# वार्षिक प्रतिवेदन
# Annual Report

2014-2015

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

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

Compilation, Editing, Production
Rakesh Tiwari

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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

वार्षिक प्रतिवेदन 2014-15 के लिये यह संदेश लिखने के इस समय तक मै औषधीय एवं सगंध पौधों के क्षेत्र में कार्य कर रहे देश के अग्रणी शोध संस्थान में बतौर निदेशक एक वर्ष का कार्यकाल पूर्ण कर चुका हूँ। विगत वर्ष मुझे मुख्यालय व केन्द्रों के वैज्ञानिकों और शोधार्थियों से चर्चा करने का अवसर प्राप्त हुआ। इससे मुझे संस्थान की क्षमता समझने में मदद मिल सकी जिसके द्वारा भविष्य की रणनीति बनाकर आन्तरिक (इन-हाउस ) और वाह्य-सहायता प्राप्त परियोजनाओं के माध्यम से शोध कार्य को गति दी जा सके। मुख्यालय और हमारे चार शोध केन्द्रों द्वारा सम्बन्धित क्षेत्रों में चलाये जा रहे अत्यन्त प्रभावी प्रसार कार्यक्रमों से अवगत होकर व उनसे जुड़कर मुझे अत्यन्त प्रसन्नता का अनुभव हुआ।

विगत वर्ष में हमारे वैज्ञानिकों द्वारा न केवल उच्च प्रभाव (हाई इम्पैक्ट) वाले शोध पत्र प्रकाशित किये गये बल्कि उनके द्वारा प्रौद्योगिकियाँ, पौधों की उन्नत किस्में और उत्पाद भी विकसित किये गये जो कि किसानों और उद्यमियों सहित विभिन्न स्टेक होल्डर्स के लिये लाभकारी सिद्ध हो सके।

सीएसआईआर-सीमैप द्वारा देश के विभिन्न भागों के बड़ी संख्या में किसानों और आदिवासियों को खेती, प्राथमिक प्रसंस्करण, विपणन और औषधीय एवं सगंध पौधों के क्षेत्र की गतिविधियों पर प्रशिक्षण दिया गया। संस्थान का प्रसार कार्यक्रम सुदूर क्षेत्रों की ओर उन्मुख रहा। इस दृष्टिकोण से व्यवसायिक महत्व वाले औषधीय एवं सगंध पौधों का उत्तर प्रदेश व ओडिशा के आदिवासी क्षेत्रों में प्रदर्शन लगाया गया। शोध केन्द्रों को सम्बन्धित राज्यों में प्रौद्योगिकी प्रसार केन्द्र (हब) के रूप में विकसित करने पर बल दिया गया।

औषधीय एवं सगंध पौधों से सम्बन्धित व्यवसाय के अवसरों को समझने तथा इस क्षेत्र में किये जाने वाले उन अनुसंधानों, जिन पर कार्य कर हमारे वैज्ञानिक सामाजिक बदलाव के उत्प्रेरक और किसानों और उद्यमियों के बीच सेतु बन सके, की जानकारी एकत्रित करने के उद्देश्य से भारत व अन्य देशों के प्रमुख उद्योगों के साथ चर्चा के प्रयास किये गये।

मुझे पूर्ण विश्वास है कि आने वाले महीनों में 'टीम सीएसआईआर-सीमैप' निर्धारित लक्ष्यों की प्राप्ति के लिये एक नई लगन और उत्साह के साथ कार्य करेगी जिसके द्वारा सीएसआईआर-सीमैप में विकसित औषधीय एवं सगंध पौधों से सम्बन्धित प्रौद्योगिकियों व सेवाओं के उपयोग से ग्रामीण क्षेत्रों के निर्धन लोगों के जीवन में परिवर्तन लाया जा सकेगा।

मैं इस अवसर पर मुख्यालय व शोध केन्द्रों पर कार्यरत समस्त वैज्ञानिक एवं तकनीकी स्टॉफ व कर्मचारियों को संस्थान की शोध एवं विकास की गतिविधियों को आगे बढ़ाने हेतु उनके योगदान के लिये सराहना एवं हार्दिक धन्यवाद व्यक्त करता हूँ।

मैं अपने सभी श्रेष्ठ जनों को वर्तमान में चल रहे और भविष्य में किये जाने वाले अनुसंधान की दिशा निर्धारित करने हेतु उनके निरन्तर सहयोग व मार्गदर्शन के लिये भी हार्दिक आभार व्यक्त करता हूँ।

**अनिल कुमार त्रिपाठी**

## Director's Message

While writing the message for the Annual Report 2014-15, I have completed one year as Director of this frontline research institute of the country in the area of medicinal and aromatic plants. During the year bygone, I had the opportunity of closely interacting with the scientists and researchers working in different disciplines, both at headquarters and centres. This has enabled me to understand the strengths of the institute so as to formulate strategy for future research, which could be taken up as in-house and externally funded projects. It has been a pleasure to acquaint and associate myself with the very impactful extension work, in which our headquarters as well as research centers are involved, and to accelerate their activities to cater to the needs of respective regions. Our scientists have not only published papers in high impact journals during the year but also developed technologies, elite plant varieties and products, which could be beneficial to different stakeholders including farmers and entrepreneurs. Several scientists won awards and received honors for their significant contributions.

A very large number of farmers and tribals from different parts of the country have been trained by CSIR-CIMAP for the cultivation, primary processing, marketing and related activities in the area of medicinal and aromatic plants. Institute's outreach programme is directed towards remote areas, and therefore the demonstrations of economically important medicinal and aromatic plants have been laid out in tribal areas in UP and Odisha. Emphasis has also been on making our research centers the hubs for technology dissemination in the respective states. Efforts were made to have dialogues with leading industries, both from India and abroad, to know about business opportunities related to medicinal and aromatic plants, and to understand the research needs which can be pursued by our scientists to act as catalyst of social change as well as a bridge between farmers and industry.

I am fully confident that in the coming months, Team CSIR-CIMAP will work with renewed zeal and vigor to achieve the mandated goals, which will help in transforming lives of poor people in rural areas through deployment of medicinal and aromatic plants related technologies and services developed by our institute.

I would like to take the opportunity of conveying my sincere appreciation and thanks to all the scientific and technical staff, and employees stationed at headquarter and research centers for their contributions towards taking the institute's R&D activities to greater heights. I also express my gratitude to all our peers for their continued support and guidance for shaping our ongoing and future research programmes.

**Anil Kumar Tripathi**

## Project : MLP.01 – Genetic enhancement of MAPs using crop specific breeding methodologies

Principal Investigator: OP Dhawan

### Seasonal variation in temperature influences tapetum mitosis patterns affecting reproductive fitness

Environmental stress in plants impacts many biological processes including male gametogenesis and affects several cytological mechanisms that are strongly interrelated. In order to understand the likely impact of rising temperature on reproductive fitness in the climate change regime, a study of tapetal mitosis and its accompanying meiosis over seasons was made to elucidate the influence of temperature change on the cytological events occurring during micro-sporogenesis on two species of an environmentally sensitive plant system i.e. genus *Cymbopogon* (Poaceae) that flower profusely during extreme summer and mild winter but support low and high seed fertility respectively in the two seasons. During the process of tapetum development there are episodes of endomitosis forming, either (i) endopolyploid genomically imbalanced uninucleate / multinucleate tapetum, and / or (ii) acytokinetic mitosis forming multinucleate genomically balanced tapetum, with the progression of meiosis in the accompanying sporogenous tissue. The relative frequency of occurrence of the two types of tapetum mitosis patterns is significantly different in the two seasons, and is found to be correlated with the temperature conditions. Whereas, former

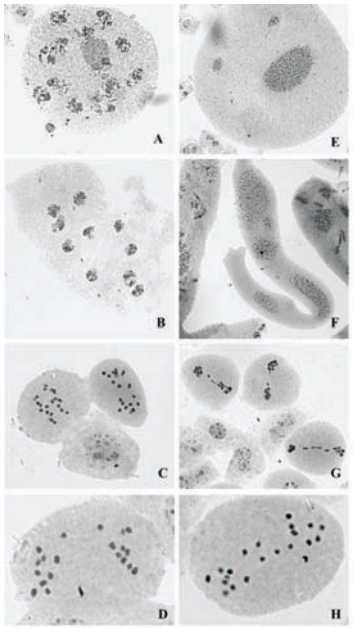



Figure. Seasonal variation in tapetum mitosis vis-à-vis meiosis: Left column – Balanced tapetum mitosis and meiosis in winter ; right column – Imbalanced tapetum mitosis and meiosis in summer

(genomically imbalanced tapetum) are prevalent during hot summer, the latter (genomically balanced tapetum) are frequent under optimal conditions. The study underpins that tapetal mitotic behaviour *per se* could be a reasonable indicator to elucidate the effect of climate change on reproductive fitness.

Genome 57: 517-521, 2014

Input: Lavania UC

### Development of a trichome-less strain of *Mucuna pruriens* (kewanch/velvet bean) with high seed and L-dopa yields

Parental line (CIM-Ajar)

Trichome-less genotypes having bold dark black seeds with high L-dopa content (5.50%) have been developed from parental variety CIM-Ajar having white seeds through single seed descent method followed by half sib selection. The

Newly developed trichomeless line

trichome-less line gives L-dopa yield of 183.32kg/ha with L-dopa content of 5.50 % as compared to the L-dopa yield of 137.32 kg/ha with L-dopa content of 6.18% in the parental check variety. The newly developed line has dark black seeds with vigorous growth. This strain can easily be distinguished from others by dark black seed colour as marker and vigorous growth.

Field view of the trichomeless line showing vigorous growth

## Genetic improvement in aromatic grasses through polyploidy

Induced tetraploid clones have been developed in lemongrass and Java citronella which were evaluated in initial evaluation trials and mean performance of these has been given below.

**Mean performance of various induced polyploid clones in two aromatic grasses**

| S. No. | Crop/Genotypes | Herb yield (kg/8$^2$m plot) | Oil content (%) | Oil yield (kg/8$^2$m plot) |
|---|---|---|---|---|
| **A.** | **Lemongrass:** | | | |
| 1. | Krishna (Tetraploid) | 13.00 | 0.92 | 119.60 |
| 2. | CIMAP Suwverna (Tetraploid) | 18.63 | 0.63 | 113.82 |
| 3. | Krishna (Diploid) | 11.53 | 0.83 | 95.70 |
| **B.** | **Java citronella** | | | |
| 1. | CTJ (Tetraploid) | 10.65 | 1.04 | 110.91 |
| 2. | Bio 13 (Tetraploid) | 8.49 | 1.13 | 94.422 |
| 3. | Bio 13 (Diploid) | 6.91 | 1.07 | 75.92 |

Results show that tetraploid clones of both lemongrass and Java citronella are superior for fresh herb, oil content and oil yield. All superior tetraploid clones shall be further evaluated in bench scale trials during upcoming season.

Input: Lal RK

## Functional characterization of flower organ identity and related genes of economic traits in opium poppy

Opium poppy is known for its medicinally important alkaloids. It is also recognized as the model plant for evolutionary developmental genetic studies as it belongs to the family Ranunculaceae which represents basal eudicots. Some of the floral identity genes have been identified and characterized by our group in opium poppy which belong to the MADS box group of transcription factors. However, APETALLA 2 (AP2) and SEPALLATA genes which play major role in floral organ identity and initiation of flowering need to be characterized. Inbred lines of the homeotic mutants alongwith their parental lines have been used to amplify these genes from their total RNA. Semi quantitative RT-PCR studies

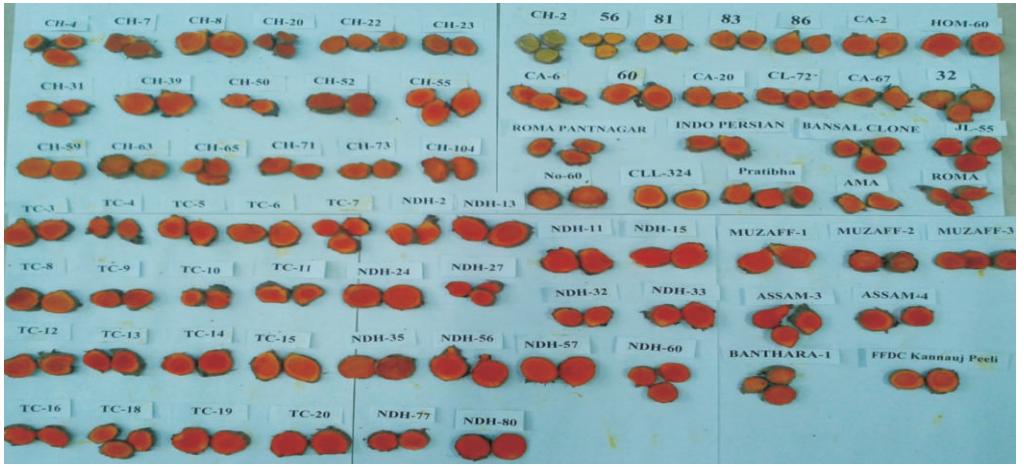
revealed differential expression pattern of these genes. The PCR products have been cloned which are being sequenced to illucidate the differences in nucleotide sequences of these genes in the parental lines leading to homeotic mutant phenotypes. Other distinguishing economic traits in the homeotic mutants like cleistogamy, early flowering and dwarf plant height are also being molecularly characterized as these traits would be utilized in breeding programmes for identifying beneficial recombinants for crop improvement.

Input: Dhawan OP

## Collection and characterization of turmeric germplasm lines from North-Eastern region of India

An exploration to Assam and bordering areas of Arunachal Pradesh has been carried out to collect germplasm lines of turmeric and its related species and 35 collections with distinctly variable traits were made from these regions. The collections included the samples procured from the market, wild and cultivated areas.

Sixty-five germplasm lines of turmeric (*Curcuma longa* L.) have been screened for high rhizome yield. The considerable amount of natural and genetic variability in agro-morphological traits have been




Range of variability in collections of turmeric lines in the germplasm

recorded. The estimates of heritability and corresponding genetic advance were found to be high for plant height and rhizome fresh weight. Genetic and phenotypic correlation coefficients among thirteen traits indicated that leaf length, leaf width, plant length, petiole length and dry weight of rhizomes had significant and positive correlation with length of stipulated tubers. Fresh weight of rhizomes also had positive correlation with germination date. However, leaf width was found to have significant and negative correlation with plant length and length of stipulated tubers. The path coefficient analysis revealed that the highest direct contribution to total yield of rhizome thickness was made by dry weight of rhizome followed by days to leaf emergence, length of stipulated tubers and plant height respectively.

## Gene bank status and conservation of germplasm accessions of MAPs

Availability of germplasm resources have been the backbone of all genetic improvement programs. National gene bank for medicinal and aromatic plants at CSIR-CIMAP is continuously conserving the germplasm lines of all the MAPs.

Following number of germplasm accessions are available in the gene bank and being maintained in seed and field gene banks at CSIR-CIMAP.

| S. No. | Number of accessions belonging of different families/genera/species being maintained | Seed bank (Mid and hort term storage) | Field gene bank* |
|---|---|---|---|
| 1 | Accessions | 2476 | 868 |
| 2 | Families | 132 | 80 |
| 3 | Genera | 386 | 176 |
| 4 | Species | 515 | 227 |

*About 130 clones of turmeric (*Curcuma* sp.), 105 collections of ashwagandha (*Withania somnifera*), 200 lines of coriander, 40 lines of fennel, 35 lines of *Allium*, 300 lines of *Papaver* and 115 released varieties (from CSIR-CIMAP) of different MAPs have been maintained in field gene bank of CSIR-CIMAP.

Input: Gupta AK

## Varietal differences for salt tolerance on seed germination in palmarosa

Palmarosa (*Cymbopogon martinii* var. *motia*) is a major essential oil bearing perennial crop. Due to presence of geraniol and geranyl acetate, it is used worldwide in the cosmetic and perfumery industries. Salt tolerance for seed germination potential and seedling vigor index of three palmarosa varieties (PRC-1, Trishna and Tripta) under four levels of NaCl concentrations (0mM, 50mM, 100mM and 150mM) at 25°C temperature were studied. The findings would be helpful for selection of suitable varieties and areas for commercial cultivation of palmarosa especially under salinity affected conditions. The results suggest that cultivation of the crop at more than 50 mM salinity in soils should be avoided. However, variety Trishna can be grown in soils with around 100 mM NaCl concentration.

## Survey for identification of high value aroma chemical bearing plant species from Awadh region of Uttar Pradesh

A preliminary survey of aromatic plant species was carried out in five districts (Lucknow, Barabanki, Raibarely, Amethi and Sultanpur) of Central Uttar Pradesh. Forty wild aroma chemical bearing species have been collected and characterized. *Ocimum africanum* identified as new record for the said areas. Neral, geranial, myrcene, sabinene, limonene, gamma-asarone, beta-caryophyllene, linalool, (E)-beta-ocimene, (alpha,alpha)-farnesene, benzaldehyde, alpha-terpineol, benzyl acetate, methylbenzoate, alpha- and beta-phellandrene, dill apiole, anethole, methyl chavicol, maaliol, eugenol, alpha-and beta-pinene were the major chemical constituents indentified in these aromatic species. The study revealed that the above mentioned aroma chemicals may be utilized in high grade perfumery, cosmetic and pharmaceutical industries.

*Ocimum africanun*

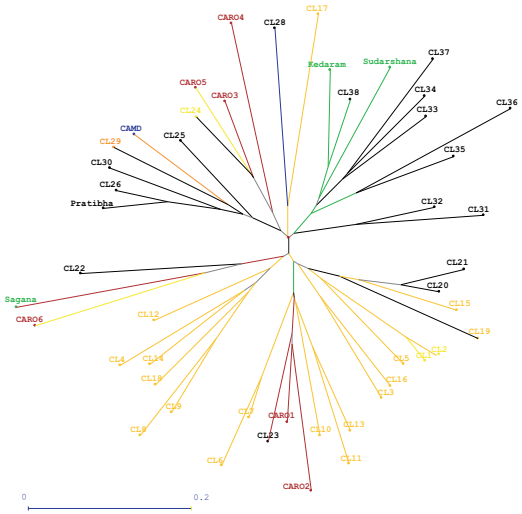
*Caesulia axillaris*

*Pogostemon benghalense*

Input: Kumar B

## Microsatellite marker resource development in *Curcuma longa*

A microsatellite marker resource of validated 96 unigene derived SSR markers from the available ESTs in the public domain have been developed in *Curcuma longa*. A set of 48 accessions including three released varieties collected primarily from Kerala, Uttar Pradesh, Assam and gene bank of CSIR-CIMAP were used for validation and characterization of diversity. Phylogenetic analysis by DARwin 5.0 programme revealed accessions to be 60% diverse. These markers will serve as tools for breeders for accelerating acceleration of genetic improvement in Curcuma.




## Identification of high biomass and high root yielding line in *Withania somnifera*

An improved breeding line has been developed in biparental F5 progenies of the CWS74Yx CWS7 cross combination. The selected line possesses biomass of 2850g/plant with a fresh root weight of 200g/plant and mean root length of 75cm/plant. The mean plant height of the advanced line was 100 cm. The roots of the advanced line possess good morphometric quality features and is a novel phenotype. The advanced breeding line has been stabilized for phenotypic traits and withanolide content. However, the evaluation of the genotype x environmental response has to be carried out.

Input: Jhang T

## Genetic improvement of spearmint (*Mentha spicata*)

Eleven elite lines have been selected in the open pollinated seed progenies (OPSPs) of spearmint on the basis of three economic traits viz., herbage yield, oil content and oil yield. OPSP line MSP- 11/2-2-01 performed best showing 26.80 percent higher herb yield with 71.61prcent carvone in oil as against check variety Neera having 53.01 percent carvone the oil. The selected line will be further evaluated for its yield performance in bench scale trial.

View of the selected OPSP line MSP-11/2-2-01 of *Mentha spicata*

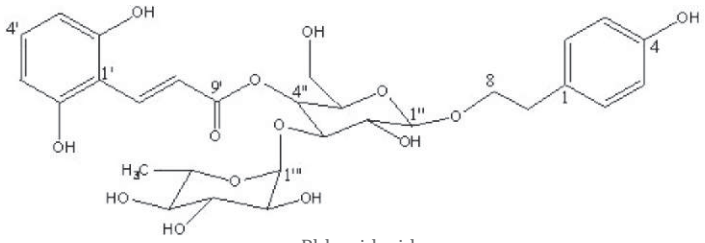
Input: Singh VR

## Project : MLP. 02 – Phytochemical exploration and value addition in bioactive molecules from MAPs

Principal Investigator: MM Gupta

### Bioactive chemical constituents from the root of *Clerodendrum phlomidis*

Hexane and ethyl acetate extracts of *C. 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-2',6'-dihydroxycinnamoyl)-glucopyranoside (phlomidoside) along with 12 known compounds. Anti-tubercular activity of extracts and isolated compounds was determined by BACTEC radiometric susceptibility assay against Mycobacterium tuberculosis H37Rv (ATCC 27294). In addition, phlomidoside was also evaluated for their effect on lipopolysaccharide-stimulated macrophages for production of pro-inflammatory cytokines, tumor necrosis factor-α and interleukin-6.



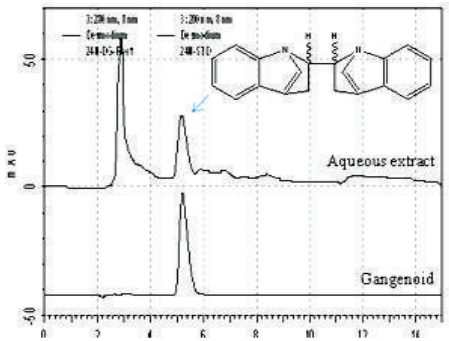

Phlomidoside

Effect of phlomidoside on TNF-α and IL-6 production from serum isolated from LPS-induced lethal toxicity model

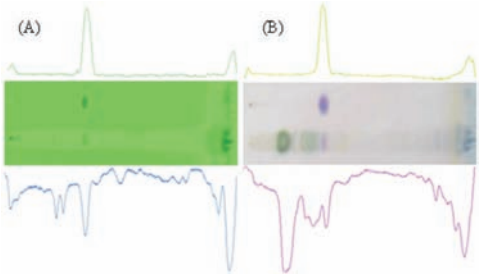
Input: Saikia D, Pal A, Gupta MM

### Validation of RP-HPLC and HPTLC methods for determination of anti-inflammatory bis-indole alkaloid in *Desmodium gangeticum*

Two simple and accurate methods, (high-performance liquid chromatography and high-performance thin-layer chromatography) are described for the detection of gangenoid, an anti-inflammatory alkaloid, in a well-known Indian medicinal plant *Desmodium gangeticum*. The proposed methods were successfully used for the estimation of gangenoid in *D. gangeticum* root.




Representative chromatograms of standard marker gangenoid and aqueous extract of *D. gangeticum* root at 280 nm.

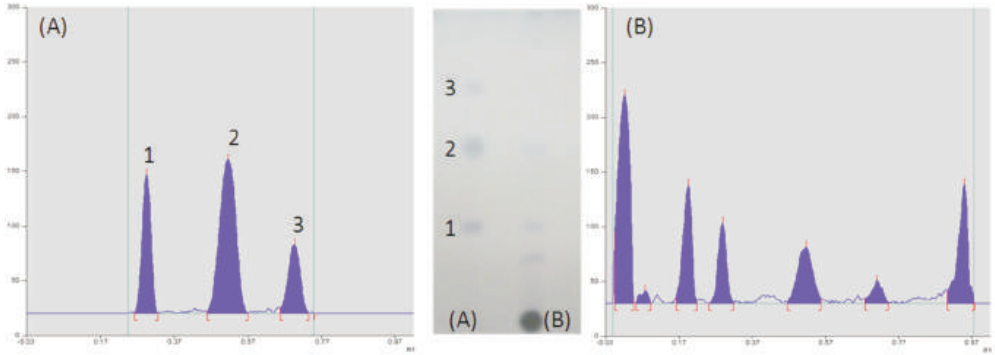



HPTLC images[(A) at 254 nm, (B) in visible light after derivatization] and digital scanning profiles [(A) at 280 nm, (B) at 580 nm] of marker gangenoid and aqueous extract of *D. gangeticum* root

Natural Product Research 28:275–277, 2014

## Simultaneous quantification of the anti-inflammatory phytoconstituents betulinic acid, 24β-ethylcholesta-5,22E,25-triene-3β-ol and lupeol in *Clerodendrum phlomidis*

A new validated HPTLC method has been developed for the simultaneous determination of anti-inflammatory compounds betulinic acid (1), 24β-ethylcholesta-5,22E,25-triene-3β-ol (2), and lupeol (3) in the roots of *Clerodendrum phlomidis*. Well-resolved separation of marker compounds was achieved on silica gel 60F254 plates using the mobile phase consisting of chloroform–methanol (98:2, v/v). Marker compounds were scanned using the densitometric reflection–absorption mode after post-chromatographic derivatization with vanillin–sulfuric acid reagent.

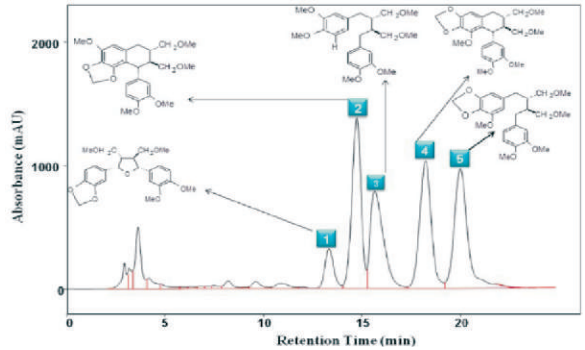



HPTLC images (in visible light) and digital scanning profiles (at 600 nm) of standard markers (A) and ethyl acetate extract (B) of *C. phlomidis*.

Journal of Planar Chromatography 27:174–180, 2014 Input: Gupta MM

## Protective mechanism of lignans from *Phyllanthus amarus* against galactosamine/lipopolysaccharide-induced hepatitis: An *in vivo* and *in silico studies*

Standardized mixture of lignans (slPA) isolated from leaves of *P. amarus* using automated chromatographic technique was used for experiments. Experimental mice were orally pre-treated with slPA (10, 30 and100mg / kg) for 7 days before intra-peritoneal injection of GalN / LPS. Acute hepatitis in mice was confirmed by significant increase of pro-inflammatory cytokines, and hepatotoxic markers.




HPLC chromatogram of slPA; A standardize mixture of lignans isolated form leaves of *P. amarus* using automated chromatographic technique. 1 virgatusin, 2 hypophyllanthin, 3 phyllanthin, 4 nirtetralin and 5 niranthin

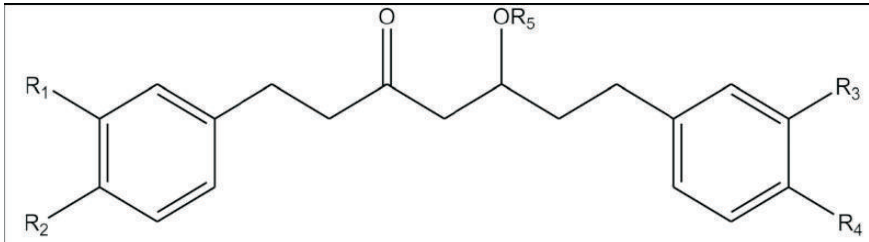
Pre-treatment of slPA exhibit significant liver protection in dose dependant manner. *In silico* molecular docking studies also suggest that lignans are preferentially more active due to strong binding affinity against pro-inflammatory cytokines; IL-1β, IL-6, and TNF-α. The electronic parameters of lignans for bioavailability, drug likeness and toxicity were within the acceptable limit. *In vivo* and *in silico* results suggest that pretreatment of slPA exhibit potent hepatoprotection against GalN/LPS-induced hepatitis in mice, and the liver protective effects may be due to the inhibition of inflammatory mediators.

Current Topics in Medicinal Chemistry 14:1045-1055, 2014

Input: Bawankule DU, Pal A , Shanker K, Singh M, Khan F, Gupta MM

## Simultaneous quantification of diarylheptanoids in *Alnus nepalensis* using a validated HPTLC method

A sensitive, selective and robust qualitative and quantitative densitometric high-performance thin-layer chromatographic method was developed and validated for the determination of platyphylloside, oregonin and hirsutanonol 5-O-b-D-glucopyranoside in the leaves of *A. nepalensis*. The separation was performed on silica gel 60F254 high-performance thin-layer chromatography plates using chloroform: methanol:formic acid (75:25:2, v/v) as mobile phase. The quantitation of diarylheptanoids was carried out using the densitometric reflection/absorption mode at 610 nm after post-chromatographic derivatization with vanillin–sulfuric acid reagent. A precise and accurate quantification can be performed in the linear working concentration range of 333–3330 ng/spot with good correlation.




| Compounds | $R_1$ | $R_2$ | $R_3$ | $R_4$ | $R_5$ |
|---|---|---|---|---|---|
| PLS( 1) | H | OH | H | OH | Glu |
| ORE( 2) | OH | OH | OH | OH | Xyl |
| HOG( 3) | OH | OH | OH | OH | Glu |

Chemical structures of compounds

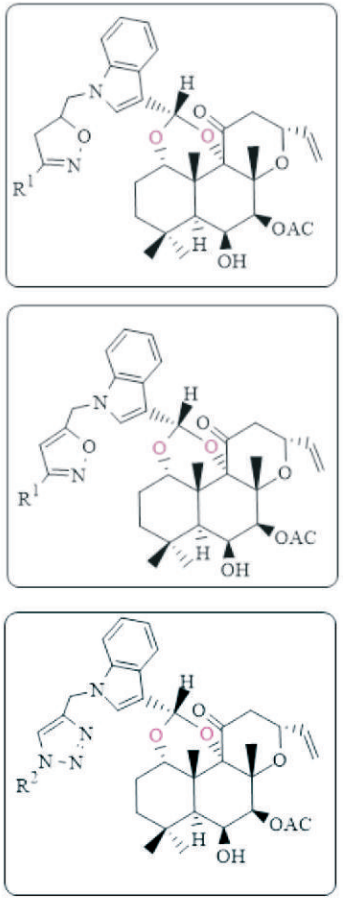
Journal of Chromatographic Science 52: 905-910, 2014

Input: Gupta MM

## Synthesis of novel derivatives of forskolin isoxazole and triazoles

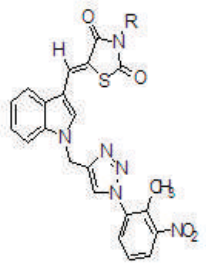
Forskolin, a highly oxygenated major labdane type diterpenoid present in the roots of *Coleus forskohlii*, exerts most of its biological activity by stimulation of adenylate cyclase by increasing cellular concentrations of the second messenger, cyclic AMP. It also displays a wide variety of physiological activities such as brancho-spasmolytic, anti-hypertensive, inotropic, anti-glaucoma, cardiovascular, anti-obesity and anti-cancer activity etc. A new class of indolylidene forskolin derivatives

containing 1,2,3-triazole or isoxazole moiety were synthesized to meet structural requirements essential for anti-bacterial, anti-diabetic and anti-cancer activity.



## Synthesis and hypolipidemic novel indole-based glitazones

Lipase inhibitors reduce the activity of lipases secreted by the pancreas when fat is present. Thus, these inhibitors could be used for the treatment of obesity, which can subsequently lead to diabetes and CVD. An example of a lipase inhibitor is orlistat. A new series of indole-thiazolidinedione derivatives were synthesized and evaluated for *in vitro* hypolipidemic activity against pancreatic lipase. Some of the compounds in the series showed significant inhibition of the enzyme when compared with the standard Orlistat drug.



Indole Thiazolidenedione

| S.No | Sample | $IC_{50}$ µM |
|---|---|---|
| 1 | 4-NO2 | 28.69 |
| 2 | 2-CN | 33.65 |
| 3 | 2-BCN | 39.43 |
| 4 | 4-Br | Not obtained |
| 5 | 3-CL | 32.56 |
| 6 | 2, 4-CL | 32.84 |
| 7 | 4-F | Not obtained |
| 8 | 4-COOH | 38.92 |
| 9 | 2-F | 29.94 |
| 10 | 2-CL | 51.81 |
| 11 | INAC | 29.84 |
| 12 | INNO2 | 48.69 |
| 13 | INCL | 40.71 |
| 14 | INF | 31.98 |
| 15 | INP | Not obtained |
| 16 | Orlistat | 62.34 |

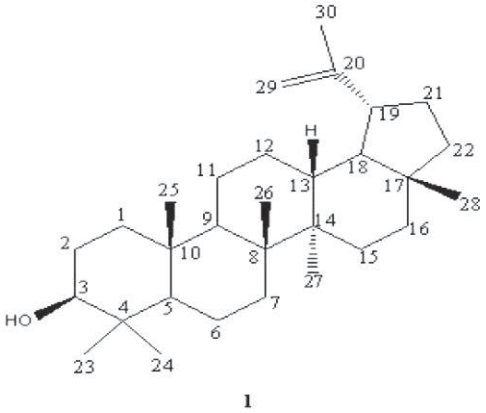
*In vitro* hypolimidemic activity of indole-thiazolidinedione

Input: Kumar JK, Srinivas KVNS, Kumar, AK

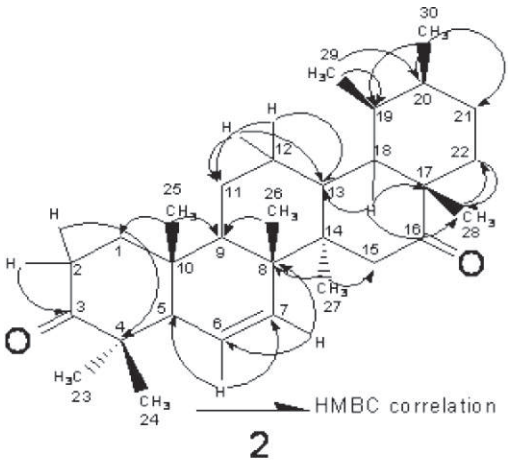
## New anti-inflammatory triterpene from the root of *Ricinus communis*

Castor bean (*Ricinus communis*, Family: Euphorbiaceae) is known as "Erand". In Ayurveda, the plant is categorized as "Vata-samanam". Purification of the n-hexane fraction led to the isolation and characterization of two triterpenes: one known compound lupeol (1) and a new diketone pentacyclic triterpene named as erandone (urs-6-ene-3,16-dione) (2).

