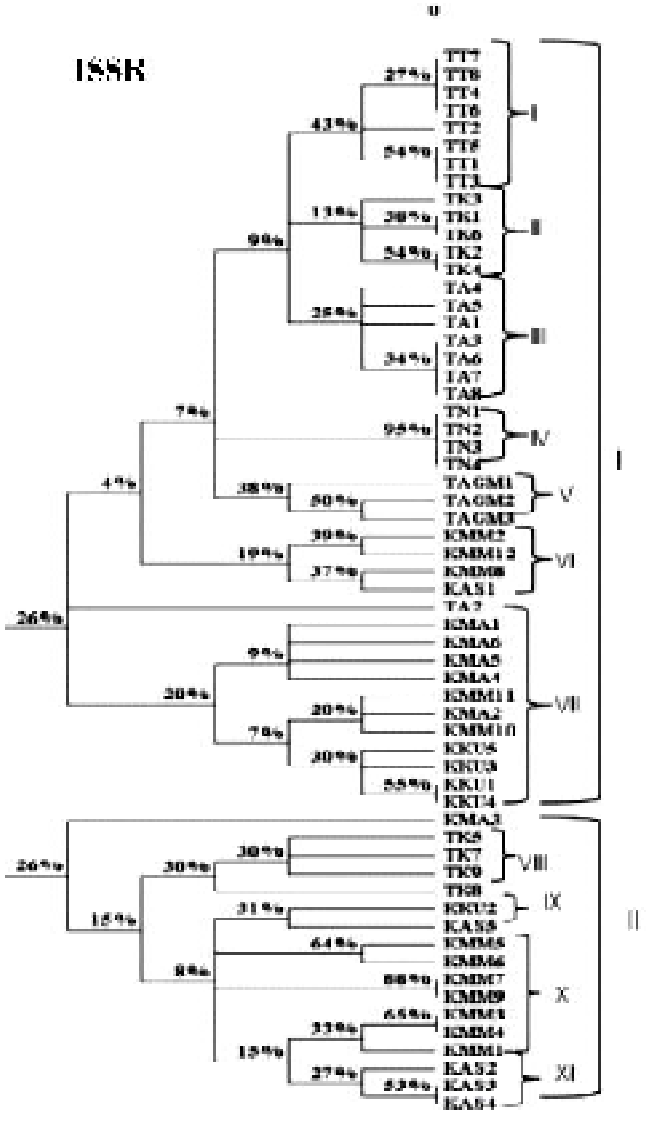


Principal coordinate analysis of combined data



Amplification profile with ISSR

variation within populations [(ISSR=54 %) and (RAPD= 64 %)]. A significant correlation (r=0.389) was found between genetic and geographic distances among the


ISSR
0
TT7
TT8
TT4
TT6
TT2
TT5
TT1
TT3
TK3
TK1
TK6
TK2
TK4
TA4
TA5
TA1
TA3
TA6
TA7
TA8
TN1
TN2
TN3
TN4
TAGM1
TAGM2
TAGM3
KMM2
KMM12
KMM8
KAS1
TA2
KMA1
KMA6
KMA5
KMA4
KMM11
KMA2
KMM10
KKU6
KKU3
KKU1
KKT4
KMA3
TK8
TK7
TK9
TH0
KKU2
KAS5
KMM5
KMM6
KMM7
KMM9
KMM4
KMM1
KAS2
KAS3
KAS4
I
II
III
IV
V
VI
VIII
VIII
IX
X
XI
I
II
27%
43%
54%
13%
38%
54%
99%
28%
34%
7%
95%
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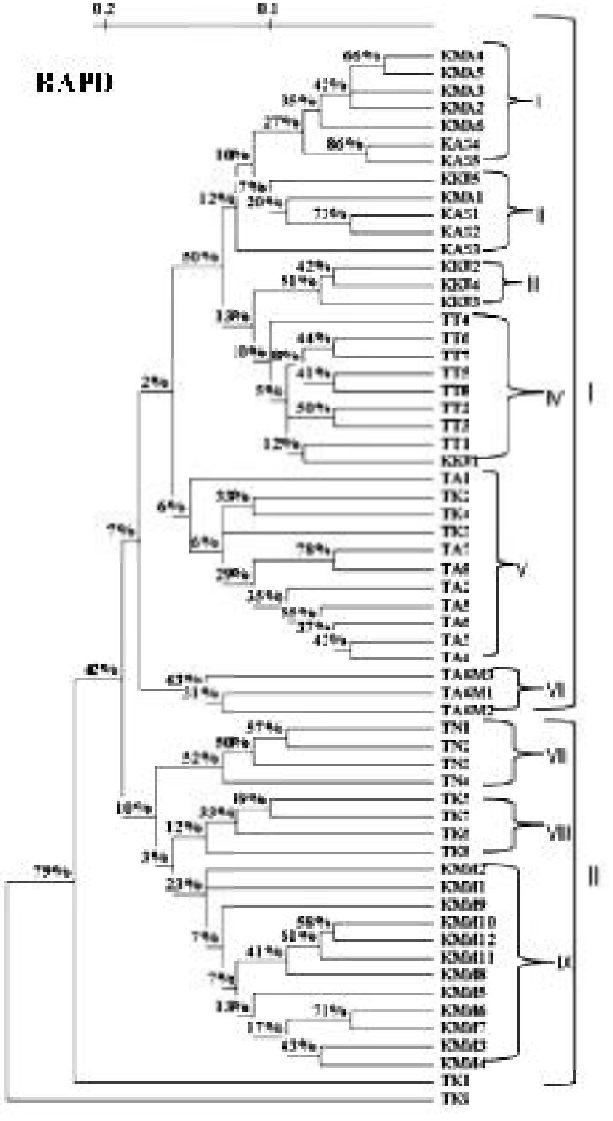
15%
27%
53%


RAPD
0.2
0.1
KMA4
KMA5
KMA3
KMA2
KMA6
KA54
KA55
KKB5
KMA1
KA51
KA52
KA53
KKB2
KKB4
KKB3
TT4
TT6
TT7
TT5
TT8
TT2
TT3
TT1
KKT1
TA1
TK5
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TK2
TA7
TA8
TA5
TA2
TA6
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TA4
TAGM3
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KMM6
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TK9
I
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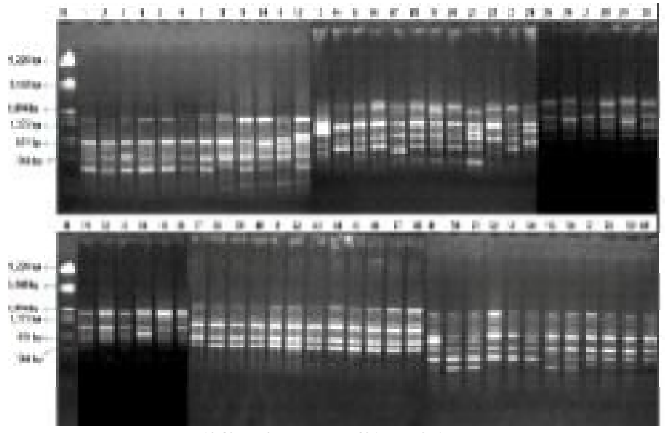
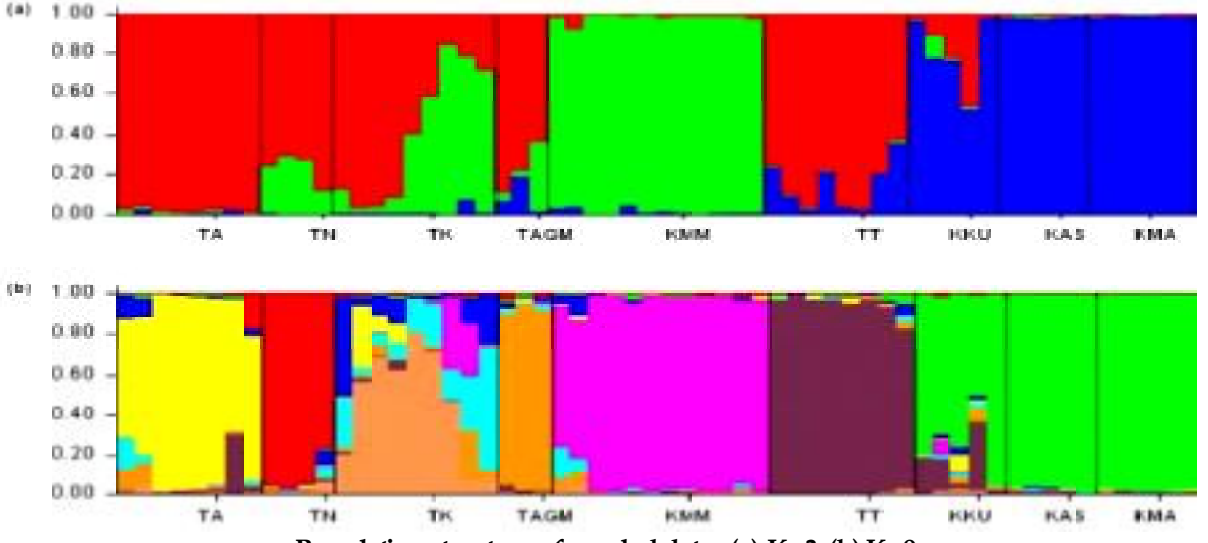
III
IV
V
VI
VII
VIII
IX
X
XI
66%
41%
35%
27%
86%
10%
79%
12%
20%
73%
50%
42%
51%
13%
44%
39%
41%
5%
50%
12%
2%
33%
6%
6%
78%
29%
35%
55%
37%
41%
7%
42%
63%
51%
57%
50%
52%
10%
19%
33%
12%
3%
23%
75%
58%
51%
41%
7%
13%
71%
17%
43%



Amplification profile with RAPD

population. According to genetic data and field observations, narrow habitat preference, genetic drift due to a small and isolated population size, restricted gene flow, population bottleneck and human activity have shaped the current population structure. With reference to our study, for popula-tions with slightly higher level of genetic variation of different regions such as TK, TT, KMM and KMA as compared to others, we suggest that their habitats be protected. These results are integrated with our understanding of the current status of *D. arayalpathra* populations to assist in making effective conservation decisions.



Population structure of pooled data; (a) K=3; (b) K=9

Applied Biochemistry & Biotechnology 176: 1413-1430, 2015 Input: V. Sundaresan

Project : Genomics of medicinal plants and agronomically important traits

Structural and functional genomics of *Ocimum* species

Background: Due to the medicinal properties and presence of important essential oils in different species of *Ocimum* genus, some are used in Ayurvedic and indigenous medicines. Therefore, sequencing of leaf transcriptomes of most prominent species popularly grown in India, including *O. sanctum*, *O. basilicum*, *O. gratissimum* and *O. kilimandscharicum*, were undertaken in this network project. During the past couple of years, leaf transcriptomes of *O. sanctum* (CIM-Ayu) and *O. basilicum* (CIM-Saumya) were sequenced, analyzed and submitted to the public domain (NCBI). In this line, another species i.e. *O. gratissimum* was grown in glass house under controlled conditions, and mature leaf tissue was subjected to transcriptome sequencing. Deep sequencing was done by using illumina platform (150 bp paired end), and sequence data was generated and analyzed.

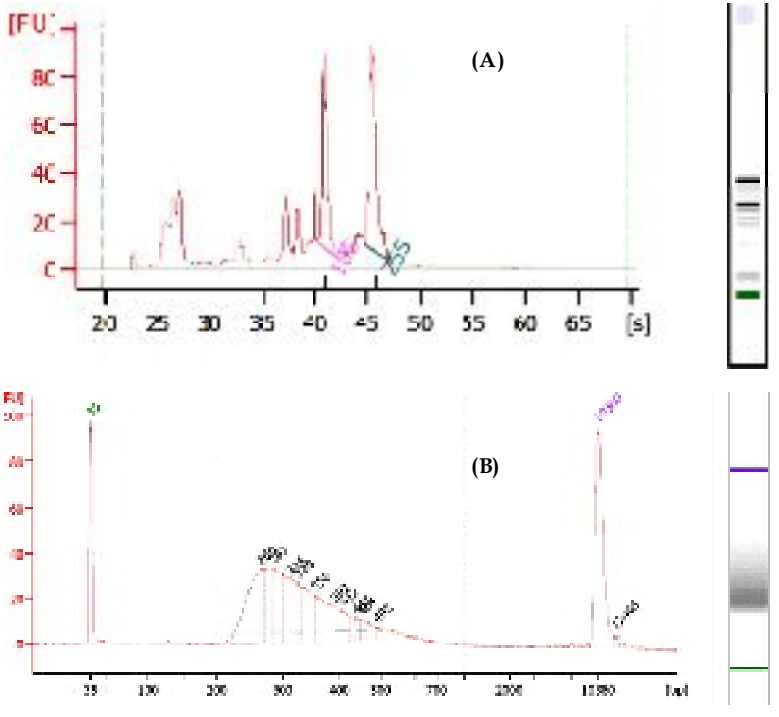


Fig. 1. Bioanalyzer profile of (A) RNA, and (B) amplified product. Insert size in library: 130-680 bp, Adapter size: 120 bp

Library construction, sequence generation, *de novo* assembly and annotation

RNA was extracted from *O. gratissimum* leaf tissue and library was constructed for deep sequencing (Fig. 1). The paired-end Sequencing-by-Synthesis (SBS) yielded raw data of ~4.00 Gb comprising more than 32 million reads. The reads were processed to remove adaptor sequences, and assembled to generate contigs which resulted in > 83,000 transcripts with an average length of 1112.8 ± 908.0 bp with N50 value of 1628. Around 57,367 and 33,719 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

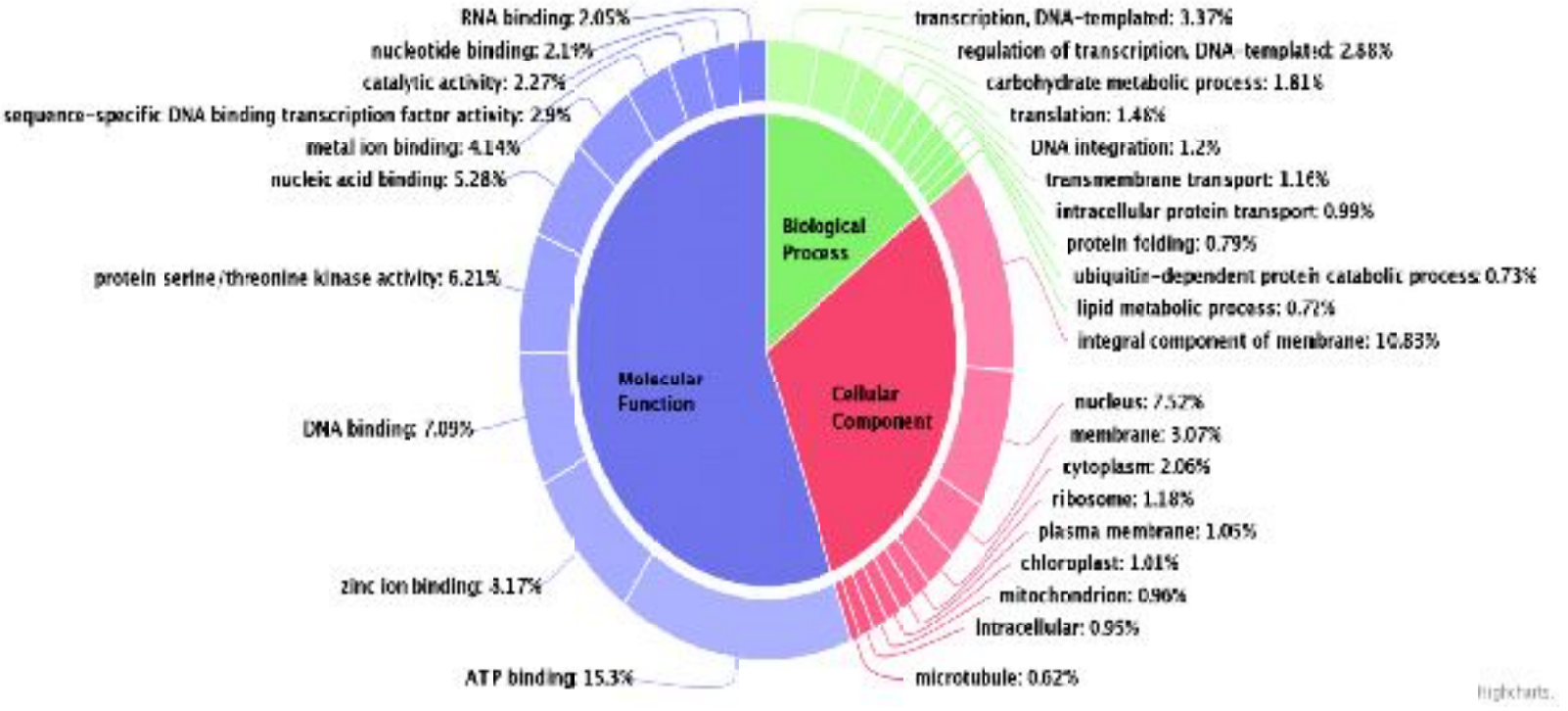


Fig. 2. Gene ontology classification of *O. gratissimum* transcripts

orthologous groups (COGs). COGs were annotated using NCBI BLASTx program against the NR protein sequences of Viridiplantae taken from Uniprot database. Un-annotated COGs were subjected to Pfam domain analysis. The associated hits were searched for their respective GO. Based on homology, 54,259 transcripts could be categorized under three main categories: BiologicalProcess (BP), Cellular Component (CC) and Molecular Function (MF) (Fig. 2).

KEGG analysis of *Ocimum gratissimum* transcriptome

To identify biological pathways operating in the leaf tissue, the 83,000 assembled transcripts were mapped to the KEGG canonical pathways and classified under different categories. Around 982 *O. gratissimum* transcripts were mapped to pathways related to secondary metabolism, which are expected to be involved in biosynthesis of diverse secondary metabolites (Fig. 3).