Anti-inflammatory activity of *Ricinus communius* root extracts and isolates were tested in carrageenan-induced hind paw edema.



1




2

| Group | Dose (mg/kg) | Edema volume (mL) (mean ± SEM) | Inhibition of edema volume growth (%) |
|---|---|---|---|
| Control (Carrageenan) | - | 0.34±0.05 | - |
| Indomethacine | 15 | 0.14±0.02* | 58.09 |
| RCM | 100 | 0.29±0.04* | 15.44 |
| RCH | 100 | 0.25±0.07* | 26.47 |
| Lupeol (1) | 100 | 0.32±0.03* | 7.35 |
| Erandone (2) | 100 | 0.31±0.04* | 8.56 |

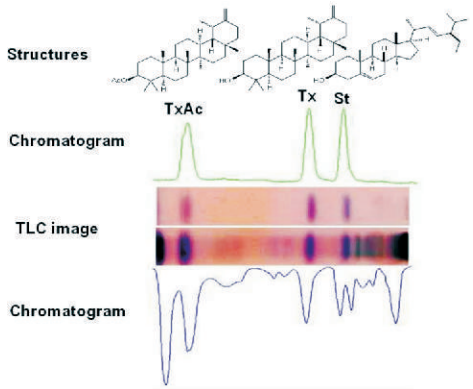
RCM- methanolic extract; RCH- hexane enriched fraction; values are mean ± SEM (n=6); statistically significant from control,* P < 0.001

Natural Product Research 28: 306-311, 2014

Input: Shanker K, Maurya AK

## HPTLC method for quality analysis of *Pluchea lanceolata*

- First time multispectral matching (DAD, NIR & MS) introduced by on/off-line coupling
- Optimization of extraction efficiency based on designs of experiments i.e. BBD and CCD
- Optimization of thermal, microwave and acoustic extraction of *Pluchea* markers
- Extractability of common organic & green solvents and techniques was optimized.
- Method is cost effective, reproducible, simple and energy efficient for the determination of taraxasterol (Tx), taraxasterol acetate (TxAc) and stigmasterol (St).



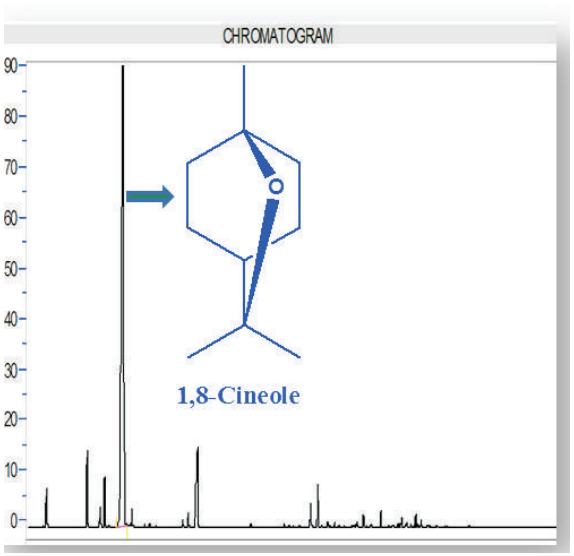

Phytochemical Analysis 25: 551–560, 2014

Input: Shanker K, Ajaykumar PV

## Exploration of new sources of bioactive aroma chemicals/essential oils for future industrial use

*Chemical characterization of essential oil of Melaleuca linarrifolia grown in India as a source of 1,8-cineole*

Essential oil composition of *Melaleuca linarrifolia* Sm. from India was analyzed using gas chromatography (GC-FID) and gas chromatography-mass spectrometry (GC-MS). Forty-four constituents were identified, accounting for 98.90% of total composition characterized by a higher content of oxygenated monoterpenoids (86.63%) represented by 1,8-cineole (77.40%) and α-terpineol (7.72%). The essential oil exhibited good anti-bacterial activity against *Escherichia coli, Salmonella typhimurium, Bacillus subtilis,* and moderate activity against Staphylococcus epidermidis, *Staphylococcus aureus* (MTCC 2940), *Staphylococcus aureus* (MTCC 96), and *Streptococcus mutans.* The essential oil composition was characterised for *M. linarrifolia* grown in India for the first time for high 1,8-cineole (>75.0%) content, hence it could be propagated and harvested as a potential source of 1,8-cineole for cosmetics and herbal formulations.



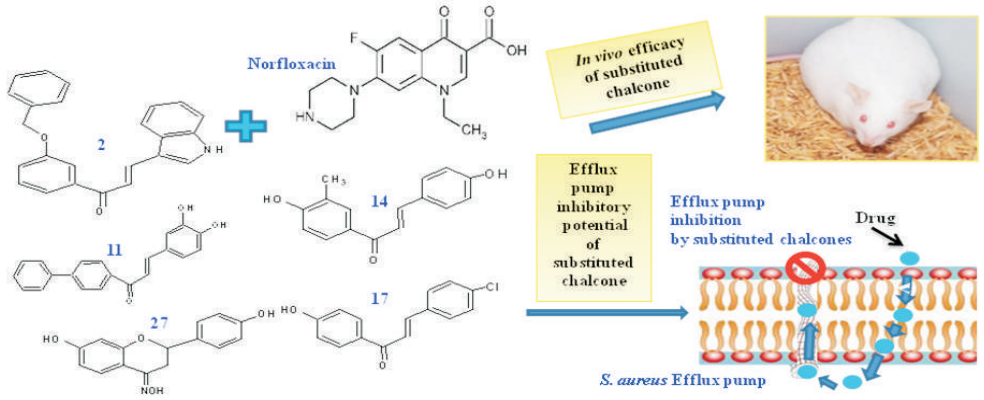

| Strains | ZI (MIC) |
|---|---|
| *Escherichia coli* | 11 (125 µg/ml) |
| *Salmonella typhimurium* | 11 (250 µg/ml) |
| *Bacillus subtilis* | 10 (250 µg/ml) |
| *Staphylococcus epidermidis* | 08 (250 µg/ml) |
| *Staphylococcus aureus-2940* | 07 (250 µg/ml) |
| *Staphylococcus aureus-96* | 06 (125 µg/ml) |
| *Streptococcus mutans* | 06 (250 µg/ml) |
| *Klebsiella pneumoniae* | na |
| *Pseudomonas aeruginosa* | na |

Industrial Crop and Products, 63: 264-268, 2015

Input: Padalia, RC, Verma, RC, Chauhan A

## Synthesis of isoliquiritingenin, liquiritingenin derivatives and their *in vitro, in vivo* synergistic activity with norfloxacin against methicillin resistant *Staphylococcus aureus* (MRSA)

A series of ISL/LTG *(Glycyrrhiza glabra)* derivatives was synthesized and evaluated with norfloxacin against MRSA. In combination study, derivatives 2 and 14 significantly reduced MIC of norfloxacin up to 16 folds (FICI<0.5), while 11, 17 and 27 reduced up to 8 folds (FICI$\leq$ 0.5). In systemically infected Swiss albino mice model, 2 and 14 significantly *(P<0.001, P<0.01)* lowered systemic bacterial load in blood, liver, kidney, lung and spleen tissues. This study supports the promising use of ISL/LTG based phenolics in the development of economical anti-bacterial combinations.




RSC Advances 5:5830-45, 2015

Inputs: Bhakuni RS, Darokar MP

## Evaluation of essential oil quality of lemon-balm (*Melissa officinalis*)

*Melissa officinalis* L. (Lamiaceae), commonly known as 'lemon-balm', holds a prime position among a diversity of aromatic plants being cultivated throughout the world. The leaves of plant are used in traditional medicine to prepare a tea for its nerve calming and spasmolytic effects. In the present study, essential oil composition of lemon-balm produced in two ecological conditions, viz. foothills and mid-hills, was evaluated using gas

chromatography-flame ionization detector (GC-FID) and GC-mass spectrometry (GC-MS). The crops gave 1.0 mL kg-1 (foothills) and 0.9 mL kg-1 (mid-hills) essential oil on hydrodistillation of fresh biomass. A total of thirty-three constituents, representing 91.4 ± 1.56 to 98.1 ± 0.60% of the total oil compositions were identified. Major constituents of the essential oil were geranial (42.3 ± 1.77 to 44.9 ± 3.23%), neral (30.7 ± 1.11 to 32.6 ± 3.57%), (*E*)-caryophyllene (2.8 ± 1.00 to 3.5 ± 1.27%), geranyl acetate (0.7 ± 0.49 to 3.3 ± 0.15%), geraniol (0.9 ± 0.93 to 2.6 ± 0.35%), and piperitone (0.6 ± 0.96 to 2.5 ± 1.81%). The examined essential oil was considerably rich in monoterpenoid aldehyde (citral; 73.0-77.5%). The essential oil of examined *M. officinalis* population was found to be rich in citral (geranial + neral), which represents the composition of a most

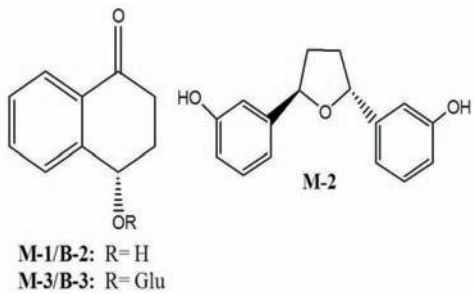
common chemotype of lemon-balm, cultivated in Cuba, Slovak Republic, Turkey, Brazil, and Tajikistan.

Input: Verma RS

## Anti-malarial potential of extracts and isolated compounds from four species of genus *Ammannia*

Properly dried and milled samples comprising various plant parts were separately extracted with methanol and the extracts were fractionated with *n*-hexane, chloroform and *n*-butanol.

*In vitro* anti-plasmodial activity against *Plasmodium falciparum NF-54, in vitro* cytotoxicity against Vero cells (VERO C1008; ATCC CRL-1586 and *in vivo* anti-malarial activity against *Plasmodium berghei* K173 was evaluated.




*In vivo* anti-malarial (day 6 % suppression of parasitaemia) *Ammania* fractions against *P. falciparum* NF-54 was VL=98.98, AC=63.33, AM3=60.0

| Selective *in vitro* anti-plasmodial activity | | | | |
|---|---|---|---|---|
| **Plant species** | **Plant part** | **Extract/fraction** | **NF54, $IC_{50}$ (µg/mL)** | **Selectivity Index** |
| *A. multiflora* | Whole plant | Methanol (AM) | 25.0 | >8.00 |
| | | Butanol (AM3) | 17.8 | >11.24 |
| *A. baccifera* | Root | Chloroform (BR2) | 3.5 | >57.14 |
| | | Butanol (BR3) | 2.7 | >74.07 |
| *A. verticillata* | Root | Chloroform (VR2) | 20.5 | >9.76 |
| | Aerial parts | Methanol (VL) | 15.4 | >12.99 |
| | | Hexane (VL1) | 14.5 | >13.79 |
| | | Chloroform (VL2) | 16.6 | >12.05 |
| *A. coccinia* | Whole plant | Methanol (AC) | 4.5 | >44.44 |

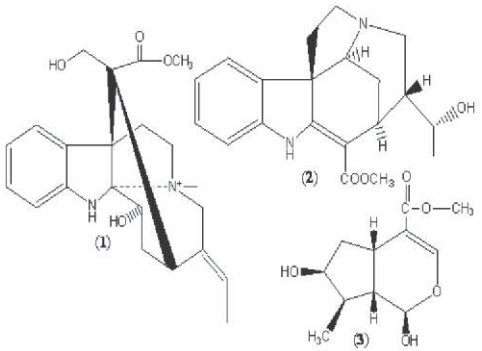
Due to high degree of selective anti-plasmodial activity, these plants may find use in anti-malarial phytopharmaceuticals as well as in the development and discovery of safer and novel anti-malarial leads.

Medicinal Chemistry Research, 23: 870-876, 2014 Input: Srivastava SK, Darokar MP

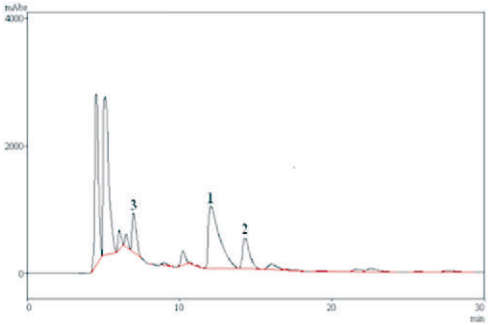
## Silica-based monolithic coupled column for the simultaneous determination of echitamine, $N^b$-demethylalstogustine and loganetin in *Alstonia scholaris* by RP-HPLC and optimization of extraction method

A simple, rapid and sensitive HPLC method for the simultaneous quantification of echitamine (1), $N^b$-demethylalstogustine (2) and loganetin (3) in *Alstonia scholaris* was

developed using silica-based monolithic coupled column. The validated method is precise, accurate and reproducible and may be applied in the overall quality assessment of *A. scholaris* containing these three marker compounds.

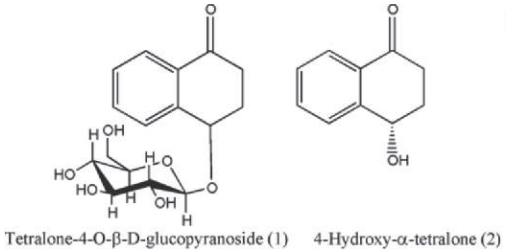


Markers for HPLC analysis



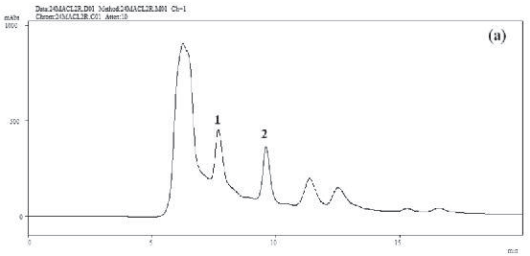
HPLC chromatogram of bark of A. scholaris

## Simple and reliable method for the determination of tetralone-4-O-β-D-glucopyranoside and 4-hydroxy-α-tetralone in three species of *Ammannia* by reversed-phase HPLC



Tetralone-4-O-β-D-glucopyranoside (1) 4-Hydroxy-α-tetralone (2)

Markers for HPLC analysis



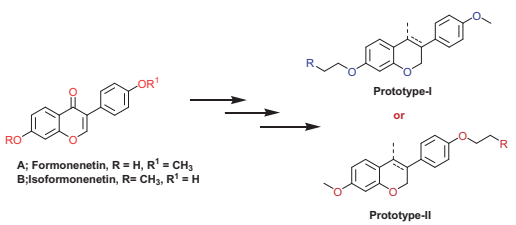
HPLC chromatogram of *Ammannia*

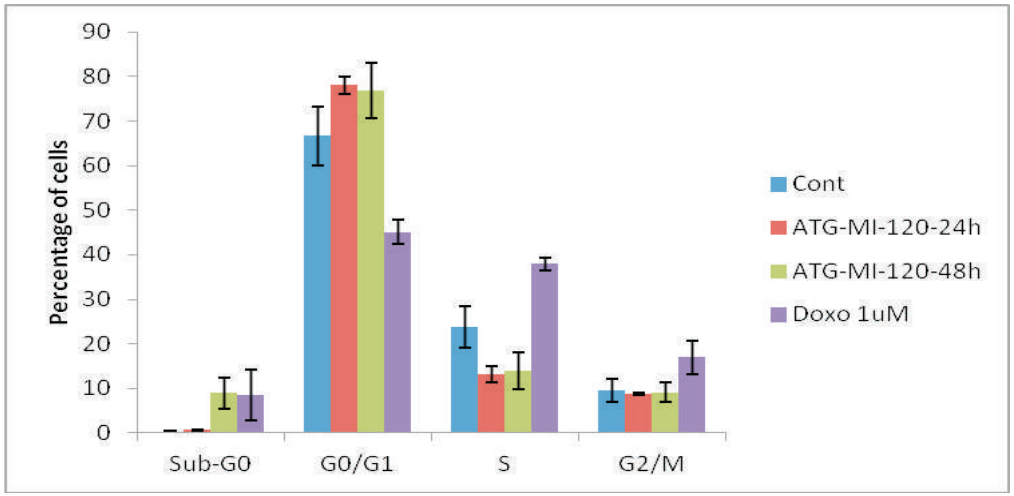
A rapid, reliable and reproducible reversed-phase HPLC method was developed for the determination of 1 and 2 in three species of *Ammannia* namely, *A. coccinea*, *A. verticillata* and *A. tenuis*. The validated method is precise, accurate and reproducible and may be applied in the overall quality assessment of *Ammania* species containing these two marker compounds.

Input: Srivastava SK

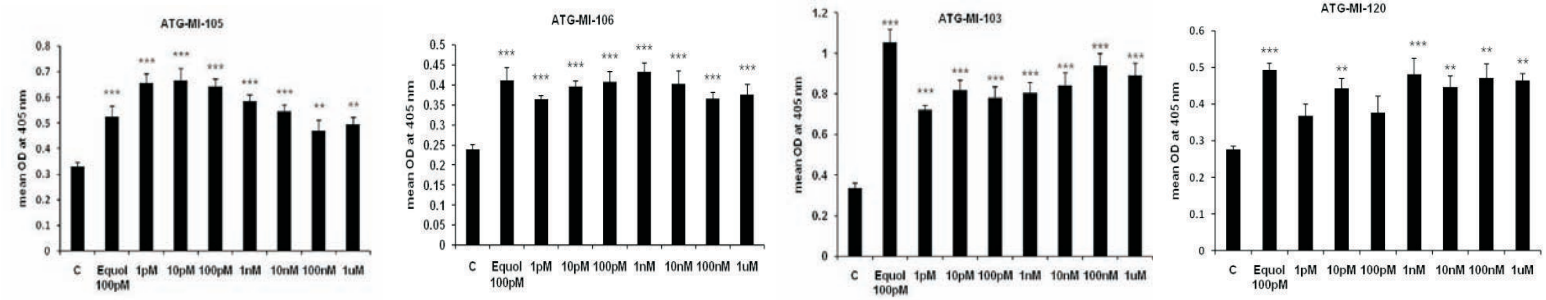
## Logical modification of phytochemicals for improved anti-cancer activity

A series of phytoestrogen based formononetin and isoformononetin analogues have been synthesized as ER- β selective SERMs. These analogues showed potential anti-cancer activity at a range of $IC_{50}$ 6.54 to 27.79 μM in different cancer cell lines viz *MCF-7*, DLD1, A549, FaDU, DU145. The most active molecule, ATG MI-120 inhibited proliferation of cells by inducing apoptosis and arresting cell cycle at G2/M phase. In addition to their anti-cancer activity these compounds also showed significant bone forming activity in mouse calvarial osteoblast cells assay.






Effect of ATG-120 on cell division cycle: Histogram showing average population cells in various phases (G1, G2, S) of cell cycle (mean ± S.E. of three independent assays)

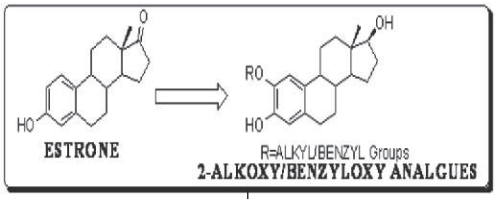



Bone forming activity of selected compounds; alkaline phosphatase (ALP) activity of compounds was determined spectrophotometrically at 405 nm. Equol at 100 pM was used as a positive control. Data shown as mean±SEM; n=8; (*)P < 0.05, (**)P < 0.01, (***)P<0.001 compared with untreated cells taken as control.

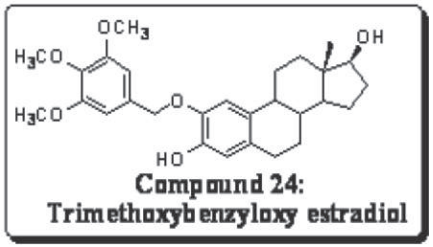
Input: Gupta A

## 2-Methoxyestradiol analogue as potent anti-cancer agent through microtubule stabilization

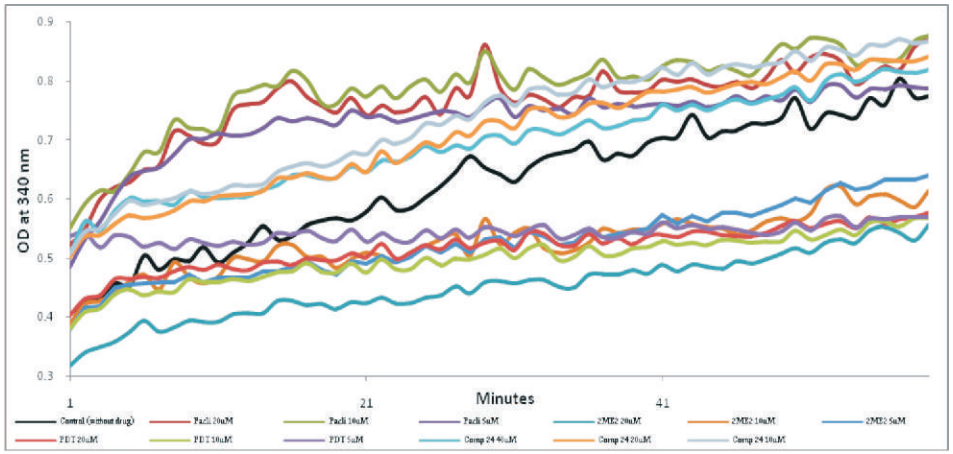
2-Benzyloxy analogue of estradiol i.e. compound 24 exhibits potent anti-breast cancer activity through microtubule stabilization at taxol binding site. The compound was non-toxic up to 1000mg/kg dose in acute oral toxicity in Swiss-albino mice.



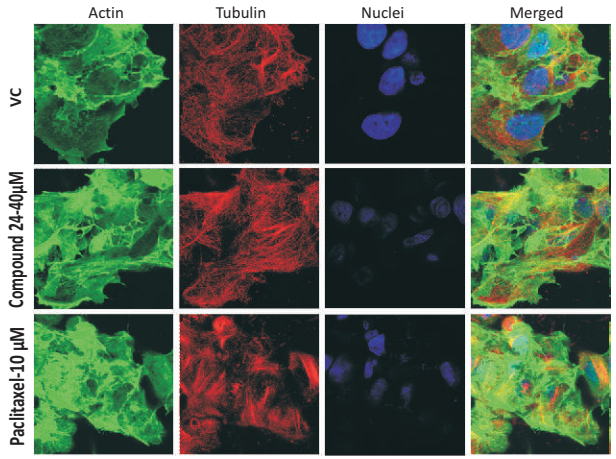

Transformation scheme



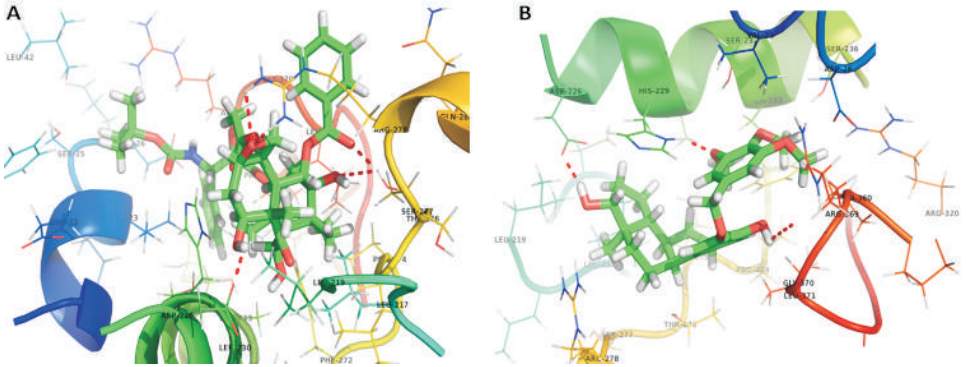

Best analogue MDAMB 231: IC50=7.0µM



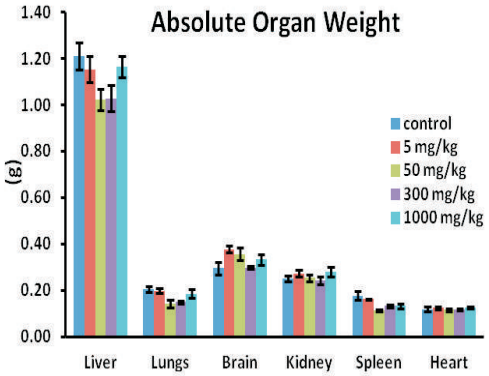

Tubulin polymerisation kinetics (stabilization) by compound 24

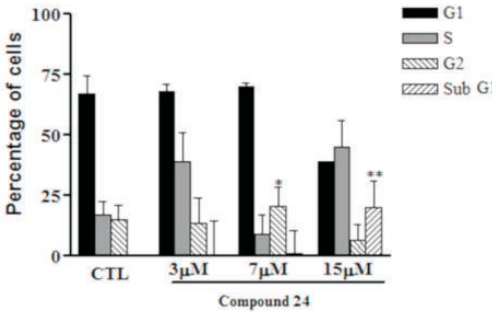



Confocal microscopy: microtubule stabilization compound 24

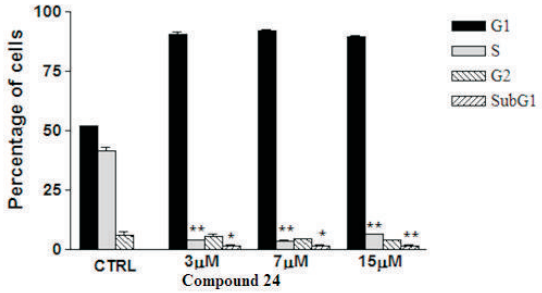



Taxol binding site interactions at tubulin A) by Taxol, and B) by compound 24

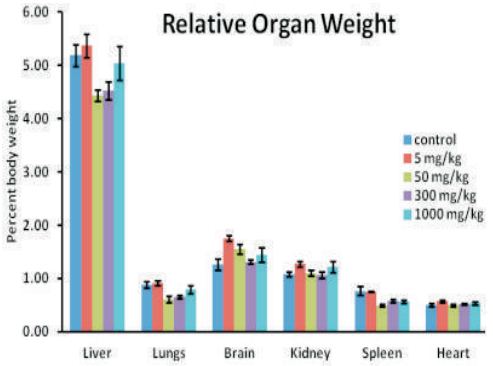



Cell cycle analysis in MCF-7, 24h: G2 phase arrest by compound 24




Cell cycle analysis in MDA-MB-231 in 48h: G1 phase arrest by compound 24




Acute oral activity of compound 24 non-toxic up to 1000mg/kg dose.

Eur. J. Med. Chem. 86:740-752, 2014

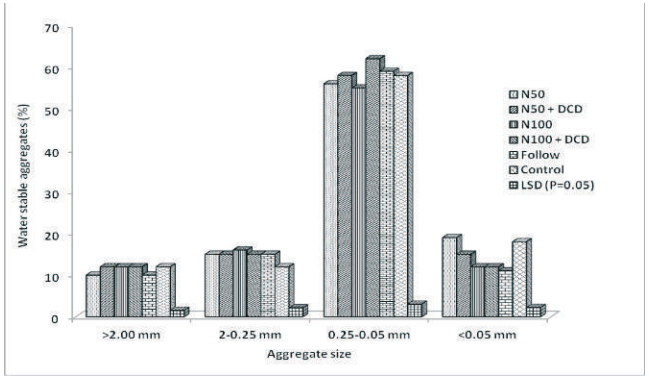
Input: Negi AS, Luqman S, Chanda D, Khan F.

## Project : MLP. 05 – Development of pre and post harvest technologies for commercially viable medicinal and aromatic crops and their popularization

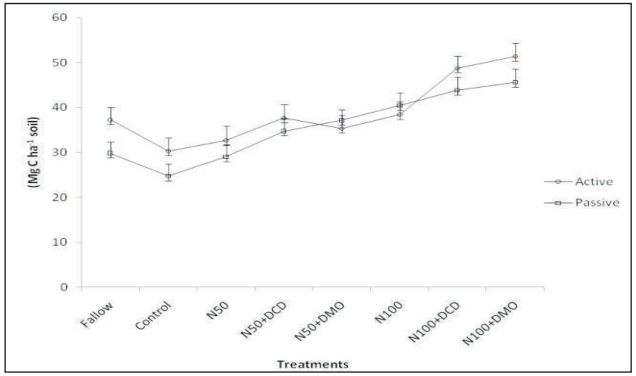
Principal Investigator: DD Patra

### Organic C dynamics and its conser-vation under wheat (*Triticum aesetivum*) – mint (*Mentha arvensis*) - *Sesbania rostrata* cropping in sub-tropical condition of northern Indo-Gangetic plains

Soil organic carbon (SOC) is accumulated or depleted as a result of cropping and management strategies. It plays a significant role in maintaining soil quality, plant productivity and mitigating greenhouse gas emission. The long-term (20 years) influence of a wheat-mint-*Sesbania* cropping system on the SOC stock was studied. Estimates of stabilization of SOC in different pools and a tentative C budget were also developed. Twenty years of cultivation caused a decrease in SOC only in control soils, which received no manure and fertilizer. However, it increased with balanced use of NPK inputs. Soil C stock decreased significantly with increase in soil depth 0-15 cm to 15-30 and 30-45 cm. About 6% (-2 to +14) of the C added in crop residues and green manure were stabilized in the soil. On an average, 12%, 14%, 59%, 15% of the water stable aggregates were in the >2 mm, 2.0-0.25 mm, 0.25-0.05 mm, and <0-0.5 size fractions, respectively. Significant improvements in structural stability and nitrogen availability were detected in all the treatments compared to the control. The amount of organic C oxidizable by a modified Walkley and Black method, which involves using only half of the amount of sulphuric acid, is a more sensitive indicator of the improvement in soil quality parameters under investigation, namely SOC, and increases in mineralizable N and water stable aggregation than the standard method.




Water stable aggregates of a 0-15 cm layer of soil under some selected treatments and fallow

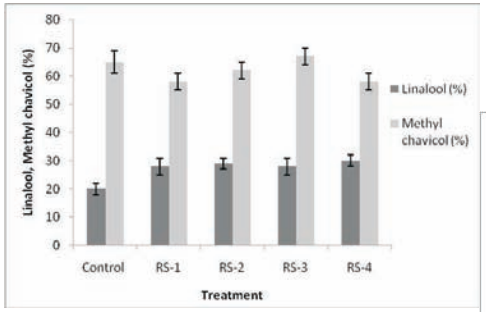



Active and passive pools of SOC (Mg C $ha^{-1}$ soil) under different treatments (error bars represent the standard error of mean)

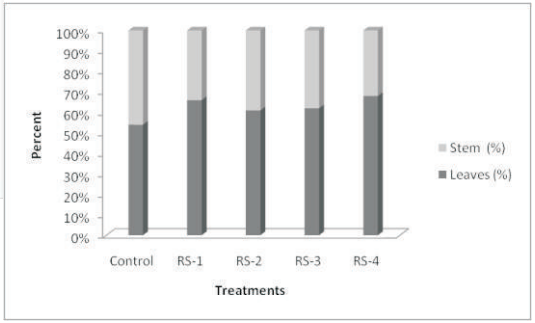
J Environ Manage 135:118-25; 2014 Input: Patra DD, Chand S

## Identification and performance of stress tolerant phosphate solubilizing bacterial isolates on *Ocimum basilicum* in sodic soil and their role in mitigating the sodicity problem

*Ocimum basilicum* is tolerant to higher salt, pH and exchangeable sodium percentage (ESP) in soil. It is as a potential crop to be grown in salt affected soil. Its tolerance to adverse condition, and association with halophilic beneficial microbes together can play a greater role for utilization and improvement of sodic waste land. After screening the potential phosphate solubilizing bacteria (PSB) (RS-1, RS-2, RS-3 and RS-4) from sodic soil, they were identified and tested in pot experiment in naturally occurring sodic soil having pH 9.3 and ESP 45. At optimum condition, these bacteria showed phosphorus solubilization potential in liquid medium containing tricalcium phosphate (TCP) under laboratory condition. Inoculation of PSB significantly increased the plant growth with respect to height, number of branches, dry matter accumulation and P content of plants. Quantity and quality of essential oil were also significantly influenced by PSB inoculation as compared to the control. It has been observed that PSB also improved the physical, chemical and biological properties of the post harvest soil.




Variation in linalool and methyl chavicol content of *Ocimum basilicum* as influenced by different inoculants.




Leaves and stem percentage of *Ocimum basilicum* as influenced by different inoculants.