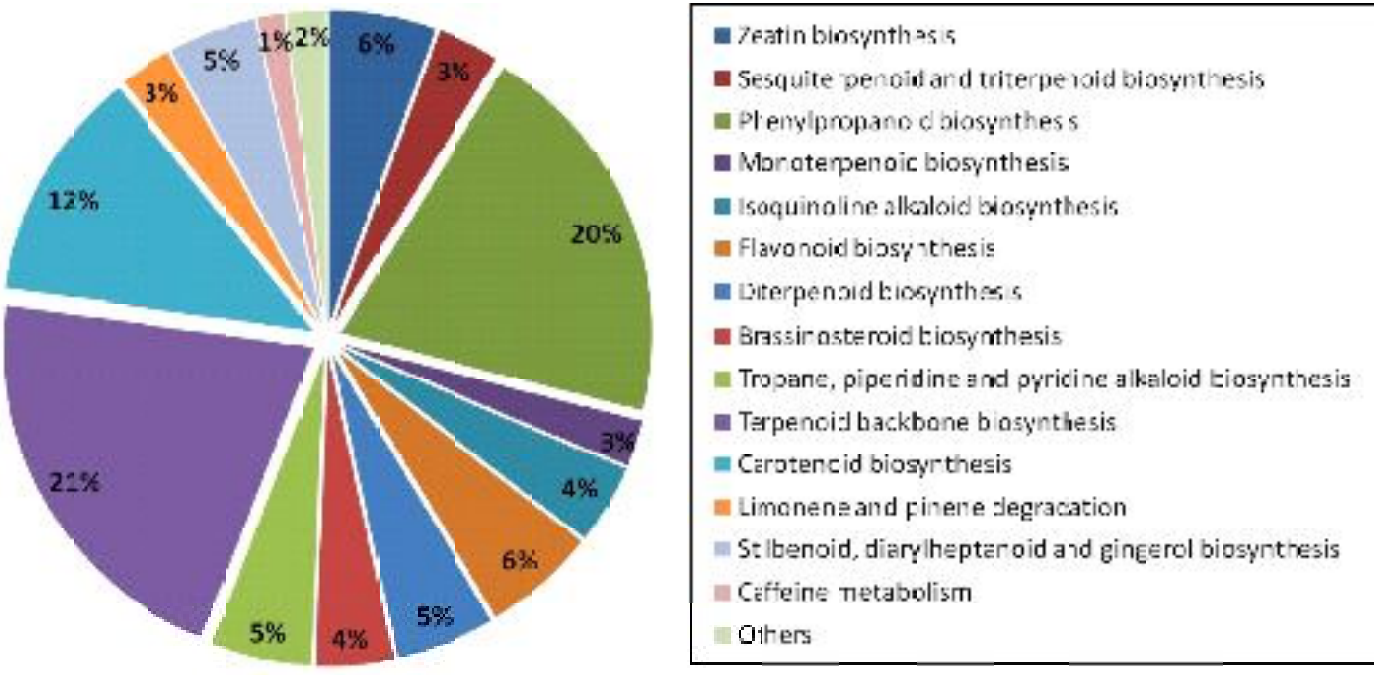


Fig. 3. Representation of selected secondary metabolism-related contigs/transcripts based on KEGG classification

Identification of simple sequence repeat (SSR) markers in the transcripts

The assembled contigs of *O. gratissimum* were analyzed for the presence of SSR markers by using MISA program. Out of 83,105 transcripts (contigs), 18,712 (22.5%) sequences contained 23,326 SSRs. Di-nucleotide repeats were highest in number followed by tri-, tetra-, penta- and hexa-nucleotide repeats (Table 1 and Fig. 4).

Conclusion: Transcriptome of *O. gratissimum* leaf tissue was sequenced, assembled and analyzed by annotation. Several important genes/transcripts related to the biosynthesis of zeatin, terpenoids, phenylpropanoids, flavonoids, carotenoids and brassinosteroids etc. could be identified in the transcriptome data. Apart from 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.

Table 1. Statistics of identified SSRs

Types of SSRs	*O. gratissimum*
Total number of identified SSRs	23326
Number of SSR containing sequences	18712
Number of sequences containing more than 1 SSR	3669
Di-nucleotide Repeats (p2: ≥ 6 repeats)	7101
Tri-nucleotide Repeats (p3: > 5 repeats)	3115
Tetra-nucleotide Repeats (p4: > 5 repeats)	205
Penta-nucleotide Repeats (p5: ≥ 5 repeats)	35
Hexa-nucleotide Repeats (p6: ≥ 5 repeats)	17

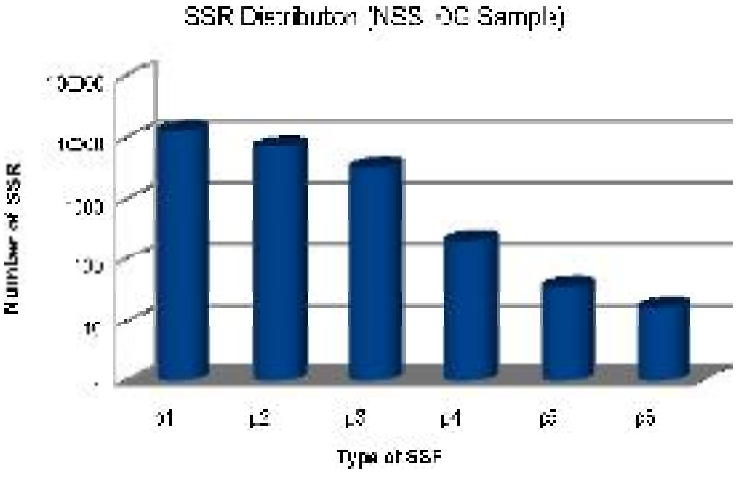


Fig. 4. Abundance of SSRs in *O. gratissimum* transcripts

BMC Genomics 16:413, 2015;
Input: Vikrant Gupta, AK Shasany, NS Sangwan, DA Nagegowda, Sumit Ghosh, RK Shukla

Improved agro-technology for palmarosa for rainfed and irrigated conditions

Palmarosa is being cultivated under both rainfed and irrigated conditions. However, the productivity is poor due to a number of factors. Out of these, the improper agronomic practices particularly identical harvesting schedule for all

Present cultivation practice

Modified cultivation practice

season (i.e. rainy, winter and summer) is an important factor. Hence, an experiment was planned to manipulate the harvesting practice at research farm, Lucknow. Results revealed that herb, essential oil yield and geraniol yield was 64.3%, 26.4% and 30.65% higher respectively over the practices being followed at present. However there was 29.5% mortality in the modified agro practice. Further work is in progress to sort out this problem.

Input: Saudan Singh

Productivity and economics of kalmegh under kalmegh+pigeon pea intercropping system

Kalmegh is a shade loving crop that performs well under different intercropping systems like kalmegh+maize, kalmegh+bajra and kalmegh+pigeon pea. However, the system productivity is highest under kalmegh+pigeon pea intercropping system. The experiments were conducted with different ratios of kalmegh and pigeon pea and it is concluded that multicut kalmegh can be grown with 3 and 1 ratio of kalmegh + arhar. The results show that highest herb yield of kalmegh was obtained when the kalmegh was intercropped with pigeon pea and harvested four times in a year. The pigeon pea grain yield was also highest in this treatment.

Input: Saudan Singh

Popularization of early mint technology (EMT) on farmers field through training and demonstration

Twenty-eight training cum demonstration programmes were organized in traditional mint growing areas of western UP, Central UP, and Bihar for the popularization of the Early Mint Technology.

About 470 farmers participated in these programmes and 94 field demonstration werelaid out by CSIR- CIMAP team.

Demonstration of modified sucker production technique on ridges

Demonstration of early nursery raising technique in the winter season

Demonstration of modified planting technique on the ridges

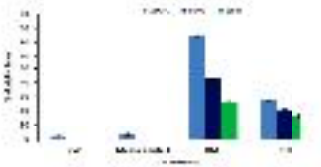
The summary of the EMT training programmes conducted is given below:-

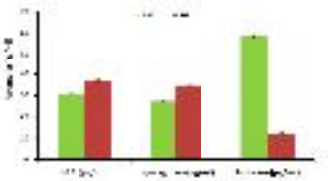
SN	State/ Location	District covered	Training/ group discussions	Partici-pants	Field demon-strations
1.	Western UP	07	15	120	29
2.	Central UP	05	10	300	50
3.	Bihar	01	03	50	15
Total	**03**	**13**	**28**	**470**	**94**

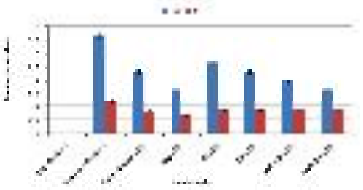
Input: Saudan Singh

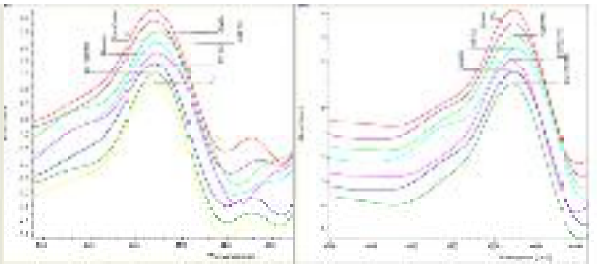
Exploitation of microbes for enhancing the bacoside content and reduction of *Meloidogyne incognita* infestation in *Bacopa monnieri*

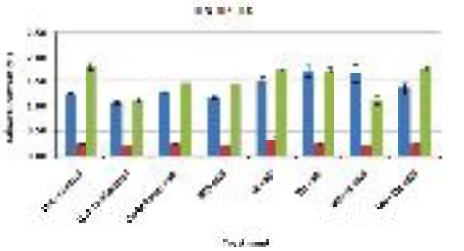
Despite the vast exploration of rhizospheric microbial wealth for crop yield enhancement, knowledge about the efficacy of microbial agents as biocontrol weapons against root-knot disease is scarce, especially in the medicinal plants, viz., *Bacopa monnieri*. In the present investigation, rhizospheric microbes, viz., *Bacillus megaterium*, *Glomus intraradices*, *Trichoderma harzianum*, and their combinations were evaluated for the management of *Meloidogyne incognita* and bacoside content enhancement in *B. monnieri* var. CIM-Jagriti. A novel validated method Fourier transform near infrared (FT-NIR) was used for rapid estimation of total bacoside content. A significant reduction (2.75 fold) in the root-knot indices was observed in the combined treatment of *B. megaterium* and *T. harzianum* in comparison to the untreated control plants. The combined treatment also











showed significant enhancement (1.40 fold) in the total bacoside contents (plant active molecule) content using FT-NIR method.

Input : Rakesh Pandey

Development of Khus Digger and its technology transfer

CIMAP has developed an improved Khus Digger technology. The technology was transfered to M/s Govind Industries, Barabanki, UP on 5% royalty basis.

Hon'ble Minister inspecting the Khus Digger

Exchange of MoU for Khus Digger

Input: JP Tiwari

Development of microbial consortia for the organic cultivation of *Andrographis paniculata*

Andrographis paniculata is source of diterpenoids and 2'-oxygenated flavonoids, which are in demands by pharmaceutical industries and ayurvedic formulations. For the productionof quality herb an experiment was conducted with different combinations of bio-inoculants and vermicompost in controlled conditions. The highest L:S ratio, herb yield and andrographolide yield was recorded in VC + *Azotobactor chroococcum* (free living nitrogen fixing bacteria) treatment. The significant improvement was noticed in all observed soil fertility parameters. Our results suggest that the application of the bio-inoculants and organic fertilizers can be help to achieving sustainability in agriculture.

Input: RKVerma

Project : Integarted NextGen approaches in health, disease and environmental toxicity

Utilization of metal-rice tannery sludge on performance of sweet basil (*Ocimum basillicum*)

The influence of tannery sludge on growth and yield of basil was studied. The maximum herb yield was obtained with the application of 20 t ha^{-1} of tannery sludge. The shoot and root accumulation of Cr, increased with the application of up to 50 t ha^{-1} tannery sludge. The essential oil yield and quality of oil were positively influenced with the application of tannery sludge.

Environ Sci Pollut Res. 22: 7470-7475, 2015

Heavy metal rich-tannery sludge influences the glutathione activity of aromatic crops

The glutathione (GSH) plays a vital role in protecting the plants against oxidative stress generated due to heavy metals. GSH content and GR activity significantly increased with heavy metal applied through tannery sludge in *Tagetes minuta, Ocimum basillicum* and *Mentha arvensis*.

Ecol. Engg. 81: 348-352, 2015

Growth, yield and metal accumulation by Clarysage (*Salvia sclarea*) in metal polluted soils

The maximum shoot and root dry matter and oil yield were obtained with application of 80 t ha^{-1} tannery sludge. The extent of increase was 94, 113, 61% respectively, over control. The accumulation of heavy meals Cr, Cd, Ni and Pb was significantly higher than other aromatic crops tested viz., basil and palmarosa. The results show that the clarysage can be used as a potential hyperaccumulation of heavy metals, *vis-à-vis* phytoremediation because of its high metal accumulation capacity.

Int. J. Phytorem. 17: 1171-1176, 2015

Oil yield, metal accumulation and antioxidant activities of *Ocimum basillicum* under heavy metal pollution (coarse and fine textured soils)

Dry matter and oil yield of Basil was not significantly different in two soils.

The heavy metal accumulation was higher in the fine textured soils as compared the coarse textured soils. The cation exchange capacity of soils played a significant role in positively affecting the metal uptake. The super oxide dismutage, and catalage activity went down in both soils. The peroxidose, melanodialdehyde and proline activity was maximum with highest level of tannery sludge.

Ecol. Engg. 83: 422-430, 2015

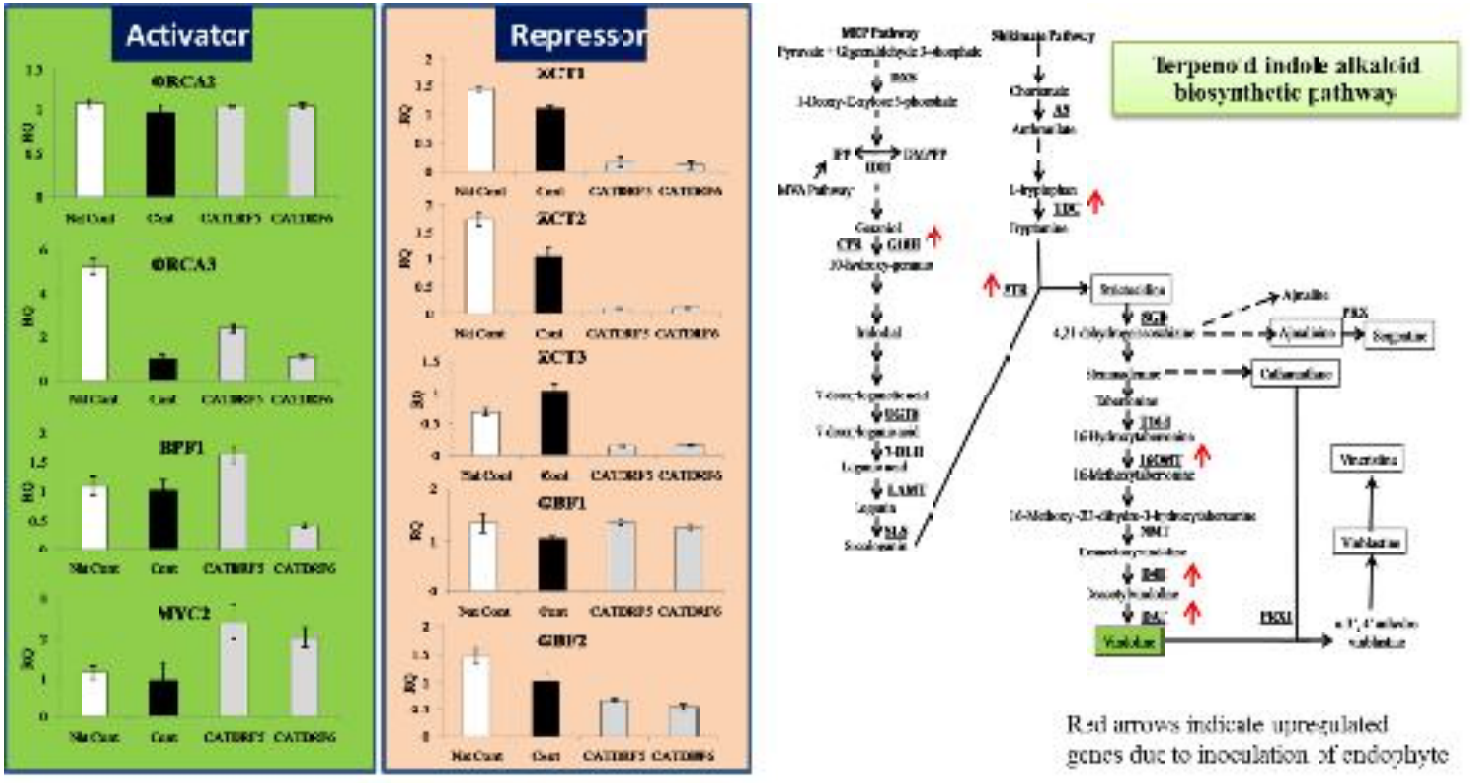
Palmarosa (*Cymbopogon martinii*) as a putative crop for phytoremediation (phytostabilization) in heavy metal polluted soils

The heavy metal-rich tannery sludge has a synergistic effect in relation to soil quality/ productivity. The sludge enhanced the productivity of crop. The metal accumulation occurred in roots with a meager translocation to shoots (phytostabilization).