Ecological Engineering 71: 639–643, 2014

## HS-SPME-GC-FID method for detection and quantification of *Bacillus cereus* ATCC 10702 mediated 2-acetyl-1-pyrroline

A rapid micro-scale solid-phase micro-extraction (SPME) procedure coupled with gas-chromatography with flame ionized detector (GC-FID) was used to extract parts per billion levels of a principle basmati aroma compound 2-acetyl-1-pyrroline (2-AP) from bacterial samples. Optimization parameters of bacterial incubation period, sample weight, pre-incubation time, adsorption time, and temperature, precursors and their concentrations have been studied. In the optimized conditions, detection of 2-AP produced by *Bacillus cereus* ATCC10702 using only 0.5 g of sample volume was 85 µg/kg. Along with 2-AP, 15 other compounds produced by *B. cereus* were also reported out of which 14 were reported for the first time consisting mainly of (E)-2-hexenal, pentadecanal, 4-hydroxy-2-butanone, n-hexanal, 2-6-nonadienal, 3-methoxy-2(5H) furanone and 2-acetyl-1-pyridine and octanal. High recovery of 2-AP (87 %) from very less amount of *B. cereus* samples was observed. The method is reproducible, fast and can be used for detection of 2-AP production by *B. cereus*.

Biotechnol Prog, 30:1356-63, 2014 Input: Patra DD

## Project : OLP.08 – Herbal products, formulations and process development using traditional/modern approaches

Principal Investigators : DN Mani, NP Yadav

### Product for knee and joint pain ready for clinical study and licensing


For effective management of knee pain, joint pain and inflammation, Rheumarth capsules have been developed. The Rheumarth capsules were standardized and scientifically validated for anti-inflammatory and analgesic conditions for rheumatoid arthritis (*aam vat roag*) related disorders. Clinical studies are proposed to be carried out in collaboration with a suitable partner.

Input: Mani DN

### Novel hydrophilic-lipophilic approach for cream formulation of citronella oil and evaluation of plant leaf extracts for anti-diabetic potential

Essential oils and plant extracts are important plant leads, which can be utilized for various therapeutic purposes. A novel hydrophilic-lipophilic balance approach was devised to develop the cream formulation of citronella oil (Fig.1), which has potent mosquito repellent properties. In another important study, plant leaf extracts of *Costus pictus* (Fig. 2) and *Cissampelos pareira* were evaluated for anti-diabetic potential in small animals through oral glucose tolerance test and STZ-induced animal model.

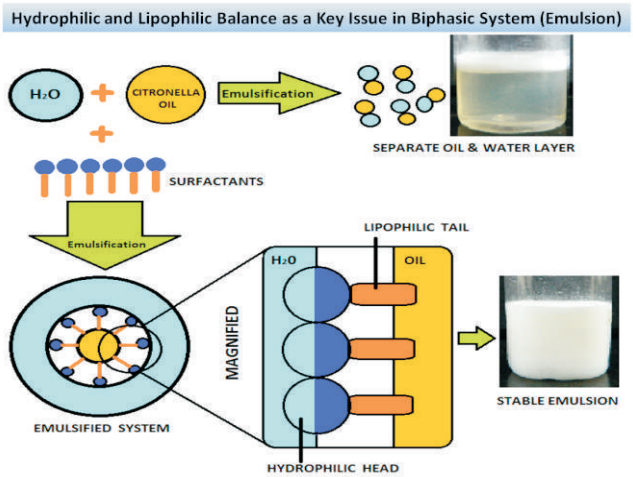



Fig. 1: Hydrophilic-lipophilic balance (HLB) approach for development of stable emulsion

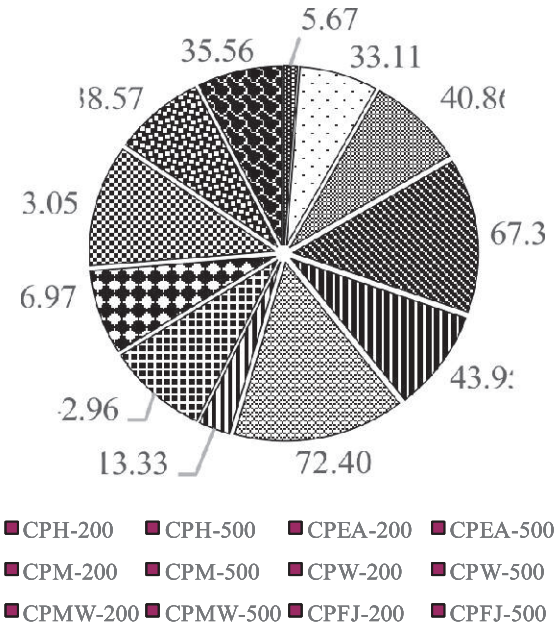



Fig. 2: Percent glucose lowering effect of *Costus pictus* leaf extracts

CPH=hexane extract; CPEA=ethyl acetate extract; CPM=methanol extract; CPW=water extract; CPMW=methanol extract; CPFI=fresh juice; 200 and 500 denotes 200mg/kg and 500 mg/kg

Stable, consistent, non-irritant and enriched cream formulation of citronella oil was developed utilizing hydrophilic-lipophilic balance approach. Plant leaf extracts *Costus pictus* D.(Don) and *Cissampelos pareira* were found effective in lowering blood glucose levels in glucose fed animals as well as STZ induced diabetic animals.

Drug Development and Industrial Pharmacy 39: 1540–1546, 2013; Journal of Pharmacy Research 6: 874-878, 2013; Annals of Phytomedicine 2: 57-62, 2013

Input: Yadav NP

## Project : OLP.13 – Metabolic modulation in pyrethrin producing plants for enhanced production

Principal Investigator: Laiq-ur-Rahman

*De novo* transcriptome assembly was performed using Illumina paired-end technology in a non-model plant *Chrysanthemum cinerariaefolium*, an important plant for the production of natural insecticide. Total contigs in flower and leaf tissues were 65,968 and 80,972 respectively. These raw reads were sequenced, trimmed and assembled into a total of 9,304 unique genes. Functional annotation studies showed known, hypothetical and unknown type of genes. Hypothetical and unknown genes were further annotated for domain and motif analysis through Pfam, Prosite and Interpro search tools. Gene ontology study through KEGG and UniprotKB revealed genes related to pyrethrin biosynthesis. Mostly assembled contigs were assigned to primary and secondary metabolism.The study will provide new insight for elucidation of biosynthetic pathway for pyrethrin production.

## Project : OLP.11 – Conservation of rare/ endangered/elite germplasm of important MAPs under *in vitro* bank

Principal Investigator: Archana Mathur

### Dual-purpose cell line of an Indian congener of Ginseng - *Panax sikkimensis* with distinct ginsenoside and anthocyanin production profiles

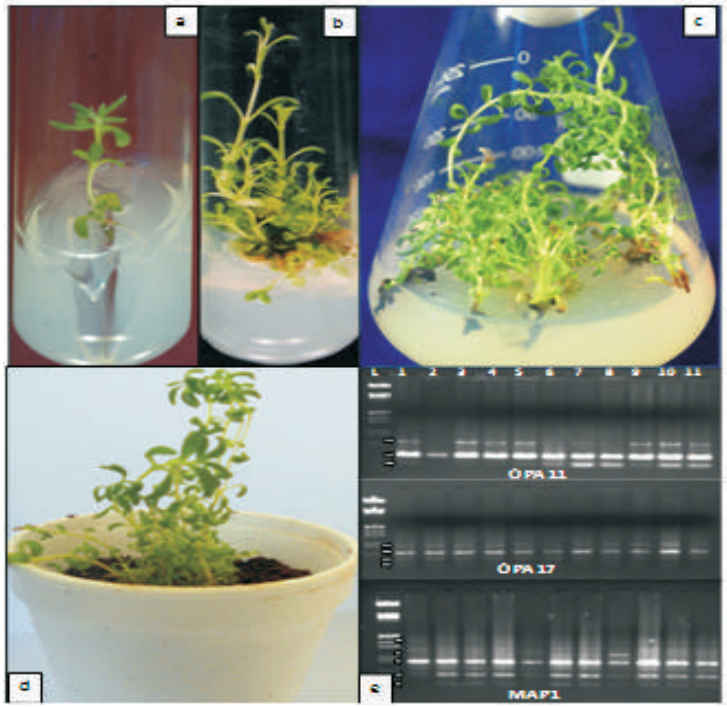
The North East Himalayas are home to many unexplored varieties of flora and fauna, and are one of the biodiversity hotspots of India. Ginseng (*P. ginseng* and *P. quinquefolium*) is the most sought after endangered herb for its adaptogenic and revitalizing virtues in traditional Chinese medicine with a global trade of 2040 million USD in 2013. India is home to many ginseng species such as *P. sikkimensis, P. sokpayensis, P. assamicus* and *P. psuedoginseng*. Inspite of being blessed, India's ginseng trade is practically nonexistent. An effort has been under-taken to establish cell suspensions of one such Indian congener *P. sikkimensis* (Lachung, Sikkim) and exploit its *in vitro* ginsenoside (bioactives) potential. This cell line has immense industrial value as maximum ginsenosides (content comparable to reported *P. ginseng* and *P. quinquefolium* lines) are produced within 3 weeks of culture as presented in Table below. Such *in vitro* production pedestals are a handy tool to overcome the major problem associated with cultivation of ginseng species.

Growth and secondary metabolite production kinetics in cell suspensions of *Panax sikkimensis* as a function of culture age

| Age (wks) | Biomass increase (%) | Cell Biomass (g)/l medium | Ginsenoside content (mg/g DW) | | | | | | | Ginsenoside yield (mg/l medium) | Anthocyanin content (mg/g DW) | Anthocyani n Yield (mg/l medium) |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Rg1 | Re | Rg2 | Rb1 | Rb2 | Rc | Total | | | |
| 1 | 111.04 | 83.28 | 0.12 | 1.27 | 0.15 | 0.04 | nd | nd | 1.58 | 11.54 | 8.66 | 63.23 |
| 2 | 156.97 | 117.73 | 0.11 | 1.16 | 0.04 | nd | nd | nd | 1.31 | 13.48 | 9.64 | 99.17 |
| 3 | 159.31 | 119.48 | 3.40 | 3.66 | 0.27 | nd | 0.04 | nd | 7.37 | 77.82 | 14.14 | 149.3 |
| 4 | 151.83 | 113.88 | 0.04 | 1.09 | 0.14 | nd | 0.02 | nd | 1.29 | 14.08 | 10.97 | 119.7 |
| 5 | 209.67 | 157.25 | 0.05 | 1.23 | 0.13 | nd | 0.02 | nd | 1.43 | 19.93 | 14.29 | 199.1 |
| 6 | 145.97 | 109.48 | 0.06 | 0.89 | 0.02 | 0.07 | nd | 0.01 | 1.05 | 10.10 | 12.79 | 123.0 |
| 7 | 106.22 | 79.67 | 0.33 | 0.48 | nd | 0.23 | nd | 0.09 | 1.13 | 7.89 | 10.95 | 76.49 |

## Genetic fidelity assessment of long-term micropropagated *Lavandula officinalis* Chaix. - an important aromatic medicinal plant

Complete plant regeneration from long term in vitro conserved shoots was achieved through axillary shoot proliferation on original 2.5 mg/l kinetin containing medium followed by rooting of individual shoots in a hormone-free half strength MS basal medium. The genetic fidelity of the regenerated plants was tested by random amplified polymorphic DNA analysis. Twenty one arbitrary decamer primers produced a total of 64 scorable bands (1–6 bands/primer) in the size range of 100–5,148 bp. All DNA fingerprints with these primers displayed monomorphic band profiles indicating homogeneity among the regenerated progeny and their uniformity with the donor parent.



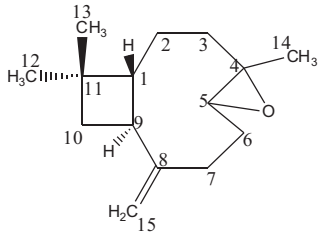

Micropropagation & genetic fidelity testing of *L. officinalis* a, b - bud elongation & shoot proliferation from stem explants; c– 6 wk old fully grown multiple shoot culture; d- In vitro developed rooted plant growing in soil; e - RAPD profiles of parent and 10 randomly selected in vitro regenerated plants with MAP1, OPA11 & OPA17 primers (Lane L corresponds to λ-DNA digested EcoR I/ Hind III double digest DNA ladder; Lane 1-Mother plant; Lanes 2-11- regenerated plants)

## Project : OLP. 14 – Natural small molecules and library of their analogues by chemical and biological means: Chemical and biological perspective

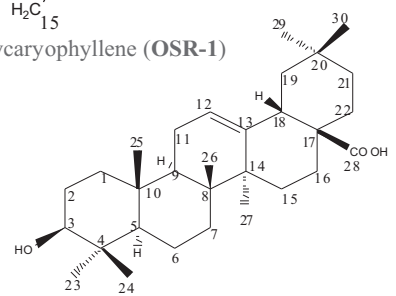
Principal Investigator: PK Chaudhuri

A new tricyclic sesquiterpenoid- 4,11,11-trimethyl-8,15-dihydroxy-tricyclo [7.2.0.0$^{4,7}$]-undecane 1 as a minor constituent was identified from the left out essential oil of *O. sanctum* after the removal of carotenoids by exhaustive NMR and MS spectra besides several known sesquiterpenoids from its oil fraction. Compound 1 has been formed biogenetically from β-caryophyllene by the ring closure of C(4)-C(7) with hydroxylation at C(8)-C(15) double bond. The structure of compound OSR-2 isolated first time from the essential oil fraction of *O. sanctum*, was identified as 5-hydroxy-caryophyllene from its physical and spectral data ($^{1}$H and $^{13}$C NMR and MS data) and semi-synthetically prepared from caryophyllene. Both the new compound 1 and reaction products OSR 1 and 2, were found to be active against the cancer cell line MCF-7. The new compound 1 showed correlation of DPPH radical scavenging activity with its anti-cancer activity *in vitro*. Among all the sesquiterpenoids, compound 1 has the highest activity against MCF-7 *in vitro*.

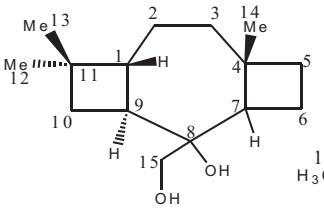
Chemical analyses of triterpenoid parts showed the presence of both oleanolic and ursolic acids belonging to ursane and oleanane skeleton.



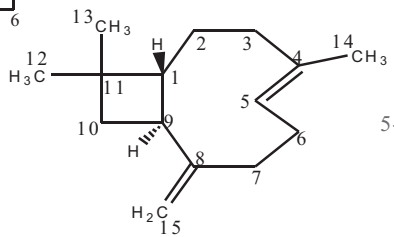
4,5-Epoxycaryophyllene (**OSR-1**)



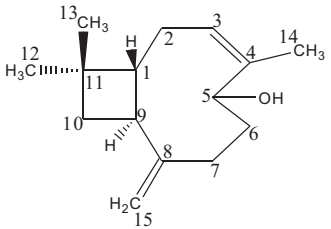
Oleanolic acid (**OS-3**)



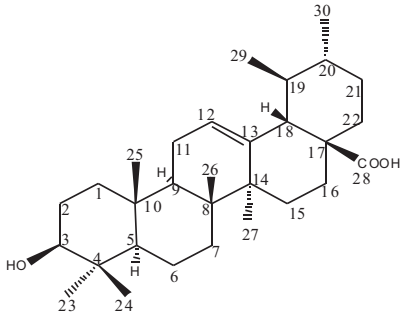
Compound 1



β-Caryophyllene



5-Hydroxy caryophyllene (**OSR-2**)



Ursolic acid (OS-2)

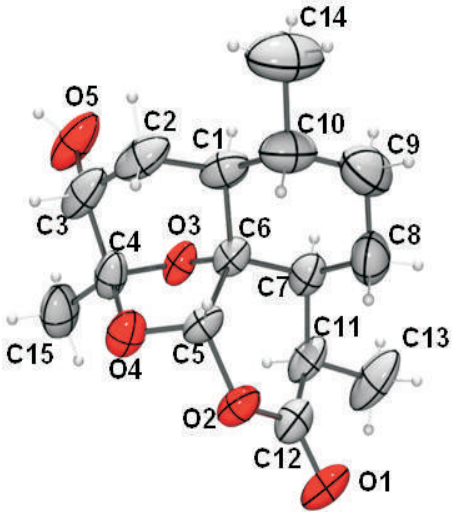
Helvetica Chemica Acta, 97, 708-711, 2014

Input: Chaudhuri PK, Darokar MP

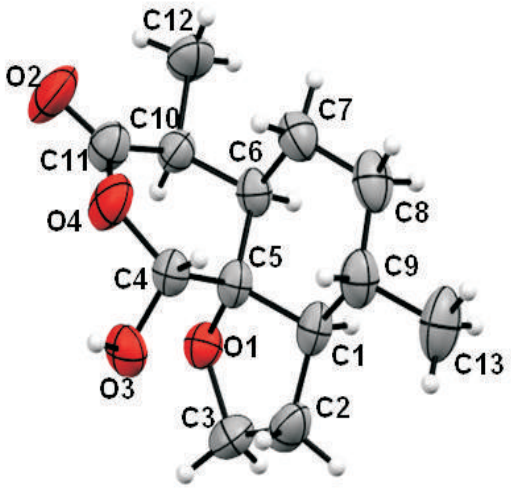
## Project : OLP.16 – Biotransformation of artemisinin through hairy root clones of medicinal plants and evaluation of their bioactivity

Project Investigators : Suchitra Banerjee, AS Negi

Selected hairy root clones of three medicinally important plants, i.e., *Atropa belladonna, Hyoscyamus muticus* and *Ocimum basilicum*, demonstrated successful biotransformation of artemisinin [1] into two biotransformed products. Structure elucidation of these molecules through spectroscopic analysis (NMR/MS) and X-ray crystallography led to their identification as 3-α-hydroxy-1-deoxyartemisinin [2] and 4-hydroxy-9,10-dimethyloctahydrofuro-(3,2-i)-isochromen-11 (4H)-one [3]. The tested hairy root clones differed in their individual bioconversion efficiencies. The HR clones of *H. muticus* accomplished the highest conversion of [1] to [2], while that of *A. belladonna* showed the maximum conversion of [1] to [3]. The HR clone of *O. basilicum* revealed an in-between reaction. The bioactivity evaluation of these derivatives (*in silico* and *in vitro*) revealed promising anti-plasmodial activity profile in combination with noteworthy TNF level lowering potential of compound [2], indicating thereby its prospective therapeutic merit in lessening the severity of cerebral malarial ailments.




3-α-hydroxy-1-deoxyartemisinin [2]




4-hydroxy-9,10-dimethyloctahydrofuro-(3,2-i) - isochromen-11(4H)-one [3].

J. Molecular Catalysis B: Enzymatic 113: 95-103, 2015

Input: Banerjee S, Kotesh J, Vasudevan P, Khan F , Pal A, Bhakuni RS, Tandon S, Gupta N, Srinivas KVNS

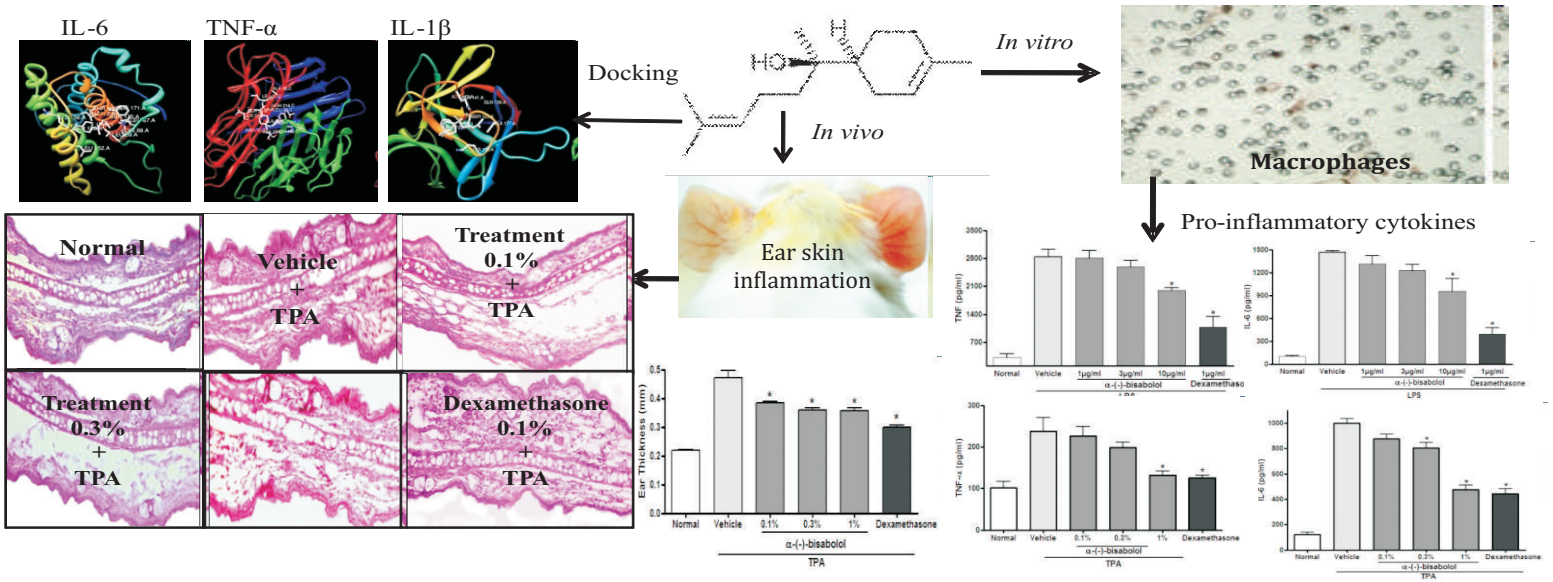
## Project : OLP. 17 - Target based validation of identified MAP leads

Principal Investigators: DU Bawankule, Suaib Luqman

### α-(-)-bisabolol reduces pro-inflammatory cytokine production and attenuates skin inflammation

#### Evaluation of the therapeutic profile of α-(-)-bisabolol against skin inflammation

α-(-)-bisabolol, a natural monocyclic sesquiterpene present in the essential oil has generated considerable interest in the chemical and pharmaceutical industries. Currently it is used in various formulations, mainly cosmetics.




*In vitro, in vivo* and *in silico* studies conclude that α-(-)-bisabolol reduces pro-inflammatory cytokine production and attenuates the skin inflammation. The study confirms the suitability of a-(-)-bisabolol as a candidate for further studies to obtain a suitable prototype drug for chronic skin inflammatory disorders.

Current Pharmaceutical Biotechnology, 15, 173-181, 2014

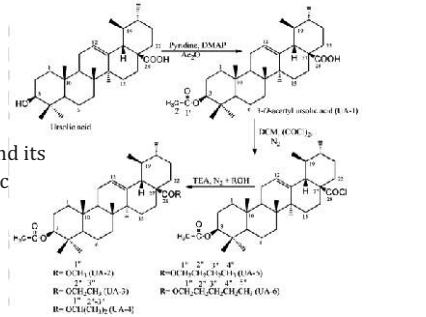
Input: Bawankule DU, Luqman S

## Drug resistance reversal potential of ursolic acid derivatives against nalidixic acid and multidrug resistant *Escherichia coli*

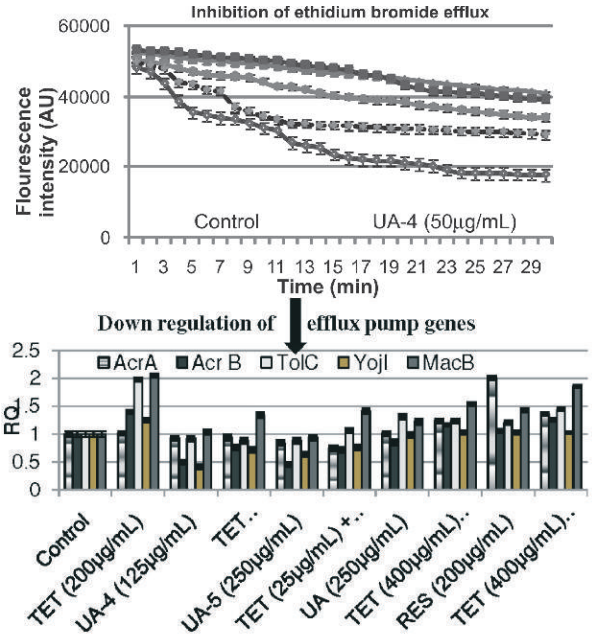
Evaluation of the drug resistance reversal potential of ursolic acid (UA) and its semi-synthetic derivatives (UA-4, UA-5) using MDR strains of *E. coli*.

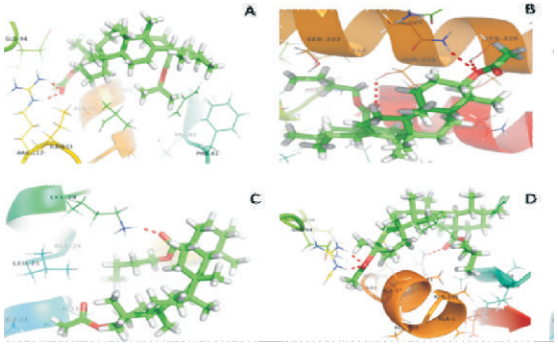
Ursolic acid, a pentacyclic triterpenoids is known for various biological activities and considered to be a suitable candidate for drug development.

Ursolic acid and its Semi-synthetic derivatives



Anti-bacterial and drug resistance reversal potential in combination with conventional antibiotic against the nalidixic acid and multidrug resistant strains of *E. coli*




*In silico* molecular docking studies elucidating the interaction of UA-4 in the binding site of YojI (A); interaction of UA-5 in the binding site of TolC (B), AcrB (C) and YojI (D).

*In vitro* and *in silico* study indicate that ursolic acid and its derivatives are able to reverse the drug resistance phenomenon in multidrug resistant clinical isolate of *E.coli* through inhibition of ATP-dependent efflux pumps. Inhibition of efflux pumps is useful in (i) lowering the doses of anti-biotics; (ii) reducing the drug resistance development frequency; and (iii) increasing the efficacy of antibiotics against multidrug resistant bacterial infections. Ursolic acid and its two derivatives may be potential candidates for further optimization and development as drug resistance reversal agent(s).

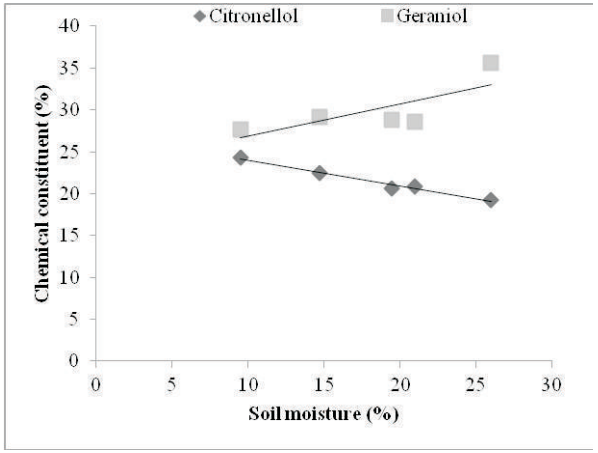
Input: Darokar, MP Srivastava SK, Khan F

## Project : BSC.203 – Chemical biology of *Ocimum* and other aromatic plants

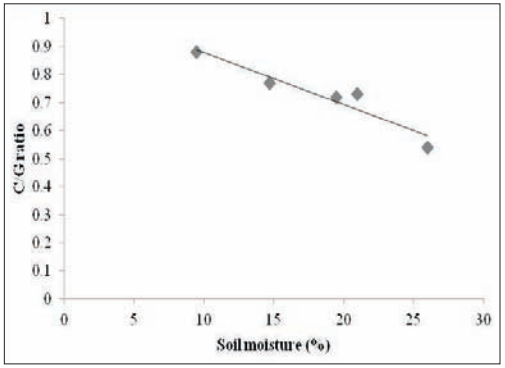
Principal Investigator : AK Shasany

### Optimizing soil moisture stress at crop maturity for higher yield of quality essential oil of rose-scented geranium

To optimize the soil moisture stress for achieving better essential oil yield and quality of rose-scented geranium (*Pelargonium graveolens* L'Herit ex Ait.), an experiment was conducted in subtropical conditions of north India. The crop was harvested under varying levels of soil moisture (9.5-26.0%). Essential oil yield and chemical composition of rose-scented geranium were significantly influenced by varying levels of soil moisture. Essential oil yield was significantly higher under moderate soil moisture conditions ($T_4$; 1.40 mL plant$^{-1}$) as compared to excessive moisture conditions ($T_2$; 1.11 mL plant$^{-1}$). Citronellol to geraniol ratio (C/G), which determines the quality of rose-scented geranium oil, was found to vary from 0.54 to 0.88 under different treatments with lowest at higher level of moisture. In conclusion, the soil moisture was a key factor at the time of crop harvest. Both very low and excess of soil moisture had adverse effect on essential oil yield of rose-scented geranium.




The contents (%) of two major constituents of the rose-scented geranium (*Pelargonium graveolens*) essential oil as influenced by soil moisture content (%) during crop harvest



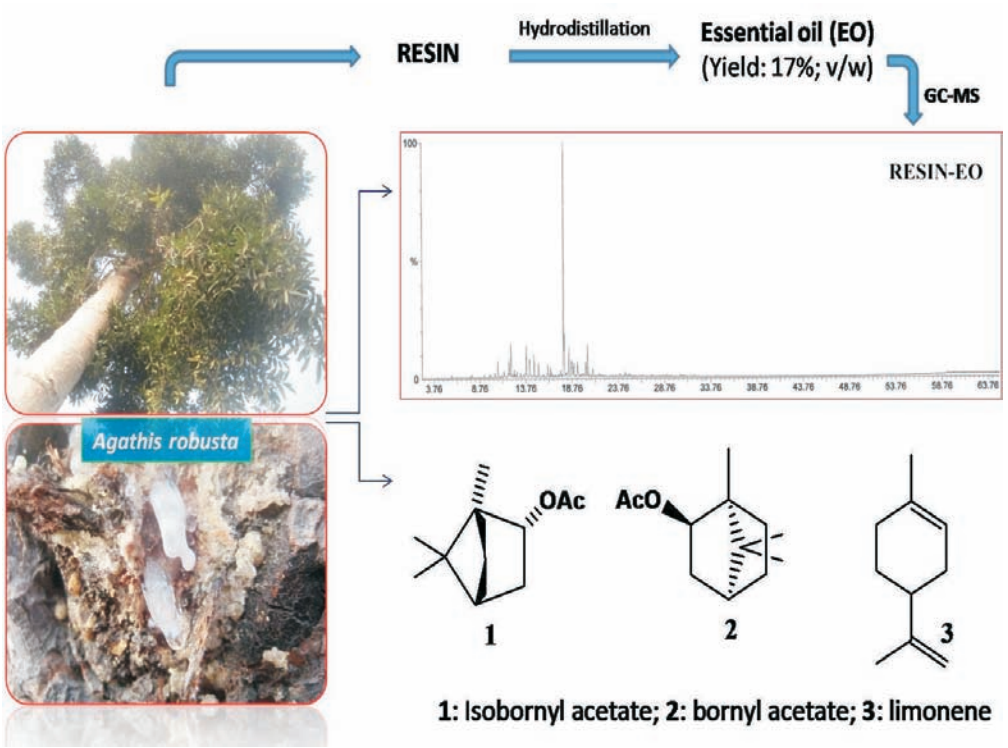

Pattern of citronellol to geraniol ratio (C/G) of rose-scented geranium (*Pelargonium graveolens*) oil under varying levels of soil moisture during crop harvest.

Input: Chauhan A, Verma RS, Padalia RC, Upadhyay RK

### Chemical constituents and anti-bacterial activity of *Agathis robusta* essential oil

*Agathis robusta* (C. Moore ex F. Muell.) F. M. Bailey, commonly known as Queensland kauri or smooth-barked kauri, is a coniferous tree of the family Araucariaceae. The resin obtained from the tree was hydrodistilled to yield essential oil (17%, v/w). The resulting essential oil was

analysed using gas chromatography-flame ionization detector (GC-FID) and GC-mass spectrometry (GC-MS). Altogether, thirty-four constituents, forming 98.2% of the total oil composition were identified. Major constituents of the oil were Isobornyl acetate (37.9%), limonene (12.3%), bornyl acetate (7.4%), myrtenol (5.8%), α-terpinyl acetate (4.6%), and β-pinene (4.3%). The oil was evaluated against nine pathogenic bacterial strains (five Gram-positive and four Gram- negative). It exhibited good activity against *Staphylococcus aureus* (MTCC 96) and moderate activity against *Staphylococcus aureus* (MTCC 2940) and *Staphylococcus Epidermidis*




Input: Verma, RS, Padalia, RC, Chauhan, A, Darokar MP

## Chemical composition of essential oil and rose-water extract of Himalayan Musk Rose

*Rosa brunonii* Lindl. (Rosaceae) is commonly known as 'Himalayan musk rose' or 'Kunja'. Leaf, flower, bark, and root of the plant are used in 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 Kumaon region of western Himalaya. Altogether, fifty-two constituents, forming 93.5% of the total oil composition were identified using gas chromatography-flame ionization detector (GC-FID) and GC-mass spectrometry (GC-MS). 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: Verma, RS, Padalia, RC, Chauhan, A

## Chemical composition and anti-bacterial activity of *Bidens pilosa*

*Bidens pilosa* L., belongs to family Asteraceae, is an annual plant distributed throughout the world. In India, the freshly harvested leaves of *B. pilosa* are used in the preparation of 'Ladakhi tea', which is known as 'Saja' or 'Soljaa' in cold desert of Ladakh Himalaya. The present study focuses on the characterisation of root essential oil composition of *B. pilosa* and anti-bacterial activity thereof from India. The root essential oil was subjected to GC/FID and GC/MS analyses. Fifty constituents, representing 89.6 ± 6.03% of the total oil composition were identified. Major constituents of the oil were octadecadienol (32.8 ± 4.45%), bornyl acetate (19.4 ± 3.11%), n-hexadecanol (7.7 ± 0.60%), 7-phenylhept-2-ena-4,6-diynyl acetate (3.2 ± 2.53%), α-pinene (2.8 ± 1.66%), camphene (2.5 ± 1.57%), α-copaene (2.4 ± 0.82%), cis-chrysanthenyl acetate (2.4 ± 0.15%), eugenol isobutyrate (1.8 ± 1.18%), octadecadienyl acetate (1.7 ± 0.30%), and isoborneol (1.6 ± 0.66%). The essential oil was tested against nine bacterial strains. The oil exhibited moderate activity against *Staphylococcus aureus* (MTCC 2940) and *Staphylococcus aureus* (MTCC 96) with the net zone of inhibition of 7.0 mm and 5.0 mm, respectively. This oil showed low activity against *Streptococcus mutans* (MTCC 890) with net zone of inhibition of 3.0 mm. However, the oil exhibited no anti-bacterial activity against Gram-negative strains.