J. Ecotoxicol. Environ. Safet.122:296–302, 2015

Project : Plant-microbe and soil interactions

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

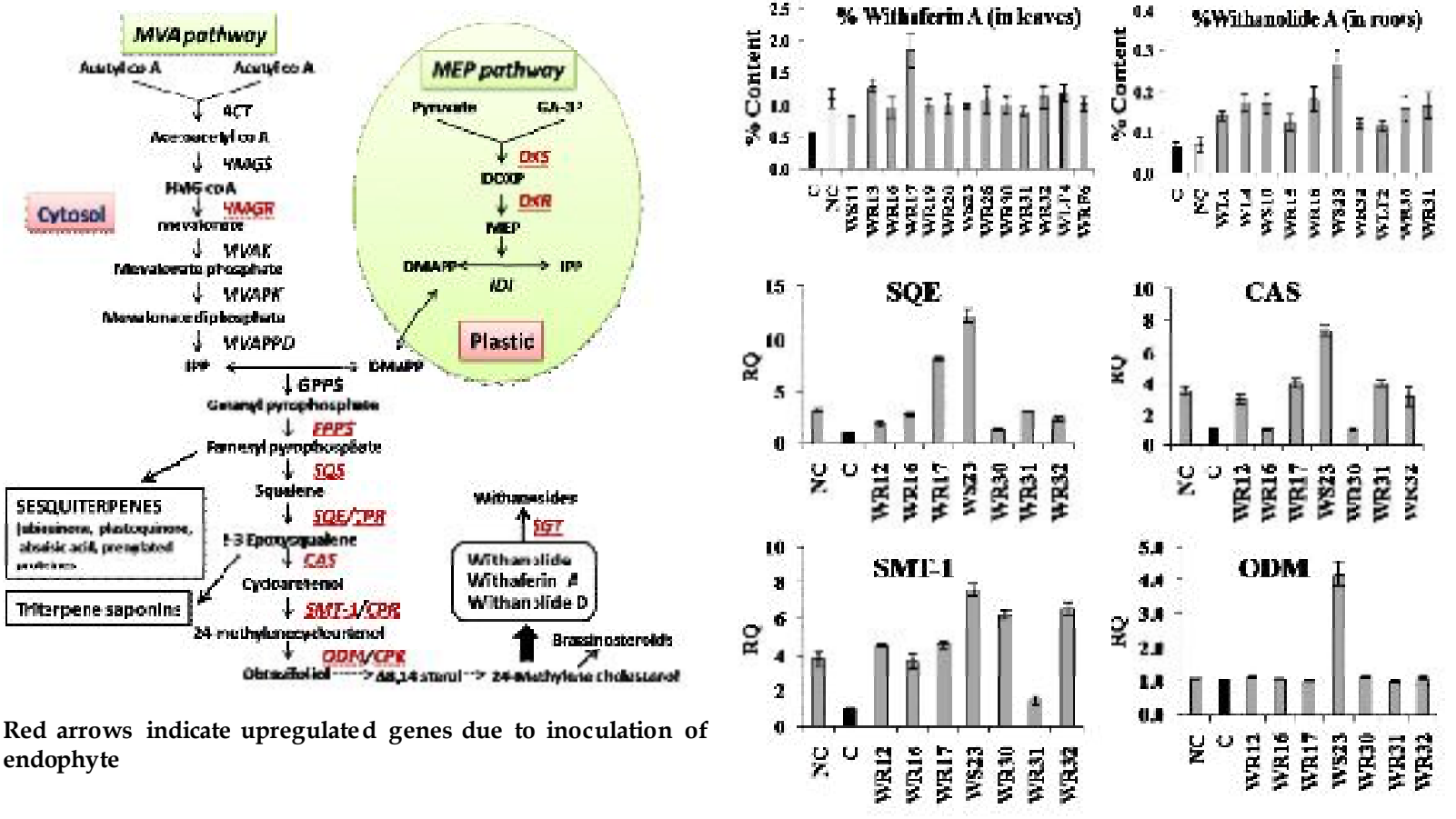


Endophytes moldulating the expression of structural and regulatory genes of TIA biosynthesis in *Catharanthus roseus*

Endophytes isolated from *Catharanthus roseus* enhanced *in planta* vindoline production by modulating the expression of structural and regulatory genes of terpenoid indole alkaloid (TIA) biosynthesis. Endophytes upregulated the expression of transcriptional activators and downregulated the expression of transcriptional repressors and enhanced vindoline production

Withania somnifera

Endophytes moldulating the expression of genes of withanolide biosynthesis in *Withania somnifera*



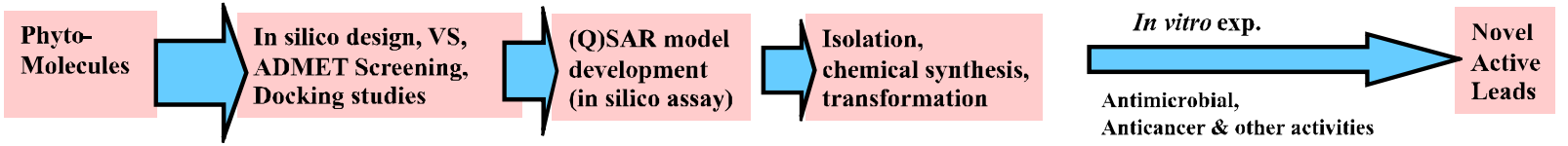
Red arrows indicate upregulated genes due to inoculation of endophyte

Endophytes isolated from *Withania somnifera* enhanced *in planta* withanolide production by upregulating the expression of key genes of withanolide biosynthesis

Project : Genomics and informatics solutions for integrating biology

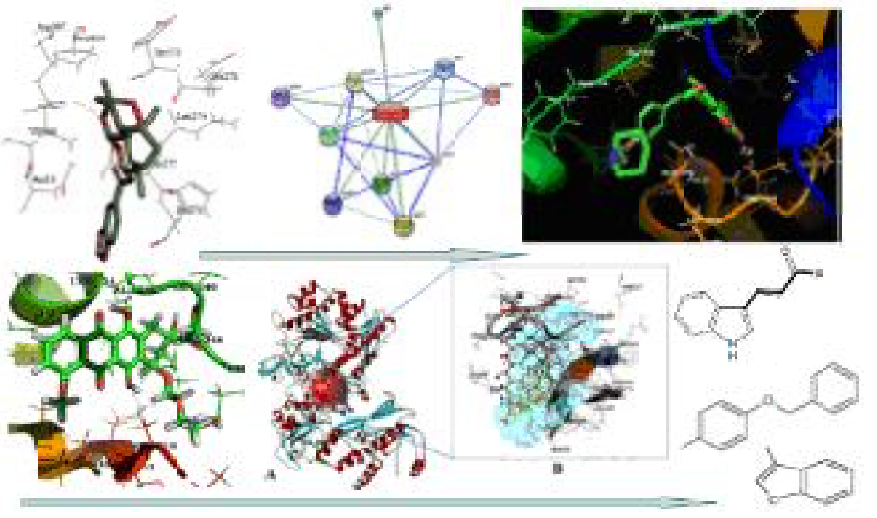
Optimization of active phytomolecules derivatives as lead against cancer & drug resistant bacterial pathogens

Development of *in silico*/*in vitro* screening methods and identification of anti-cancer and anti-bacterial leads



Outcomes:

- Identified chemical properties and target binding site responsible for anti-tubercular activity of chalcone derivatives against *M. tuberculosis H37Rv*.
- Identified chemical properties and target binding site responsible for anti-cancer activity of camptothecin derivatives against DNA topo I.
- Identified chemical properties and target binding site responsible for anti-tubercular activity of agents from *Glycyrrhiza glabra*.
- Identified chemical properties and target binding site responsible for anti-cancer activity of indolyl chalcones.



- Identified binding site and mode of action of cyclic 1,9-acetal derivatives of forskolin.

Conclusion: Natural anti-cancer and anti-TB agents were identified through chemical synthesis/lead optimization guided by *in vitro* activity evaluation, and *in silico* quantitative structure-activity relationship (QSAR), docking and ADMET studies.

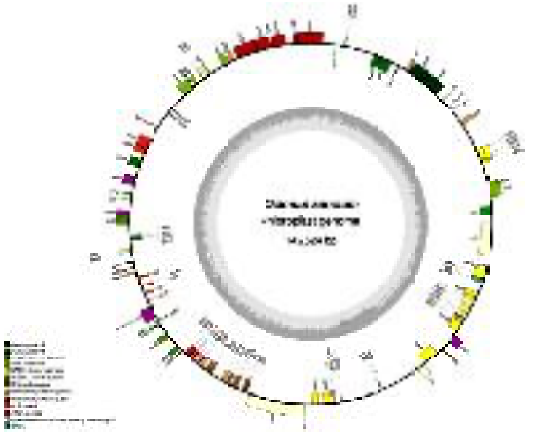
Input: SK Srivastava, AS Negi, A Gupta, MP Darokar, DU Bawankule, S Luqman, D Chanda

Project : Chemical biology of *Ocimum* and other aromatic plants

First report on complete nuclear and chloroplast genome of *Ocimum sanctum*

- Sequenced for the first time combining the sequence data from 4 libraries and three NGS platforms.
- The saturated draft assembly of the genome was about 386 Mb.
- Plastid genome of 142,245 bp.
- Pathway analysis indicated an abundance of phenylpropanoids in *O. sanctum*.

Description	Contigs	Scaffolds	GapClosed scaffolds	Super-scaffolds
Contigs Generated	107785	22776	22776	9059
Maximum Contig Length	115044	414711	411690	2211552
Minimum Contig Length	147	200	200	200
Average Contig Length	3454	16984	16629	44354
Total Contigs Length	372395755	386828951	378759759	401803260
Total Number of Non-ATGC Characters	0	17898452	2665702	26110056
Percentage of Non-ATGC Characters	0	4.627	0.704	6.498
Contigs >= 1 Kb	43174	14791	14769	4159
Contigs >= 10 Kb	11594	7544	7407	2357
N50 value	12769	61854	61242	303233
N90 value	2071	12742	12534	73672



Complete chloroplast genome

Repurposing L-menthol for systems medicine and cancer therapeutics? L-Menthol induces apoptosis through caspase 10 and by suppressing HSP90

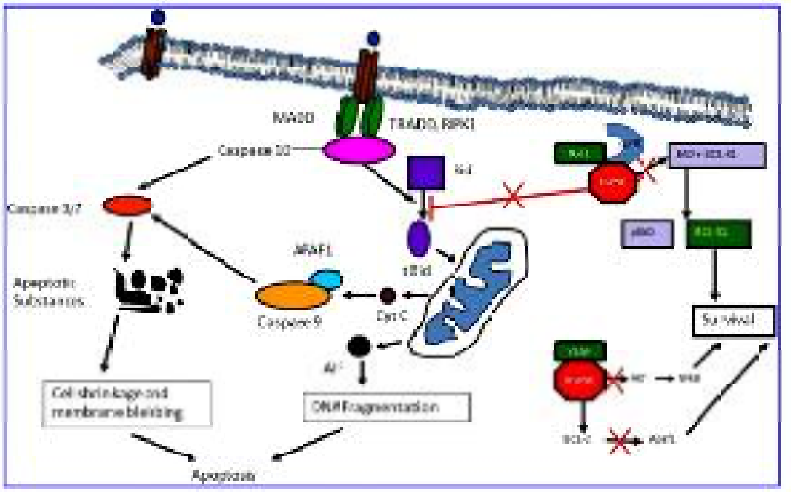
Monoterpenes like L-menthol might offer veritable potentials in systems medicine, for example, as cheaper anti-cancer compounds. Earlier, it has been shown that L-menthol modulates tubulin polymerization and apoptosis to inhibit cancer cell proliferation. An apoptosis-related gene microarray in conjunction with proteomics analyses as well as *in silico* interpretations has now been used to study gene expression modulation in human adenocarcinoma Caco-2 cell line in response to L-menthol treatment. The microarray analysis identified caspase 10 as the important initiator caspase, instead of caspase 8.

The proteomics analyses showed down-regulation of HSP90 protein (also corroborated by its low transcript abundance), which in turn indicated inhibition of AKT-mediated survival pathway, release of pro-apoptotic factor BAD from BAD and BCLxL complex, besides regulation of other factors related to apoptosis.

Based on the combined microarray, proteomics and *in silico* data, a signaling pathway for L-menthol-induced apoptosis has been presented for the first time.

Model predicting the possible mode of action of L-menthol

As described, the initial response is through Caspase 10 and followed by Caspase 3 and Caspase 7. Caspase 10 may also influence the activation of BID to tBID. This step is inhibited by HSP90, but due to lower expression in L-menthol-treated cell, the availability of HSP90 decreases. After release of cytochrome c from mitochondria, APAF1 and Caspase 9 induce Caspase3 and Caspase 7 towards apoptosis. HSP90 may not be available insufficient amount to trigger the AKT- and NFkB-mediated survival pathway. Similarly, BAD (a pro-apoptotic factor) is released from the complex "BAD and BCL-xL" due to low availability of HSP90.



OMICS: A Journal of Integrative Biology 20, 53-64, 2016

New report of a sweet basil leaf blight caused by *Cochliobolus lunatus* in India

During the rainy season a severe leaf blight was observed on sweet basil plants in experimental fields (approximately 5 ha) at the CSIR-CIMAP and adjoining areas in Lucknow. Initial symptoms comprised small, irregular, necrotic lesions that coalesced into leaf blight and the leaves turned black during wet and humid conditions. The incidence of symptoms ranged from 20 to 30% and blackish-brown fungal colonies developed on PDA. Brown conidiophores that were cylindrical, septate, unbranched, and straight or geniculate near the apex were seen under microscope. Conidia were three-septate, mostly curved at the third cell from the base; intermediate cells were brown or dark brown; terminal cells were subhyaline or pale brown and 16 to 23.5 × 8.5 to 11.5 µm. On the basis of these characteristics, the fungus was identified as *Cochliobolus, lunatus* (anamorph *Curvularia lunata* (Wakk.) Boedijin). Genomic DNA was extracted and subjected to a polymerase chain reaction (PCR) assay with the universal primers ITS1 and ITS4. The amplified product was cloned, sequenced

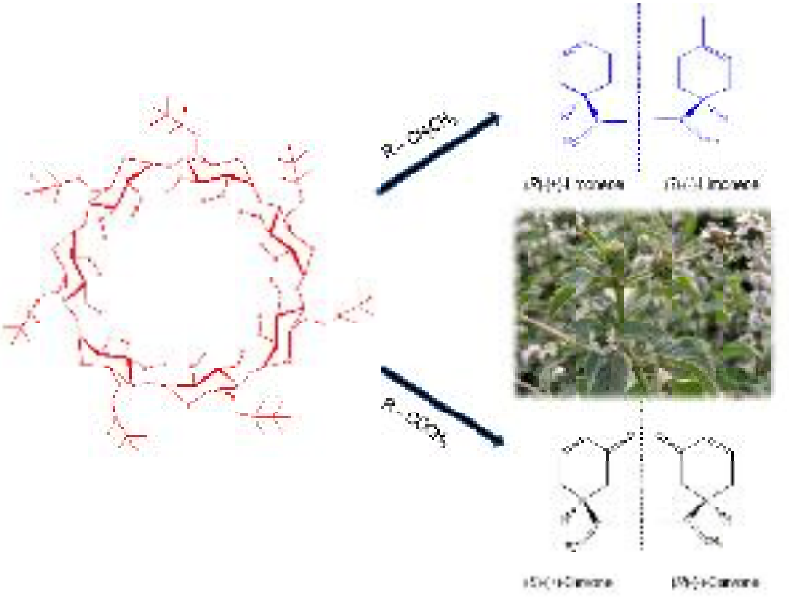
Fig. a. Symptoms on sweet basil infected with *C. lunatus*; b. Conidiophore with conidia attached sympodially; c. Single conidium of *C. lunata*, the anamorph of *C. lunatus*

(KM272001) and showed greatest homology (98% similarity) with the ITS sequence of *C. lunatus* (GenBank Accession No. DQ836800). A pathogenicity test was carried out using 10 plants in pots and five plants treated similarly with sterilized, distilled water served as a control treatment. Fungi re-isolated from inoculated leaves resembled *C. lunatus* on the basis of microscopic and sequence data, fulfilling Koch's postulates. To our knowledge, this is the first report of a sweet basil leaf blight caused by *C. lunatus* in India.

Input: A. Samad

Role of substituents in cyclodextrin derivatives for enantioselective gas chromatographic separation of chiral terpenoids in the essential oils of *Mentha spicata*

Enantioselective GC–FID and enantioselective GC–MS have been utilized under temperature gradient mode with differently substituted heptakis- and octakis-cyclodextrins to achieve the resolution of chiral terpenoids in the essential oil of indigenously grown cultivars of *Mentha spicata*. Chiral constituents such as (+)-isomenthone, (–)-menthone, (1*R*,2*S*,5*R*)-(–)-menthol and (4*S*)-(+)-piperitone exist as a single enantiomer with >99% excess. Existence of (*R*)-(+)-limonene and (*S*)-(+)-



carvone enantiomers has been proven first time in *M. spicata* essential oils and can be used as the marker for Indian origin.

J. Chromatogr. B 1002: 30-41, 2015

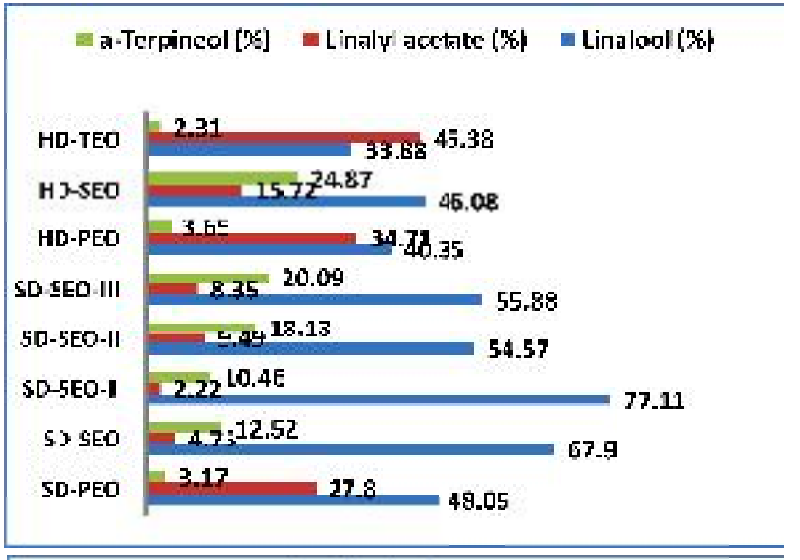
Anti-phytopathogenic activity of *Syzygium cumini* essential oil, hydrocarbon fractions and its novel constituents

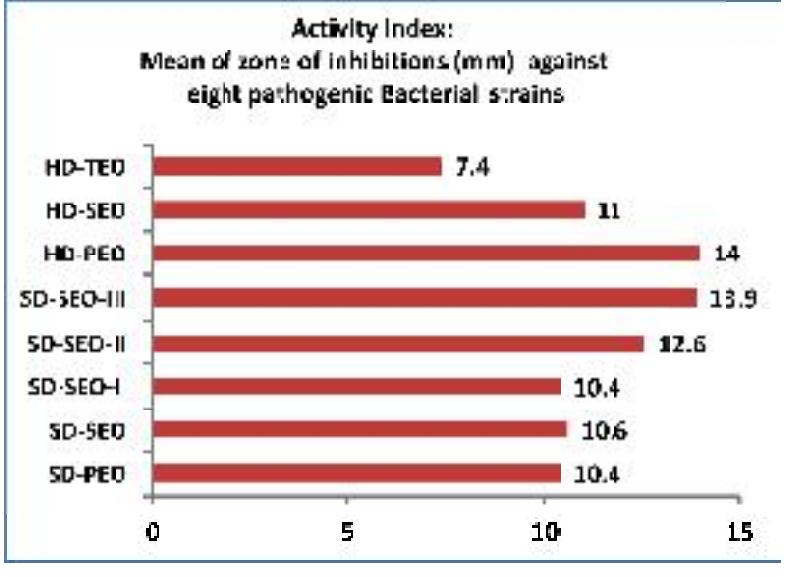
This study aimed to explore natural anti-phytopathogenic compounds for plant disease management. The essential oil of *Syzygium cumini* and its compounds were screened for their anti-fungal assay against two phytopathogenic fungi, *Rhizoctonia solani* AG 4HG-III and *Choanephora cucurbitarum*. The findings suggest that 7-hydroxycalamenene, 7-acetoxycalamenene, 1-epi-cubenol, α-terpineol, and (*Z*)-β- & (*E*)-β-ocimene have a potential as antifungal agents for the medicinal plants. A novel compound 7-acetoxycalamenene has been reported from a natural source for first time.