Input: Verma, RS, Padalia, RC, Chauhan, A, Darokar MP

## Chemical characterization and anti-fungal potentials of essential oils of Indian *Ocimum taxa* against *Rhizoctonia solani* and *Choanephora cucurbitarum*

The composition of hydrodistilled essential oils of *Ocimum basilicum L.* (four chemovariants), *O. tenuiflorum L., O. gratissimum L.*, and *O. kilimandscharicum* Guerke were analyzed and compared by using capillary gas chromatography (GC/FID) and GC-mass spectrometry (GC/MS). Major constituents identified in essential oil of four chemovariants of *O. basilicum* were methyl chavicol (86.3%); methyl chavicol (61.5%)/linalool (28.6%); citral (65.9%); and linalool (36.1%)/citral (28.8%). Eugenol (66.5% and 78.0%) was the major constituents of *O. tenuiflorum* and *O. gratissimum*. Eugenol (34.0%), β-bisabolene (15.4%), (E)-α-bisabolene (10.9%), and methyl chavicol (10.2%) were the major constituents of *O. kilimandscharicum*. The anti-fungal potential of essential oils were assessed against two phytopathogen *Rhizoctonia solani* and *Choanephora cucurbitarum* causing root and wet rot diseases in various commercial crops. *O. tenuiflorum, O. gratissimum*, *O. kilimandscharicum* exhibited complete growth inhibition against *R. solani* and *C. cucurbitarum* at 24h and 48 h intervals, whereas methyl chavicol chemotype of *O. basilicum* showed complete inhibition against *R. solani* till 48 h study, while it showed 90% inhibition of *C. cucurbitarum* at 24h. Other chemotypes of *O. basilicum* showed variable growth inhibitions (63.0-100%) against these two phytopathogens.

Natural Product Communication, 9: 1507-1510, 2014

Input: Padalia RC, Verma RS, Chauhan A

## Chemical and enantiomeric analysis of volatile constituents of *Taxodium distichum*

The leaf essential oil composition of *Taxodium distichum* was studied by GC(FID), GC-MS and chiral analysis. The essential oil composition was mainly dominated by monoterpene hydrocarbon represented mainly by α-pinene (86.765%). Other constituents identified were β-pinene, sabinene, limonene, 1,8-cineole, linalool and terpinen-4-ol. Chiral analysis

of *T. distichum* essential oil on ethyl substituted β-DEX capillary column shows the existence of α-pinene in racemic form, with (1R)-(+)-α-pinene (49.3%) and (1S)-(-)-α-pinene (50.7%).

Input: Padalia RC, Verma RS, Chauhan A

## Diurnal and organ specific variations in essential oil yield and composition of *Ocimum* taxa

Diurnal variability in oil yield and composition of *O. basilicum, O. gratissimum, O. americanum, O. kilimandscharicum* were studied as a function of different harvesting time viz. morning (6.00 a.m.), noon (12.00 p.m.) and evening (6.00 p.m.). *O. basilicum* (four studied chemotypes), *O. americanum*, and *O. kilimandscharicum* (camphor type) gave higher essential oil when harvested in noon, while in *O. gratissimum*, higher oil yield was obtained in the evening, followed by noon and morning. Oil yield in *O. kilimandscharicum* (eugenol/methyl chavicol type) was found in order of : morning > noon > evening. Significant qualitative and quantitative differences in composition of essential oils of *O. gratissimum,* and *O. kilimandscharicum* chemotypes were noticed, while in *O. basilicum* chemotypes, little quantitative changes in compositions were noticed. Moreover, variations in essential oil contents and compositions of the leaves and inflorescences were also analyzed and compared. Chromatographic results and subsequent hierarchical cluster analysis showed that the distribution of constituents, both qualitatively and quantitatively, varied considerably in leaf and inflorescence essential oils.

Journal of Essential Oil Research 26, 409-419, 2014

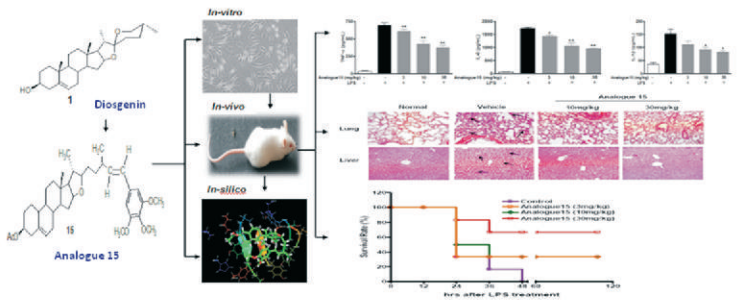
Input: Padalia RC, Verma RS, Chauhan A

## Synthesis of diosgenin analogues as potential anti-inflammatory agents

### Anti-inflammatory mechanism of diosgenin and its analogues: *in vitro, in vivo* and *in silico* studies

Diosgenin is a C27 spiroketal steroidal sapogenin abundantly available in nature. It is mainly present in the plants including Trigonella, Dioscorea, Costus and Smilax species. Several analogues of diosgenin were synthesized by modifying at spiroketal ring.

Diosgenin and its analogues inhibit the



production of pro-inflammatory cytokines in both in vitro and in vivo condition; it was further confirmed with docking study. Among all, Analogue 15 was most potent. This finding confirms the suitability of diosgenin analogues as candidates for further investigation towards the management of inflammation related diseases.

Journal of Steroid Biochemistry and Molecular Biology 143 : 323–333, 2014

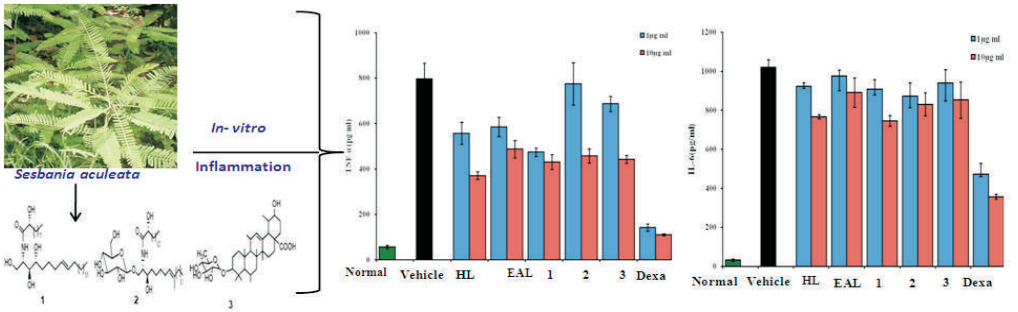
Input: Bawankule DU, Negi AS, Khan F

## Novel chemical constituents with anti-inflammatory activity from the leaves of *Sesbania aculeata*

### Anti-inflammatory potential of extracts and compounds isolated from *Sesbania aculeata*

*Sesbania aculeata* (Family Fabaceae) commonly called dhaincha belongs to legume family and it is an ideal green manure crop as it is quick growing, easily decomposable with low moisture requirements and produces maximum organic matter.

From the extracts of the leaves of *Sesbania aculeata*, three novel chemical compounds were isolated and fully characterized as compound 1, (ceramide type); compound 2, (cerebroside type) and compound 3 as a




triterpene acid 3-O-α-L-rhamnopyranoside along with nine known compounds. Hexane leaf extract (HL), ethyl acetate leaf extract (EAL) and compounds 1, 2 and 3 showed significant inhibition of TNF-α, a pro-inflammatory cytokine. In vitro cell cytotoxicity study using MTT assay revealed that these compounds were non toxic to the normal cells.

Apart from having bio-fertilizer potential, *Sesbania aculeata* would also provide new opportunities to the chemists and biologists to explore the new chemical entities with pharmacological significance.

Phytochemistry 100:132-40 , 2014

Input: Chattopadhyay SK, Bawankule DU

## QSAR and docking based semi-synthesis and *in vivo* evaluation of artemisinin derivatives for anti-malarial activity

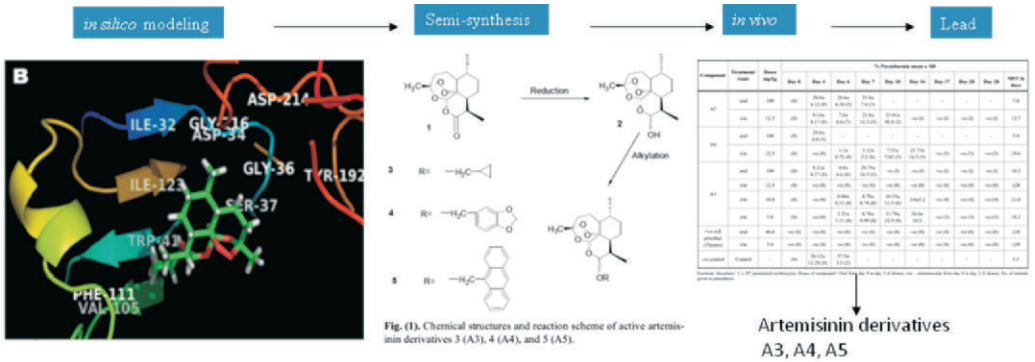


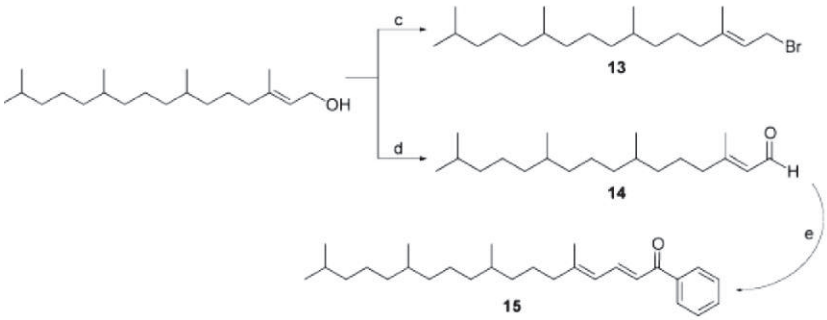

Fig. (1). Chemical structures and reaction scheme of active artemisinin derivatives 3 (A3), 4 (A4), and 5 (A5).

Three active anti-malarial novel artemisinin derivatives viz., β-artecyclopropylmether HMCP (A3), β–artepipernoylether (PIP-1) (A4) and 9-(β-Dihydroartemisinoxy)methyl anthracene (A5) were screened using QSAR modeling approach.

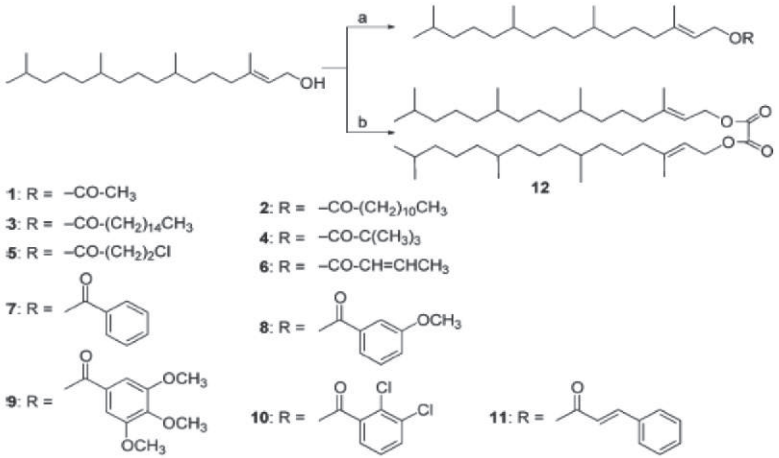
Curr Drug Targets 15:753-761, 2014 ; Curr Drug Targets 15:374-409, 2014

Input: Bhakuni RS, Dhawan OP, Khan F

## Novel phytol derivatives as drug resistance reversal agents




Synthesis of acyl/aryl derivatives 1-12 of phytol



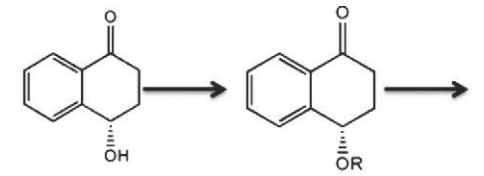

Synthesis of derivatives 13 & 15 of phytol

Phytol was chemically transformed into fifteen semi-synthetic derivatives. All the derivatives were evaluated for their anti-bacterial and drug resistance reversal potential in combination with nalidixic acid against the sensitive (CA8000) and multidrug resistant (DH5a) strains of E. coli. The derivatives 4, 9, 10, 11 and 14 of phytol were also evaluated on another anti-biotic, tetracycline, against the multidrug resistant MDREC-KG4 clinical isolate of E. coli. Derivative 4 decreased the MIC of the anti-biotics by 16-fold, while derivatives 9, 10, 11, and 14 reduced MIC values of the anti-biotics up to eightfold against the E. coli strains. Derivatives 4, 9,10, 11, and 14 inhibited the ATP-dependent efflux pump; this was also supported by their in silico binding affinity and down-regulation of the efflux pump gene yojI, These derivatives may the potential lead for the development of cost effective anti-bacterial combination.

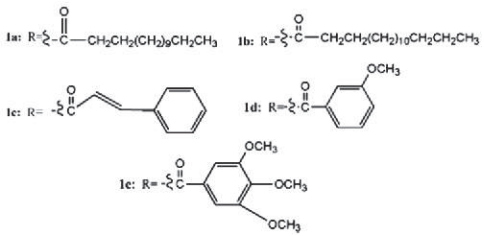
Chem Med Chem 9, 1860 – 1868, 2014

Input: Srivastava SK, Darokar MP

## 4-Hydroxy-α-tetralone and its derivative as drug resistance reversal agents in multi drug resistant *Escherichia coli*




4-hydroxy-α-tetralone (1)




4-Hydroxy-α-tetralone (1) isolated from *Ammannia* spp. was chemically transformed to various acyl and aryl derivatives (1a–1e) and tested against multidrug resistant strain of *Escherichia coli* (MDREC). The test compounds did not show significant anti-bacterial activity of their own, but in combination, they reduced the MIC of tetracycline (TET). In time kill assay, compound 1 and its derivative 1e in combination with TET reduced the cell viability in concentration dependent manner. Compounds 1 and 1e were also able to reduce the mutation prevention concentration of TET. Both compounds showed inhibition of ATP dependent efflux pumps. In real time polymerase chain reaction (RT-PCR) study, compounds 1 and 1e alone and in combination with TET showed significant down expression of efflux pump gene (yojI) encoding multidrug ATP binding cassettes (ABC) transporter protein.

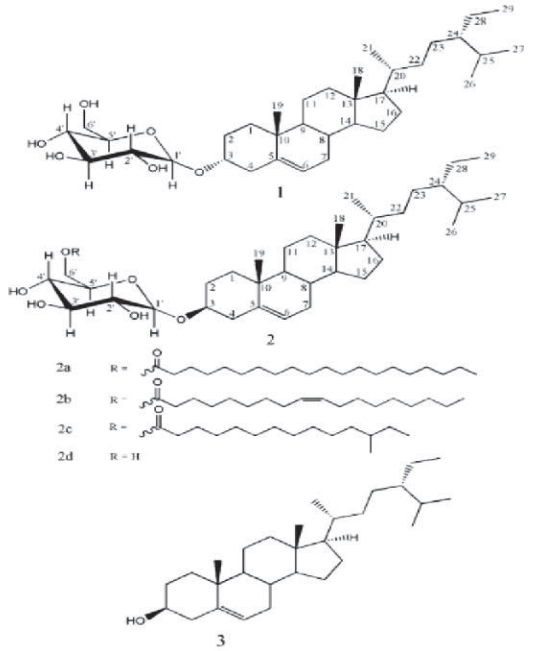
This study confirms that compound 1 and its derivative 1e are ABC efflux pump inhibitors which may be the basis for the development of anti-bacterial combinations for the management of MDR infections from inexpensive natural product.

Chem Biol Drug Des 83: 482–492, 2014

Input: Srivastava SK, Darokar MP

## Clionasterol glucoside and acylated clionasterol glucosides from *Oplismenus burmannii*

A new clionasterol glucoside, clionasterol-[(1'→ 3α)-O-β-D]-glucopyranoside (1), a new acylated clionasterol glucoside, clionasterol-[6'-O-acyl-(1'→ 3β)-O-β-D]-glucopyranoside (2) and clionasterol (3) were isolated from the aerial parts of *Oplismenus burmannii*. The compound 2 was characterized as a mixture of three new compounds, clionasterol-[6'-O-eicosanoyl-(1'15→ 3β)-O-β-D]-glucopyranoside (2a), clionasterol-[6'-O-(8Z)-octadeca-9-enoyl-(1'→ 3β)-O-β-D] glucopyranoside (2b) and clionasterol-[6'-O-(12-methyltetradecanoyl)-(1'→ 3β)-O-β-D]-glucopyranoside (2c).

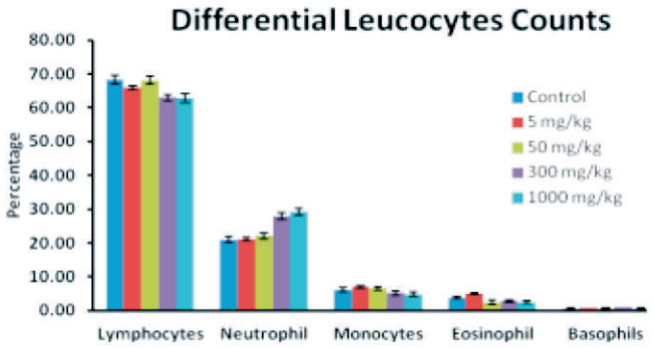


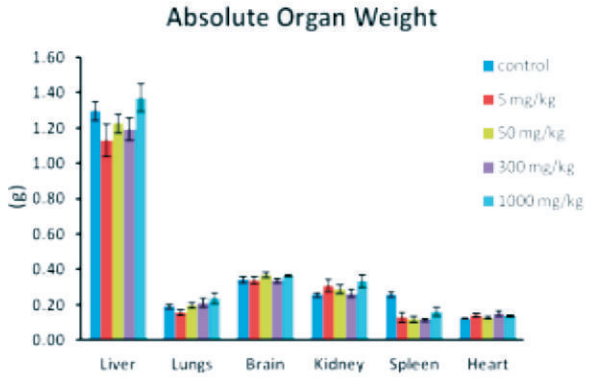

J. Chin. Chem. Soc. 61: 1121-1126, 2014

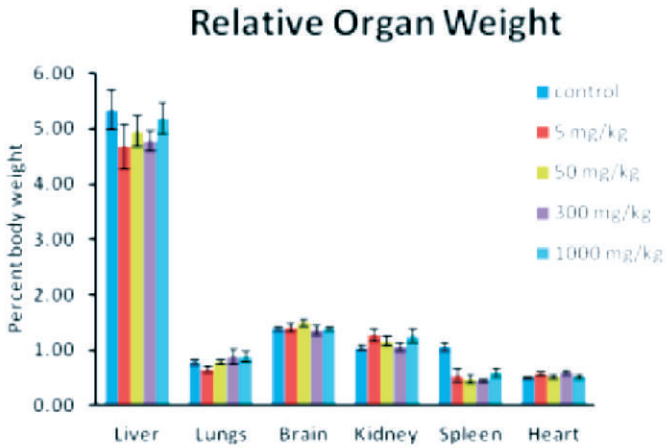
Input: Srivastava SK

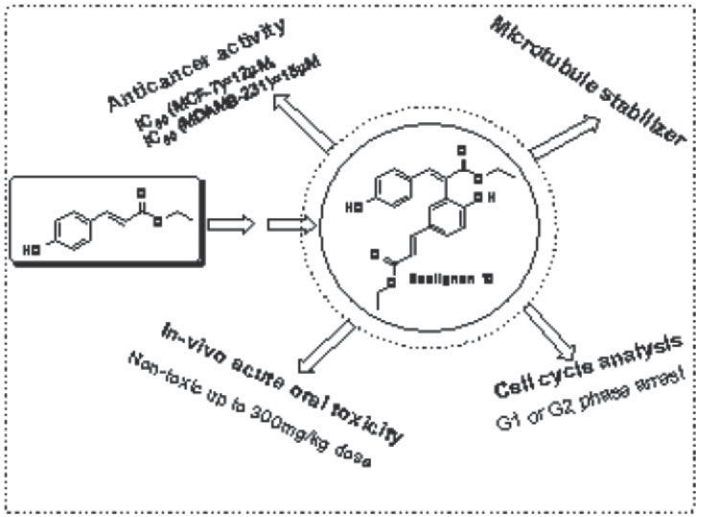
## Modification of phenylpropanoids to potent anti-cancer neolignans

Neolignan 10 exhibits potent anti-breast cancer activity through microtubule stabilization.



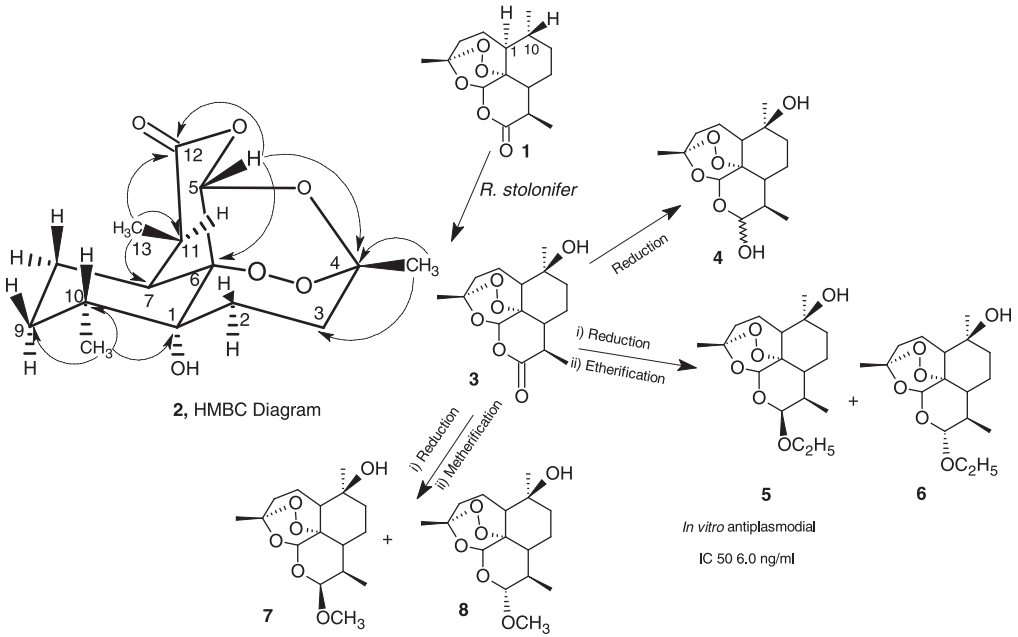

Bioorganic Medicinal Chemistry 22 : 1342-54, 2014

Input: Negi AS, Luqman S, Chanda D, Pal A, Khan F

Acute oral toxicity

## Novel biotransformation products of artemisinin

Stereoselective hydroxylation of anti-malarial artemisinin by fungus *Rhizopus stolonifer* afforded two novel compounds 1α-hydroxyartemisinin (2) and, 10β-hydroxyartemisinin (3). The fungus expressed high metabolic activity (66.5%). Major compound 3 (54.5%) was chemically converted to five new derivatives 4-8. 10b-Hydroxy-12β-arteether (5), IC50 at 18.29 nM was found to be 10 times higher *in vitro* anti-malarial active than parent precursor 4 (184.56 nM) and equipotent l with artemisinin. Therefore, the major biotransformation product 3 can be exploited for further modification into new clinically potent molecules.

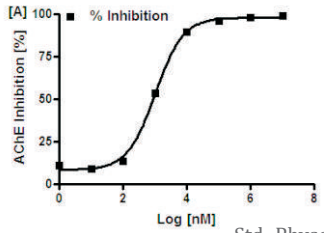



Phytochemistry 107, 135-140, 2014

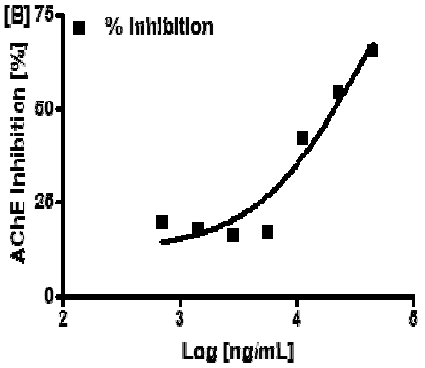
Input: Bhakuni RS, Darokar MP

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

The study is first report on validation of the Indian traditional and folklore claims of *Artemisia maderaspatana* L. (syn. *Grangea maderaspatana* L.). The *in vitro* acetylcholinesterase (AChE) inhibition of the volatile organic constituents (VOC's) of *A. maderaspatana* aerial part was evaluated. GC-MS analysis confirmed the prsence of α-humulene, β-caryophyllene, α-copaene , β-myrcene Z(E)-α-farnesene , calarene. Chemical variability among other *Artemisia* spp. from different climatic regions of India and countries viz. Iran and France was observed. VOCs of *A. maderaspatana* have significant acetylcholinesterase inhibitory activity (IC50 value 31.33 ± 1.03 µg/mL). The *A. maderaspatana* VOCs of North Indian origin could inhibit AChE moderately. Therefore, possibility of novel AChE inhibitors might exist in VOCs of this plant.




Std.-Physostigmine

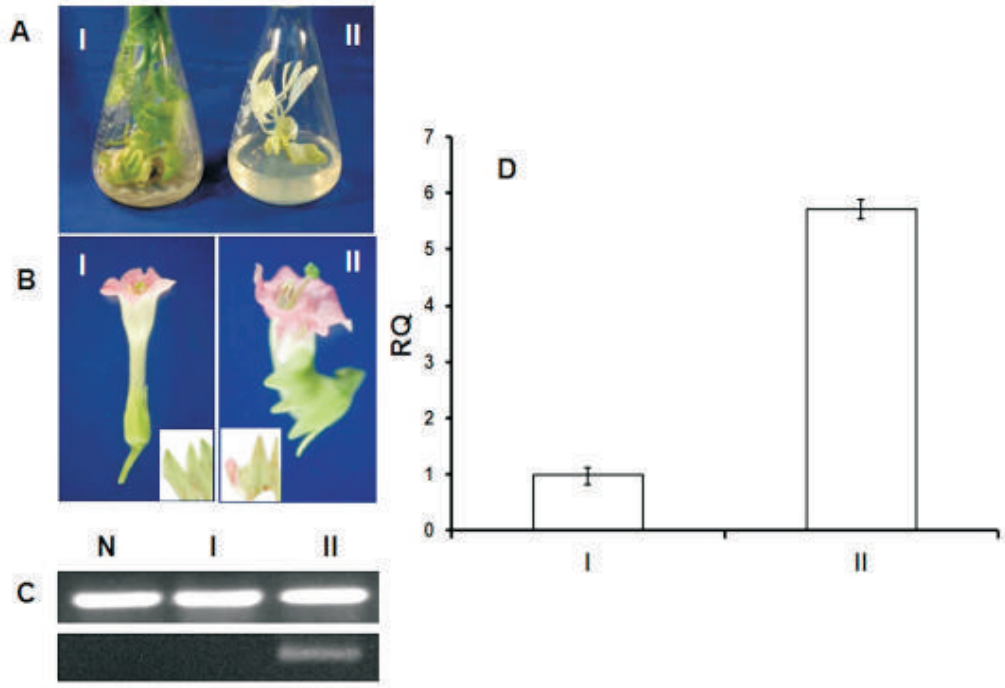



Spl.- VOCs of *A. maderaspatana*

Input: Shanker K, Chanda D

## Recessive loci *Pps-1* and *OM* differentially regulate *PISTILLATA-1* and *APETALA3-1* expression for sepal and petal development in *Papaver somniferum*

Involvement of PISTILLATA (PI) and APETALA (AP) transcription factors in the development of floral organs has previously been elucidated but little is known about their upstream regulation. Two novel mutants of *Papaver somniferum* have been analyzed - one with partially petaloid sepals (*Pps-1*) and another having sepaloid petals (OM). Ectopic expression of *PapsPI-1* in tobacco resulted in a partially petaloid sepal phenotype at a low frequency.




**Flower of tobacco plant transformed with *PapsPI-1*.**

A: Plants in culture (I: Vector transformed; II: Transformed with *PapsPI-1*);

B: Flower (I: Vector transformed; II: Transformed with *PapsPI-1*; inset normal sepal and partially petaloid sepal);

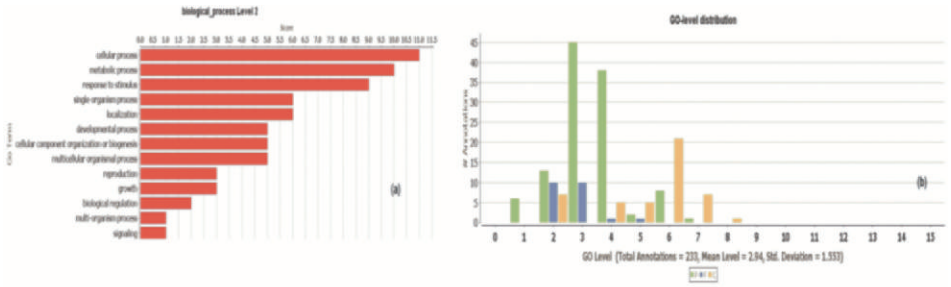
C: Semi-quantitative expression of *PapsPI-1*(upper gel shows ubiquitin expression and the lower shows expression of transgene PapsPI-1) in: N: Non transformed, I: Vector transformed and, II: transformed with *PapsPI-1*);

D: Quantitative expression in vector transformed (I) and *PapsPI-1* transformed tobacco sepal (II).

PLoS ONE 9: e101272. doi:10.1371/journal.pone.0101272 Input: Shukla AK, Dhawan OP, Shasany AK

## *In silico* identification of miRNAs and their regulating target functions in *Ocimum basilicum*

Diverse group of regulatory events are controlled by non-coding RNAs. microRNAs (miRNAs) are 21–25-nucleotide small non-coding RNAs controlling the gene expression at the posttranscriptional level through transcriptional cleavage or translational repression. The presence of terpenoids, alkaloids, and flavonoids in the *Ocimum basilicum* supports for its enormous pharmaceutical potential and medicinal use. With concern to medicinal properties a deep understanding of the regulatory system governed by the miRNAs is required in this important medicinal plant. In this study, we used *In silico* approaches to identify miRNAs and their targets regulating different functions in *O. basilicum* using EST approach. Additionally, functional annotation, gene ontology and pathway analysis of identified target transcripts was also done. Nine sequences potentially encoding for miRNA belonging to 7 miRNA families were identified. Meaningful regulations of the target transcript by identified miRNAs were computationally evaluated. Four miRNA families have been reported by us for the first time from the Lamiaceae. Phylogenetic analysis was carried out to determine the relation between *O. basilicum* and other plant pre-miRNAs. Thirteen potential targets were evaluated for 4 miRNA families. miRNA 5021 was also indicated for playing an important role in the amino acid metabolism and co-factor metabolism in this plant. Majority of the identified target transcripts regulated by miRNAs showed response to stress. The result may shape the relationship of miRNA-stress-metabolite response to secondary metabolite regulation.




Target gene annotation result byBlast2GO (go level 2). a) Biological process, c) GO level distribution

Gene 552, 277–282, 2014

Input: Sharma A

## Seed viability of Ocimum *basilicum* var. CIM-Saumya stored at ambient room temperature

Results of seed viability of *O. basilicum* var. CIM-Saumya stored at ambient room temperature for the period of four years exhibited that more than two years old seeds have highest germination percentage and vigour index.

Input: Kumar B

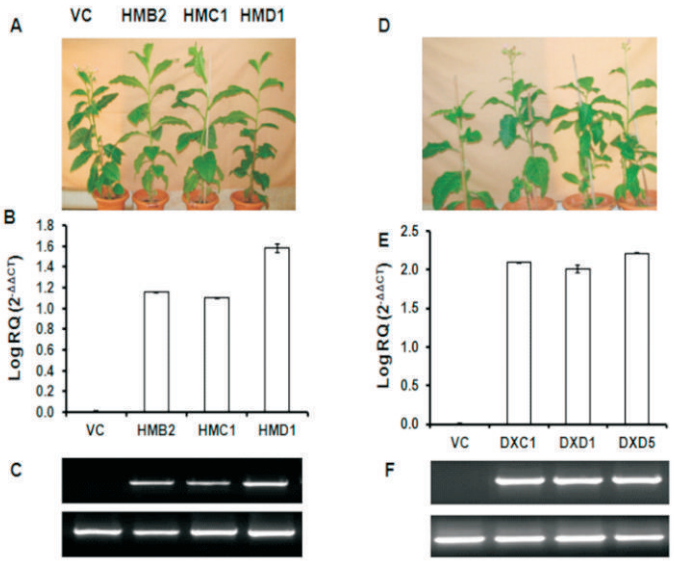
## Sterol partitioning by *HMGR* and *DXR* for routing intermediates towards withanolide biosynthesis

Withanolides biosynthesis in the plant *Withania somnifera* (L.) Dunal is hypothesized to have diverged from sterol pathway at the level of 24-methylene cholesterol. The conversion and translocation of intermediates for sterols and withanolides are yet to be characterized in this plant. To understand the influence of MVA and MEP pathways on sterols and withanolides biosynthesis in planta, we overexpressed the *WsHMGR2* and *WsDXR2* in tobacco, analyzed the effect of transient suppression through RNAi, inhibited MVA and MEP pathways and fed the leaf tissue with different sterols. Overexpression of *WsHMGR2* increased cycloartenol, sitosterol, stigmasterol and

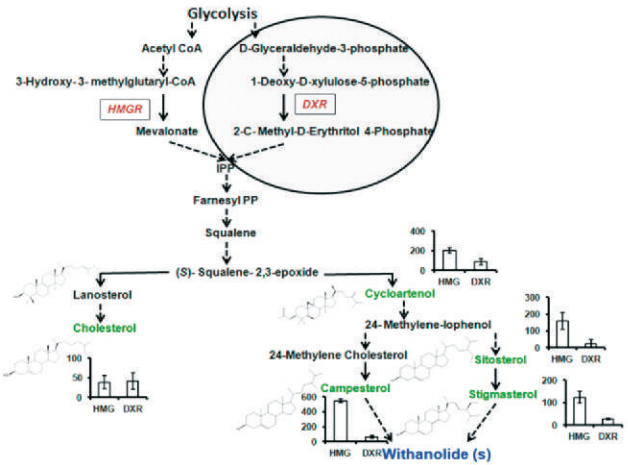
campesterol compared to *WsDXR2* transgene lines. Increase in cholesterol was, however, marginally higher in *WsDXR2* transgenic lines. This was further validated through transient suppression analysis, and pathway inhibition where cholesterol reduction was found higher due to *WsDXR*2 suppression and all other sterols were affected predominantly by WsHMGR2 suppression in leaf. The transcript abundance and enzyme analysis data also correlate with sterol accumulation. Cholesterol feeding did not increase the withanolide content compared to cycloartenol, sitosterol, stigmasterol and campesterol. Hence, a preferential translocation of carbon from MVA and MEP pathways was found differentiating the sterols types. Overall results suggested that MVA pathway was predominant in contributing intermediates for withanolides synthesis mainly through campesterol/ stigmasterol route in planta.

Physiol Plant 152: 617-33, 2014

Input: Shanker K, Chanotiya CS, Gupta MM, Shasany AK




(A) Vector transformed plants (VC) compared to WsHMGR2 transformed tobacco lines HMB2, HMC1 and HMD1, (B) relative transcript quantity and (C) expression analysis through semiquantitative PCR. Similarly, D, E and F shows vector transformed plants (VC) compared to WsDXR2 transformed tobacco lines DXC1, DXD1and DXD5, relative transcript quantity and expression analysis through semiquantitative PCR respectively. Data are means ± SE (n=3 biological replicates).




Proposed pathway for showing sites of action for mevinolin and fosmidomycin inhibition.

## Virus induced gene silencing of *Withania somnifera* squalene synthase negatively regulates sterol and defense related genes resulting in reduced sterols, withanolides and biotic stress tolerance

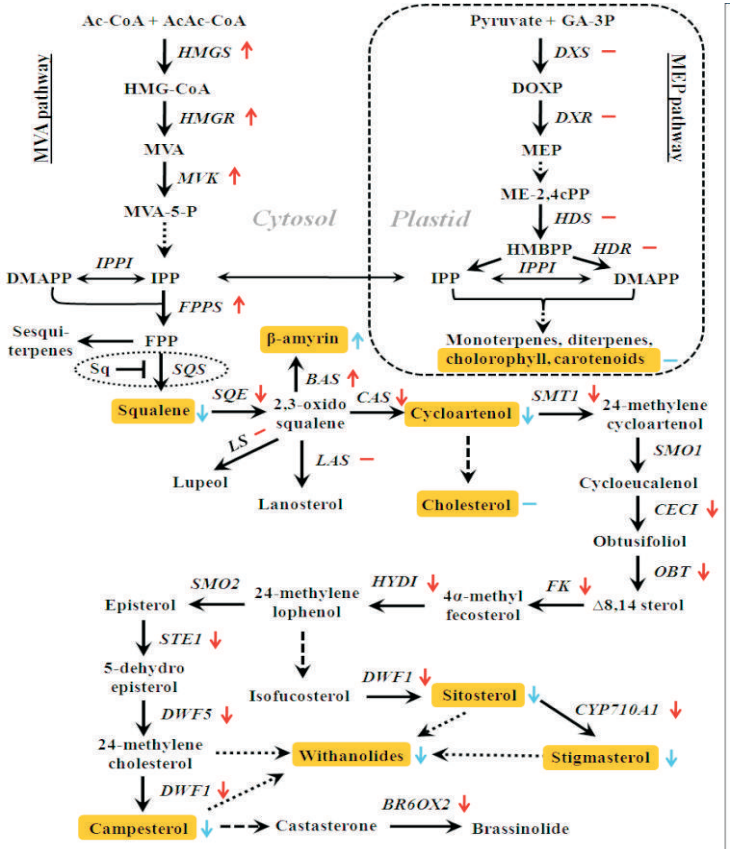



**Figure 1.** Simplified view of isoprenoid biosynthesis in plants.

Red arrows or hyphen indicate gene expression level; blue arrows or hyphen indicate metabolite levels. Upward and downward arrows indicate the increase or decrease, whereas hyphen indicates no change.

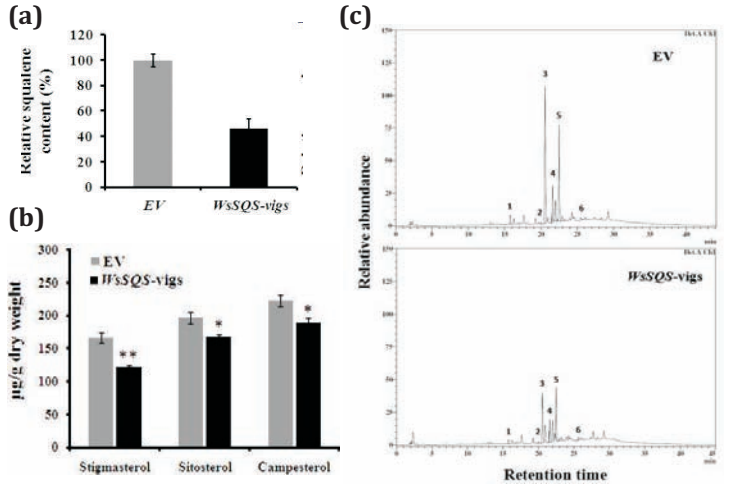



**Figure 2.** Effect of *WsSQS-vigs* on squalene (a), phytosterols (b) and withanolides (c) accumulation. 1, withanoside IV; 2, withanoside V; 3, withaferin A; 4, 12-deoxywithastramonolide; 5, wthanolide A; 6, withanolide B.

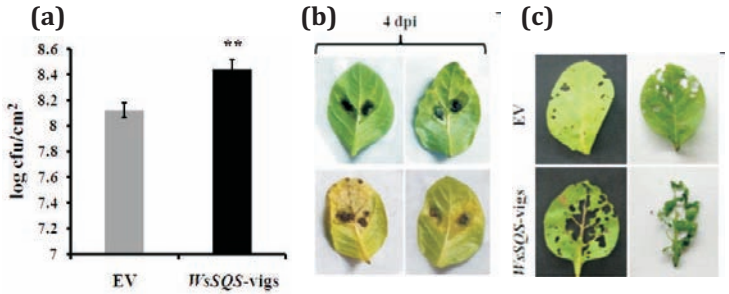
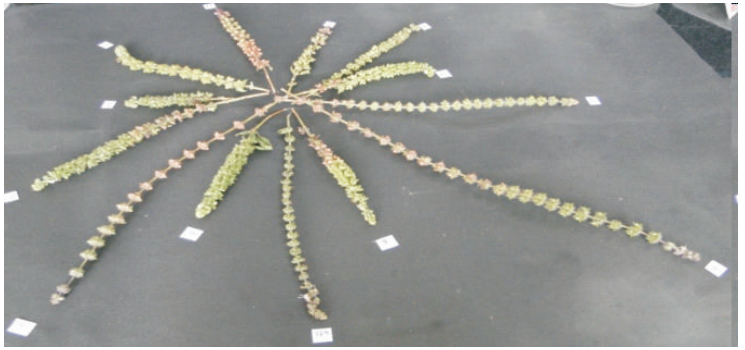



**Figure 3.** Effect of *WsSQS*-vigs on biotic stresses. (a) *Pseudomonas syringae* growth assay (a), *Botrytis cinerea* infection assay (b) and *Spodoptera litura* feeding assay (c) on EV and *WsSQS*-vigs leaves.

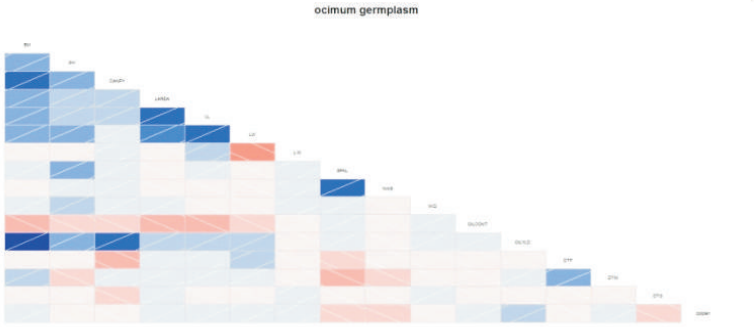
Input: Nagegowda DA, Shasany AK, Venkata Rao DK

## Genome wide association mapping (GWAS) in *Ocimum* spp using natural variation

Leaf characteristics and spike characteristics distance for six species under study (*O. klimancharicum, O. sanctum, O. basilicum* French basil, *O. basilicum*, Sweet basil, *O. gratissimum*).



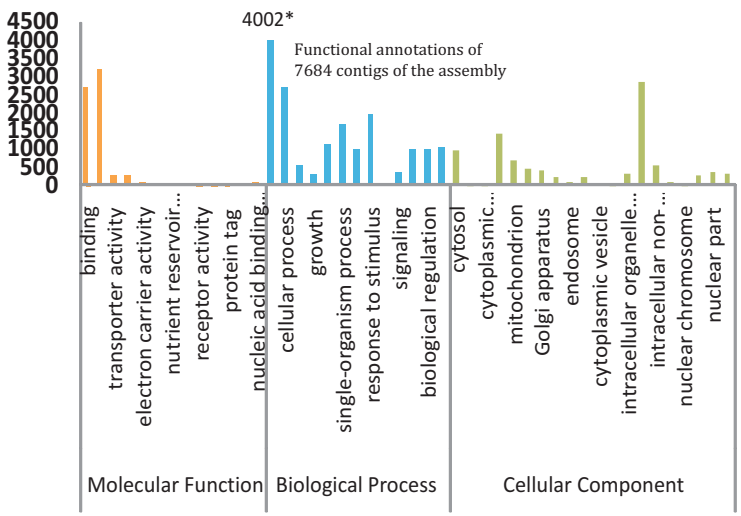
Natural variation present in Spike characteristics within the *Ocimum basilicum* accessions




Correlation Plot showing correlation between economically important matrices like biomass (BM), plant height (PH), plant canopy (CANPY), leaf area, leaf length, leaf width, leaf length by breadth ratio spike length, number of whorl per spike, distance between whorl on the internode, oil content oil yield days to flowering and days to maturity and seedling trait, days to germination and coleoptile length

Oil yield was significantly correlated with biomass or herbage yield ( 0.8) and plant canopy(0.6)followed by plant height(0.33).

Class I SSR, 123; Class II SSR, 332 totalling to 455 SSRs were mined.




Input: Jhang T

## Outreach activity for rural development and livelihood generation

Distillation of Palmarosa at Sahajbahali, Angul

Two training programs were organized on the cultivation and processing aspects of aromatic plants at Bamur, Angul district of Odisha. More than 100 farmers of backward area of Angul and Sambhalpur district of Odisha were trained on cultivation aspect of drought resistant aromatic crops like palmarosa and basil (Tulsi), etc. One distillation unit was installed at village Sahajbhali, Bamur, angul for processing of the aromatic crops. About 20 demonstrations of palmarosa and 10 demonstrations of tulsi as a rain-fed crop were organized at farmer's field.

Input: Suresh R, Tomar VKS, Kumar S

## Project : BSC. 106 – Bio-prospection of plant resources and other natural products

Principal Investigator: Anirban Pal

Forty-nine accessions from 14 genus were taken up for DNA barcoding activity, wherein the PCR amplification followed by the PCR purification of the product amplicons of *Garcinia indica* has been done using rbcL1f, rbcL724r, trnH-psbA, ITS5a and ITS4 primers, which are being sequenced.

Under the objective of metabolite profiling and bio-prospection, 04 plants (*Mesua ferrea, Terminalia paniculata, Garcinia morella and Acronychia pedunculata*) were considered for metabolite profiling and bioprospection studies. The ethyl acetate extract of *Mesua ferrea* yielded a pure compound (12-13-furano-8-hydroxy napthyl-6-O-β-2'-3', 4'-6' tetrahydroxy 5'-5' dimethylcyclohexyl ether) Fig.1. The compound also exhibited a significant anti-malarial activity (6.5µg/ml) against *P. falciparum* (NF 54). Further, the ethyl acetate and hexane extracts of *Acronychia pedunculata* leaves exhibited an $IC_{50}$ of 6.5µg/ml and 10µg/ml respectively. The metabolite profiles of both the plants were derived through HPTLC Fig.2 and Fig.3.

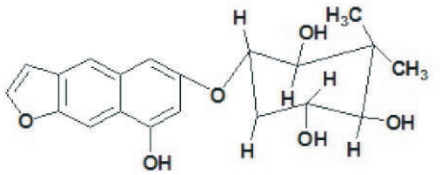
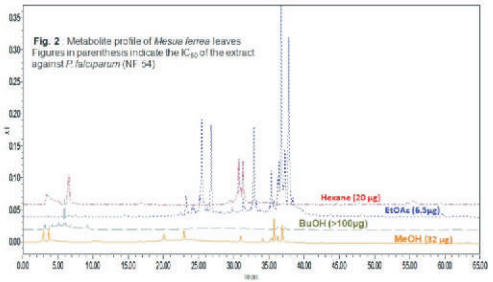
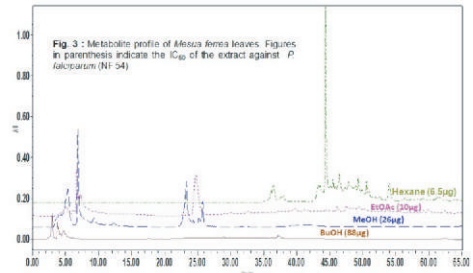



Fig. 1: 12-13-furano-8-hydroxy napthyl-6-O-β-2'-3', 4'-6' tetrahydroxy 5'-5' dimethylcyclohexyl ether




Plant Systematics and Evolution, 300:1409-1420; Natural Product Research, 28:306-311; Phytochemical Analysis, 25:551-60

## Project : BSC.107– Genomics of medicinal plants and agronomically important traits

Principal Investigator : Vikrant Gupta

### Structural and Functional Genomics of *Ocimum* species

*Ocimum* L. belongs to the family Lamiaceae and is one of the best known genera for its medicinal properties and economically important aromatic oils. Some *Ocimum* species are used as constituents of Ayurvedic and indigenous medicines. This genus is highly variable and possesses wide range of intra- and inter-specific genetic diversity comprising at least 65 to more than 150 species distributed all over the world. Five most prominent species which are grown in India include *O. sanctum, O. basilicum, O. gratissimum, O. kilimandscharicum* and *O. americanum*. To understand the metabolic diversity deduced at the transcriptome level, the transcriptome sequencing of primarily two species i.e. *O. sanctum* (CIM-Ayu) and *O. basilicum* (CIM-Saumya) was completely done and analyzed.

### Transcriptome sequencing, *de novo* assembly and functional annotation of contigs

Paired-end Sequencing-by-Synthesis (SBS) yielded raw data of ~4.75 Gb and ~5.23 Gb for *O. sanctum* and *O. basilicum*, respectively. Transcript generation was carried out after removing the adapter sequences from the raw data that resulted in 69117 and 130043 transcripts for *O. sanctum* and *O. basilicum*, respectively. In both cases, average contig lengths were found to be 1646 ± 1210 bp and 1363 ± 1139 bp with N50 values of 2199 and 1929 in *O. sanctum* and *O. basilicum*, respectively. Gene Ontology (GO) annotation was done to assign putative functions to the transcripts that were generated after the assembly. The transcript sequences were compared against the NR protein sequences of *Arabidopsis thaliana*, rice and lamiaceae family available at Uniprot database using BLASTx algorithm. The associated hits were searched for their respective GO. Based on sequence homology, 59380 sequences from *O. sanctum* and 104856 sequences from *O. basilicum* were categorized into 51 functional groups under three main categories: Biological Process (BP), Cellular Component (CC) and Molecular Function (MF) (Figure 1).

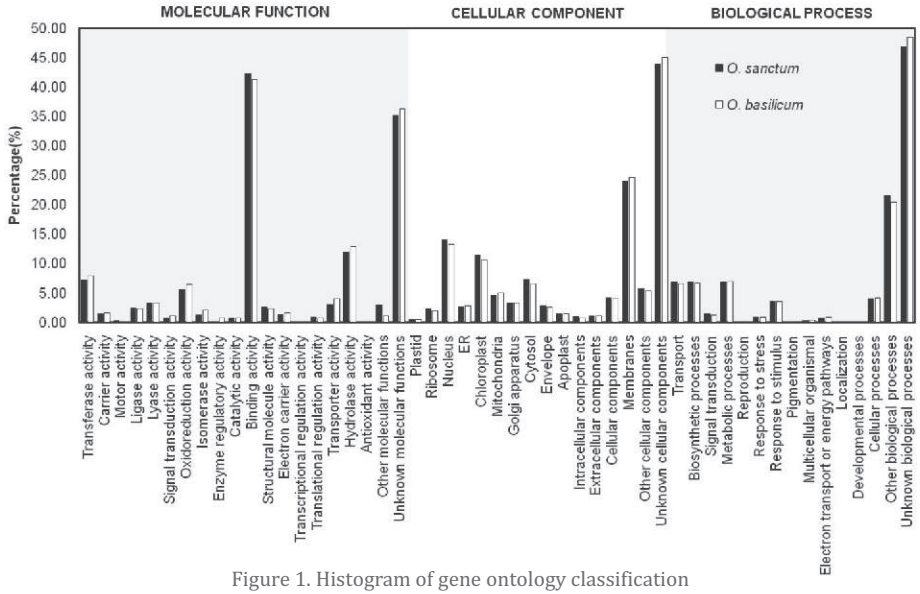
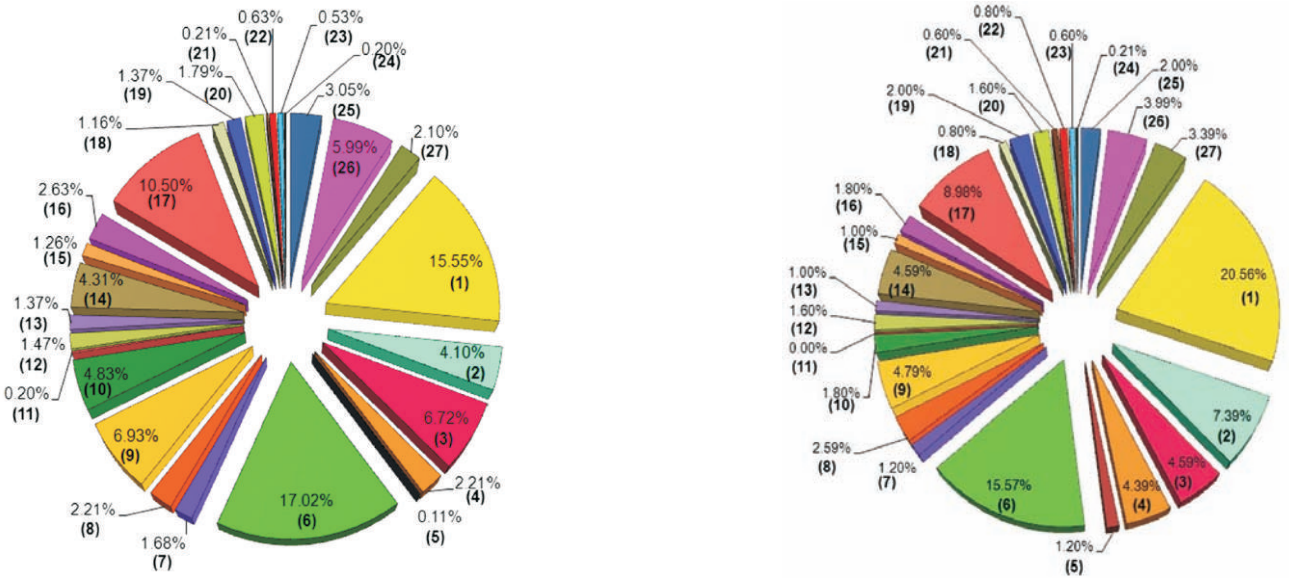



Figure 1. Histogram of gene ontology classification

## KEGG analysis of *O. sanctum* and *O. basilicum* transcriptomes

In an attempt to identify biological pathways operating in the leaf tissues of these two *Ocimum* species, 69117 and 130043 assembled transcripts were mapped to the reference canonical pathways in KEGG. All the transcripts were classified mainly under five categories: metabolism, cellular processes, genetic information processing, environmental information processing and others. Highest number of transcripts from both *O. sanctum* and *O. basilicum* were related to metabolism followed by others. In total, all transcripts from *O. sanctum* and *O. basilicum* were assigned to 332 KEGG pathways. Interestingly, 501 and 952 transcripts, respectively, from *O. sanctum* and *O. basilicum* were found to be involved in biosynthesis of various secondary metabolites (Figure 2).




*Ocimum sanctum* *Ocimum basilicum*

Figure 2. KEGG classification based on secondary metabolism categories

Bracketed numbers represent various secondary metabolic pathways abbreviated as: (1) Terpenoid backbone biosynthesis; (2) Streptomycin biosynthesis; (3) Stilbenoid, diarylheptanoid and gingerol biosynthesis; (4) Sesquiterpenoid and triterpenoid biosynthesis; (5) Polyketide sugar unit biosynthesis; (6) Phenylpropanoid biosynthesis; (7) Novobiocin biosynthesis; (8) Monoterpenoid biosynthesis; (9) Limonene and pinene degradation; (10) Isoquinoline alkaloid biosynthesis; (11) Indole alkaloid biosynthesis; (12) Glucosinolate biosynthesis; (13) Geraniol degradation; (14) Flavonoid biosynthesis; (15) Flavone and flavonol biosynthesis; (16) Diterpenoid biosynthesis; (17) Carotenoid biosynthesis; (18) Caffeine metabolism; (19) Butirosin and neomycin biosynthesis; (20) Brassinosteroid biosynthesis; (21) Biosynthesis of siderophore group nonribosomal peptides; (22) Biosynthesis of ansamycins; (23) Betalain biosynthesis; (24) Anthocyanin biosynthesis; (25) Zeatin biosynthesis; (26) Tropane, piperidine and pyridine alkaloid biosynthesis; (27) Tetracycline biosynthesis.

## Candidate CYP450s with probable involvement in phenylpropanoids/terpenoid biosynthesis

Cytochrome P450s (CYP450s) are nature's most versatile biological catalysts forming the biggest gene families in plants accounting for more than 1% of the total gene annotations in individual plant species. These are generally involved in the biosynthesis of terpenoids, sterols, lignins, hormones, fatty acids, pigments, and phytoalexins in plants. All the CYP450s involved in the secondary metabolism identified in *O. sanctum* and *O. basilicum* transcripts were classified into 26 families.

**Number of transcripts encoding cytochrome P450s involved in phenylpropanoids metabolism**

| | CYP transcripts of *O. sanctum* | | CYP transcripts of *O. basilicum* | | Functions |
|---|---|---|---|---|---|
| | ***Arabidopsis* annotation** | **Lamiaceae annotation** | ***Arabidopsis* annotation** | **Lamiaceae annotation** | |
| CYP72A14 | 2 | | 8 | | Phenylpropanoid Metabolism |
| CYP73A1 | 5 | 7 | 23 | 33 | Cinnamate 4-hydroxylase (C4H) |
| CYP75B1 | 8 | | 8 | | Flavonoid biosynthesis |
| CYP81D1 | 2 | | 16 | | Phenylpropanoid Metabolism |
| CYP81F3 | 1 | | 9 | | Phenylpropanoid Metabolism |
| CYP84A1 | 2 | | 1 | | Coniferaldehyde 5-hydroxylase |
| CYP93D1 | | | 1 | | Phenylpropanoid Metabolism |
| CYP98A3 | 12 | | 25 | | 4-Coumaryl shikimic/quinic ester 3′-hydroxylase. |
| CYP98A14 | | 16 | | 46 | *p*-Coumaryl shikimate hydroxylase |
| CYP707A2 | 5 | | 4 | | Phenylpropanoid Metabolism (abscisic acid 8′-hydroxylase) |
| CYP707A3 | 12 | | 13 | | Secondary metabolism (abscisic acid 8′-hydroxylase) |
| CYP710A1 | 3 | | 7 | | Phenylpropanoid Metabolism |
| CYP711A1 | 1 | | 1 | | Core phenylpropanoid metabolism |
| CYP712A1 | | | 2 | | Stilbene, coumarine and lignin biosynthesis |

**Number of transcripts encoding cytochrome P450s involved in terpenoid metabolism**

| | CYP transcripts of *O. sanctum* | | CYP transcripts of *O. basilicum* | | Functions |
|---|---|---|---|---|---|
| | ***Arabidopsis* annotation** | **Lamiaceae annotation** | ***Arabidopsis* annotation** | **Lamiaceae annotation** | |
| CYP51G1 | 4 | | 13 | | Obtusifoliol 14α-demethylase |
| CYP71A-like | 1 | | 9 | | (+)-Menthofuran synthase |
| CYP71B12 | | | 1 | | Biosynthesis of prenyl diphosphates |
| CYP71B31 | 1 | | | | Mono-/sesqui-/di-terpene biosynthesis |
| CYP71D13/ D15 | | 10 | | 16 | (- )-Limonene-3-hydroxylase |
| CYP71D18 | | 45 | | 43 | (- )-Limonene-6-hydroxylase |
| CYP71 with unknown function | 43 | 99 | 113 | 237 | Unknown function |
| CYP72A15 | 26 | | 48 | | Carotenoid biosynthesis |
| CYP76C3 | 3 | | 8 | | Monoterpene biosynthesis |
| CYP76C4 | | | 2 | | Mono-/sesqui-/di-terpene biosynthesis |
| CYP82G1 | 1 | | 2 | | Mono-/sesqui-/di-terpene biosynthesis |
| CYP85A2 | 4 | | | | Brassinosteroid biosynthesis |
| CYP90B1 | | | 1 | | Triterpene, sterol, and brassinosteroid metabolism |
| CYP90C1 | 2 | | 8 | | Steroid biosynthesis |
| CYP94D2 | 5 | | 6 | | Carotenoid biosynthesis |
| CYP96A9 | 1 | | | | Mono-/sesqui-/di-terpene biosynthesis |
| CYP706A7 | | | 4 | | Biosynthesis of steroids |
| CYP707A4 | 10 | | 14 | | Sterol biosynthesis |
| CYP716A2 | | | 1 | | Monoterpene biosynthesis |
| CYP734A1 | 3 | | 1 | | Triterpene, sterol, and brassinosteroid metabolism |

## Identification of simple sequence repeat (SSR) markers

The transcriptome data of *O. sanctum* and *O. basilicum* were analyzed for the presence of SSR markers. Out of 69117 and 130043 transcripts of *O. sanctum* and *O. basilicum*, 27.77% transcripts (19191) from *O. sanctum* and 17.79% (23141) transcripts from *O. basilicum* were observed to be having SSRs. Di-nucleotide repeats were highest in number for both the species (14.64% in *O. sanctum* and 6.94% in *O. basilicum*), while penta-nucleotide repeats were of lowest occurrence (0.16%) in *O. sanctum* and hexa-nucleotide repeats (0.08%) in *O. basilicum*.

| **Statistics of identified SSRs** | ***O. sanctum*** | ***O. basilicum*** |
|---|---|---|
| Total number of sequences examined | 69117 | 130043 |
| Total size of examined sequences (bp) | 113791599 | 177312343 |
| Total number of identified SSRs | 26232 | 28947 |
| Number of SSR containing sequences | 19191 | 23141 |
| Number of sequences containing more than 1 SSR | 5128 | 4383 |
| Number of SSRs present in compound formation | 2301 | 2091 |
| Di-nucleotide repeat | 10118 | 9025 |
| Tri-nucleotide repeat | 4859 | 6029 |
| Tetra-nucleotide repeat | 314 | 363 |
| Penta-nucleotide repeat | 109 | 115 |
| Hexa-nucleotide repeat | 223 | 107 |

Leaf transcriptomes of *O. sanctum* and *O. basilicum* were sequenced. Several important genes of terpenoid and phenylpropanoids pathway and cytochrome P450s related to secondary metabolism could be identified in the generated transcriptome data. Several SSR markers were also detected in the sequence data which could be used as a resource for *Ocimum* breeding.

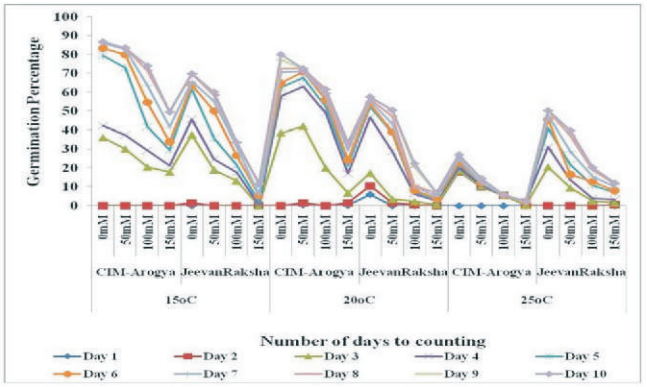
BMC Genomics 15:588, 2014

Input: Gupta V, Shasany AK, Sangwan NS, Nagegowda DA, Ghosh S, Shukla RK

# Project : BSC.109 – Studying adaptation biology and understanding / exploiting medicinally important plants for useful bioactives

Principal Investigator : AK Shasany

## Varietal differences in salt tolerance of *Artemisia annua* seeds at different concentrations of salt and temperature regimes.




Graph 1. Effect of NaCl treatment on seed germination of CIM-Arogya and Jeevan Raksha under different temperature regimes in *Artemisia annua*

**The study concludes that:**

- Germination percentage decreased as NaCl concentration increased.
- Salt concentration had a direct relation with reduction of plumule and radicle growth.
- Would be helpful for selection for new areas for wider adaptability.
- Variety CIM-Arogya has shown the best salt tolerance potential upto 100mM at 15C in respect to seedling vigor I and II.
- At time of nursery raising saline soils and higher temperature should be avoided.

Input: Kumar B

## Project : BSC. 110 – Introduction, domestication, improvement, and cultivation of economically important plants

Principal Investigator: Saudan Singh

### High leaf yielding and late flowering/ maturing clones of stevia, suitable for cultivation in Northern Indian plains identified

Two elite clones of Stevia (*Stevia rebaudiana* Bert.) were selected in evaluation trials. They were further evaluated at bench scale trial (BST, RBD, reps. 3, plot size=1m$^2$) along with check variety *CIM Madhu*. Promising clones v/s check performance were L8-11 (dried leaf yield 750.0 g/plot, stevioside 10.30 % and rebaudioside 0.77 %), L 11-12 11 (dried leaf yield 650 g/plot, stevioside 10.18 % and rebaudioside 1.03 %), selected v/s check variety *CIM Madhu* (leaf yield 400 g/plot, stevioside 6.40 % and rebaudioside 0.68 %). Both high yielding clones are now planted for pilot evaluation trial for further evaluation.

Promising clone L8-11 of Stevia

Input: Lal RK

### Co-Cultivation of menthol mint with traditional crops for enhancing farm productivity and profit

Cultivation and production of menthol mint has been profitable for the farmers of India for last few decades. But after introduction of synthetic menthol mint in market at cheaper rate, the crop has become less profitable due to decrease in the demand for natural menthol. Hence there is a need to produce natural menthol mint at a lower cost. If this crop is grown with major food crops as an additional crop, the production cost of menthol mint oil can be reduced as compared to its pure culture.