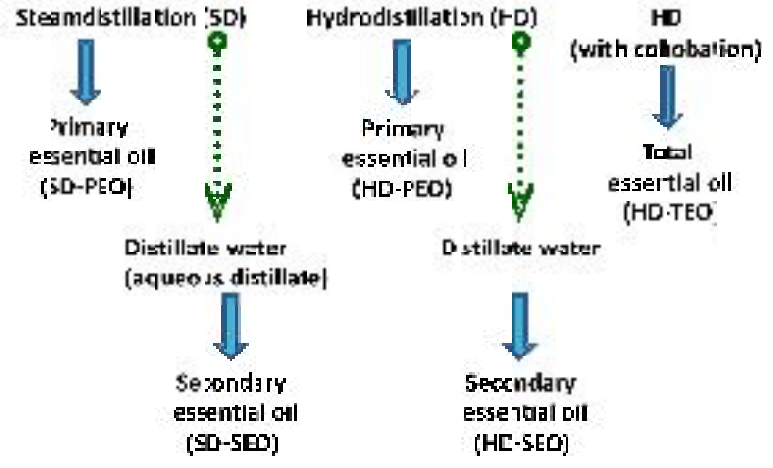
Industrial Crops and Products 74: 327-335, 2015

Chemical composition and anti-microbial activity of bergamot mint (*Mentha citrata*) essential oils isolated from the herbage and aqueous distillate using different methods

The essential oil of bergamot mint was isolated using steam and hydrodistillation methods. The essential oil and aqueous distillate volatiles (hydrophilic fractions) were isolated. The comparative chemical compositions and anti-bacterial







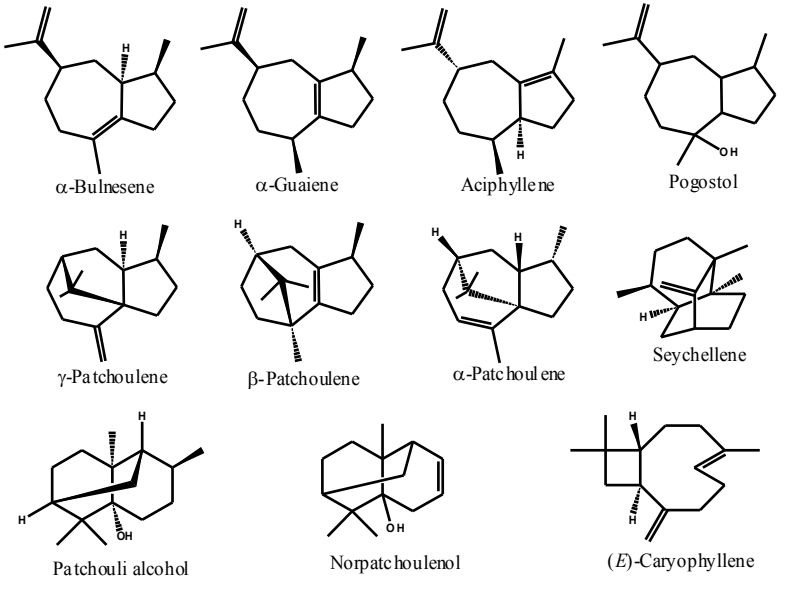
Flow chart of the experiment

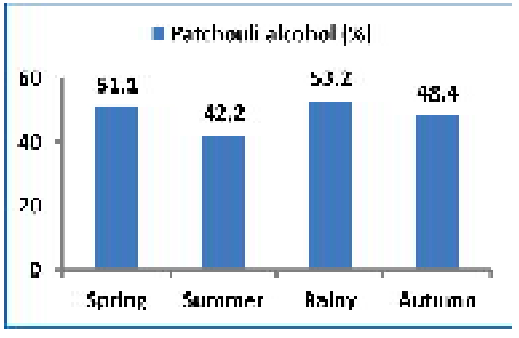
activity were assessed. The chemical composition was substantially influenced by type of essential oil and isolation methods. The anti-bacterial activity against test strains (ZOI: 0.0–27 mm; MIC: 125– >1000 µg/mL) was substantially influenced by the type of essential oil and isolation methods.

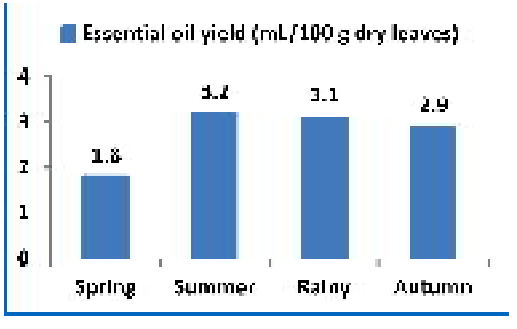
Input: RS Verma

Essential oil composition of patchouli (*Pogostemon cablin*) harvested over different seasons in the subtropics

To explore the possibility of commercial cultivation of patchouli [*Pogostemon cablin* (Blanco) Benth.], the crop was grown in the subtropical region of north India. The essential oil yield during the different seasons varied from 1.8% to 3.2% in dried leaves. The oil yield was highest in summer followed by rainy season. The oil was mainly composed of sesquiterpenoids (86.8-92.2%), represented by oxygenated sesquiterpenes (47.8-60.4%), and sesquiterpene hydrocarbons (29.9-39.0%). The major constituents of the oil were patchouli alcohol (42.2-53.2%), α-bulnesene (9.0-13.0%),







α-guaiene (6.4-8.4%), pogostol (4.0-5.0%), seychellene (3.4-4.2%), α-patchoulene (2.1-2.8%), and (*E*)-caryophyllene (2.1-2.7%). The results show that the cultivation of patchouli in subtropical region can produce superior quality oil and would be competitive in the market for essential oils.

Input: R.S. Verma

Chemical composition of essential oil and rose-water extract of Himalayan musk rose (*Rosa brunonii*)

Rosa brunonii (Rosaceae) is commonly known as 'Himalayan musk rose' or 'Kunja'. The leaf, flower, bark, and root of the plant are used in the traditional medicine. The aim of the present study was to characterise the aroma constituents of flower essential oil and hydrolate (rose-water) extract of *R. brunonii* growing abundantly in the Kumaon region of western Himalaya. Fifty-two constituents, comprising 93.5% of the total oil composition were identified using gas chromatography-flame ionization detector (GC-FID) and GC-mass spectrometry (GC-MS). The major constituents of the oil were eugenol (23.9%), geraniol (19.2%), n-heneicosane (7.7%), n-nonadecane (6.4%), and α-pinene (5.7%). However, main constituents of the rose-water extract were eugenol (52.0%), geraniol (13.3%), phenyl ethyl alcohol (9.4%), n-heneicosane (4.5%), and n-tricosane (3.0%).

Input: RS Verma

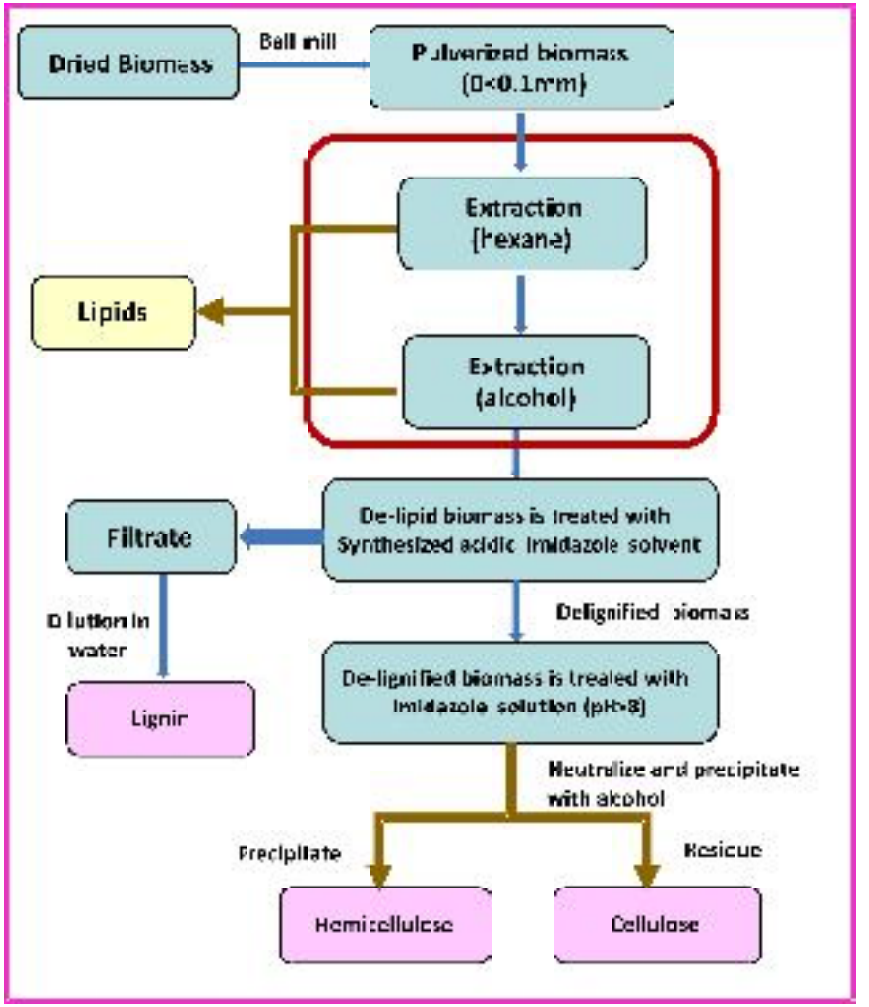
Essential oil composition of *Perilla frutescens*

The essential oil of *Perilla frutescens* (purple type), extracted at flowering and seed setting stages was analysed using GC-FID and GC-MS. The yield of essential oil was 0.24-0.25% on dry weight basis. A total of 31 constituents, representing 91.7-95.2% of the total oil composition were identified. Major

constituents of the oils were perilla ketone (63.3% and 48.2%), isoegomaketone (10.1% and 9.1%), (*E*)-caryophyllene (5.6% and 11.2%), germacrene D (2.4% and 7.4%), linalool (3.3% and 3.1%) and perillene (1.4% 3.3%).

Input: R.S. Verma

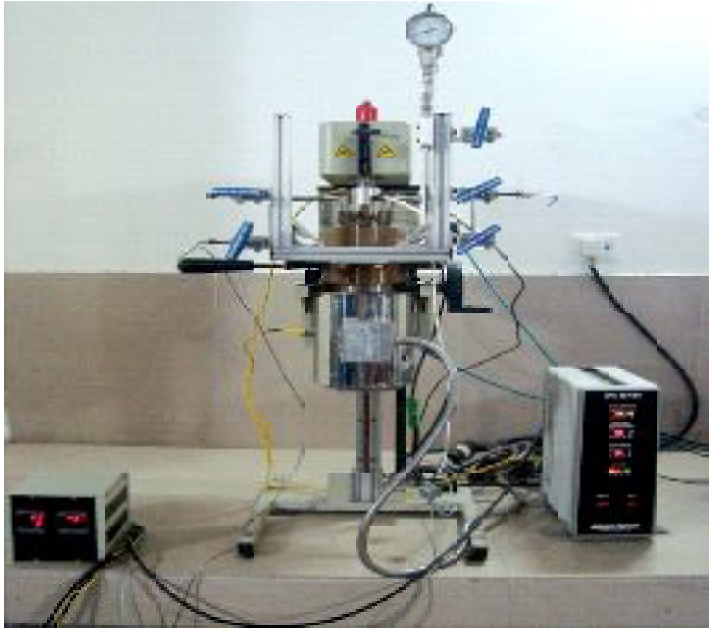
Process for isolation of major biopolymer from aromatic biomass



Flow diagram of the process

Important steps of the process

- Pulverizing the dry spent aromatic biomass to a particle size of <0.1 mm
- Isolation of lipids in organic solvents
- Isolation of lignin from aqueous filtrate
- Isolation of hemicellulose as precipitate with alcohols
- Isolation of cellulose as solid particle



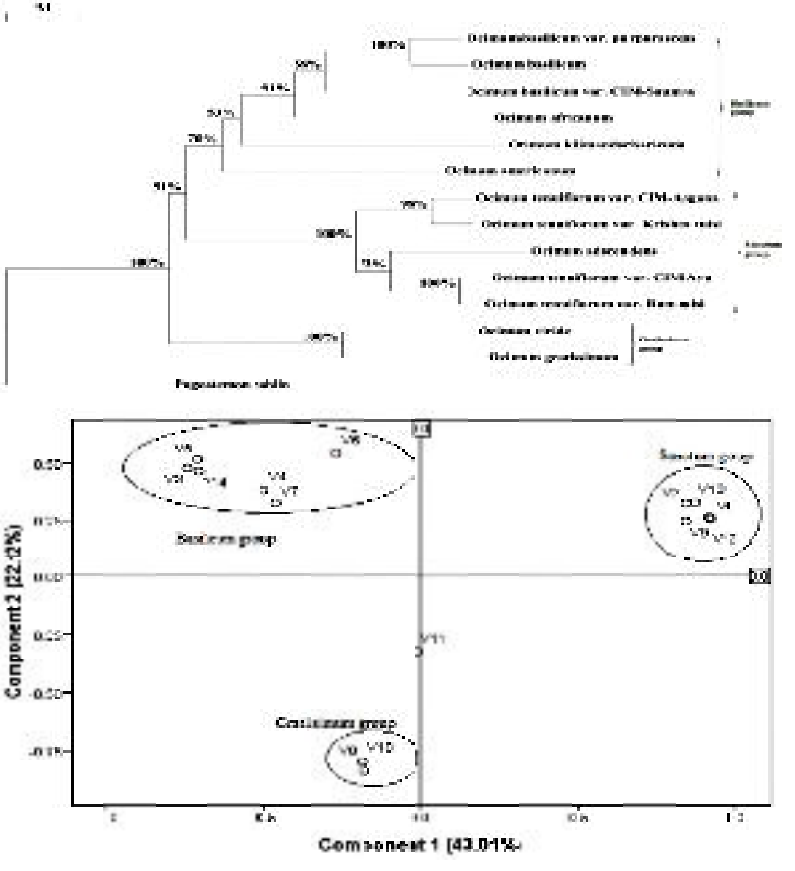
A view of the instrument setup

Patent India 0269NF2014; Input: PK Rout, AD Nannaware

Higher efficiency of ISSR markers over plastid *psbA-trnH* region in resolving taxonomical status of genus *Ocimum* L.

A high level of morphological and chemical variability exists within the genus *Ocimum* and, its taxonomy and

Neighbour joining tree with ISSR dataset

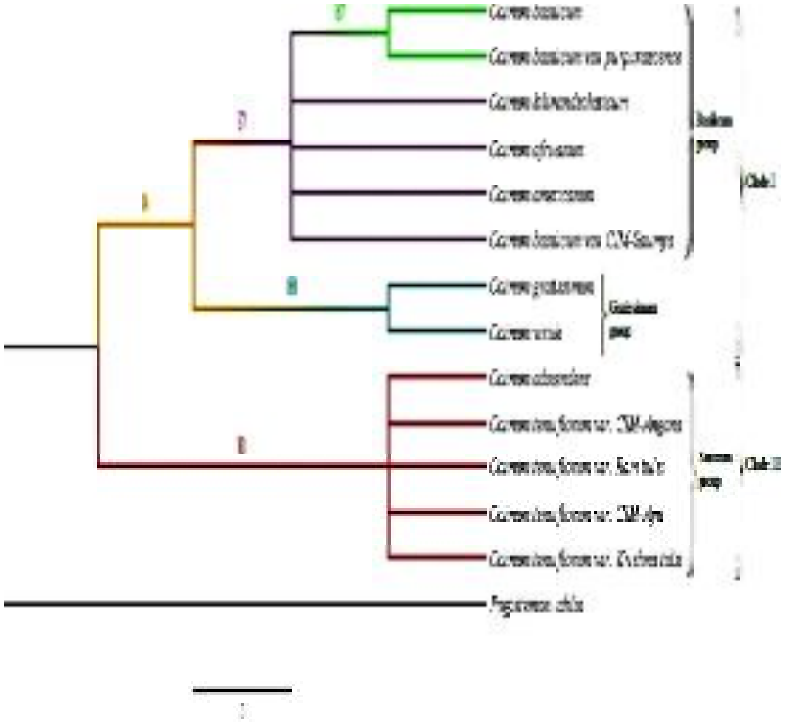


Geographical location of *Ocimum* seed collections

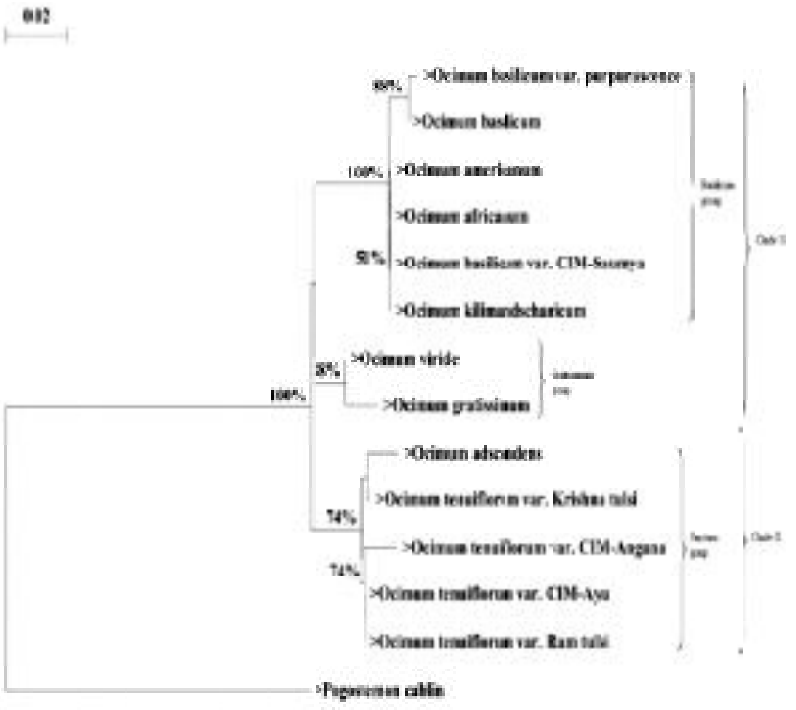
SN	Species	Place of collection	State
1	*Ocimum tenuiflorum* var. Ram tulsi	Venkates-warapuram	Tamil Nadu
2	*Ocimum tenuiflorum* var. Krishna tulsi	Rasipuram	Tamil Nadu
3	*Ocimum basilicum*	Hilsa	Bihar
4	*Ocimum africanum*	Kanyakumari	Tamil Nadu
5	*Ocimum basilicum* var. purpurascens	Vasudevanallur	Tamil Nadu
6	*Ocimum americanum*	Vellur	Tamil Nadu
7	*Ocimum kilimandscharicum*	Yercaud	Tamil Nadu
8	*Ocimum gratissimum*	Yercaud	Tamil Nadu
9	*Ocimum adscendens*	Rajapalayam	Tamil Nadu
10	*Ocimum viride*	Jammu Tawi	Jammu & Kashmir
11	*Pogostemon cablin*	Bangalore	Karnataka
12	*Ocimum tenuiflorum* var. CIM-Ayu	Lucknow	Uttar Pradesh
13	*Ocimum tenuiflorum* var. CIM-Angana	Lucknow	Uttar Pradesh
14	*Ocimum basilicum* var. CIM-Saumya	Lucknow	Uttar Pradesh

phylogenetic relationships are still doubtful. For evaluating the inter-specific genetic relationships among the *Ocimum* species, genotyping with intersimple sequence repeat (ISSR) markers and sequence analyses of non-coding *psbA-trnH* inter-genic region belonging to chloroplast DNA, were carried out. The average polymorphic information content (0.344) and resolving power (6.285) depicted through ISSR markers proved to be efficient in discriminating the studied species of *Ocimum*. The primers used in the present study revealed 99.585% polymorphism across the species demonstrating the polymorphic nature of ISSR markers.

The present study revealed that the ISSR markers are more efficient than *psbA-trnH* sequences in resolving the current status of *Ocimum* L. genus. The study provides information for potential application of ISSR markers in the phylogenetic



Maximum parsimony and neighbour joining tree with *psbA-trnH* data set

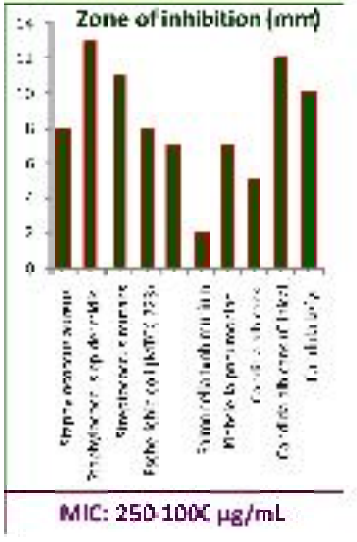


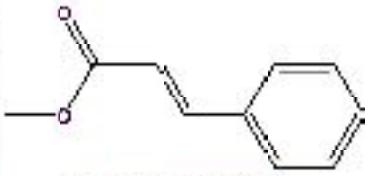
investigation. The technique has scope in resolving intra- or inter-specific status in many genera or in deciding the uniqueness of different genera within a family.

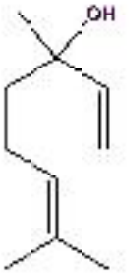
Input: V. Sundaresan

Ontogenic compositional variability in 'linalool-menthyl cinnamate' chemotype of *O. basilicum* in two cropping seasons

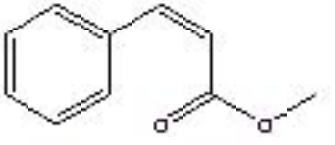
An experiment was carried out to study the effect of growth stages [vegetative, half bloom, full bloom and seed setting (SS)] and cropping seasons on essential oil yield and composition of 'methyl cinnamate-linalool' chemovariant of *Ocimum basilicum* L. from India. Essential oil yield was 0.28–0.32% and 0.40–0.52% during spring-summer and rain-autumn cropping season, respectively with the maximum at full bloom stage. Phenyl propanoids (42.4–74.0%), represented by (*E*)-methyl cinnamate (36.6–66.4%),







Linalool



(Z)-Methyl cinnamate

(Z)-methyl cinnamate (5.4-7.6%); and monoterpenoids (19.9-46.0%), represented by linalool (11.2–43.8%). The essential oils were subject of considerable variation in their composition during the various developmental stages of two cropping seasons, particularly concerning the content of (*E*)-methyl cinnamate and linalool. Anti-microbial study results showed that the essential oil possessed good anti-bacterial activity against *Streptococcus mutans*, *Staphylococcus epidermidis*, *Escherichia coli*, and antifungal activity against *Candida kefyr* and *Candida albicans*.

Input: R.C. Padalia

Chemical characterization the essential oil of *Artemisia stelleriana* from India

Artemisia stelleriana (Asteraceae) is commonly known as 'dusty miller' is used traditionally as a carminative and in treatment of peptic ulcer. Essential oil yield was 0.15% (v/w) on fresh weight basis. A total of fifty-three constituents, forming 90.41% of the total oil compositions were identified.

Compounds	Content (%)
1,8-Cineole	29.32
cis-Sabinene hydrate	1.95
cis-Chrysanthenyl acetate	1.45
β-Caryophyllene	1.93
Germacrene D	9.91
Artedouglasia oxide C	5.22
Artedouglasia oxide A	6.55
Lacintha furanone H	1.86
Artedouglasia oxide D	3.55
Davanone B	2.41
Caryophyllene alcohol	0.60
Artedouglasia oxide B	3.81
Vulgarone B	4.16
Class composition	
Monoterpene hydrocarbons	1.72
Oxygenated monoterpenes	39.91
Sesquiterpene hydrocarbons	17.80
Oxygenated sesquiterpene	30.98
Total identified (%)	90.41

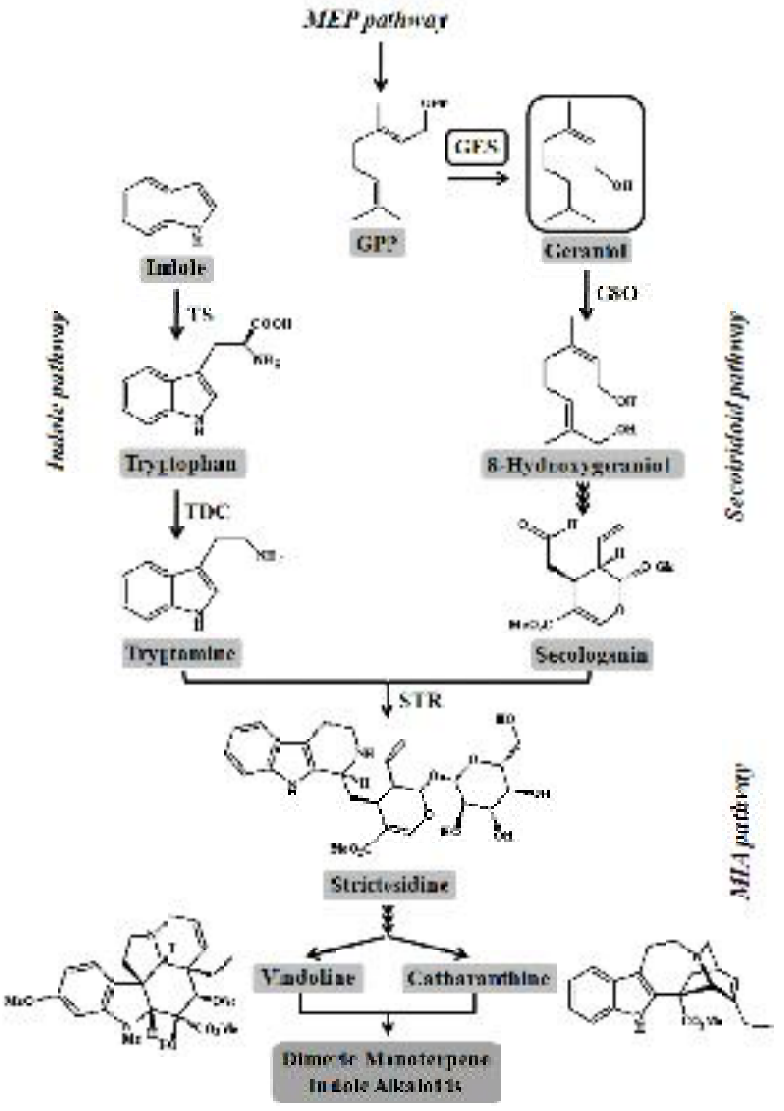
Input: R.C. Padalia

Critical role of geraniol in monoterpene indole alkaloid (MIA) biosynthesis in *Catharanthus roseus*

Feeding of *Catharanthus roseus* leaves with geraniol without tryptophan (precursor for tryptamine) increased the accumulation of the MIAs catharanthine and vindoline, indicating the limitation of geraniol in MIA biosynthesis. This was validated by molecular and *in planta* characterization of *geraniol synthase*, which catalyzes geraniol formation.

VIGS of *CrGES* drastically reduced the MIA content, which was restored to near-WT levels on geraniol feeding. Moreover, the transient over-expression of *CrGES* in *C. roseus* leaves increased MIA content. *CrGES* expression exhibited correlation with MIA levels in leaves of different *C. roseus* cultivars and has signiûcantly lower expression relative to other pathway genes.

Our results demonstrated that the transcriptional regulation of *CrGES* and thus, the *in planta* geraniol availability plays crucial role in MIA biosynthesis. The overexpression of

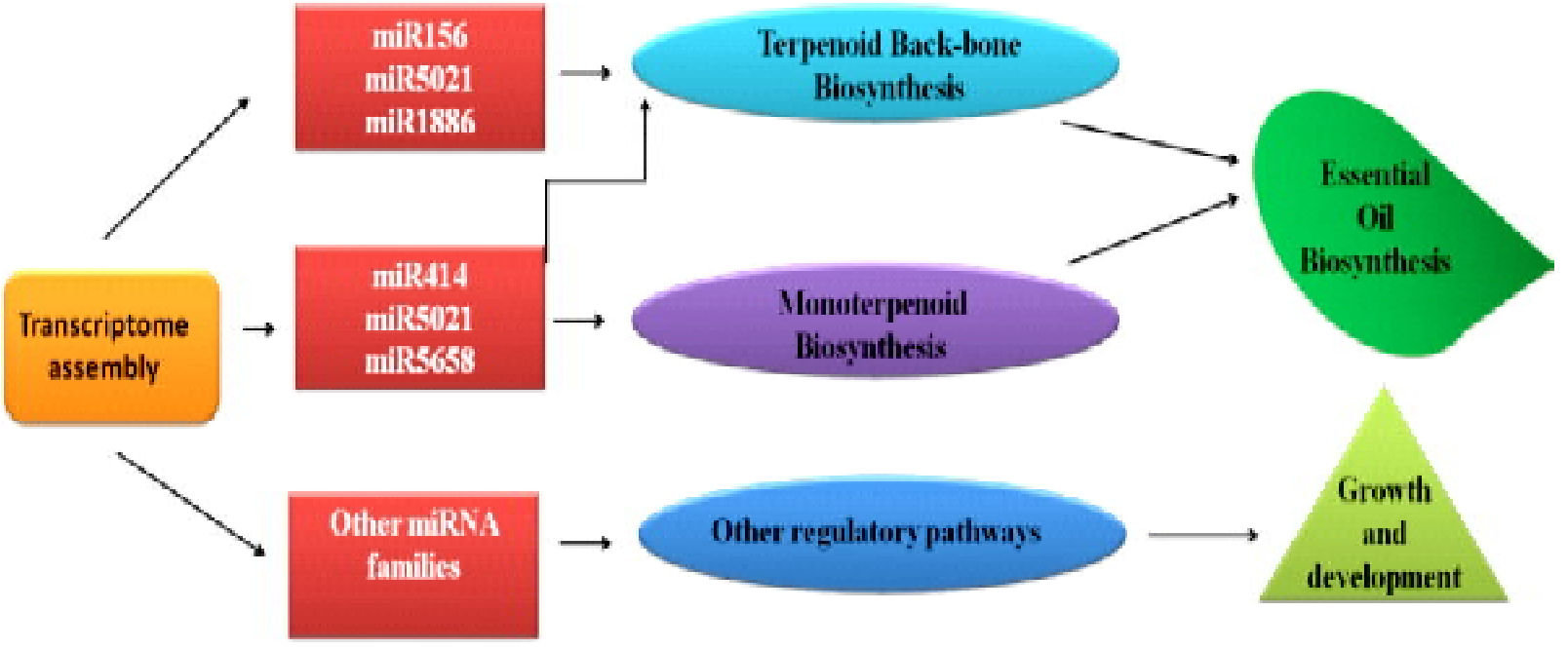


GES can be a used as a metabolic engineering tool to increase the MIAs in *C. roseus*.

Plant Science 239: 56–66, 2015
Input: DA Nagegowda, AK Shukla, K Shanker

In silico identification of miRNAs and their targets involved in the secondary metabolic pathways of *Mentha* sp. using a transcriptome assembly

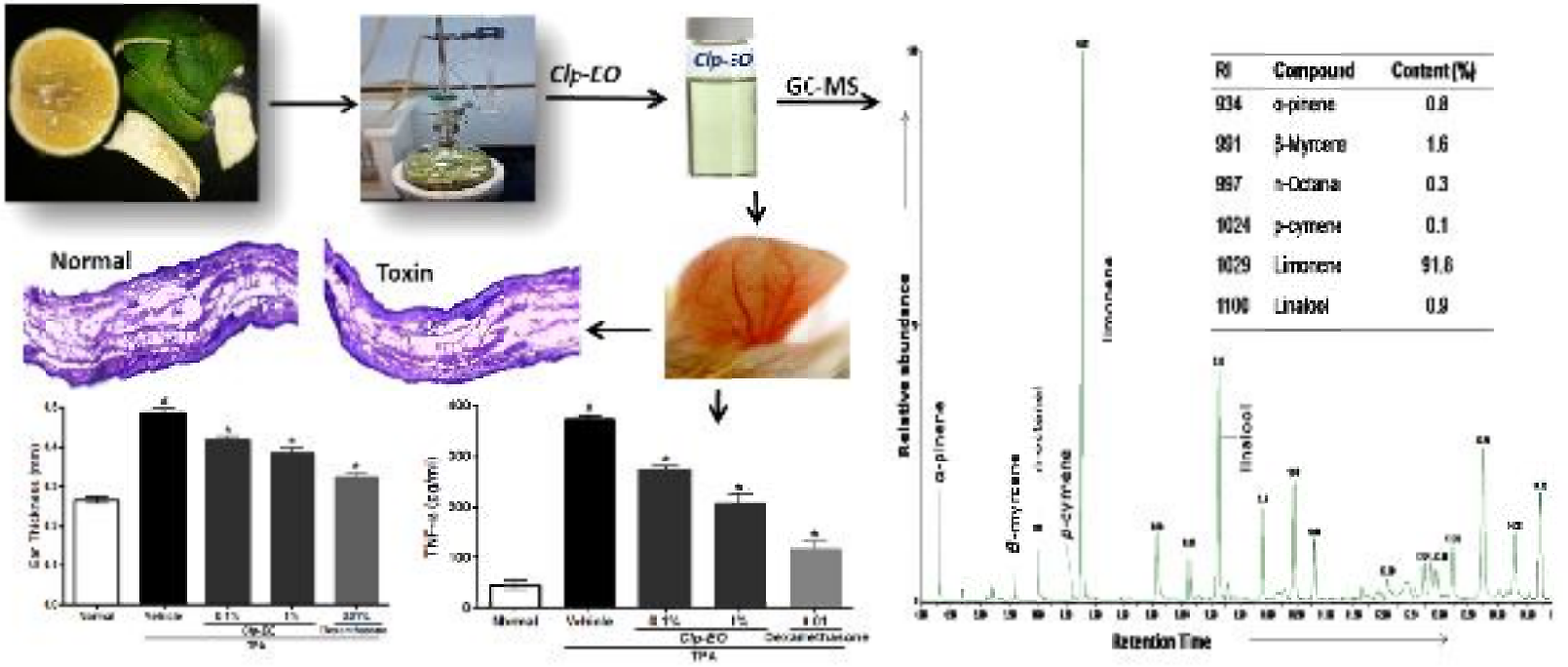
The endogenous small non-coding functional microRNAs govern the regulatory system of gene expression and control the growth and development of the plant. *Mentha sp.* are well known herb for its flavor, fragrance, and medicinal properties. In the present study, we used a computational approach to identify miRNAs and their targets involved in different secondary metabolic pathways. Additionally, phylogenetic and conservation analysis were also done for the predicted miRNAs. 44 candidate miRNAs were identified which belonged to 24 miRNAs families. We reported 14 miRNA families for the first time for Lamiaceae family. A total of 361 targets were predicted for 16 miRNAs families. All the predicted targets regulated by predicted miRNAs were shown to control the reproduction, signaling, stimulus response, developmental processes and also different metabolic process. The study reveals that the regulatory system of essential oil biosynthesis may be governed by miR156, miR414, miR5021, miR5658 and miR1886 families in mint family through different aspects as CYP450s and stress with probable involvement in secondary metabolite pathways. Furthermore, five miRNA



candidates (miR156, miR414, miR5021, miR838, miR5015b) were observed to be involved in trichome development also. To the best of our knowledge this is the first *in silico* study describing miRNAs and their regulation in secondary metabolic pathways in *Mentha* sp.

Essential oil of *Citrus limetta* peels reduces pro-inflammatory cytokine production and attenuates skin inflammation

The essential oil from peel of *Citrus limetta* (*Clp-EO*) was analyzed using GC-MS and subjected to pharmacological evaluation for the exploration of its effect on skin inflammation using *in vitro* and *in vivo* bioassays. The chemical fingerprint of *Clp-EO* revealed the presence of monoterpene hydrocarbon and limonene is the major component. The pro-inflammatory cytokines production (TNF-α, IL-6, IL-1β) was significantly inhibited by *Clp-EO* in dose-dependent manner in cell culture supernatant as well as in ear homogenate .The ear thickness and histological damage in inflammatory ears were also significantly inhibited by topical application of *Clp-EO* .