Data recorded on the productivity and profit of the different cropping system revealed that menthol mint can be grown successfully with traditional food crops such as sugarcane, maize, okra, radish , onion and wheat and aromatic crop vetiver. The production cost of menthol mint oil was reduced significantly under co-cultivation system with all the crops. The lowest cost of production (Rs 137/ kg) was under onion + menthol mint ( Table 1 and Fig 1).

Fig. 1. Field view of menthol + onion

**Table 1. Production cost of the essential oil of menthol mint under different co-cultivation system**

| Cropping system | Cost of Cultivation (Rs ha$^{-1}$) | Total income from main crop (Rs ha$^{-1}$) | Equivalent yield of menthol mint oil (kg ha$^{-1}$) | Yield of Menthol mint oil (kg ha$^{-1}$) | Total yield of menthol mint oil (kg ha$^{-1}$) | Production cost of Menthol mint oil (Rs ha$^{-1}$) |
|---|---|---|---|---|---|---|
| Menthol mint sole | 54000 | - | - | 150 | 150 | 360.00 |
| Sugarcane + Menthol mint | 78000 | 156000 | 223 | 110 | 333 | 234.00 |
| Vetiver + Menthol mint | 66000 | 138000 | 197 | 140 | 337 | 196.00 |
| Maize (for grains) + Menthol mint | 60000 | 49000 | 70 | 140 | 210 | 286.00 |
| Maize (for cobs) + Menthol mint | 72000 | 150000 | 214 | 140 | 354 | 203.00 |
| Okra + Menthol mint | 66000 | 120000 | 171 | 130 | 301 | 219.00 |
| Radish + Menthol mint | 78000 | 250000 | 357 | 120 | 477 | 164.00 |
| Onion + Menthol mint | 78000 | 300000 | 429 | 140 | 569 | 137.00 |
| Wheat + Radish ± Menthol mint | 89000 | 144000 | 205 | 80 | 285 | 312.00 |
| CD ( P =0.05) | - | - | - | - | 55.5 | 50.5 |

Input: Singh S

## Improvement in the yield and quality of kalmegh under the sustainable production system

*Andrographis paniculata* Nees is an annual erect herb with wide medicinal and pharmacological applications due to the presence of andrographolide and other active chemical constituents. The large-scale cultivation of kalmegh is not in practice. The study aims to establish sustainable production systems of *A. paniculata cv* CIM-Megha with the application of different bioinoculants and chemical fertilizers. *A. paniculata* herb and andrographolide yield in the dried leaves was found to be highest (218% and 61.3%, respectively) in treatment $T_3$ (NPK+ *Bacillus sp.*) compared with $T_1$ (control). The soil organic carbon, soil microbial respiration, soil enzymes activity and available nutrients improved significantly with combined application of bio-inoculants and chemical fertilizers.

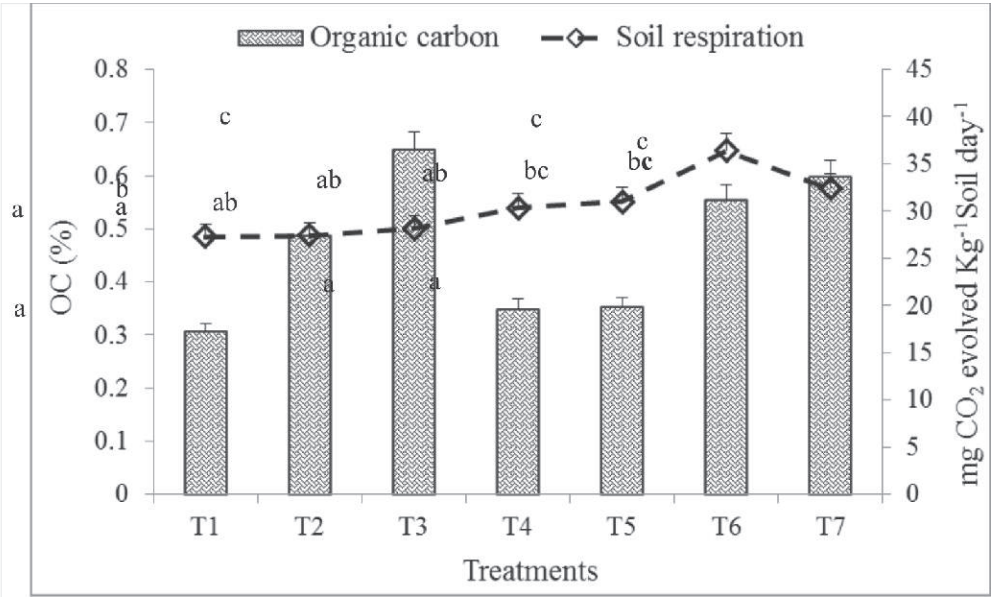



Figure. Soil organic carbon and soil microbial respiration status of *Andrographis paniculata* grown soil (letters in diagrams show "Duncan's multiple range test", P<0.05)

## Intercropping of aromatic crop *Pelargonium graveolens* with *Solanum tuberosum* for better productivity and soil health

Geranium (*Pelargonium graveolens* L.) is a vegetatively propagated, initially slow growing, high value aromatic crop. Potato (*Solanum tuberosum* L.) is also vegetatively propagated high demand cash crop. A field experiment was carried out in temperate climate to investigate the influence of geranium intercropping at different row strips (1:1 and 1:2) and plant density (60×45,75×45 and 90×45cm) with potato intercrop on the biomass ,oil yield, monetary advantage, and soil quality parameters. The row spacing 60×45cm and row strip1:1 was found to be superior and produced 92 t $ha^{-1}$ and 14 kg $ha^{-1}$ biomass and oil yield, respectively. The row strip 1:2 intercrop earned a maximum $2107, followed by $ 1862 with row strip 1:1 at 60×45cm plant density. Significant variations were noticed in soil organic carbon ($C_{org}$), total N ($N_t$), available nutrients, soil microbial biomass ($C_{mic}$) and nitrogen ($N_{mic}$) content. Maximum improvement of Corg (41.0 %) and $N_t$ (27.5%) with row strip 1:1 at 75 × 45cm plant density. While higher soil respiration rate, $C_{mic}$, $N_{mic}$, and $q^{CO}2$ was found with 1:2 row strip at 60 × 45 plant density. The buildup of the $C_{org}$ and $C_{mic}$ with potato intercrop can promote long term sustainability on productivity and soil health.

## Integrated nutrient management on biomass, oil yields and essential oil composition of peppermint (*Mentha piperita* L.) and residual fertility in a hilly soil

Field experiment was conducted to study the influence of combined use of farm yard manure (FYM) and inorganic fertilizers (IF) on biomass and essential oil yields, chemical and microbial biomass carbon and nitrogen of soil grown with peppermint (*Mentha piperita*). Combined application increased the biomass and oil yields of peppermint compared to sole inorganic fertilizers treatments. The combined treatment improved the soil organic carbon and total N from 3.9 to 7.0 g $kg^{-1}$ soil and 0.27 to 0.58 g $kg^{-1}$ soil, respectively. A significant improvement has been noticed in soil respiration, soil

microbial biomass carbon and nitrogen compared to inorganic fertilizer alone. Moreover, different proportions of inorganic fertilizers with farm yard manure had significant variation on available major soil nutrients. A significant correlation coefficient (r= 0.41 to 0.98) was observed between yields and soil properties. The quality of essential oil was good and acceptable to the market.

Input: Verma RK

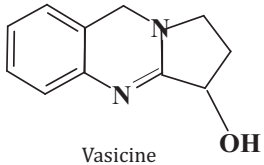
## Post-harvest storage effect on essential oil content and composition of *Cymbopogon distans*

The members of *Cymbopogon* genus are of commercial importance due to essential oils which are highly prized in flavor and fragrance industries. *Cymbopogon distans* is an under-explored aromatic member of this genus which is found abundantly wild in western and central Himalayan region. The lemon-scented chemotype of *C. distans*, domesticated in foothills was studied for post-harvest storage under shade and open field conditions. The results revealed that there were no losses in essential oil content up to 15 days of storage (0.46%) under shade conditions. However, in field conditions a loss of 6.52% and 10.87% of essential oil was observed over a fresh herb after 7 days and 15 days of storage, respectively. Major constituents of the essential oil, *viz*. geranial (20.3-25.9%), neral (13.2-17.5%), geraniol (15.3-18.6%), and geranyl acetate (17.2-23.0%) showed change under post-harvest storage. In conclusion, *C. distans* should preferably be distilled fresh or it may be stored in shade conditions up to 15 days without any loss of essential oil.

Input: Chauhan A

## Vascisine from *Adhatoda vasica* leaves as insect feeding-deterrent and larvicidal towards *Spilarctia obliqua* larvae

Based on previous findings on bioactivities of methanol extract of *Adhatoda vasica* leaves, bioactivity guided fractionation was done to isolate and identify bioactive compounds. Out of 369 fractions obtained, fraction no. 351-369 subjected to column chromatography for isolation and identification of bioactive molecule, vascisine showed 92.6% larvicidal activity at 2000 ppm concentration towards 4$^{th}$ instar of *Spilarctia obliqua*. In the anti-feedant bioassay, vascisine showed 100% feeding deterrence at 1000 ppm concentration. Thus compound vascisine was significantly more active than the *A. vasica* extrac.



Vasicine

Input: Tripathi AK

## Screening of *Curcuma* spp. against root-knot nematode infestation

Large number of *Curcuma* spp. line were screened for their resistance against root-knot nematode, *Meloidogyne incognita* (Kofoid and White) Chitwood. All lines were found to be susceptible to the root-knot infestation. For the management of root-knot disease in *Curcuma* sp., large number of rhizobacteria were isolated from the rhizosphere and their biochemical analysis was done. The isolated rhizobacteria show chitinase activity on colloidal chitin selective media

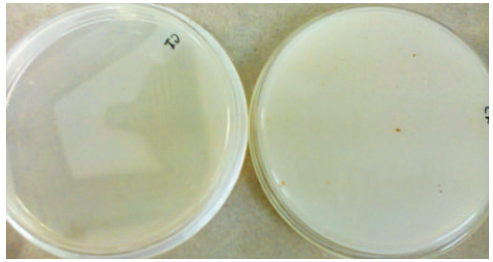


Fig. 1: Chitinase activity of isolated bacteria with control

by hydrolyzing the media substrate through the production of chitinases enzyme. The halo zone around the point of inoculation was measured and the zones beyond 40 mm were recorded as the most potent (+++) activity. Fig.1 shows the chitinase activity in the rhizobacterial isolates in respect to control.

**Table: 1- Chitinase activities of selected bacteria isolated from rhizosphere of Curcuma spp.**

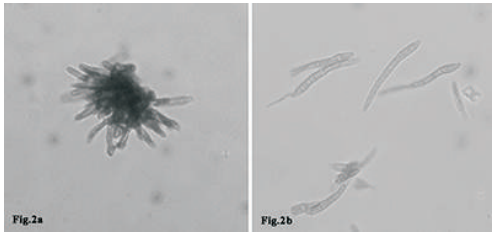
| SN | Bacterial isolate | Reaction |
|---|---|---|
| 1. | CMTN-5 | + |
| 2. | CMTN-9 | +++ |
| 3. | CMTN -11 | ++ |
| 4. | CMTN -16 | + |
| 5. | CMTN -17 | +++ |
| 6. | CMTN -22 | + |
| 7. | CMTN -27 | ++ |
| 8. | CMTN -36 | + |
| 9. | CMTN -39 | + |
| 10. | CMTN -48 | +++ |

Input: Pandey R

## Black leaf spot–a new fungal (*Pseudocercospora fuligena*) disease of *Withania somnifera*

*Withania somnifera* commonly known as ashwagandha, originated in India and commercially cultivated for its roots – a natural rich source of glycowithanolides, tannins, potassium nitrate, etc., which are an anti-inflammatory, anti-tumor, anti-oxidant, anti-ulcer, and regulator of the nervous system. During the monsoon of July 2013, black spots on the leaves of infected plants were observed in the ashwagandha growing in Lucknow, Raibareilly, and adjoining areas of Uttar Pradesh. About 27 infected samples were collected from different locations of the fields for isolation of the causal organism and microscopic studies. On the basis of cultural and morphological studies, the pathogen was identified as *Pseudocercospora fuligena*. The pathogen identity was further confirmed at molecular level using universal primers ITS1/ITS4 through PCR, cloned into pGEM-T Easy vector, sequenced, and deposited in GenBank (Accession No. KF881898). NCBI BLASTn showed 99% identity with *P. fuligena* (GU214675) strain CPC 12296, isolated from *Lycopersicon* sp. Pathogenicity test was carried out on 10 plants of *W. somnifera cv. Poshita*. Typical symptoms appeared on all the inoculated plants after 12 to 17 days. Control plants remained free of infection. Re-isolation of the pathogen on PDA fulfilled Koch's postulates. *P. fuligena* has the potential to reduce yield of *W. somnifera.*


Field view of black leaf spot caused by *P. fuligena* on *Withania somnifera* (a, b) and healthy crop (c).




Microscopic features of the pathogen, *Pseudocercospora fuligena*. Conidiophores (a) and conidia (b).

Input: Samad A

## Chemical profiling of *Rosmarinus officinalis* L. cv. *CIM-Hariyali* and *Thymus linearis* essential oils under foothill agro-climates

*Rosmarinus officinalis*, commonly known as 'rosemary', belongs to family Lamiaceae. It is commercially cultivated in several countries such as Spain, Dalmatia, Turkey, Egypt, Italy, Greece, France, Northern Africa, Portugal, and Yugoslavia for the production of fresh or dry leaves and essential oil, which finds extensive application in perfume, cosmetic, and pharmaceutical industries. In the present study, essential oil composition of *R. officinalis* cv. *CIM-Hariyali* grown under foothill conditions of Uttarakhand was evaluated using gas chromatography-flame ionization detector (GC-FID) and GC-mass spectrometry (GC-MS). The fresh herb of the crop gave 0.88% essential oil on hydrodistillation. Altogether, forty-nine constituents, representing 96.4% of the total oil composition were identified. Major constituents of the oil were camphor (22.7%), 1,8-cineole (18.5%), α-pinene (14.6%), verbenone (7.8%), camphene (6.6%), limonene (5.5%), β-pinene (3.0%), α-phellandrene (2.2%), α-terpineol (2.0%), and borneol (1.7%).

*Thymus species*, also belonging to family Lamiaceae, are cultivated mainly in European countries (Spain, France, Italy and Bulgaria etc.) for the production of fresh and dry herbs and also processed for essential oil and oleoresin. *Thymus linearis* is an underutilized potential aromatic herb, occurring in Indian Himalaya. In order to explore its potential for industrial use, an attempt was made to introduce this plant to the sub-tropical region. The essential oil composition of *T. linearis* grown in foothills of north India was examined using gas GC-FID and GC-MS. The fresh herb of T. linearis yielded 0.50% essential oil on hydrodistillation. In all, forty-eight constituents, representing 97.2% of the total oil composition were identified. Major constituents of the oil were thymol (53.9%), γ-terpinene (16.6%), p-cymene (10.2%), thymol methyl ether (2.8%), cis-sabinene hydrate (1.5%), β-bisabolene (1.5%), myrcene (1.4%), and α-pinene (1.4%).

Input: Verma RS

## Essential oil composition of menthenols rich chemotype of *Cymbopogon distans* introduced at foot hills of Uttarakhand, India

*Cymbopogon* is one of the most important essential oil yielding genus of family Poaceae. Various members of this genus are of importance owing to their high quality essential oils. *Cymbopogon distans* is a perennial aromatic grass that grows wild in upper Himalayan region. One of its chemotype (menthenols rich) distributed in Himalayan region was introduced and domesticated in subtropical conditions of north India. The essential oil yield was found to be 0.75% (v/w, fresh weight basis). *cis*-p-Menth-1-en-2-ol (28.28%), *trans*-p-menth-1-en-2-ol (16.17%), δ-2-carene (15.18%), cis-piperitol (7.55%), and *trans*-piperitol (7.24%) were identified as the major constituents in essential oil. The essential oil of this plant showed moderate to good anti-bacterial activity against *Escherichia coli, Salmonella typhimurium, Bacillus subtilis, Staphylococcus epidermidis, Staphylococcus aureus* (MTCC 2940), *Staphylococcus aureus* (MTCC 96). Therefore, the potential of this chemotype of *Cymbopogon distans* can be further explored for its essential oil production and use in herbal formulations.

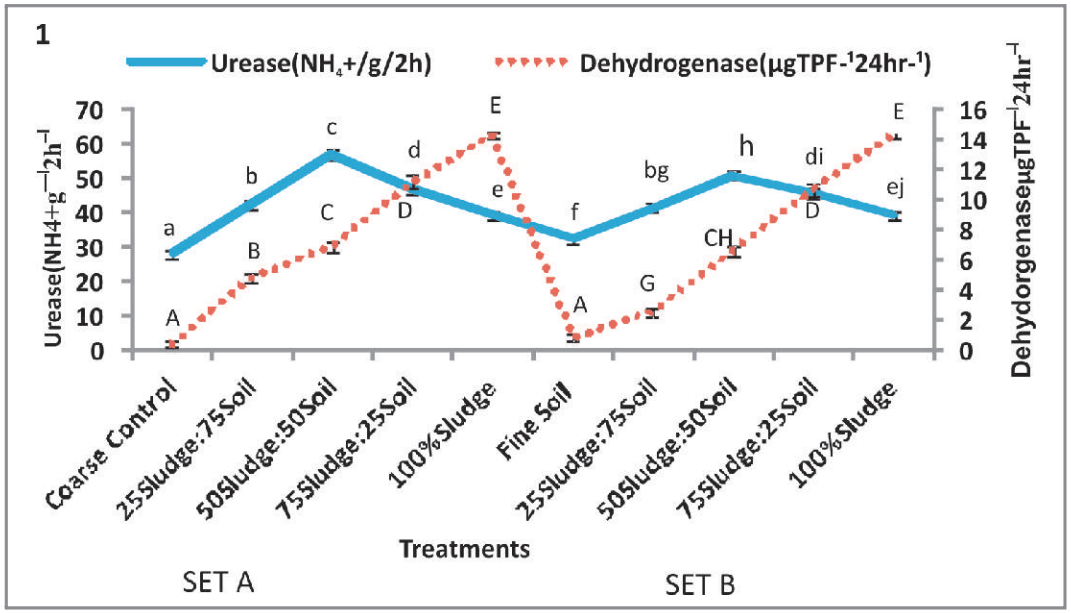
Input: Padalia RC

## Project : BSC. 111 – Integrated NextGen approaches to health, disease and environmental toxicity

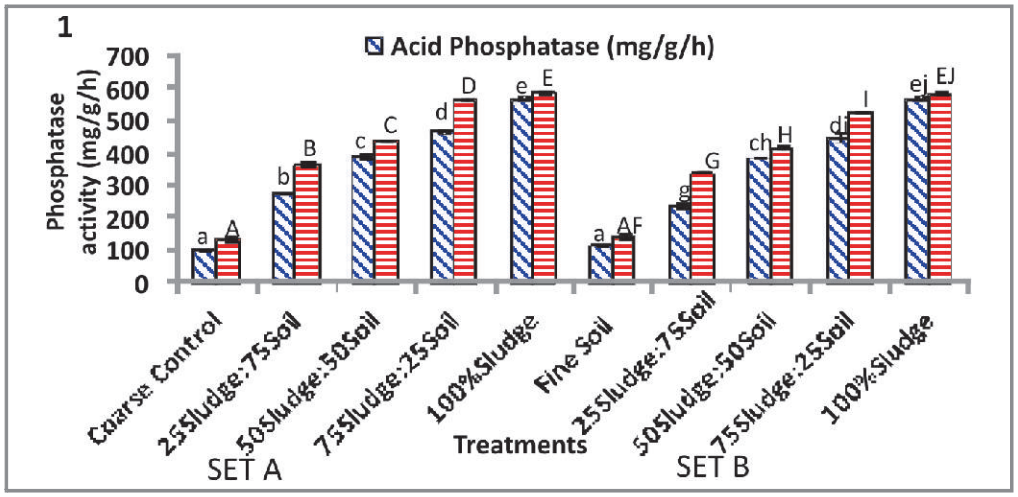
Principal Investigator : DD Patra

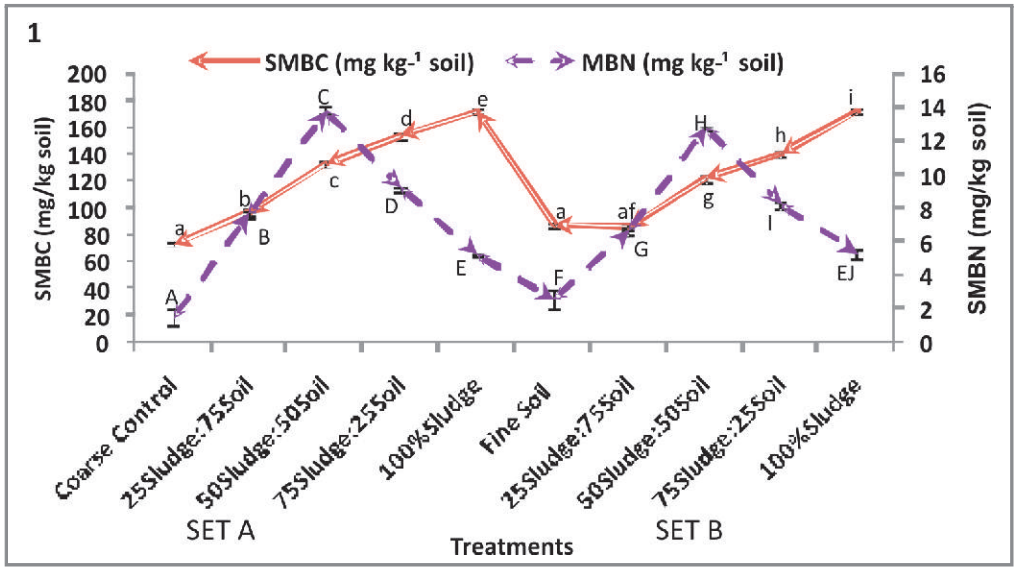
### Influence of heavy metal rich tannery sludge on soil enzymes vis-à-vis growth of *Tagetes minuta*, an essential oil bearing crop

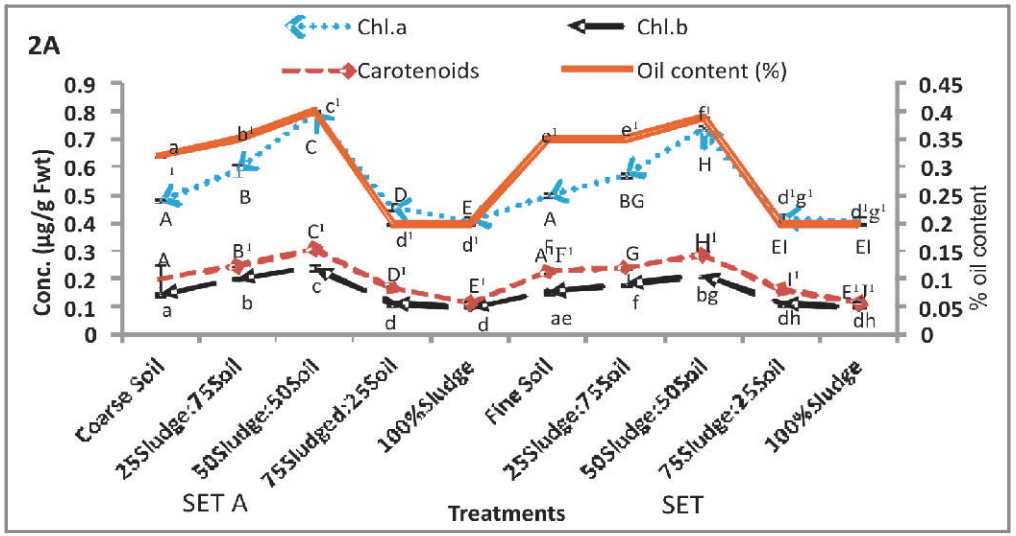
Tannery sludge is available in plenty and is hazardous to environment as well as plant and animal life. It is very important to manage the tannery sludge in an environmentally sound manner. The aim of this study was to assess the physico-chemical, microbial and biochemical properties of soil treated with different levels of sludge in *Tagetes minuta*, an essential oil bearing crop. Application of tannery sludge (TS) increased the growth and oil yield of plant and also the activity of urease and soil microbial biomass nitrogen (SMBN) when applied in 50:50 combinations of soil: sludge. The crop performed well in coarse soil with a soil: sludge ratio of 50:50. High concentration of tannery sludge exhibited inhibitory effect on SMBN and urease activity. Acid/alkaline phosphatase, dehydrogenase and soil microbial biomass carbon (SMBC) increased as the sludge concentration increased in soil. This may be due to high organic matter present in tannery sludge. Roots accumulated more metal than the shoot. No detectable amount of metal was found in oil of *T. minuta*. Principal component analysis (PCA) indicates that cation exchange capacity (CEC), SMBC, dehydrogenase, acid and alkaline phosphatases were grouped in group 1. SMBN, urease and cis-ocimene content in oil were in group 2, whereas biomasss, chlorophyll, limonene, Z and E-tagetone were in group 3. PC-I contributes 54% of total variance and PC-II contributes 38% of the total variance. The results concluded that *T. minuta* can mitigate metal toxicity by root absorption. Microbial activity and biomass of plant was higher in coarse soil with TS than fine soil with TS.



The texture of soil was of higher importance for soil microbial properties when mixed with tannery sludge. Microbial activity was higher in the coarse soil than in the fine soil treated with tannery sludge. Coarse soil (SET A) combination facilitated more uptake of metals in roots and leaves than fine soil (SET B) combination. Cation exchange capacity enhanced the growth of microbial biomass carbon, dehydrogenase and acid and alkaline phosphatase activity which was further proved by PCA analysis. On the whole, the plant performed best in terms of biomass and oil yield at 50:50 combinations. Heavy metal present in tannery sludge were mostly deposited in the roots of *T. minuta*. So this plant cannot be a good candidate for phytoremediation. However, this can mitigate metal toxicity by root absorption. *T. minuta* can be preferred over food and other edible crops for utilization of TS. Unlike food crops the *Tagetes* oil does not contain toxic metal, as the oil was extracted through hydro-distillation.





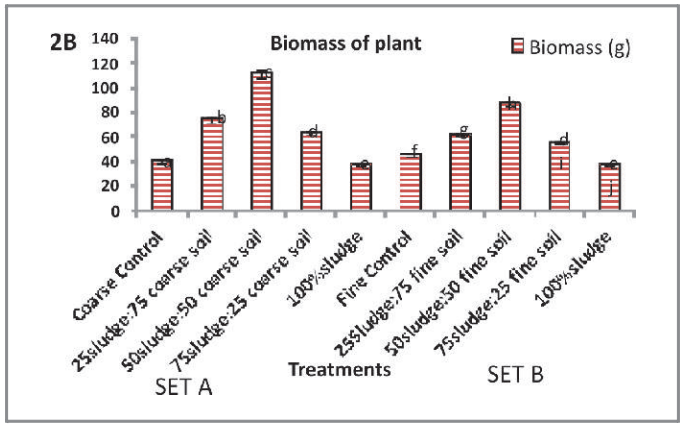
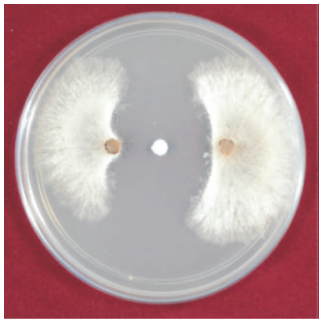




Fig. 2A and B. (A) Chlorophyll a, chlorophyll b, carotenoid and percent oil content of *Tagetes minuta* grown on different textured soils treated with different levels of tannery sludge. (B) Biomass of *Tagetes minuta* grown on different textured soils treated with different levels of tannery sludge.

Chemosphere 112:323-32; 2014

## The interaction pattern between a homology model of 40S ribosomal S9 protein of *rhizoctonia solani* and 1-hydroxyphenaize by docking study

1-Hydroxyphenazine (1-OH-PHZ), a natural product from *Pseudomonas aeruginosa* strain SD12, was earlier reported to have potent anti-fungal activity against *Rhizoctonia solani*. In the present work, the anti-fungal activity of 1-OH-PHZ on 40S ribosomal S9 protein was validated by molecular docking approach. 1-OH-PHZ showed interaction with two polar contacts with residues, Arg69 and Phe19, which inhibit the synthesis of fungal protein. Our study reveals that 1-OH-PHZ can be a potent inhibitor of 40S ribosomal S9 protein of *R. solani* that may be a promising approach for the management of fungal diseases.



Anti-fungal activity of 1-hydroxyphenazine at 40 µg/disc against *Rhizoctonia solani*.

BioMed Research International 1-6, 2014

## Impact of plant growth promoting *Pseudomonas monteilii* PsF84 and *Pseudomonas plecoglossicidia* PsF610 on metal uptake and production of secondary metabolite (monoterpenes) by rose-scented geranium (*Pelargonium* species) grown on tannery sludge amended soil

Bacterial strains PsF84 and PsF610 were isolated from tannery sludge polluted soil. 16S rRNA gene sequence and phylogenetic analysis confirmed the taxonomic affiliation of PsF84 as *Pseudomonas monteilii* and PsF610 as *Pseudomonas plecoglossicida*. A greenhouse study was carried out with rose-scented geranium (*Pelargonium graveolens* cv. *bourbon*) grown in soil treated with tannery sludge in different proportions viz. soil: sludge ratio of 100:0, 25:75, 50:50, 75:25 and 0:100 to evaluate the effects of bacterial inoculation on the heavy metal uptake. The isolates solubilized inorganic phosphorus and were capable of producing indole acetic acid (IAA) and siderophore. The isolate PsF84 increased the dry biomass of shoot by 44%, root by 48%, essential oil yield 43% and chlorophyll by 31% respectively, over uninoculated control. The corresponding increase with the isolate PsF610 were 38%, 40%, 39% and 28%, respectively. Scanning electron microscopic (SEM) studies reveal that the Cr(VI) accumulation resulted in breakdown of vascular bundles and sequestration of Cr(VI) in roots. The glandular trichomes (GT) were investigated using SEM studies as these glands are probably the main site of essential oil synthesis. Owing to its wide spectrum action, these isolates could serve as an effective metal sequestering bioinoculants due to the production of IAA, siderophore and solubilization of phosphate for geranium in metal-stressed soil. The present study has provided a new insight into the phytoremediation of metal contaminated soil.

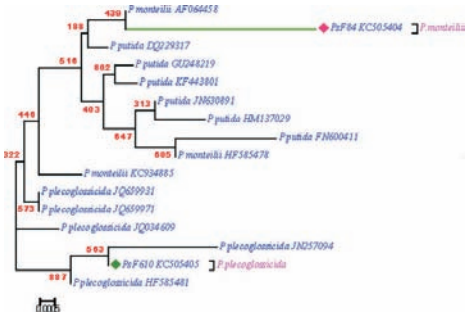



Fig. 1. Phylogenetic relationship based on 16S rRNA gene sequences between strains PsF84 and PsF610 and sequences retrieved from NCBI Genbank database. Distance and bootstrap values 1000 replicates indicate at branching point. The present strains were dotted in this study.

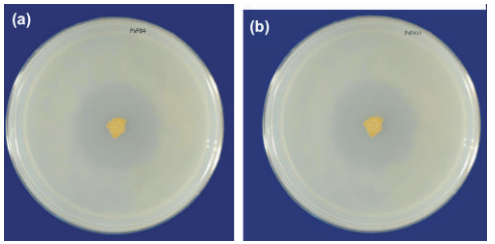



Fig. 2. Phosphate solubilization on Pikovskaya's agar medium by (a) *Pseudomonas monteilii* PsF84 and (b) *Pseudomonas plecoglossicida* PsF610.

Chemosphere 117: 433–439; 2014

## Purification, characterization, and *in vitro* activity of 2, 4-di-tert-butylphenol from *Pseudomonas monteilii* PS F84: conformational and molecular docking studies

A novel strain of *Pseudomonas monteilii*, PsF84, was isolated from tannery waste polluted soil from Jajmau, Kanpur, India. Phylogenetic analysis of 16S rRNA gene sequence confirmed the taxonomic affiliation of PsF84 as *P. monteilii*. An anti-fungal volatile organic compound (VOC) active against hyphal growth of *Fusarium oxysporum* (CIMAP-IMI-357464) *in vitro* was isolated from strain PsF84 by using chromatographic techniques. The molecular formula of the anti-fungal VOC was deduced to be C14H22O by EI-MS and 1D and 2D NMR spectral analysis. 2,4-Di-

tert-butylphenol was found to be effective against *F. oxysporum* in inhibiting spore germination and hyphal growth. Molecular docking analysis of 2,4-ditert-butylphenol with β-tubulin further validated the potential of β-tubulin binding in *F. oxysporum*. Two residues of β-tubulin protein, HIS 118 and THR 117, showed hydrogen binding with ligand. To the authors' knowledge, this is the first report of anti-fungal VOC (2,4-di-tert-butylphenol) produced by *P. monteilii* PsF84 that can be a potent inhibitor of β-tubulin of *F. oxysporum*.