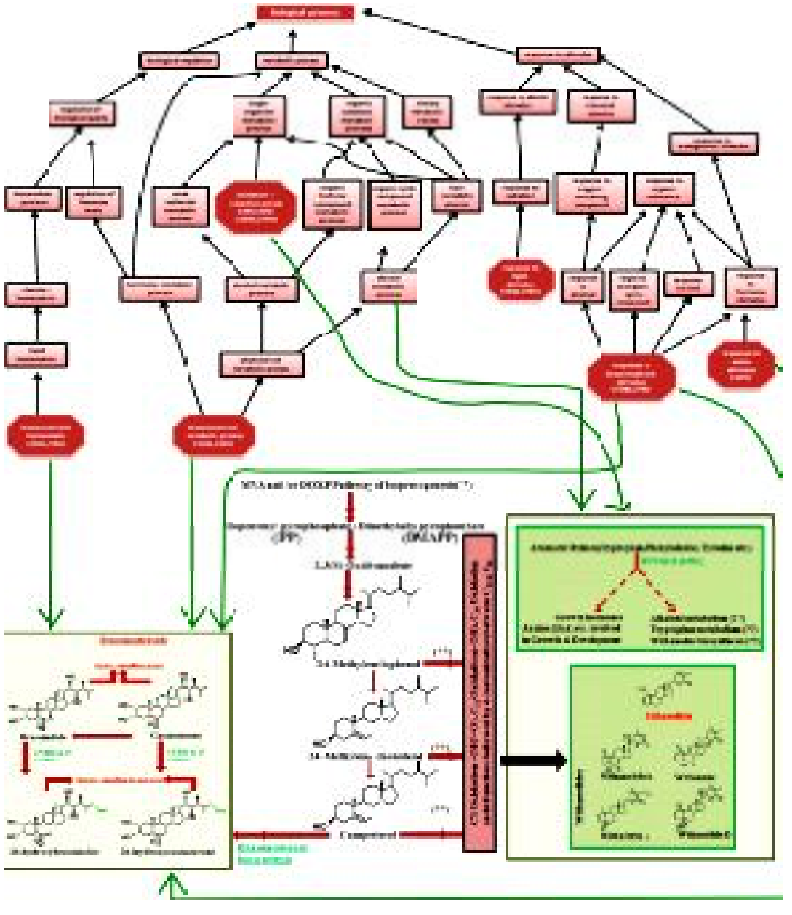


The findings suggest the *Clp-EO* as a therapeutic candidate for further investigation towards the management of skin inflammation.

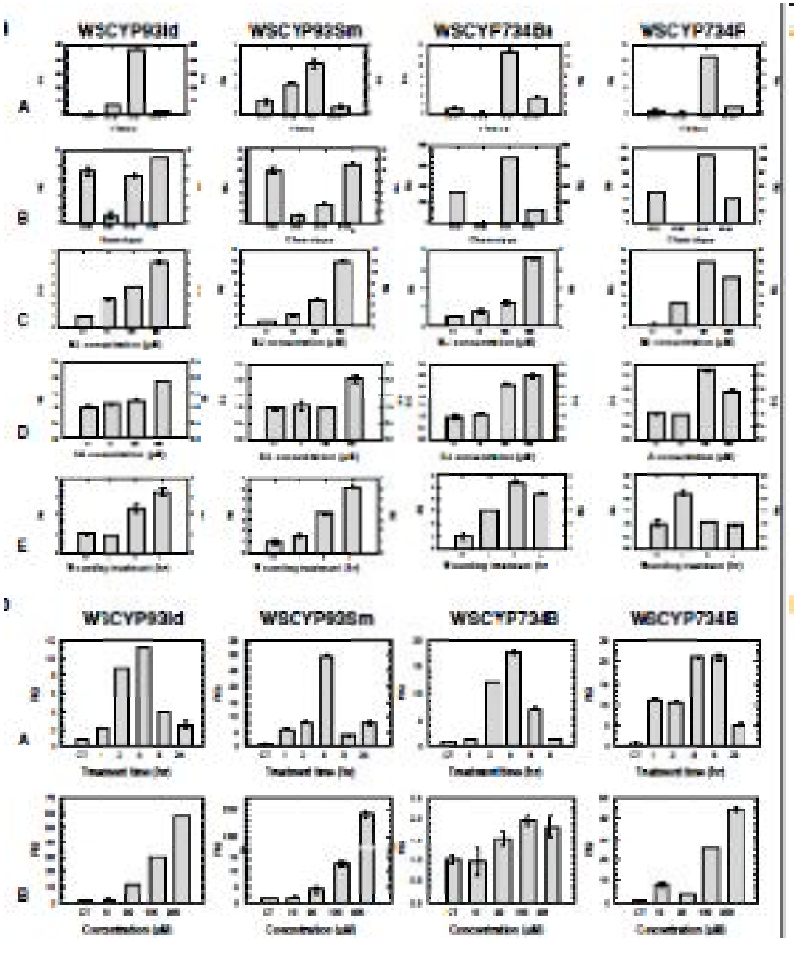
Input: DU Bawankule, CS Chanotiya, Anirban Pal

Light and auxin responsive cytochrome P450s from *Withania somnifera* Dunal: cloning, expression and molecular modelling of two pairs of homologue genes with differential regulation

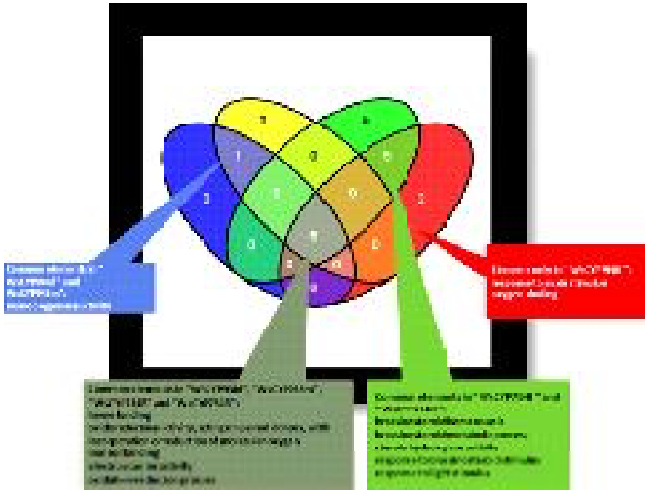
- Cytochrome P450s (CYPs) catalyse a wide variety of oxygenation/ hydroxylation reactions that facilitate diverse metabolic functions in plants.
- Four complete complementary DNAs (cDNAs) of CYP genes were isolated, christened as WSCYP93Id, WSCYP93Sm, WSCYP734B and WSCYP734R from *Withania somnifera*.
- Phylogenetic and molecular modelling analysis, categorized WsCYPs into two CYP families, CYP83B1 and CYP734A1.
- Their differential expression profiles were analyzed in the leaf tissues of selected chemotypes of *W. somnifera* as well as in response to treatments such as methyl



Combined biological process GOgraph depicting involvement of the four cytochrome P450 proteins in various processes.

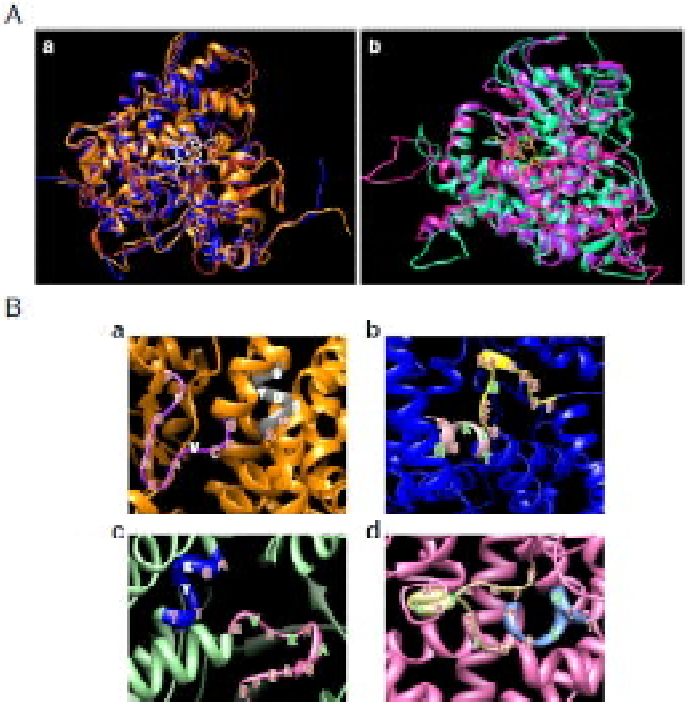


Quantitative expression analysis of all four WsCYPs in different tissue, chemo type and treatments.



Individual assignment of the GO terms to the four CYP proteins of *W. somnifera* and their possible involvement in metabolic processes

Phylogram of cytochrome P450s (WSCYPs) and other plant CYPs belonging to different families of CYP superfamily.



Predicted protein models for the four WSCYPs: A Models superimposed with their respective templates and focused heme site; B Conserved domains of the four proteins

jasmonate, wounding, light and auxin.

- WSCYP93Id was heterologouly expressed in *E. coli* and catalytic capabilities of the recombinant WSCYP93Id protein

Protoplasma 252:1421-37, 2015
Input: NS Sangwan

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

Technology licensings

M/s U Toll Corporation Limited, Delhi for the technology transfer for low cost sanitary Napkin (Rs. 14.60 Lakhs)

M/s T.A Herbals for licensing of knowhow for pain relieving oil Relexomap (Rs. 5.70 lakhs)

M/s Pirnic Pharma, New Delhi for licensing of knowhow for pain relieving oil Relexomap (Rs. 5.70 lakhs)

M/s BGP, Healthcare Private Limited, Mehasana, Gujarat, for licensing of knowhow for Artemisinin from *Artemisia annua* herb. (Rs. 4.56 lakhs)

Market Survey

Major markets of the medicinal and aromatic plants were surveyed at different locations in northern part of the country. The locations included Faizabad, Basti, Gorakhpur, Kushinagar, Barabanki and Lucknow. The major commodities traded were Ashwagandha, Satavar, Kalmegh, Serpgandha, Amla, dry rose flowers and essential oils of menthol mint, lemongrass, palmarosa, vetiver and tulsi along with other MAPs in smaller quantities. About 15 wholesellers, retailers and buyers were identified during the survey for solving the marking problem of farmers.

Training programmes on the production medicinal and aromatic plants

15 – 16 January, 2015, Lucknow, 43 participants, sponsors Directorate of Horticulture, Government of UP

17 January, 2015, Gorakhpur, 514 participants, sponsors Horticulture Department Government of UP

20 – 22 January, 2015, Lucknow 40 participants, sponsors ATMA Siwan, Bihar

27 – 28 February, 2015, Basti, 112 participants, sponsors NMPB, New Delhi

11 – 13 March, 2015, Lucknow, 33 participants, sponsors, ATMA Madhepura Bihar

10 – 11 July, 2015, Mizoram, 30 participants, sponsors SIDBI

28 – 31 July, 2015, Lucknow, 57 participants, sponsors SIDBI

14 – 16, October, 2015, Lucknow, 45 participants, sponsors, SIDBI

Training program for women on the making of agarbattis using floral bio-resource

26-27 October, 2015, Coimbatore, 30 tribal women participants, sponsors TRIFED. The self help group of tribal women has launched hand-made agarbattis under brand 'Puspa-gandha'.

31 October, 2015, Chandrika Devi temple near Bakshi-ka-Talab at the Women Entrepreneurial Training Facility of CSIR-CIMAP, 25 rural women The group has started making agarbattis and cones for marketing.

Visitors

About three thousand six hundred visitors comprising students (928), farmers (2545), government officials (175), and others (29) visited CSIR-CIMAP and were apprised about cultivation, processing and marketing of medicinal and aromatic plants.

Major events organized

One day awareness programme on the aromatic plants cultivation on 1 May, 2015 in the flood prone area of Saryu river in village Dingrapur of Basti district (125 farmers).

National Technology Day on 11 May, 2015 (about 100 farmers, entrepreneurs and women) The participants discussed the role of medicinal and aromatic plants technologies under climatic change conditions .

Awareness cum training programme on 4th and 5th November 2015 on MAPs suitable for Vidhrabha region of Maharashtra held at Gau Anushandhan Kendra, Davelapar, Nagpur (80 farmers)

One-day awareness programme on 7th December, 2015 at Gujarat, jointly organized with IPCA laboratories (about100 farmers)

One-day awareness programme 9th December, 2015 for the under-utilized lands of Bhuj (125 farmers). The participants were apprised of the cultivation practices of crops for lands affected by salt stress.

Two-day training programme for teachers from 15 – 16 December, 2015 (28 science/agriculture teachers). The program was supported by CSIR-HRDG, New Delhi.

Publicity and extension literature

- Two video films on Menthol mint and *Artemisia annua* cultivation (u-tube)
- 'Aus- Gyanya'- booklet on medicinal and aromatic crops (Hindi)
- CSIR-CIMAP Information Bro-chure (Hindi & English)
- Early Mint Technology Folder (Hindi)
- CIM Kranti Folder (Hindi)

Livelihood generation through MAPs adoption by tribal farmers of Dudhwa tiger reserve

About 30 demonstrations of the menthol mint cultivation were organized on tribal farmer's field in five villages of tiger reserve and the farmers were given hands on training on cultivation and processing aspects of mint and other suitable crops for the area. The farmers were also demonstrated the menthol mint cultivation with sugar cane as intercrop for additional income generation from limited resources. About 175 kg of menthol mint oil was produced by the farmers.

Field view of menthol mint with sugarcane as an inter crop

Agarbatti making training at Dudhwa Tiger Reserve

Two days training programme on agarbatti and rose water making was organized on 14 and 15 May, 2015 at two villages Chhediya Pashchim and Dhuskiya of Dudhwa Tiger Reserve district Lakhimpur Kheri. The programme was attended by about 200 women. The women were trained in agarbatti making and rose water distillation for extra income generation.

Kisan Mela 2016

The Kisan Mela 2016 was organized on 31st January 2016 in the Lucknow campus. The Union Minister of Science & Technology and Earth Sciences was the Chief Guest and Deputy Chairman, State Planning Commission Shri Naveen Chandra Bajpei and Shri Praveer Kumar Agriculture Production Commissioner, Uttar Pradesh were the Guests of Honor. About 5000 farmers and entrepreneurs from UP, Bihar, Punjab, Haryana, Madhya Pradesh, Gujarat, Rajasthan, Jharkhand, Odisha, Tamil Nadu and others states participated along with represen-tatives from MAPs industries (IPCA, Jindal Drugs, Herbochem Industries, AIMIL Pharmaceutical, PIRNIC Pharmaceutical, AMORE Laboratories, Ajmal Group and EOAI). Dr Harsh Vardhan in his inaugural address urged the farmers and entrepreneurs engaged in cultivation, processing and value addition in the area of medicinal and aromatic plants to adopt improved technologies and improved varieties for raising their income besides producing quality raw material by user industries.

Release of artemisia variety

Dr Harsh Vardhan, Hon'ble Minister visiting a stall at Kisan Mela

The major attractions of the kisan mela were interactive meet with farmers and entrepreneurs on the production and marketing of medicinal and aromatic plants, sale of high quality planting material of mint, aromatic grasses and other medicinal plant varieties developed by CIMAP and publications, demonstration of impro-ved plant varieties and herbal products, live demonstration of distillation/ processing using CIMAP's improved units, training on rose water and flower-based agarbatti making, demonstration of 'Early Mint Technology', integration of medicinal and aromatic plants in the traditional cropping system. A pilot-scale herbal product manufacturing unit 'Technology Business Incubator Centre (TBIC)' was also inaugurated by the Chief Guest. In TBIC, various machines have been installed to facilitate manufacturing of creams, gels, shampoo, oils, face wash, floor mopping liquid.

Input: Sanjay Kumar, VKS Tomar, Alok Krishna, RP Bansal, Ram Suresh, RP Yadav

Technologies transferred

Artemsinin extraction technology: Extraction and isolation technology for artemsinin from leaves of *Artemisia annua* was successfully demonstrated at 20 kg / batch size in Chemical Engineering pilot plant to M/s BGP International Ltd, Mehsana, Gujarat from 7-10 September 2015. CIMAP received an amount of Rs 4.66 lakhs as technology transfer fees.

Demonstration of artemisinin extraction technology

Preparation of a techno economic feasibility report: A techno feasibility report on the processing aspects for betel leaf and *Cyprus tagetum* essential oils being cultivated in Orissa for Mr. Pulkit Jain, Baleshwar, Orissa was prepared. A consultancy fee of Rs 34,000 was realized for the same.

Improved directly fired field distillation unit: An improved directly fired type field distillation unit of capacity 1000 kg/batch was designed, fabricated and installed for distillation of Mints and other aromatic crops at Village Ghursara, Gosaiganj Distt. Lucknow The unit was successfully commissioned at a programme held in May 2015.

Technology for mobile distillation unit: A mobile distillation unit was designed and developed by CSIR-CIMAP under a consultancy project for the Indian Institute of Integrative Medicine (CSIR-IIIM Jammu) in July 2015. The unit was successfully installed and was demonstrated by in the Kisan Mela organized by IIIM Jammu at Bhasuali in J&K. An amount of Rs 10 lakhs was realized from IIIM Jammu as consultancy charges for the same

Technical consultancy for designing and installation of improved directly fired field distillation unit:

Eight improved directly fired field distillation unit of 500 kg/batch were installed at KVK Munger, Bihar. The units have been designed, fabricated and successfully installed at eight different bio villages in and around 200 kms of Munger during the period of January to March 2015. The farmers of the area cultivating mentha distilled the oils using these units. An amount of Rs 18.72 lakhs was generated in form of ECF.

Five 500 kg/batch directly fired type improved field distillation units for mentha oil were designed and fabricated, and successfully installed and commissioned

under a Krishi Vigyan Kendra KVK Rohtas project in the district of Bikramganj, Bihar at five different villages in and around 200 kms of Bikramganj in May-June 2015. An amount of Rs 15.00 lakhs towards consultancy charges has been taken from KVK for the project.