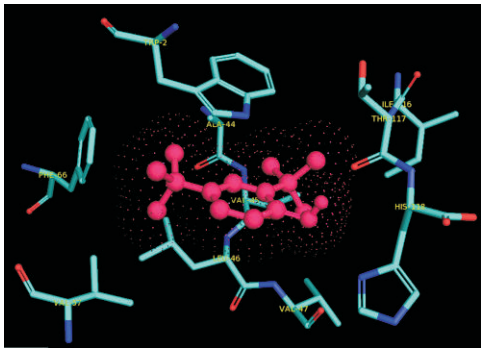
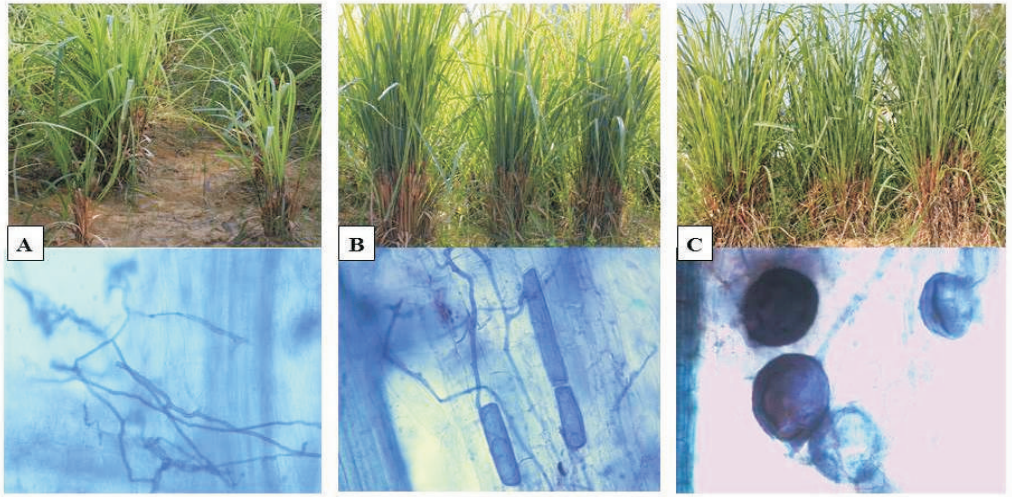


Fig. 2,4-Di-tert-butylphenol (pink) showing docking with active site residues (labeled in yellow).

J. Agric. Food Chem. 62: 6138-46, 2014

Input: Patra DD

## Changes in the mycorrhizal colonization of lemongrass in the first year and subsequent cropping (2nd and 3rd) years




Plant growth and AMF root colonization in different cropping years: (A) 1st year crop (plant crop) (B) 2nd year (1st ratoon); (C) 3rd year (2nd ratoon)

Lemongrass is grown as a high value crop with low input and is a good source of essential oil for aroma industry. Mycorrhizal fungi help in phosphorus acquisition and also improve absorption of N from $NH4^{+}$-N mineral fertilizers. The objective of this was to study the changes on plant growth and development of arbuscular mycorrhizal fungi (AMF) root colonization of lemongrass in first year and subsequent cropping 2nd year (1st ratoon) and 3rd year (2nd ratoon). The arbuscular mycorrhizal fungi colonization of lemongrass crop was significantly affected by cropping years. AMF developmental variation along with cropping years (plant crop and subsequent years) is shown in figure A, B & C. The percent AMF root colonization was 39.9%, 57.3% and 74.4%, respectively in 1st year, 2nd year and 3rd year lemongrass crop respectively. Improvement in the AMF root colonization with the age of crop would be support to plant life.

Input: Verma RK, Patra DD, Singh S

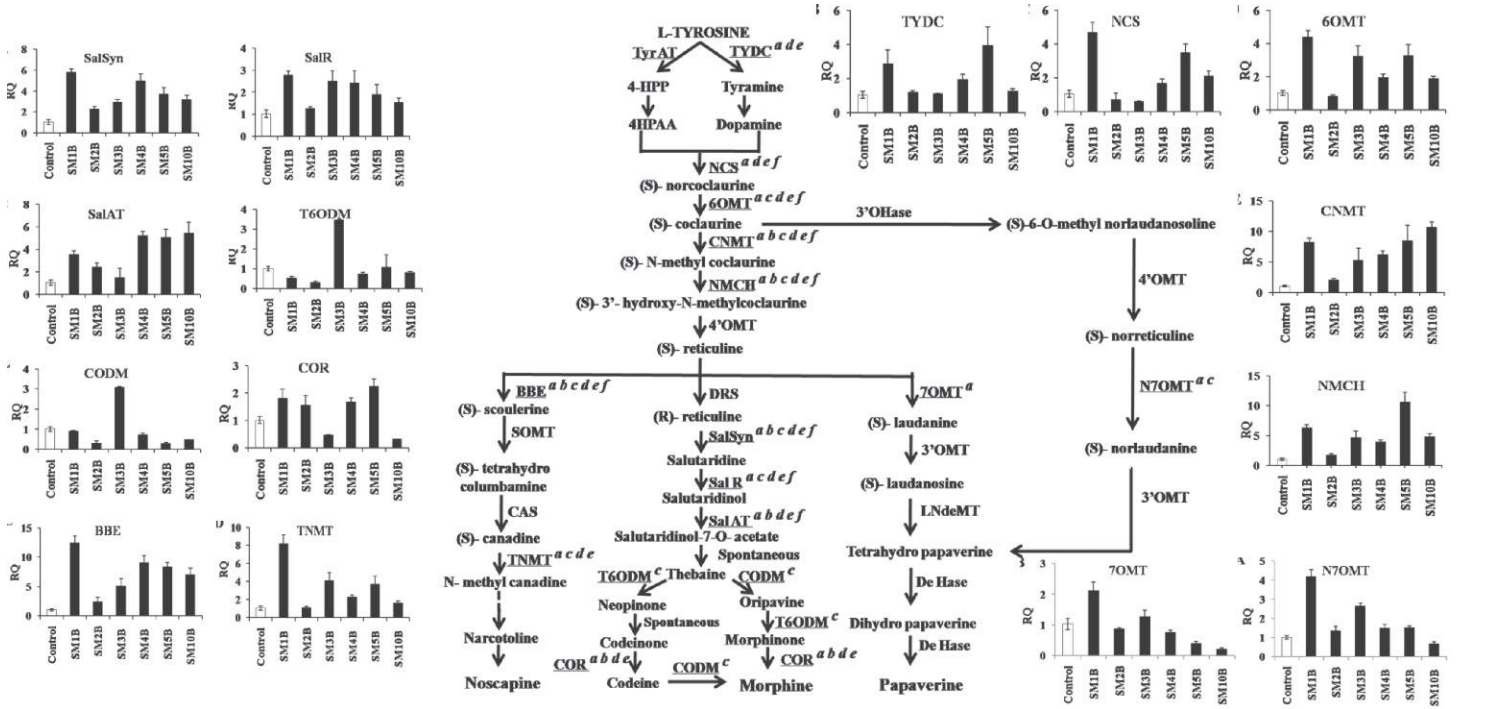
## Project : BSC. 117 : Plant-microbe and soil interactions

Principal Investigator: Alok Kalra

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

A total of 32 endophytes isolated from *Papaver somniferum*, 46 from *Catharanthus roseus* and 44 from *Withania somnifera* were molecularly characterized.

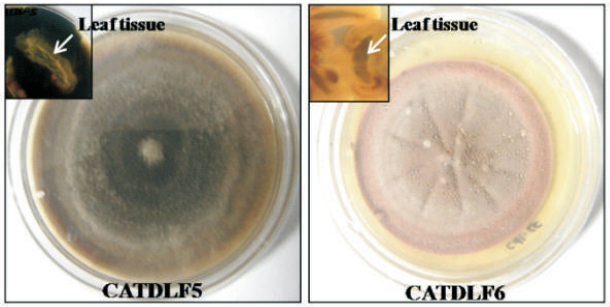
Endophytes isolated from capsule of opium poppy enhanced benzylisoquinoline alkaloids (BIAs) production by modulating expression of genes involved in BIAs biosynthesis.

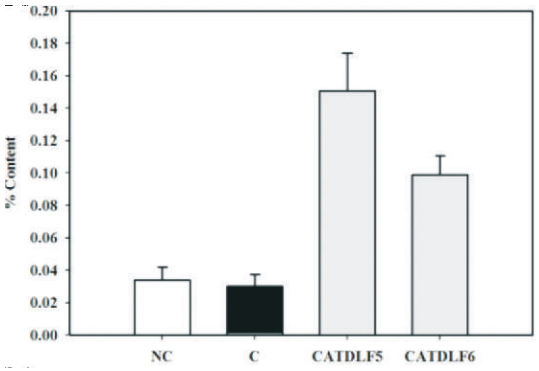



Genes encoding key regulatory enzymes of BIAs biosynthesis were upregulated by endophytic treatments suggesting a critical role of endophytes in alkaloids biosynthesis.

Superscript letter over enzymes of pathway represent endophytes upregulating the respective genes.
a -SM1B, b -SM2B, c -SM3B,
d -SM4B, e -SM5B, f -SM10B

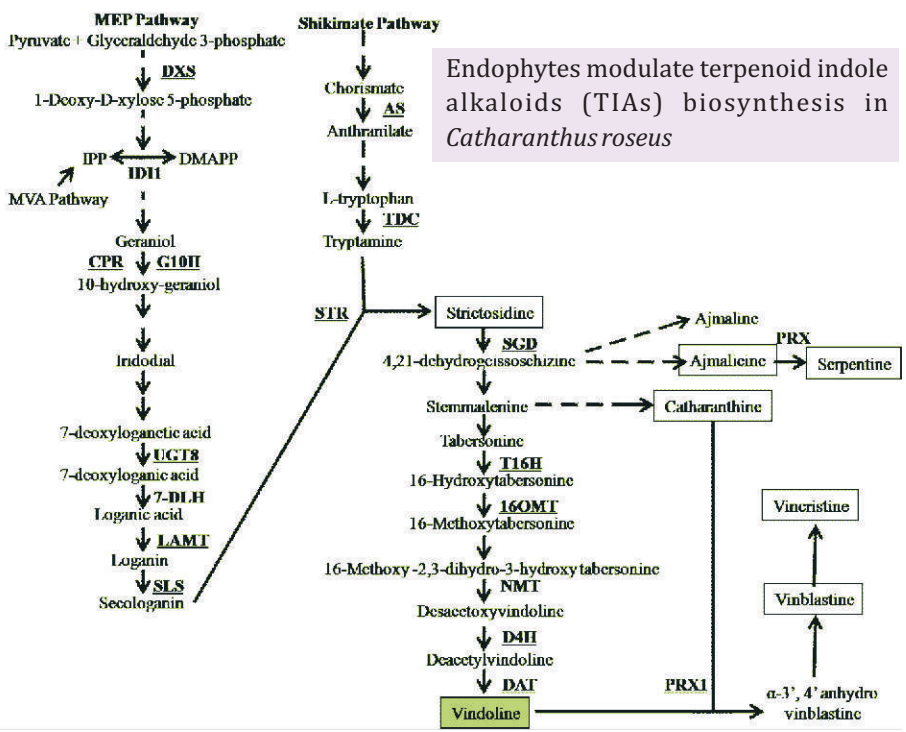
## Plant-endophyte interactions responsible for enhancing yields of selected therapeutically useful secondary metabolites



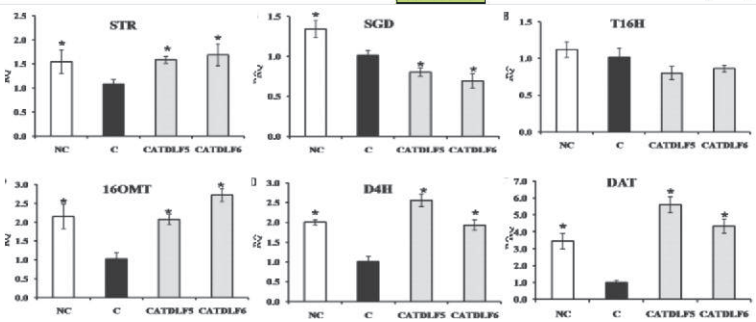




Fungal endophytes CATDLF5 and CATDLF6 inoculation enhanced vindoline production (229-403%) in leaves of *Catharanthus roseus* (NC- natural control and C- non inoculated endophyte free control plants)

CATDLF5 and CATDLF6 inoculation upregulated the expression of key genes involved in vindoline production.




Endophytes modulate terpenoid indole alkaloids (TIAs) biosynthesis in *Catharanthus roseus*



## Project : BSC.121 - Genomics and informatics solutions for integrating biology

Principal Investigator: Feroz Khan

### Optimization of active phytomolecules derivatives as lead against cancer and drug resistant bacterial pathogens.

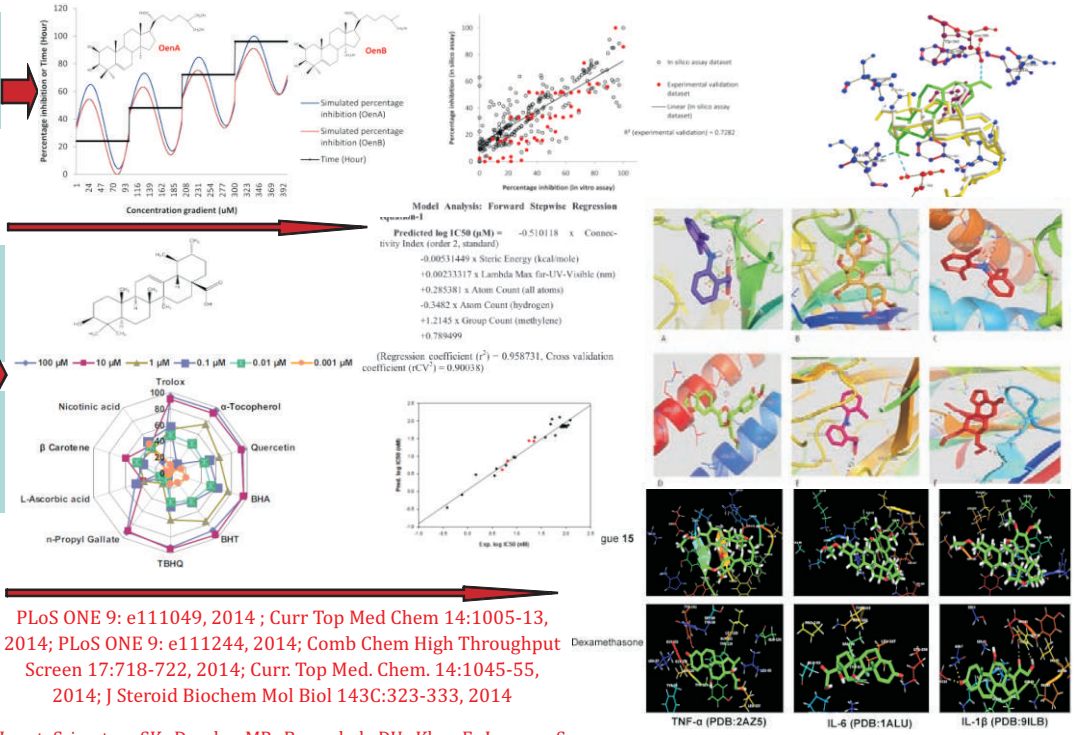
Objective: Development of in *silico / in vitro* screening methods and identification of anti-cancer and anti-bacterial leads

Phyto-Molecules → *In silico* design, ADMET, Docking studies → QSAR model Development/ in silico assay → Isolation, chemical synthesis, transformation → *In vitro / in vivo* exp. → Active Leads

Anti-microbial, anti-cancer & others activity

*Outcome:*

- Developed *in silico* assay for screening of Tetracyclic Triterpenoids as anti-cancer agents against human breast cancer cell line MCF7.
- Identified *in silico* & *in vitro* anti-cancer & anti-filarial activity of ursolic acid derivatives.
- Developed *in vitro* optimized ABTS radical cation based method to evaluate scavenging potential of phenolic & non-phenolic group of molecules.
- Identified *in vivo* & *in silico* protective mechanism of lignans from Phyllanthus amarus against galactosamine/ lipopolysaccharide induced Hepatitis
- Synthesis of diosgenin analogues as potential anti-inflammatory agents




**Conclusion:** Anti-cancer, anti-filarial and anti-inflammatory lead identification, SAR and assays were developed

PLoS ONE 9: e111049, 2014 ; Curr Top Med Chem 14:1005-13, 2014; PLoS ONE 9: e111244, 2014; Comb Chem High Throughput Screen 17:718-722, 2014; Curr. Top Med. Chem. 14:1045-55, 2014; J Steroid Biochem Mol Biol 143C:323-333, 2014

Input: Srivastava SK , Darokar MP , Bawankule DU , Khan F , Luqman S

## Project: BSC.105 – New initiatives to boost agriculture productivity through maximizing pre and post harvest yields

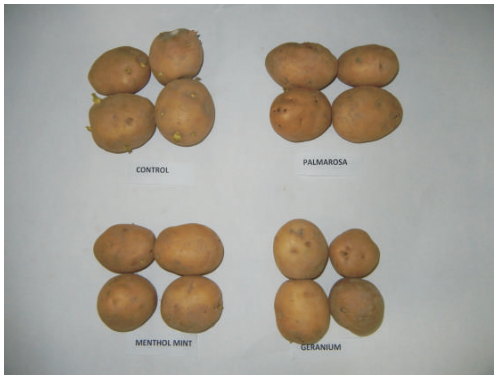
Principal Investigator: AK Tripathi

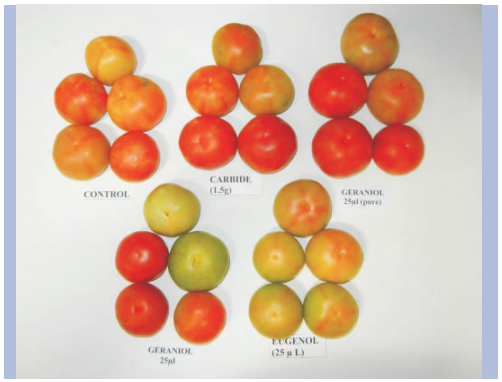
The project aims at delivering formulations/products for prevention of stored grains from insect damage and natural deterioration of food products apart from improving shelf life using herbal essential oils/oleoresins.

Fifty-four extracts and nine essential oils were tested a) for stored grain protectant activity b) as anti-ripening agent and c) ripening agent for fruits and vegetables. Ethanol, acetone and acetonitrile extracts of fennel (*Foeniculum vulgare*) and ethanol and acetonitrile extract of cinnamon (*Cinnamomum zeylanicum*) showed 90-100% insecticidal activities against stored grain insect *Tribolium castaneum* adults at a concentration of 40µl/ml in contact toxicity assay. The essential oil of carum (*Trachyspermum ammi*) gave 100% adulticidal activities towards *T. castaneum* in vapour toxicity assay at 10µl/ml.

As a preventive measure for post harvest losses in fruits and vegetables, essential oils and their constituents were tested for inducing and inhibiting ripening in tomatoes. Geraniol was found as an effective ripening agent and eugenol as anti-ripening agent. Essential oils of geranium and palmarosa were found to be inhibitory to sprouting of potatoes whereas oil of lemongrass promoted it. Oil of clove prevented spoilage of *Aloe vera* juice at 1% concentration; it completely inhibited the growth of microbes involved in spoilage of juice.

Generally Recognized as Safe (GRAS) listed plants being evaluated for desired bioactivities may provide lead materials as an eco-friendly and safe alternative to hazardous synthetic pesticides being used in stored grains, fruits and vegetables.



## Project : OLP.18 – Development and deployment of improved agro and processing technologies of economically important medicinal and aromatic crops for income enhancement and employment generation

Project Investigator: RP Bansal

### Demonstration programmes

i. CSIR-CIMAP Research Centre, Bengaluru: Six farmers from different districts of Karnataka and Andhra Pradesh were selected for field demonstration. The various crops selected included palmarosa, lemongrass, rosemary, geranium, patchouli and tulsi. The area for demonstration was in the range of 1-3 acres. Palmarosa and tulsi seeds were given to the selected farmers. Patchouli, geranium and rosemary were planted in model demo plots of the farmers' fields.

ii. CSIR-CIMAP Research Centre, Hyderabad: Fifty-thousand slips of citronella are being raised in nursery for providing the planting material to ten selected tribal farmers in Vishakhapatnam district. About 2 quintal seeds of *Withania somniferum* var. *poshita* were provided to five farmers of Ananthapur district for sowing.

Field Demonstration at Bengluru

Team at farmer's field at Bengluru

iii. CSIR-CIMAP, Lucknow: Twenty-five farmers were selected in different villages in Lucknow, Barabanki, Lakhimpur, Jhansi and Raebareli districts of Uttar Pradesh for demonstration of different crops like gernanium, vetiver, *Artemisia annua*, menthol mint var CIM-Kranti, palmarosa and lemongrass. The planting material (seeds/slips/suckers) of the above plants and information of improved agro-technology were made available to the selected farmers.

### Training programmes

CSIR-CIMAP Research Centre at Hyderabad and Bengaluru organised two-day training programme at each location from 27–28 January, 2015 and 29–30 January, 2015, respectively. These programmes were attended by 33 and 25 participants at Hyderabad and Bengaluru centres, respectively.

Input: Sundaresan V, Bhaskaran

## Farmers' meet to promote cultivation of medicinal plants in Uttarakhand

CSIR-CIMAP organized a Kisan Gosthi (farmers' meet) on 17th November, 2014 at its Research Centre, Purara located near Garur-Baijnath, district Bageshwar, Uttarakhand . About 80 farmers hailing from different districts of Uttarakhand participated. The meet was partially supported by State Medicinal Plants Board (SMPB), Uttarakhand and Uttarakhand Council of Science & Technology (UCOST).


Shri Lait Farswan addressing the participants

Prof. Tripathi distributing a kit of planting material to the participants

## Project : MLP. 03 – Dissemination of medicinal and aromatic plants related technologies for socio-economic gains

Principal Investigator: Sanjay Kumar

### 1 (a) Technology licensing

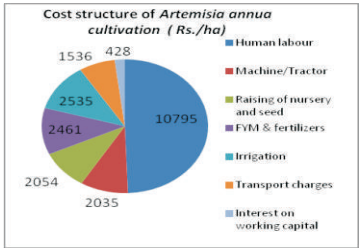
- M/s AIMIL Pharmaceuticals Ltd, Delhi for Technology transfer of Diabetic management product NBRMAP transfer (jointly developed by CSIR-CIMAP & CSIR-NBRI) (Rs.30.0 lakhs)
- M/s Toll Corporation Limited, Delhi for Technology transfer of Low cost sanitary Napkin transfer to a Delhi base company (Rs.13.00 lakhs)

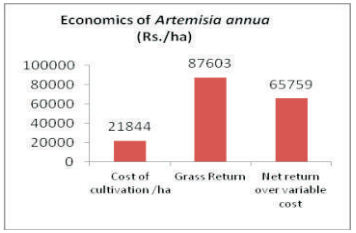
### (b) Consultancy and technical services

- Kirshi Vigyan Kendra, Munger (Bihar), consultancy project relating to the supply of 8 distillation units of 500 kg capacity (Rs.18.72 lakhs)
- Kirshi Vigyan Kendra, Bikramganj, Rohtas (Bihar), consultancy project relating to the supply of the 5 distillation units of 500 kg capacity (Rs.15.00 lakhs)
- Kirshi Vigyan Kendra, Bikramganj, Rohtas (Bihar), consultancy project for development of herbal garden and nursery raising (Rs.4.25 lakhs)
- Mr. Ramana Poturaju, Nacharam Hyderabad, technical service for palmarosa cultivation (Rs. 0. 50 lakhs)
- Mr. Pankaj Shah, Kutch, Gujarat, supply of design drawing of distillation unit (Rs.0.16 lakhs)
- Mr. Sudhir Sule of Maharashtra, supply of CIM- Asvika (Rs.0. 25 lakhs)

### 2. (a) Economics of *Artemisia annua* cultivation

*Artemisia annua* crop is an important source of artemisnin used as anti-malarial drug. The present study was conducted in Uttar Pradesh. Primary data on cost aspects has been collected from 80 selected farmers. It has been observed that total variable cost was found to be ₹ 21,844 per hectare. The major portion of cost of cultivation was shared by human labour. The total return was found ₹ 87,603 per hectare. The net return over variable cost was found to be ₹ 65,759 per hectare with a benefit-cost ratio of 4.01. The estimated resource-use efficiency in this crop ($R^2$ value) was found 0.907 which indicates that 91 per cent of the variations in *Artemisia anuua* were influenced by the explanatory variables like human labour, seed and nursery raising, manure and fertiliser and transport charge.



### (b) Market Survey

Major markets of medicinal and aromatic plants were surveyed at different locations in northern part of the country. These included Lucknow, Barabanki, Kanpur, Kannauj, Bareilly, Varanasi, Haridwar, Rishikesh, Deharadun, Tanakapur, Delhi and Neemach. In these markets, major commodities traded were found as ashwagandha, satavar, makoi, kalmegh, serpgandha, amla, dry rose flowers and essential oils such as menthol mint, peppermint, lemongrass, palmarosa, geranium, citronella, vetiver, tulsi along with other MAPs in small quantities. About 85 whole sellers, retailers and buyers were identified during the study.

## 3. Training programs on production of medicinal and aromatic plants

- 24-27 June, 2014 at Lucknow, participants 48 ,sponsored by SIDBI
- 1 -2 August, 2014 at West Champaran, participants 62, sponsored by ATMA, West Champaran ( Bihar)
- 6-8 August, 2014 at Bangalore, participants 32, sponsored by SIDBI
- 6 August, 2014 at Lucknow, participants 32, sponsored by MSME
- 12 August, 2014 at Kanpur, participants 24, sponsored by MSME
- 2-4 September, 2014 at AMPRI Bhopal, participants 30, sponsored by SIDBI
- 16-18 September, 2014 at Lucknow, participants 42, sponsored by ATMA, West Champaran ( Bihar)
- 23-25 September, 2014 at Lucknow, participants 41, sponsored by ATMA, Buxer (Bihar)
- 20 October, 2014 at Lucknow, participants 130, sponsored by KVIB
- 5-6 November, 2014 at Renukoot Sonebhadra, participants 176, sponsored by NMPB
- 9-10 December, 2014 at Lucknow, participants 21, sponsored by CSIR-HRDG
- 16-19 December, 2014 at Lucknow, participants 40, sponsored by SIDBI
- 21 Dec, 2014 Awareness camp at Mandvi (Bhuj) Gujarat ,participants 274, sponsored by Vivekanand Rural Training Institute, Mandvi
- 15-16 January, 2015 at Lucknow, participants 43, sponsored by Directorate of Horticulture, Government of UP
- 17 January, 2015 at Gorakhpur, participants 514, sponsored by Horticulture Department, Government of UP
- 20-22 January, 2015 at Lucknow, participants 37, sponsored by ATMA, Siwan (Bihar)

### Entrepreneurial training on making of agarbattis using floral bio-resource

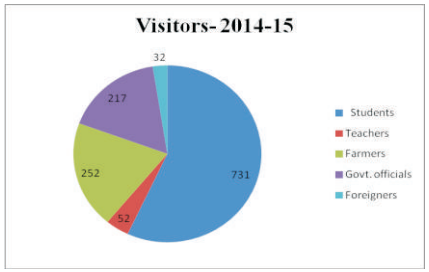
Entrepreneurial trainings programmes on making of scented agarbattis using flowers and other plant bio-resources were organised. More than 90 participants were imparted hands on training during the year. Two such training programmes were held at CIMAP's Women Entrepreneurial Training Facility (WETF) located near Chandrika Devi Temple, vill. Kathwara, Bakshi-ka-Talab, Lucknow on 4 April, 2014 and 18 October, 2014 for 16 and 40 participants, respectively. Another programme was organised 12 April, 2014 at vill. Kalli Pashchim in which about 20 women participated. The trainees were also apprised about the

perfuming and packaging of the agarbattis and encouraged to form the groups for manufacturing and marketing.

Training on agarbatti making in vill. Kalli Pashchim

## 5. Visitors

About one thousand three hundred visitors including students, entrepreneurs, government officials, representative of industries, NGO and common people visited CSIR-CIMAP and were apprised about cultivation, processing and marketing of medicinal and aromatic plants.




## 6. Major events organized

- National Technology Day was organised on 11 May, 2014.About 150 farmers, entrepreneurs and women participated in the event and discussed about the medicinal and aromatic plants technologies.
- Two entrepreneurial workshops were organized on medicinal and aromatic plants based technologies on 6th August, 2014, at CSIR-CIMAP, Lucknow and on 12th August, 2014 respectively at Kanpur Dehat. These programmes were sponsored by MSME, Govt. of India, New Delhi.
- One day entrepreneurial workshop on medicinal and aromatic plants based technologies was organized on 20th October, 2014. This workshop was attended by about 120 participants and sponsored by Uttar Pradesh Khadi Village and Industries Board, (UPKVIB).
- Two day training-cum-workshop sponsored by National Medicinal Plants Board (NMPB) on medicinal and aromatic plants suitable for Vindhyan region of Uttar Pradesh was organized on cultivation, processing and marketing aspects during 5-6 November, 2014 at Renukoot, disrtict Sonbhadhra . The workshop was attended by about 175 participants including farmers, extension workers, forest officers and representatives from Agriculture and Horticulture departments, Government of Uttar Pradesh.
- Two-day CSIR-HRDG supported training programme for teachers organised on 09-10 December, 2014 in which 21 science teachers from various local schools/colleges Lucknow, Hardoi and Barabanki participated.

## 7. Impact assessment of distillation technology

Survey Feedback studies have been carried out to asseses impact of innovating technology based on interactive research inputs taken from 200 farmers. The study was conducted among the farmers of east U.P, West U.P and Bihar. The result analysis demonstrated/exhibited better oil recovery with minimum cost input, CIMAP improved field distillation unit demonstrated better results in case of low consumption period (3.25 hrs), high recovery of oil (54.6 litre), high oil recovery percentage (79.3%) and low

cost (Rs.346) per shift distillation time. Comparison between the conventional, rural type and CIMAP distillation technology have been illustrated.

**Table 1.** Economic benefit of distillation units

| State | No. of farmers | Distillation unit type | Av. oil recovery/ shift/ ton capacity | Av. distillation time (hrs) | Av. cost per Shift distillation (Rs) | Av. oil recovery % | Av. cost of 5 q distillation unit with no. of farmers | Av. cost of 10 q distillation unit with no. of farmers |
|---|---|---|---|---|---|---|---|---|
| **East U.P.** | 20 | Rural type distillation unit | 34 Lit. | 6 | 700 | 50% | 30000 (16) | 80000 (4) |
| | 40 | Improved distillation unit | 55 lit. | 3½ | 350 | 80% | 50000 (35) | 250000 (5) |
| **West U.P** | 25 | Rural type distillation unit | 32 lit. | 5½ | 750 | 52% | 30000 (22) | 800000 (3) |
| | 15 | Improved distillation unit | 53 lit. | 3¼ | 340 | 78% | 50000 (13) | 250000 (2) |
| **Bihar** | 40 | Rural type distillation unit | 32 lit. | 5¼ | 725 | 52% | 30000 (36) | 80000 (4) |
| | 60 | Improved distillation unit | 56 lit. | 3½ | 350 | 80% | 50000 (50) | 250000 (10) |

**Table 2.** Comparison of conventional, local and improved field distillation unit

| Parameters | Primitive/conventional | Rural type field distillation unit | Improved field distillation unit |
|---|---|---|---|
| **Efficiency** | Water/hydro distillation-Process is slow and the distillation time is much higher and consuming more fuel. | Water and steam distillation-Low steam generation, lesser time consuming than conventional type but inferior than improved one. Constructed with more fuel consumption, cheaper quality material. | Technologically improved over easier, higher steam generation due to more heating surface area and consuming lesser time. More fuel efficient and save 20-30% fuel, technically designed with better quality material. |

| Parameters | Primitive/conventional | Rural type field distillation unit | Improved field distillation unit |
|---|---|---|---|
| Tank | Made up of copper called 'Deg', Bamboo pipe, copper vessels etc | Mild/Stainless steel, tank shape varies circle, oval and cylindrical | Using high quality mild steel/stainless steel, cylindrical distillation tank fitted on a square inbuilt boiler/calandria having smoke pipe. |
| Capacity | Capacity is around 40 kg per batch | Capacity varies from 5 quintal per batch | Capacity varies from 10 quintal per batch. |
| Condenser | Material dipped in water, bamboo pipe is used for vapour connection, small furnace, and water tank is used for consideration of oil and vapour in a copper vessel. | Material is loaded on a grid below which water is boiled. Furnace has no design, vapour and oil passed through long vessel and then simple coiling in water tank, manual discharge of distillation waste. | Cylindrical distillation tank fitted with specifically designed furnace having fire gate, fuel duct and fire door. Furnace connected with chimney of optimum height, tube type condenser, stainless steel type separator with inbuilt baffle, chain pulley hoist system for easy discharge of waste. |
| Operation | Easy, simple and portable and used for rooh and attar of Gulab, Khus, Rajnigandha, Bela etc. | Easy to fabricate, installed at farmers field, low cost, simple construction, easy operation, not safe and less recovery of oil and time consuming, used in Menthol mint, Citronella, Lemongrass, Basil oil distillation. | Slightly costly, economic and efficient, fuel and time saving, eco-friendly and safe, can be used in Menthe, Citronella, Lemongrass, Basil, Palmarosa, Geranium, Vetiver, Chamomile, etc. |
| Quality of oil | Poor quality of oil due to direct contact of material with fire which imparts an objectionable odour to the essential oil. Deterioration of essential ester of essential oil. It also causes air pollution at work place. | Oil recovery less than improved field distillation unit, utilizes more quantity of agro waste/spent marc as fuel due to inferior technology. Deterioration of essential ester of essential oil due to high temperature in condensation. | Good oil recovery, 10-15% higher, utilizes agro waste/spent marc as fuel, no smoke in work area. No deterioration of essential ester of essential oil. |
| Self life | 2-3 years | 4 years | 10 years |
| Cost of unit | Rs. 30,000/- | Rs. 50,000/- | Rs. 250000/- |

## Technology feedback of CIM-Asvika

Performance index of newly developed multi-utility portable distillation technology was evaluated amongst the farmers of Uttar Pradesh and Bihar. These units were sold to farmers and received feedback of the technology. CIM-Asvika-distillation unit is especially designed for producing good quality oil and rose and Khus water. It can also be used for extraction of spices and other aromatic oils of high grades. It is made up of stainless steel, simple low cost, portable type, highly efficient and low fuel consuming distillation unit. This unit can produce 10-15 kg fresh rose water from 12 kg of rose flowers. The cost of this unit is about Rs. 12000/unit. It can be operated by firewood, agro waste, liquefied petroleum gas, kerosene burners.