Trainings

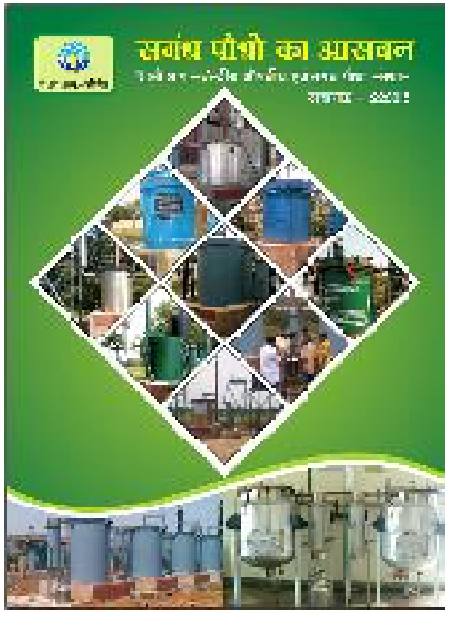
Entrepreneurial training on *Aloe vera* processing technologies

A four day entrepreneurial training programne on *Aloe vera* processing technologies was held from 1 – 4 December 2015. The course was designed to impart knowledge on the practical aspects of the technologies along with the details of plant and machinery, economics of production, details of preservatives, stabilizers, quality monitoring etc. The course provides a platform for new entrepreneurs to learn the technical aspects for production of *Aloe vera* based products and formulations such as juice, sap, aloe gel and cream.

Group photo of the trainees

Publication on distillation of aromatic crops

Hindi technical bulletin entitled 'सगंध पौधों का आसवन' was published and released on the occasion of Kisan Mela 2016. The 40 page booklet in Hindi contains detailed information on the various techniques of distillation, important parameters of distill-ation, purifi-cation and good storage practices of essential oils and the important do's and don'ts for getting high quality essential oil.



Input: Sudeep Tandon

Awards & Recognitions

CSIR Technology Award for research and extension in Ashwagandha

CSIR-CIMAP in association with the research teams of CSIR-NBRI, Lucknow, CSIR-CDRI, Lucknow and CSIR-IICB, Kolkata was conferred CSIR Technology Award-2015 in Life Sciences for the development of improved varieties and promotion of cultivation of Aswagandha (*Withania somnifera*) for improving the economy of small and marginal farmers in semi-arid tropical (SAT) regions of the Deccan Plateau. The award was presented by Dr. Harsh Vardhan, Minister for Science & Technology and Earth Sciences and Vice President CSIR on the occasion of CSIR Foundation Day function held at Vigyan Bhawan, New Delhi on 26th September, 2015. A group of farmers received the seeds of a newly developed variety of Ashwagandha, NMITLI-101 from the Minister of State for Science & Technology and Earth Sciences, during the function.

CSIR Technology Award ceremony

Rural Development Award

CSIR Award for S&T Innovation for Rural Development (CAIRD – 2014) has been awarded to CSIR-CIMAP for enhancing incomes of farming communities through vetiver (khus) based technological interventions. The award will be presented by the Prime Minister in a function to be held at a later date.

New Varieties

The new varieties of medicinal and aromatic plants released by the institute during the year 2015-16 are as under:

CIM-Sanjeevani (Artemisia) is a late flowering, artemisnin rich (1.2%), 2 – 2.25 m tall variety of *Artemisia annua* that gives 10 – 125 higher yield than the existing variety CIM-Arogya. The new variety would fetch an extra income of Rs.10000-15000 per ha to the farmers.

CIM-Sunahari (Satawar) is a high Yielding Peeli Satawar with semi-erect fast growing dark green broad leaves with light green stem colour. The new variety gives 9.75 t/ha dry root yield having 11.03% saponin content. CIM-Sunahari would enhance the income of farmers by one and half times.

CIM-Shikhar (Lemongrass) is a high yielding lemongrass variety with long leaf (100 – 105 cm) green to greyish green in colour with purple coloured stem. The new variety has oil content of 1.63% with 86% citral in the oil. The oil yield is >200 kg/ha. CIM-Shikhar has potential to fetch an extra income of Rs. 25000-30000 per ha to the cultivators.

NIMITLI-101 (Ashwagandha) is a high yielding variety with improved immunomodulatory activity. The plant of the new variety has medium height with profuse branching, drak green medium sized leaves, red coloured berries, yielding 23 Q dry roots/ha with total withanoloide content of 0.28%

CIM-Sharda (Tulsi) is an improved variety with curly leaf margin, purple pigmented stem. The variety is ever green in nature and the oil is rich in methyl chavicol. The oil content is 0.70 % with 85 – 89% methyl chavicol. The oil yield of CIM-Sharda is 206 kg/ha.

CIM- Nirom (Kewanch) is variety with dark green stem, distinctive curled blue petals, hairless pods. The ripened pods and seeds are dark black. The L-dopa content is 4.50% and the seed yield is 33.30 q/ha.

Khus-Khusnalika (Khus) is a fast growing, low flowering variety that initially spreads plant canopy with white feathery stigma. The khusinol percentage is >45% in the essential oil with an oil content of >1% and oil yield of 16 – 18 kg/ha.

CIM-Harit (Clary Sage) is an early maturing, high yielding variety with pale green bract. The oil content is 0.12 – 13%, the oil yield 20 – 22 kg/ha with 45 – 50% linalyl acetate in the oil.

CIM-Medha (Mandookparni) is dark green broad leaf variety with brown ting in the centre. The petiole is light purple and stolen is purple in colour. The dry herb yield is 11.29q/ha with asiaticoside content of 50.36mg/g dry wt.

IORA – the International meet on medicinal plants

The second meeting of medicinal plants focal points of Indian Ocean Rim Association Regional Centre for Science and Technology Transfer (IORA RCSTT) cum Exhibition was organized by CSIR-CIMAP at Lucknow during 18-19 March, 2015. Delegates from the member countries including Bangladesh, South Africa, Egypt, Indonesia, Iran, Madagascar, Malaysia, Sultanate of Oman, Republic of Seychelles, Sri Lanka, Tanzania, Thailand, Iran and India participated in the meeting and presented their respective country papers.

The recommendations of the meeting are summarized under:

1. To characterize medicinal plants considering the individual country position used in traditional system of medicine including safety and efficacy via traditional usage.
2. To develop standard protocols for quality of identified genotypes of species, their cultivation, quality control of their harvested products, clean post harvest processing, product formulation and storage of materials and related final products in suitably controlled environment.
3. To promote cultivation of characterized medicinal plants using improved planting material varieties / genotypes, which give optimum yields of raw herb and or marker constituent(s) per unit area.

A view of the IORA meeting

4. To procure the medicinal plants from the cultivated sources from within and among IORA member states for development of herbal products. Efforts should be made to develop similar strategy for medicinal plants of perennial origin.
5. To develop human resources in all fields of the enterprise (in different areas like cultivation, processing, manufacturing, value addition, quality testing, marketing, etc.,) through training and educational programmes for capacity building.

6. To harmonize regulations for quality control and trade among the member countries, for the purpose of international consumption of products.
7. To share knowledge, know-how, services, facilities through regular interactions, visits, technology transfer, etc.
8. To formulate the strategy for the protection of the intellectual property rights (IPR) and continued improvements in the regulations and benefit sharing in the area of medicinal plants .
9. All above should be integrated with the cultural and traditional knowledge and faith being pursued in the respective regions.
10. It is also recommended that each member state may identify at least 10 medicinal plants of economic and medicinal importance of human and veterinary usage and work out the above parameters for them for exchange of information and benefit for the whole region.

International Symposium ICOMP

Inaugural creremony of ICOMP

International conference on "Medicinal Plants: Resource for Affordable New Generation Healthcare" was organized in during 13-15 February, 2015 in Lucknow, India. The conference was attended by more than 350 delegates drawn from 10 countries including France, Thailand, Morocco, Egypt, Nigeria, South Africa, Nepal, Iran and Comores, besides the host Nation India. Indian participants who attended the conference represented the states of Karnataka, Tamil Nadu, Jammu & Kashmir, Punjab, West Bengal, Meghalaya, Gujarat, Maharashtra and Uttar Pradesh.

The conference explored the development of strategic R&D approaches for the global positioning of Indian medicinal plants and their products in affordable complementary healthcare systems. The meeting opened newer possibilities and avenues for research collaborations and networking among R&D institutions and end user industry institutions of this important economic sector. Leading researchers, farmers, small entrepreneurs, industry and other stake-holders in the field of medicinal plant sectors discussed and exchanged their information. In all 52 oral presentations and 270 posters were arranged under different thematic sessions.

Release of the abstract volume of ICOMP

National scientific seminar in Rajbhasha (Hindi Sangosthi)

Prof. AK Tripathi, Director CIMAP addressing the Hindi Sangoshti

A scientific seminar on "New Dimension of Science in Development of Agriculture, Energy & Health" was organized in Hindi. The conference was organized jointly by CSIR-CIMAP and Hindi Sahitya Parishad, BARC, Mumbai during 4-6 Nov. 2015. The topics covered were new dimension of science in development of agriculture, energy and health. The seminar was inaugurated by the former Director General, CSIR and J.C. Bose National Fellow Dr. P.S. Ahuja.

The seminar focused on the following major points:

- Current status of atomic energy and environmental protection
- Technologies developed by Bhabha Atomic Research Centre and their technology transfer
- Processing and protection of food products through radiation
- Application and achievements of nuclear technology in agriculture
- Role of isotope technology in health and societal upliftment of people
- Improved agro-technology and processing in context of medicinal and aromatic plants
- Biotechnology-plant improvement and chemistry
- Chemical extraction and quality control
- Production, marketing and commercialization
- Plants protection and microbial technology
- Herbal products and intellectual property protection

The seminar was divided into six technical sessions with 19 invited lectures and 70 poster presentations. A scientist-farmers-industry interactive meet was also organized.

Release of the souvenir in the Hindi Sangosthi

Jigyasa-2015

Jigyasa-2015, a 2-day symposium on "Translating Medicinal and Aromatic Plants Research for Mankind" organized by the research scholars of CSIR-CIMAP was held during 28-29 Nov. 2015.

Prof. (Mrs.) Paramjit Khurana, University of Delhi delivered a plenary lecture in symposium on the topic of "A Genomic Insight into Mulberry Research". Prof. Supriya Chakraborty

A view of the audience

from Jawaharlal Nehru University, New Delhi delivered a plenary lecture on the topic of "Understanding and Harnessing of Virus Induced Gene Silencing in Plant". A souvenir in form of a CD containing abstracts of the papers was also released in the symposium. A total of 38 research papers were be presented during the two day symposium divided into four technical sessions. About 300 students and scientists participated in the symposium.

Inaugural function of Jigyasa

Brain storming session on "Integration of medicinal and aromatic crop cultivation and value chain management for small farmers"

National Academy of Agricultural Sciences and CSIR-Central Institute of Medicinal and Aromatic Plants, Lucknow organized one day brainstorming session on "Integration of medicinal and aromatic crop cultivation and value chain management for small farmers" on 18th August, 2015 at NASC Complex, New Delhi. The session was attended by thirty area experts from CSIR and ICAR institutes, Agriculture universities, National Medicinal Plants Board, National Spices Board, Ministry of Micro, Small & Medium Enterprises, Essential Oil Association of India, industry representatives from Himalayan Drug Company,


Views of the brain storming session

Zandu Foundation for Health Care, Siva Essential Oils & Chemicals and progressive farmers of Uttar Pradesh and Tamil Nadu. Dr RB Singh, Immediate Past President, NAAS presided over the brain storming session.

The deliberations, held under two sectional themes entitled "Success stories, models and prospects of cultivation of MACs" and "Linking MACs cultivation with markets – expectations of farmers & user industry", were focused on how to strategize and advance to address certain key issues such as need for high quality scientific intervention for preparing dynamic MACs based cropping systems to accommodate fluctuating industrial demand and preference, preparation of area-specific dossier of MACs for solo as well as inter/mixed cropping for better land utilization and economic returns for farmers, workable mechanism for accreditation, certification and traceability of cultivated MACs, setting up of nursery chains for supply of planting stocks, utilization of strong ICAR extension service networks for popularizing MACs-related technologies, identification of suitable arid, semi-arid, rain-fed and salt-affected areas as primary targets for MACs cultivation and, establishment of organized marketing out-lets and demand-forecasting mechanisms for growers.

Visit of Hon'ble Ministers

Visit of Ho'ble Minister for Science and Technology and Earth Sciences and Vice-President, CSIR

Dr Harsh Vardhan, Union Minister for Science and Technology and Earth Sciences and Vice-President CSIR visited CSIR-CIMAP on 11 April 2015. Hon'ble Minister was accompanied by Dr M. O. Garg, Director General, CSIR and Dr Sudeep Kumar, Head, PPD, CSIR. Prof. A. K. Tripathi, Director, CSIR-CIMAP welcomed and briefed the Hon'ble Minister about the significant contributions of CSIR-CIMAP and major ongoing activities and projects in the area of medicinal and aromatic plants.

Planting of tree by the Minister

Release of the Ocimum variety by the Hon'ble Minister

Hon'ble Minister having a look at the Manav Upvan

On this occasion, Hon'ble Minister inaugurated the building of a new laboratory (Ocimum ChemBio) and released a high-essential oil and methyl chavicol-rich variety of *Ocimum basilicum*, suitable for cultivation under rainfed conditions. He also released two new monographs, one each on the Improved Varieties of Medicinal and Aromatic Plants and Herbal Formulations developed by CSIR-CIMAP. He further visited the Manav Upvan situated in the CIMAP campus.

Visit of Hon' ble Minister of State, MSME Shri Giriraj Singh

Honble Minsiter of State for Micro, Small and Medium Enterprises (MSME) visited CSIR-CIMAP Lucknow on 20 January 2016. The Minister interacted with the Director and Scientists on the potential and possibility of cultivation of medicinal and aromatic plants and opportunities available for entrepreneurship development in the area. After interaction, he visited the pilot plant facilities especially the fractional distillation and rose oil distillation.

Hon'ble Minister interacting with the Director

Mentha technology awareness programs

CSIR-CIMAP organized four awareness programs to popularize new mint variety CIM-Kranti and Early Mint Technology among the farmers and entrepreneurs in the mint growing belt of the Uttar Pradesh. These awareness programs were organized during 21 – 23 December at Rampur, Sambhal. Badaun and Barabanki districts of UP in collaboration with the Essential Oil Association of India. In all approximately 5000 farmers and entrepreneurs participated in the four programs.

Kisan Mela at Research Center Pantnagar

One-day farmer's fair was organized at CSIR-Central Institute of Medicinal and Aromatic Plants Research Center, Pantnagar on 6th February 2016. Kisan Mela was inaugurated by Dr Mangla Rai, Vice Chancellor, G.B. Pant University of Agriculture and Technology, Pantnagar. Over 800 participants (including farmers, entrepreneurs, academicians, scientists, industry representatives etc.) from different states viz. Uttarakhand, Uttar Pradesh, Bihar, Delhi, Madhya Pradesh participated in the farmer fair. A Kissan Gosthi was organized for farmers that covered various aspects of MAPs cultivation, processing, marketing, and recent advances in MAPs. Demonstration of agro-technologies of MAPs, distillations processes, rose water technology, and early mint technology was carried out in the farmer fairs. A new variety of Yellow Satawar namely 'CIM-Sunhari' was released for commercial cultivation in India. Hands-on training for agarbattis/incensesticks production

Release of publication during the Pantnagar Kisan Mela

was given to the women participants of the farmer fair. Quality planting material of mints was sold to the farmers. Various stalls displayed different activities pertaining to MAPs technologies, herbal products, agro-advisory, industrial herbal products, and CIMAP publications.

Visit of Dignitaries

25 Feb 2015

The delegates from Thailand Institute of Scientific and Technological Research (TISTR), Bangkok, Thailand visited CSIR-CIMAP on 25th February 2015 to discuss on possible collaboration (Medicinal Plants & Herbal Drugs): The delegates included : Mrs. Chantara Phoonsiri, Deputy Governor, R&D for Bio-industries

Dr.Chuleratana Banchonglikitkul, Chief Research Expert , Pharmaceutical and Natural Products Department

Ms.Krittalak Pasakawee, Research Officer, Food Technology Department

Ms.Pimprapai Supornrat, Assistant International Relations Officer

Delegates from Thailand

6 May 2015

A delegation of from Myanmar visited CSIR-CIMAP to study the management of medicinal and aromatic plant research and benefit sharing on 6th May 2015.

Delegates from Myanmar with the Director

A view of interaction with delegates of the Natural Mint Industry, USA

8 June - 2015

Visit of Natural Mint Industry of USA and GEM Aromatics Mumbai on 8, June - 2015

Delegates of the Natural Mint Industry, USA

17 June 2015

Visit of Japanees Mint Industries Association (JMIA) on 17-June-2015 at CSIR-CIMAP Lucknow to understand the dynamics of Mint cultivation and varieties of the crop.

Delegates of the Japanese Mint Industries Association

Director addressing the delegates of the Japanese Mint Industries Association

Vietnam's Second Secretary, Science & Technology interacting with the Director

5 December, 2015

Mr Kien Nguyen Trung, Second Secretary, Science & Techonology Division, Embassy of The Socialist Republic of Vietnam in India visited CSIR-CIMAP on 15th December, 2015 to discuss on the implementation of the MoU between CSIR-Central Institute of medicinal Plants (CIMAP), Lucknow, India and National Institute of Medicinal Materials (NIMM), Hanoi, Vietnam.

Director welcoming the Vietnam team

22 January, 2016

A delegation of BASF Germany visited CSIR-CIMAP on 22nd January 2016 to discuss on use of medicinal plants in the area of agriculture, pharmaceutical and home and personal care area.

Delegation from the BASF, Germany

16 October 2015

The office bearers of Essential Oil Association of India (EOAI) visited CIMAP and held discussion with the a team of CIMAP scientists for scientist industry collaborations

Interaction with EOAI delegates

Jammu & Kashmir Aroma Arogya Gram (JAAG) Project

Field demonstration of region specific medicinal and aromatic plants genotypes for socio-economic upliftment of masses in J&K region is being organized under the Jammu & Kashmir Aroma Arogya Gram (JAAG) Project being implemented in which CSIR-CIMAP is a participating laboratory. The project is being coordinated by IIIM, Jammu as nodal laboratory. Under this project, about 29.4 ha of area was planted with aromatic crops such as Lemongrass var. Krishna, Vetiver var. KS-1, *Mentha piperita, Mentha spicata* and Geranium. Seeds of Palmarosa were made available to IIIM for raising nursery. These demonstrations have been organized on 87 farmers' field from 31 villages falling under district Kathua of J & K.

Khus plantation at Kathua (J&K)

Patents granted

1. Novel anti-psychotic activity in the leaf extracts of *Rauwolfia tetraphylla* and their useful herbal formulations

Patent No. AU- 2010231489, 08.01.2015 and US- 9018226, 28.04.2015

(SK Srivastava, AK Agarwal, SC Singh, VK Khanna, Janardan Singh, Chandeshwar Nath, MM Gupta, Shikha Gupta, RK Verma, Anirban Pal, DU Bawankule, Dharmendra Saikia, AK Gupta, Anupam Maurya, SPS Khanuja)

The invention relates to novel anti-psychotic activity in the leaf extracts of *Rauwolfia tetraphylla* and their useful herbal formulations for the treatment of psychosis based on *in vivo* validation on animal model and proportional binding affinities for dopaminergic-D_2, cholinergic (muscarinic) and serotonergic ($5HT_{2A}$) receptors for anti-psychotic activity. The invention also provide a process for obtaining anti-psychotic extracts from the leaves of *Rauwolfia tetraphylla*, which are non-toxic and devoid of extra pyramidal side effects.

2. A process for chemical conversion of isolated cellulose from aromatic spent biomass to hydroxyl methyl furfural

Patent No. US-9199930, 01.12.2015

(PK Rout, AD Nannaware, Ram Rajasekharan)

The invention relates to the development of green process for the preparation of hydroxymethyl furfural (HMF) from cellulose isolated from spent aromatic biomass. HMF is a key intermediate substance useful as substitute of petro chemicals. As cellulose is the major constituent (40-50%) of the spent aromatic biomass (hemicellulose, 25-30% and lignin 15-20%) it is being used for synthesis of HMF. The synthesis of HMF from isolated cellulose is an economical process and is completely environment-friendly which describes the development of sustainable, integrated and holistic strategy for utilizing the waste aromatic biomass to produce various valuable bio-chemicals.

New Staff Members

1. Mr. Venkateshwarlu Gadde SO at CRC Hyderabad w.e.f. 30.6.15
2. Mr. Mohd Moseen, MTS w.e.f. 23.7.15
3. Mr. Baljeet Singh, CoF&A w.e.f. 2.12.15

Research Centre Bangalore

Participation in Totagarike Mela (Horticulture Show) from 19-21 December 2015 at University of Horticultural Sciences, Bagalkot, Karnataka

CSIR-CIMAP Research Center, Bangalore participated in the Totagarike Mela (Horticulture show) held from 19 to 21 December 2015 at University of Horticultural Sciences, Bagalkot, Karnataka. Live 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 acquainted themselves with the agrotechnologies and distillation process of medicinal and aromatic plants. Eight brochures on medicinal and aromatic plants such as Lemongrass, Palmarosa, Vetiver, *Eucalyptus citriodora*, Senna, *Ocimum sanctum*, Ashwagandha and Kalmegh in the local language (Kannada) were distributed to the visitors.

A view of the visitors at CRC CIMAP Bengaluru stall

Externally funded projects

Biological transformation of natural compounds by hairy root cultures for production of value-added products of therapeutic impact. (Ms Pallavi Pandey, Rs.13.64 lakhs)

Character of quorum sensing inhibitors from medicinal and aromatic plants for management of rice leaf streak disease caused by Xanthomonas oryzae. (Dr Akanksha Singh, Rs.31.30 lakhs)

Medicinal plants market scenario in Uttar Pradesh. (Dr. Sanjay Kumar, Rs.2.00 lakhs)

Development of model nursery for production and supply of quality planting material of commercially important medicinal crops-Ashwagandha in Andhra Pradesh. (Dr. J Kotesh Kumar, Rs.20.00 lakhs)

Development of model nursery for production and supply of quality seeds of CIMAP varieties in Andhra Pradesh state. (Dr. J Kotesh Kumar, Rs.4.00 lakhs)

Providing technical services/consultancy for designing, fabrication and setting up a 500 kg/batch directly fired type Mobile Tractor Trolley Mounted Distillation Unit based on CSIR-CIMAP know how and design. (Er. Sudeep Tandon, Rs.10.00 lakhs)

Water quality monitoring of Ganga River from Gomukh to Hooghly. (Dr.MM Gupta, Rs.24.15 lakhs)

Genetic modifications to improve biological nitrogen fixation for augmenting nitrogen needs of cereals. (Dr. Anil Tripathi, Rs.286.79 lakhs)

RNA-seq for discovery of novel transcriptome-based markers in withaholide pathway genes and their mapping across Indian Ginseng Withania somnifera. (Dr Tripta Jhang, Rs.37.684 lakhs)

Inventorization, Digitization and web enabling of the Geo-spatial Maps of Medicinal and Aromatic Plants cultivated in the states of Andhra Pradesh, Tamil Nadu, Karnataka, Kerala and Odisha. (Dr. J Kotesh Kumar, Rs.31.24 lakhs)

Defict irrigation practices following strategic moisture stress for enhancing yield of industrially important substances in selected Medicinal and Aromatic Plants using Withania somnifera and Mentha arvensis as model test crops. (Dr. Saudan Singh, Rs.32.492 lakhs)

Synthesis, Biological Evaluation and Structural Elucidation of Novel Analogues of the Antibiotic CC-1065 and the Duocarmycins (Dr. Dushyant Singh Raghuvanshi, Rs.95.00 lakhs)

Establishment of Amla Juice Processing Facility at CIMAP Research Centre, Hyderabad in Collaboration with TSMPB. (Dr. J Kotesh Kumar, Rs.10.00 lakhs)

Design, synthesis, QSAR, system pharmacology, in vitro and in vivo studies of plant molecules and their derivatives for anticancer activity. (Mr. Sarfaraz Alam, Rs.39.474 lakhs)

Development of vermicompost based formulations of consortia of microbes useful as biofungicide and biofertilizer as bio-agri farm input for plant and soil health. (Ms. Suman Singh, Rs.18.757 lakhs)

Synthesis of Levulinic Acid from Spent Biomass of Aromatic Crops by Green Processes. (Dr. Prasant Kumar Rout, Rs.21.54 lakhs)

Nanotube based immobilization of novel plant peroxidases for the potential application in biosensors. (Dr Veda Prakash Pandey, Rs.33.20 lakhs)

Development of anti cancer & anti inflamatary agents from dioscorea floribunda. (Dr Arvind Singh Negi, Rs.36.48 lakhs)

Economics of cultivation of important medicinal plants grown at farmers' field. (Dr.Sanjay Kumar, Rs.32.34 lakhs)

Molecular understanding of the biosynthesis of medicinally active pentacyclic triterpenes in plants. (Dr Sumit Ghosh, Rs.45.23 lakhs)

Husain Zaheer Memorial Bridge Tournament

Prestigious Husain Zaheer Memorial Bridge Tournament was hosted at CSIR-CIMAP, Lucknow. Chief Guest of the event, Dr. S.B. Nimse, Vice Chancellor of Lucknow University and Director CSIR-CIMAP & President CSIR Sports Promotion Board Prof. Anil K. Tripathi inaugurated the tournament on 8th January, 2016 at CIMAP campus with march past by the participating teams from all over the country namely CSIR- CECRI, Karaikudi, CSIR- CFTRI, Mysore, CSIR- CGCRI, Kolkata, CSIR- CMERI, Durgapur, CSIR- IGIB, New Delhi, CSIR- IMMT, Bhubaneswar and CSIR- NPL, New Delhi.

Inauguration of Husain Zaheer Memorial Bridge Tournament

Participation of CSIR-CIMAP Cricket and Volley Ball teams in 47th SSBMT Tournament

CSIR-CIMAP Cricket and Volley-ball teams participated in 47th SSBMT Tournament held at CSIR-NGRI, Hyderabad. Our Volley-ball team qualified for 47th SSBMT out Door final played at CSIR-NAL, Bangaluru. Prof. Anil K. Tripathi Director CSIR-CIMAP and President CSIR SPB was the Special Guest of the mega event.

Cricket & Volley-ball teams in 47th SSBMT outdoor tournament

Other Staff Club activities

- CIMAP Sports Meet 2015 (CSM 2015) was organized by CSIR-CIMAP Staff Club (Mahak), from 18-24 May, 2015 for CIMAP staff, students and wards. More than 72 staff & scholars, 27 women and 15 children of staff participated in seven sports events. To encourage the CIMAPs literary talent a internal Kavi sammelan and

mushaira was also organized which was well attended and enjoyed by all.

- **CIMAP Mahak Utsav 2016** was organized on 20th Feb. 2016. To encourage the Indian cultural talents among spouse of CIMAP staff and students, like Rangoli, flower decoration, salad decoration, singing, dancing, fancy dress etc, were organized and profusely attended. The Utsava was inaugurated by Mrs. Anju Tripathi and Prof. Anil. K. Tripathi, Director and President, Staff Club.

Inauguration of Mahak Utsav by Mrs. Anju Tripathi and Prof. Anil. K. Tripathi

CIMAP Staff Club with National Mission

CIMAP Staff Club (Mahak) joined with national mission of making Aadhaar enrollment of all CIMAPians including their spouse by organizing a camp in its campus from 9-10 June, 2015

National Festivals

CIMAP Staff Club celebrated our National festivals, Independence Day on 15th August 2015 and Republic Day on 26th January 2016 with full enthusiasm. It started with the Flag Hoisting by Prof. Anil K. Tripathi, Director, CSIR-CIMAP and president Staff Club, followed by his address to CIMAP Staff, students and their families.

Prof. Anil. K. Tripathi addressing CIMAPians after the Flag Hoisting on 26 Jan. 2016

On this occasion, there was sweet distribution, sports events organized for staff, students and their families including children. Programme ended with prize distribution by the Director to the winners and participation prizes to all the children.

Staff superannuated

Mr. SAI Zaidi, Sr. Technician (2)
Mr. Mohd Aslam Khan, JSG
Dr. PK Chaudhary, Sr. Principal Scientist
Mr. Rajanna, Helper
Dr. KP Sastry, Chief Scientist
Mr. AK Sharma, Section Officer (G)
Dr. RN Kulkarni, Chief Scientist
Dr. HS Chauhan, Chief Scientist
Mr. SB Shah, Assistant (G) II
Dr. BRR Rao, Chief Scientist
Mr. Raja Ram, Sr. Technician (2)
Mr. G. Appa Rao, Lab Attendant
Mr. Sadanand, JSG
Dr. DD Patra, Chief Scientist
Mr. Inder Raj, Administrative Officer
Dr. SK Srivastava, Chief Scientist
Dr. JR Bahl, Chief Scientist
Dr. SC Singh, STO
Mr. AK Srivastava, STO
Dr. NK Srivastava, Sr. Principal Scientist
Mr. AK Srivastava, Sr. Technician (2)
Mr. Mohd Ameen Khan, Lab Attendant
Mr. KP Dubey, Assistant (G) I
Mr. Om Prakash, Lab Attendent
Dr. RK Verma, STO
Mr. Jamil Ahmed, STO
Dr. RP Bansal, Principal Scientist
Mr. Durga Prasad, T. Driver

Scientific contributions of superannuated scientists*

Dr RN Kulkarni

Dr R N Kulkarni joined CSIR-CIMAP as Scientist B (Plant Breeding) at its then Regional Centre, Bangalore, on 09-09-1981, after a meritorious academic career at UAS, Bangalore and IARI, and New Delhi. He was promoted to Scientist G (now referred to as Chief Scientist) in the year 2006.

He initiated systematic genetics and breeding work in some of the aromatic & medicinal plants such as lemongrass, palmarosa, davana, periwinkle, geranium, French basil and patchouli. The work demonstrated the progress that can be achieved through sustained & systematic breeding efforts based on genetics and plant breeding principles. In the lemongrass, oil content could be increased by about 150% over the initial base population through five cycles of phenotypic recurrent selection for increased essential oil content, without adversely affecting herb yield or citral content in oil. The research programme yielded two superior clonal varieties, 'Cauvery' and 'Krishna', from base and Cycle-2 populations, respectively.

Mass selection programmes in palmarosa and davana demonstrated that direct selection for oil content was more effective in the increasing oil content than indirect selection through inflorescence: leaf+stem ratio in palmarosa and that herb yield in davana could be increased by 12% per cycle after three cycles of simple honey comb mass selection.

Dr Kulkarni generated somaclonal variation for the first time in exclusively vegetatively propagated aromatic plants, patchouli and geranium, leading to the development of a superior somaclone, 'Narmada' in geranium and a somaclonal variety, 'CIM-Shreshtha' in patchouli.

*based on the inputs received from the respective scientists

He carried out extensive genetic studies in periwinkle, the source of anti-cancer and anti-hypertension alkaloids and identified more than 40 genes affecting 10 traits, including alkaloids content, male sterility, disease resistance, pollination mechanism, etc. He showed that periwinkle is an allogamous species, with phenotypic assortative mating for corolla colour brought about by the butterflies. He also discovered self-pollinating strains and allelic gene system for self-pollination in periwinkle, similar to that governing incompatibility system promoting allogamy in plants. He created cleistogamy in periwinkle, for the first time in any herkogamous/allogamous plant, by pyramiding four recessive alleles, with utility in the pollen containment. An induced lesion mimic mutant was isolated for the first time in any MAP with the enhanced contents of alkaloids, suggesting a simple of way of increasing content of secondary metabolites in MAPs. Two improved varieties of periwinkle, 'Nirmal' with resistance to die-back and 'Dhawal', with higher contents of leaf alkaloids were developed.

Dr Kulkarni is a recipient of INSA Young Scientist Medal and EOAI Meritorious Scientist Award. He was Young Associate of Indian Academy of Sciences, Bangalore. He has published around 100 research articles in National/ International peer reviewed journals, seminars/symposia, including six book chapters. He was a member of Editorial Board of 'Medicinal and Aromatic Plants', a journal of OMICS group of journals and is currently a member of the Editorial Board of 'Journal of Applied Research on Medicinal and Aromatic Plants', an Elsevier Journal.

Dr DD Patra

Dr DD Patra did research on developing dual ^{15}N labeling technique for precise estimation of dinitrogen fixation and concurrent transfer of N from legumes to cereals in cereal-legume mixed cropping system by eliminating the special and temporal variation of ^{15}N enrichment in soil. It also deals with compartmentalization of N in different pools. He also developed novel essential oil/ by-product mediated natural nitrification inhibitors for retarding nitrogen transformation (oxidation and reduction) to inhibit N losses through different pathways viz. mineralization, volatilization, denitrification etc, thereby increasing N use efficiency in soil-plant-atmosphere continuum. Additionally, Dr Patra has been testing the tolerance of different species of medicinal and aromatic plants to soil salinity and sodicity and utilization of salt affected soils through cultivation of high value medicinal and aromatic soils.

Dr Patra established microbial biomass C, N and S as the most important indicators for assessing the changes in soil health much earlier than estimating the total organic matter because of a lower half life of the former.

Dr Patra worked on sludge mediated toxic heavy metal polluted soils, utilization of which through cultivation of agriculture is a problem, as the metals taken up by the plant can enter in to the food chain of human and animals. As the essential oils are being extracted through hydrodistillation of aromatic plants, the oil does not contain any trace of heavy metals. In this context, metal polluted soils has been found to be safe for cultivation of aromatic crops.

Most important and high value crops found to be suitable for salt and heavy metal polluted soils are vetiver (*Vetiveria zizanioids*), lemongrass (*Cymbopogon flexous*), palmarosa (*Cymbopogon martini*) and clarysage (*Salvia sclaria*). These aromatic crops play a major role in phytoremediation of salt and heavy metals from polluted soil.

He has published > 150 research papers in international peer reviewed journals. In recognition of his research work, Dr Patra received several awards including Vasvik Award. He is a fellow of the National Academy of Sciences, India, National Academy of Agricultural Science and Indian Society of Soil Science. He has guided 17 Ph.D. students.

Dr Janak Raj Bahl

Dr Janak Raj Bahl joined CIMAP in February 1986 as Research Associate and subsequently got appointed as Scientist B in April 1988. He served this institute for nearly 30 years working in the area of genetics and plant breeding for crop improvement, agro-technology and extension of medicinal and aromatic plants and superannuated as Chief Scientist in November 2015. During this period he worked in different capacities as Scientist, as Farm In-Charge Lucknow (for more than 10 years) and as Scientist-In-Charge for Research Center Pantnagar (for more than four years). He has published 74 research papers in national and international research journals and 16 patents. He is credited as the main plant breeder of the first plant variety patent of India for a new hybrid variety of mint, called Himalaya. Besides, he was involved in the development of 32 improved varieties of different medicinal and aromatic plants though systemic breeding efforts. Most popular varieties developed by him includes Himalaya of menthol mint, CIM-Pawan of geranium and cold and frost tolerant variety CIM-Kranti of menthol mint, which were developed by him as the principal breeder.

He has significantly contributed to the institute's major mission projects on Menthol mint, *Mentha arvensis* under Ambedkar Vishesh Rojgar Yojna in Uttar Pradesh; and geranium that was launched as a Bio-Village approach in Uttrakhand. As a result, the geranium crop has been successfully introduced in Uttrakhand leading to two-fold increase in the geranium production and its oil in India. He has also contributed in societal mission programmes for development of several Herbal Parks including a Herbal Garden at Rashtrapati Bhawan, New Delhi which was appreciated by the Honorable President of the India, Dr. APJ Abdul Kalam and a concept technology park called Manav Park at CIMAP, Lucknow. The layout of the Manav Park is in the shape of a human body and the medicinal and aromatic plants are planted according to their use in the respective body part.

Dr. Bahl is a recipient of several prestigious awards as team member including CSIR Award for S&T Innovations for Rural Development 2008 for Bio-village Strategy for Agri-business of Medicinal and Aromatic Plants, Golden Peacock Eco-Innovation Award 2008 for adding value to the environment through strategic agri-input development and preventing farm chemical pollution, conferred by World Environment Foundation and FICCI Annual Award 2004 – 2005 in recognition of corporate initiative in Rural Development through innovative R&D in Medicinal and Aromatic Plants.

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Finance & Accounts Officer
CSIR-CIMAP, Lucknow

Mr. BD Vashisth
Controller of Administration
(Member Secretary)
CSIR-CIMAP, Lucknow

Budget at a glance*

	Allocation	Expenditure
Pay and allowances	2411.319	2408.427
Contingency	277.500	256.666
HRD	0	0
Lab maintenance	132.00	131.309
Staff qtr. maintenance	22.50	23.384
Chemicals / consumables	400.180	301.155
Works and services	140.00	94.706
Apparatus and equipment	800.30	193.190
Office equipment	3.00	2.998
Furniture and fitting	3.00	1.256
Library books	0	0
Library journal	70.00	69.085
Staff qtrs. (construction)	10.00	0.997
CSIR network projects	1471.707	629.09
Total	**5850.506**	**4224.104**
Pension	1616.00	1562.157
External Budgetary Resources		
Lab Reserve Fund (LRF)	–	0
External Cash Flow (ECF)	621.52	476.79

*as on 11 March 2016

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(as on 31 March 2016)

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Mr. Prem Singh

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Notes

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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)

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