The performance report indicates that 95% farmers are satisfied with CIM-ASVIKA in terms of usability and quality in micro enterprises development. A Self Help Group has been formed in village Samraha Udholi of Barabanki and women groups have started cultivation desi rose for the production of rose water. It produces nine liters rose water from ten kilograms flower and generates Rs. 1200/- with an expenditure of Rs. 475 (Table. 3) and selling in open market under brand name, Sakhi Gulabark

**Table 3:** Performance of CIM-ASAVIKA

| Performance Index | States and no. of farmer use CIM -ASAVIKA | |
|---|---|---|
| | **U.P (10)** | **Bihar (4)** |
| Cost | Low cost | Low cost |
| Usability | Portable easy to operate | Portable easy to operate |
| Technology tested by farmers/users | Yes, Fit for various application | Yes, Fit for various application |
| Capacity | 10 Kg flowers per batch | 10 Kg flowers per batch |
| Cost of Rose water production | Rs 475/ - per batch | Rs 400/ - per batch |
| Time of distillation and raw material quality per day batch | Three batch in a day of 30 Kg flowers (4 hours) | Three batch in a day of 30 Kg flowers (3.5 hours) |
| Rose water production per day | 30 litre | 28 litre |
| Net return / acre | 110 litre of rose water @185 per litre | 100 litre of rose water @175 per litre |

## Livelihood to Sahariya tribes of Bundelkhnand

CSIR-CIMAP's cultivation and processing technology of Palmarosa is transforming the daily lives of tribal Sahariya cast of dominated in district Lalitpur ,U.P. Tribes are dependent on forest for fuel wood and collection of herbs for livelihood. CIMAP has introduced Palmarosa crop under rainfed condition which yielded 2.7 kg oil per 1000 sq.mt area demonstration plots and earned Rs.3510 in 1st cutting. It is better than conventional Maize crop. A

distillation unit of 500 Kg has been set up amongst the farmers groups. A local organization Bundekhand KHETI Kendra in maintaining distillation unit including marketing of oil.

Tribal women with Palmarosa crop

Training of distillation & yield data recording

## Farmers' fare (Kisan Mela)

Kisan mela 2015 was organized in Lucknow campus on 31st January. About 4000 farmers and entrepreneurs from various states of the country participated in the mela. Hon'ble Governor of Uttar Pradesh Shri Ram Naik was the chief Guest and Mrs. Eva Sharma, Chief Conservator of Forest was the special guest. During the Kisan Mela, an improved distillation unit named 'Unnat Asvika', a souvenir-cum-extension book on MAPs named 'Aus-Gyanya' and a booklet on the co-cultivation of menthol mint, were released. Farmer – scientist interaction on production and marketing of medicinal and aromatic plants, sale of quality planting material and farm bulletins, demonstration of improved plant varieties and herbal products, live demonstration of MAPs distillation and processing, training on rose water extraction and agarbatti making and demonstration of 'Early Mint Technology' were the major attractions of the Kisan Mela. Representatives of IPCA Lab, SIDBI and buyers and sellers of MAPs also participated in the Kisan Mela. National Botanical Research Institute, Biotech Park and various other industries and mentha growers association put up their stalls during the Mela.

Mela inauguration


Release of Aus - Gyanya


## MoU with Fragrance and Flavour Development Centre (FFDC), Kannauj

A memorandum of understanding (MoU) between CSIR-CIMAP and FFDC to work jointly on the value addition, utilization and marketing in major essential oils was signed during the Kisan Mela. The MoU will help in the value addition and development of new technologies and products in the area of major essential oils and also extend benefit to the farmers and entrepreneurs of MAPs.

Input: Tomar VKS, Krishna A, Kumar S, Bansal RP, Suresh R, Yadav RP

## Entrepreneurial training on essential oil processing technologies (EOPT 2014)

*$26^{th}$ - $31^{st}$ May 2014, Number of Trainees: 17 from different states of Karnataka, Tamil Nadu, Andhra Pradesh, Maharashtra, Gujarat, Haryana, Punjab and UP; ECF generated: Rs. 2.04 lakhs*

The six day training course covered all technical aspects related to pilot and commercial scale production of essential oils using different distillation techniques, fractional distillation of essential oils for isolation of aroma chemicals, production of concretes and absolutes from flowers. Value additions techniques including menthol flakes crystallization, derivatisation of aroma chemicals and quality analysis procedures for the essential oils including GLC, physic-chemical parameters like optical rotation, refractive index, solubility, and specific gravity was a part of the workshop.

### Entrepreneurial training on Aloe vera processing technologies (AVPT-2014)

*24th to 27th November 2014, No of Participants: 25 from Kerala, Karnataka, Andhra Pradesh, Mizoram. Madhya Pradesh, Punjab, Uttarakhand and U.P. ECF generated Rs.3.00 Lakhs*

The Aloe vera training 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. The four day course helps the participants to learn the practical aspects of the technologies along with details of plant & machinery, economics of production, details of preservatives, stabilizers, quality monitoring etc.

## Project : CNP. 302 - Designing and setting up of eight directly fired improved distillation units in Munger, Bihar

Principal Investigator: Sudeep Tandon

The project was awarded for providing technical consultancy for designing and setting up of 8 x 500 kg/batch directly fired type improved field distillation units for mentha oil in the Munger District of Bihar. The units have been designed, fabricated supplied to the Krishi Vigyan Kendra, Munger and the installation of the units has been completed. An amount of Rs 18.72 lakhs was generated in form of ECF

Input: Tandon S, Ahmad J

## Project : CNP. 301- Designing and setting up of directly fired improved distillation unit in Gangtok, Sikkim

Principal Investigator: Sudeep Tandon

A technical consultancy project was undertaken in which designing, and setting up a 500 kg/batch directly fired type improved stainless steel field dual type distillation unit based on CIMAP know-how & design at ICAR Research Complex for NEH Region, Sikkim Center, Tadong, Gangtok Sikkim was to be done. The dual type unit specially designed for all types of essential oils was successfully fabricated, installed and commissioned at ICAR Research Complex Tadong in August 2014. An amount of Rs 6.00 lakhs was generated in form of ECF.

Directly fired improved distillation unit

Input: Tandon S, Ahmad J

## Project : BSC. 125 – S&T interventions to combat malnutrition in women and children

Principal Investigator: HS Chauhan

### Study on nutritional status in selected villages

Four villages were targeted for collection of data with respect to the nutritional status of selected population before distribution of the herbal products developed by CSIR labs. These villages are CSIRTech Vill Dau (Unnao), Dewarai Kala (Lucknow), Tulsipur (Amethi) and Ahmadpur (Rae-bareilly) in Uttar Pradesh. Project team visited the selected villages for interaction with the villagers especially women and children. Awareness programmes and camps were also held for creating awareness and ensuring participation of the villagers. The team approached and interacted with the Gram Pradhans, Anganbadi workers and school teachers in the respective villages to get maximum participation of the under privileged women and children. A Health Mela was organized in Dau village on 14 August, 2014 in which, CSIR-CIMAP, NBRI, IHBT, NIIST and NEIST participated.

**Status of four adopted villages**

**Tulsipur** : Amethi, Uttar Pradesh; Population: 1224 (M-674; F-550), Children-212, Dates of visit: 15.01.2015 and 02.02.2015

**Ahmadpur** : Raebareilly, Uttar Pradesh, Population: 1036 (M-529; F-507), Children-212, Dates of visit: 16.01.2015 and 09.02.2015

**Dewarai Kala** : Near BKT (Lucnow-Sitapur Road), Population: 1293 (M-704; F-507), Children-182, Dates of visit: 10.04.2014 and 21.05.2014

**Dau Village** : Unnao District (CSIR TechVill), Population: 2600, Dates of visit: 05.06.2014, 08.08.2014, 14.08.2014, 15.09.2014, 17.10.2014, 13.11.2014, 22.12.2014 and 10.01.2015

The primary health profile of children and women of vill. Dewarai Kala was prepared.

In all 27 families were surveyed and based on the general observation, about 60 members of these families including children of various age groups and women were marked as apparently malnourished who may require S&T intervention under the project. However, detailed health profile will be prepared after getting the blood sample analyzed during January/February, 2015.

### Health Mela -2014

One day 'Health Mela' was organized on 14 August, 2014 in CSIR Techvill Dau (Block Purva), District Unnao (UP). About 500 people comprising children and women in large number participated. The mela was inaugurated by Dr. (Mrs.) Manju Sharma, former Secretary, Department of Biotechnology, Government of India. Dr. Sharma also visited various stalls put up on the occasion.

Dr (Mrs) Manju Sharma interacting with the team of doctors in the CSIR Health Mela

## Project : CSIR 800 - Development of self-sustaining technology enabled villages through CSIR Technological Interventions

Principal Investigator: HS Chauhan

Under the project, a second distillation unit was installed and commissioned in the adopted tech village Dau of district Unnao. The new unit is an improved dual stainless steel directly fired type field distillation units of 800 kg / batch capacity. The unit has been specially designed for distillation of geranium, mentha, vetiver and aromatic grasses. The unit shall be used for the distillation of the aromatic crops being grown by the beneficiary farmers under the Tech Vill and CSIR 800 project.

Improved field distillation units

So far, the total crop-wise land under cultivation of MAPs in Unnao district is: *Atremisia annua* (5 ha), vetiver (1 ha), palmrosa (0.8 ha), lemongrass (0.2 ha) and *Matricaria chamomila* (0.01 ha).

## CIMAP Research Centre, Bengaluru

### Skill-cum-technology upgradation programme for farmers

CIMAP Research Centre, Bengaluru conducted three-day skill-cum-technology upgradation programme on 'Production technology of medicinal and aromatic plants' during 6-8 August, 2014. The program was sponsored by SIDBI. Thiry-two participants from the different states included farmers, entrepreneurs and academicians participated. Dr. U. V. Singh, Additional Principal Chief Conservator of Forests & Chief Executive Officer, Karnataka State Medicinal Plants Authority, Bengaluru was the Chief Guest. He apprised the participants about the schemes of National Medicinal Plants Board (NMPB). Technical lectures on agronomy, breeding and chemistry aspects of aromatic and medicinal plants like citronella, lemongrass, palmarosa, vetiver, geranium, patchouli, rosemary, *Eucalyptus citriodora*, ashwagandha, senna, kalmegh, *Ocimum*, and Coleus were held. Lectures on distillation and quality aspects of essential oils and processing of medicinal plants were also arranged. Preparation of soil beds, planting methods, preparation of cuttings and distillation of essential oil was demonstrated. An interactive session was arranged with the representatives from trading companies for marketing of medicinal plants/ aromatic oils and buyback arrangements. The participants had an opportunity to clarify their doubts with the representatives. Dr. Sanjay Joshi, Asst. General Manager, SIDBI, Bengaluru was the Chief Guest of the valedictory function held on 8th Aug. 2014. He apprised the participants about the various schemes of SIDBI in general and for medicinal and aromatic plants, in particular.

Inauguration of the programmes

Welcome address by Dr. V. Sundaresan, Scientist Incharge, CIMAP Research Centre, Bangaluru

## CIMAP Research Center, Hyderabad

- Two awareness camps were conducted on the aromatic grass cultivation Valasi and Vontlamamidi tribal villages of Visakhapatnam district of Andhra Pradesh on 17th and 18th of December, 2014 benefitting 47 tribal farmers.
- One lakh slips citronella and vetiver were distributed to 37 tribal farmers. Planting, maintenance and distillation methods of suitable MAPs were demonstrated to the tribal farmers. Now the 37 fields are serving as demonstration plots for the other tribal farmers in the district.
- Self Help Group (SHG) of 250 tribal farmers was formed to start cultivation of MAPs in the year 2015-16.
- CIMAP varities Poshita (3000 kg) and NIMTLI-118 (2000 kg ) were produced and supplied to Ananthapur, Kurnool, Ranga Reddy and Nalgonda district farmers at subsidised rates with funding support from AP State medicinal Plants Board. One hundred and twenty five farmers were given 40 kg seed each.
- Data base of farmers cultivating aswagandha in 10,000 acres in Andhra Pradesh has been prepared.
- Project proposal entitled "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" submitted by Dr. K.P. Sastry, Scientist-in-Charge, CIMAP Research Centre, Hyderabad was sanctioned by NMPB for a period of 2 years at the total cost of Rs. 31.24 lakhs.


1&2: Awareness camps; 3,4,5&6: Demonstration of cultivation and distillation; 7&8: Aswagandha seed distribution and honouring CSIR-CIMAP farmers

## New variety

### CIM Jyoti - A high citral rich essential oil yielding variety of lemon scented basil (*Ocimum africanum* Lour.)

Lemon scented basil belongs to the family "Lamiaceae". The essential oil of *Ocimum* is extracted by hydro or steam distillation from the leaves or whole herb and is used to flavour foods, dental and oral preparations, in fragrances, and in traditional medicines. The cultivar CIM Jyoti of *Ocimum* has been developed by CSIR-CIMAP through intensive breeding efforts for high yield of herb and essential oil with high citral content (68-75%). The average herb yield of CIM Jyoti is 200 q/ha and oil yield 150 kg/ha. Essential oil with rich citral content is in high demand. The lemongrass crop is the only source of essential oil for the extraction of citral. Lemongrass being a 4-5 years crop, farmer hesitates to cultivate lemongrass crop for long time in their field. Farmers prefer citral-rich oil from a short duration crop without disturbing their traditional cereal and other crops. CIM Jyoti will produce citral in short duration of 70-80 days. It also fits in crop rotation/intercropping between wheat and paddy and with other vegetables crops of small farmers. Leaves of this variety can be used in lemon tea.

Lemon scented basil variety CIM Jyoti

## Externally funded projects (Grant in lakhs of Rs.)

| Project title, principal investigator and funding agency | Grant |
|---|---|
| Technical consultancy to Krishi Vigyan Kendra, Munger, (Er Sudeep Tandon) | 18.72 |
| Studies on development and formulation of photochemical based nanopestisides to protect stored grains from insect damage by Department of Science and Technology, New Delhi (Dr Vandana Singh) | 20.60 |
| *Centella asiatica* transcription factors; novel insights into transcriptional regulation of secondry metabolism in Apiaceae by Department of Science and Technology, New Delhi (Ms Sandhya Tripathi) | 20.60 |
| Studies on virulence functions of *Xanthomonas oryzae* cv. *oryzae*: A system level analysis of two component signal transduction systems for their role in pathogenesis by Department of Science and Technology-INSPIRE Faculty, New Delhi (Dr Alok Pandey) | 95.00 |
| Organization of divisional workshop for promotion of economically important medicinal plants in different agro-climatic zones of Uttar Pradesh by National Medicinal Plant Board, New Delhi (Dr VKS Tomar) | 6.00 |
| Assessment of genetic diversity and systematics of the genus *Physalis* L. (Solanaceae) in India, using PCR based methods by Department of Science and Technology, New Delhi (Dr Kamalesh Singh Mahar) | 24.00 |
| Introduction of CIMAP-SAUMYA variety of *Ocimum basillicum* (Babui Tulsi) and NIMITLI variety of Ashwagandha (*Withania somnifera*), in Tikampur district of M.P. by National Bank for Agricultural and Rural Development ( Dr Alok Krishna) | 2.59 |
| Technical consultancy for designing and setting up of five 500 kg/batch directly fired type distillation unit based on CIMAP know-how & design by Krishi Vigyan Kendra, Rohtas (Er. Sudeep Tandon) | 15.00 |
| Development of herbal garden and nursery at KVK Bikramganj, Rohtas, Bihar by Krishi Vigyan Kendra, Rohtas (Dr Sanjay Kumar) | 4.25 |
| Differential gene expressions studies in *Mentha arvensis* for developing drought tolerant genotype/s (less water consuming) by Department of Biotechnology, Bio-CARe, New Delhi (Dr Sunita Singh Dhawan) | 28.460 |
| Studies on *Camelina sativa* seed/oil cake for exploring novel bioactive constituents by Defense Research & Development Organization, Haldwani (Dr Suaib Luqman) | 7.64 |
| Studies of novel natural and semisynthetic phytoestrogenic analogues from diosgenin, gallic acid and 18B glycyrrhetinic acid for cardiovascular potential using *ex vivo* by Department of Science and Technology, New Delhi (Dr Debabrata Chanda) | 23.800 |
| Identification and validation of novel and conserved miRNAs targeted to withanolide biosynthesis pathaway in *Withania somnifera* by Department of Biotechnology, Bio-CARe, New Delhi (Dr Smrati Mishra Trivedi) | 32.899 |

## Ph.D. degrees awarded

**Biochemical and molecular studies on essential oil monoterpene metabolism in citronella (*Cymbopogon winterianus*) leaf**

Awarded to Mr. Anil Kumar by Academy of Scientific & Innovative Research (May 2014)

**Molecular cloning and characterization of tropinone reductase from Ashwagandha (*Withania somnifera* Dunal)**

Awarded to Mr. Amit Kumar Kushwaha by Jawaharlal Nehru University, New Delhi (May 2014)

**Chemical investigation and development of validated analytical methods for some selected medical plants**

Awarded to Mr. Anupam Maurya by Dr. Ram Manohar Lohia Avadh University, Faizabad (June 2014)

**Development of synergistically performing microbial consortium for promoting plant growth in salt stressed soils**

Awarded to Ms. Nidhi Bharti by Jawaharlal Nehru University, New Delhi (July 2014)

**Cloning and characterization of stress inducible Apetala2 (PsAP2) homologue from *Papaver somniferum*.**

Awarded to Ms. Sonal Mishra by Jawaharlal Nehru University, New Delhi (July 2014)

**Studies on hairy roots as bioreactors for normal and elicited biotransformation of exogenous molecules**

Awarded to Mr. Vikash Srivastava by Lucknow University (July 2014)

**Synthesis, anti-malarial and anti-cancer studies of artemisinin, liquiritigenin and isoliquiritigenin derivatives**

Awarded to Ms. Rashmi Gaur by Academy of Scientific & Innovative Research (August 2014)

**Chemical investigation of some important Indian medicinal plants**

Awarded to Shelly Sharma by Dr. Ram Manohar Lohia Avadh University, Faizabad (August 2014)

**Bioprospection of two Cameroorian medicinal plants for possible anti-malarial, anti-inflammatory, anti-cancer and anti-oxidant properties and their safety in laboratory rodents**

Awarded to Mr. Pone Kamdem Boniface by Jawaharlal Nehru University, New Delhi (December 2014)

**Chemical and biological investigation of *Premna integrifolia* and *Alnus nepalensis***

Awarded to Ms. Deepti Yadav by Jawaharlal Nehru University, New Delhi (January 2015)

**Studies on anti-aging activities of *Bacopa monnier*i (L.) Pennel in *Caenorhabditis elegans***

Awarded to Mr. Virendra Shukla by Jawaharlal Nehru University, New Delhi (January 2015)

**Studies on chromium (VI) remediation from *Centella asiatica* (L.) rhizospheric bacteria**

Submitted by Ms. Shilpi Saikia Khare by Jawaharlal Nehru University, New Delhi (February 2015)

## HRD activities at a glance

Students enrolled for Ph.D. (AcSIR and JNU Ph.D. programmes): 35

Ph.D. degrees awarded: 12

Ph.D. thesis submitted: 5

Graduate Trainees: 53

Project Assistants: 121

## Awards and Recognitions

**Prof. Anil K Tripathi :** Fellow Indian National Science Academy, New Delhi

**Dr Ashutosh K. Shukla :** Member, Editorial Board, Alternative & Integrative Medicine, USA

**Dr Karuna Shanker :** Editorial Board member, Journal of Chemistry & Applied Biochemistry

**Dr Puja Khare :** Fellow of Indian Council of Chemist, Indian Council of Chemist India

**Dr Ajit Kumar Shasany :** Samanta Chandrasekhara Award, Odisha Bigyan Academy, Government of Odisha

**Dr Sumit Ghosh :** NASI-Young Scientist Platinum Jubilee Award, India

## Patent granted

1. **An improved process for the production of brevifoliol from *Taxus wallichiana***

   **Patent No. EP 1572618, 18.06.2014** (*SK Chattopadhyay, Sachin Srivastava, AS Negi, TRS Kumar, Ankur Garg, SPS Khanuja*).

   The invention provides an economic process for large scale production of an anticancer taxoid brevifoliol from plants belonging to the genus *Taxus*.

## New staff members

**Shri Inder Raj**
Administrative Officer
w.e.f. 28 August 2014

**Shri Banwari Lal Meena**
Store Purchase Officer
w.e.f. 8 September 2014

## Staff superannuated

**Dr SK Chattopadhyay,** Chief Scientist, superannuated on 30.04.2014

**Mr. S. Siva Subramani,** Sr. Technician (2), superannuated on 30.06.2014

**Dr UC Lavania,** Chief Scientist, superannuated on 31.07.2014

**Dr Shashi Kant Srivastava,** Library Officer, superannuated on 31.07.2014

**Mr. Ramesh Chandra Verma,** Lab Attendant, superannuated on 31.07.1954

**Mr. Santosh Kumar Srivastava,** Assistant Gr I, superannuated on 31.07.2014

**Mr. FA Siddiqui,** Technician (Electrician), superannuated on 31.08.2014

**Dr AK Singh,** Chief Scientist, superannuated on 31.08.2014

**Mr. Ram Baksh Singh,** Gr.D(NT), superannuated on 31.10.1954

**Mr. Israr Ali,** Sr.Tech(2), superannuated on 31.12.2014

**Dr Laxmi Narayan Mishra,** Chief Scientist, superannuated on 31.01.2015

**Mr. Om Prakash Pandey,** Sr.Tech(2), superannuated on 31.01.2015

**Mr. Om Prakash,** Lab Attendant, superannuated on 31.01.2015

**Mr.Thankappan Y.,** Clerk, superannuated on 28.02.2015

## Scientific contributions of superannuated scientists*

### Dr SK Chattopadhay

Dr. Sunil K Chattopadhyay joined CSIR- CIMAP in May 1993 as a Scientist EI and served the institute till April 2014 in different categories of Scientist EII, Scientist F and Chief Scientist. He has produced eight Ph.D. students in Chemistry and all the students are settled in different levels in government and private organizations. He has published almost one hundred research papers in reported international and national journals. Moreover, he has seventeen international patents and thirty one national patents to his credit. He has developed and transferred the technology for the production of anticancer drug Taxol to M/S Morepan Labs Limited. He has also developed the process for the production of a potent liver protective drug Cleomiscosins from the seeds of *Cleome viscosa* and the technology for that would also be transferred to industry. He has also contributed several chapters in books and the most important one is "Flash Chromatography and Low Pressure Chromatographic Techniques for Separation of Phytomolecules" (2006) published in Extraction Technologies for Medicinal and Aromatic Plants, chapter 12: P 195-208 (2008). He has also participated the International Centre for Science and High Technology-United Nations Industrial Development Organization (ICS-UNIDO), Italy and delivered a an important lecture on "Sourcing plants for animal health using combination of ethno veterinary medicine and bioactive's research" in 2007.

### Dr Anil Kumar Singh

During his tenure at CSIR-CIMAP for over thirty-three years, Dr Anil Kumar Singh has been actively involved in dissemination of medicinal and aromatic plants related knowhow, technologies and services developed and validated at CIMAP to several thousands of people throughout the country through interactive meets, farmers' fairs, exhibitions, trainings, demonstrations, correspondence, publicity campaign through newspapers and electronic media and publications. He also contributed in

* based on the inputs received from the respective scientists

institutional management and developmental programmes as member of Management Council and Secretary of Research Council. Besides undertaking routine work assigned to him as a scientist and Team Leader of his division, Dr Singh also handled several extension oriented projects funded by DBT, DST, NMPB, UP Govt., USERC, etc. as PI.

The innovative activities / projects / programmes undertaken by his team have been nationally recognized in form of several awards to the institute, including FICCI Rural Development Award 2005, CSIR Award for S&T Innovation in Rural Development 2008, Mahindra Samridhi India Agri Award 2011 and CSIR Technology Award 2012.

Dr Singh visited UK (1998) for attending a short term training in Business Management in Manchester Business School, USA (1999) for attending International Training Course in Medicinal and Aromatic Plants at University of Purdue, China (2001) for attending a Trade Fair, Singapore (2009) for attending a Trade Fair, Malaysia (2009) for Business Development related activity and Vietnam (2010) for attending NAM S&T Workshop on the Development of Occupational Villages.

Dr Singh has published 83 papers which include research papers, review and popular articles, besides contributing in 5 books and number of bulletins.

**Dr UC Lavania**

Obtaining M.Sc. 1973 in Botany with 1st Class 1st from Agra University, Ph.D 1980 Calcutta University, and permanent faculty in PG Department for 09 years, Dr. Umesh Chandra Lavania moved to CIMAP as Scientist-C (Cytogenetics) on 27th July 1982, and rose to the position of Scientist G (the then Director Grade Scientist) on 1st April 2002. While working at CIMAP, he obtained DSc 1998 from Calcutta University. At CIMAP he had implemented international bilateral (DST and JSPS) collaborative projects, established state of art facilities and trained students in Molecular Cytogenetics. He has published 75 original papers (28 as single author) in SCI journals, delivered invited plenary lectures at international conferences at RBG, Kew; Osaka University, SUNY-ESF Syracuse, organized 5th International Conference on Vetiver at CIMAP with participants from 22 countries. In recognition of his scientific work at CIMAP, he has been elected to the fellowships of the Indian National Science Academy, and National Academy of Sciences India, President of Plant Sciences section of ISCA in centenary year, and invited as: Associate Editor of *Journal of Genetics* (Springer), Member Editorial Board and Guest Editor of *Plant Genetic Resources* (Cambridge Univ Press), and Managing Editor of the *Nucleus* (Springer).

Lavania's scientific contributions are focused on structure and behavior of chromosomes at cellular, *in vitro* and organismic level, to elucidate evolutionary dynamics of chromosomes and genomes in speciation and genetic improvement. Based on extensive studies on cytogenetics of polyploids he has : (i) proposed and implemented 'polyploid model' for fixation of heterozygosity, (ii) suggested and implemented 'genotypic strategy' for pre-selection of diploid progenitors for distal chiasma localization to realize high fertility and stability in autopolyploids, (iii) elucidated differential response of polyploidy to body size vis-à-vis qualitative composition and metabolic costs of native secondary metabolites, (iv)

underpinned ploidy elicited enhanced bud-sport formation in palaeopolyploids for mining of de novo diversity, and (v)

# Publications

## Research Papers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Professor of Eminence
National Institute of Plant Genetic Resources (NIPGR), New Delhi

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Chief Scientist & R&D Head
Research & Technology Innovation
ITC R&D Centre, Bengaluru

Prof. Sudip Chattopadhyay
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Adviser & Head
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Department of Science & Technology
New Dehli

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## Director

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Planning & Performance Division
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## Member - Secretary

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Chief Scientist
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Director
CSIR-CIMAP, Lucknow

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**Dr HP Singh, Pr. T.O.**
CSIR-CIMAP, Lucknow

**Mr. MS Mehra**
Finance & Accounts Officer
CSIR-CIMAP, Lucknow

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

## Budget at a glance

As on 27.02.2015

| | Allocation | Expenditure |
|---|---|---|
| Pay and allowances | 2465.1 | 2442.487 |
| Contingency | 204 | 200.331 |
| HRD | 0 | 0 |
| Lab maintenance | 104.6 | 112.697 |
| Staff qtr. maintenance | 10 | 11.062 |
| Chemicals / consumables | 250 | 236.228 |
| Works and services | 48 | 4.927 |
| Apparatus and equipment | 410 | 131.357 |
| Office equipment | 0 | 0 |
| Furniture and fitting | 0 | 0 |
| Library books | 0 | 0 |
| Library journal | 80 | 41.354 |
| Staff qtrs. (construction) | 0 | 0 |
| CSIR network projects | 1076.779 | 829.416 |
| **Total** | **4648.479** | **4009.859** |
| Pension | 1165 | 1055.235 |
| EMR(P-81) | 0 | 147.46 |
| **External Budgetary Resources** | | |
| Lab Reserve Fund(LRF) | | 130.293 |
| External Cash Flow(ECF) | 492.364 | 376.219 |

# Staff Members
# (as on 1 March 2015)

## Director

Prof. AK Tripathi

## Chief Scientist

Dr BRR Rao
Dr RN Kulkarni
Dr DD Patra
Dr MM Gupta
Dr Ashok Sharma
Dr KP Sastry
Mr. Anil Kumar
Dr AK Mathur
Dr RS Sangwan
Dr SK Srivastava
Dr OP Dhawan
Dr Alok Kalra
Dr RK Lal
Dr Suchitra Banerjee
Dr AK Tripathi
Mr. Rakesh Tiwari
Dr Abdul Samad
Mr. PV Ajay Kumar
Dr Harmesh Singh

## Sr. Principal Scientist

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Dr Mohd Yaseen
Dr VKS Tomar
Dr JR Bahl
Mr. JP Tiwari
Dr Archana Mathur
Dr PK Chaudhary
Dr Neelam Singh Sangwan
Dr AK Shasany
Dr Saudan Singh
Dr Alok Kumar Krishna
Dr Ved Ram Singh

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Mr. Sudeep Tandon
Mr. MP Darokar
Dr AS Negi
Dr Birendra Kumar
Dr AK Gupta
Dr Dharmendra Saikia
Dr Laiq-ur-Rahman
Dr Dinesh A Nagegowda
Dr Vikrant Gupta
Dr Rakesh Pandey
Dr RP Bansal
Dr Anirban Pal

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Dr Dayanandan Mani
Dr Venkata Rao DK
Dr CS Vivek Babu
Dr Sumit Ghosh
Dr Prema G Vasudev
Dr Rajesh Kumar Verma
Dr Karuna Shanker
Dr Sanjay Kumar
Mr. Manoj Semwal
Dr DU Bawankule
Dr Feroz Khan

## Scientist

Dr Narayan Prasad Yadav

Dr Suaib Luqman
Dr Deeptanjali Sahoo
Dr V Sundaresan
Dr Ram Swaroop Verma
Dr Ashutosh Kumar Shukla
Mr. KVN Satya Srinivas
Dr RC Padalia
Dr PK Rout
Dr CS Chanotiya
Dr Debabrata Chanda
Dr Puja Khare
Dr Rakesh K. Shukla
Dr Tripta Jhang
Dr Preeti Srivastava
Mr. Bhasker Shukla
Dr Poornima Priyadarshini C.G.
Dr Rakesh Kr Upadhyay
Ms. Abha Meena
Dr Atul Gupta

### Junior Scientist

Dr Ram Suresh
Er. Ashwin D Nannaware

### Group-III
### Principal Technical Officer

Dr VK Agarwal
Dr HP Singh
Dr Man Singh
Dr Mohd Zaim
Mr. SK Kushwaha, SSE

### Sr. Technical Officer (3)

Mr. Kundan Singh
Dr SC Singh
Dr Dinesh Kumar
Mr. Jamil Ahmad
Dr AK Srivastava
Dr RK Verma
Mr. AM Khan
Mr. Prem Singh
Dr DK Rajput
Dr Sukhmal Chand
Dr Dasha Ram

### Sr. Technical Officer (2)

Mr. Anand Singh
Mr. K Bhaskaran
Mrs. Sudha Agarwal
Dr Ateeque Ahmad

### Sr. Technical Officer (1)

Mr. Govind Ram

### Technical Officer

Ms. Anju Kumari Yadav
Mr. Shiv Prakash
Mr. Anil Kumar Singh
Ms. Manju Prajapati
Mr. Ram Pravesh
Mr. Rajendra Patel
Mr. Rakshpal Singh
Dr Amit Chauhan

### Technical Assistant

Mr. Anil Kumar Maurya
Mr. Amit Mohan
Ms. Namita Gupta
Mr. Sanjay Singh
Mr. A Niranjan Kumar
Ms. Anju Kesarwani
Mr. Balakishan Bhukya

Mr. Amit Kr. Tiwari
Mr. Manoj Kumar Yadav
Mr. Ashish Kumar
Mr. Prawal Pratap Singh Verma
Mr. Ashish Kr. Shukla

**Sr. Technician (3)**

Mr. SK Sharma

**Sr. Technician (2)**

Mr. S Selveraj
Mr. Phool Chand
Mr. AK Srivastava
Mr. RD Ram
Mr. Raja Ram
Mr. JP Singh
Mr. Pawan Prasad
Mr. Shyam Behari
Mr. AR Kidwai
Mr. SAI Zaidi
Ms. IV Rautela
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Mr. Durga Prasad
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Mr. Salim Baig

Dr Abdul Khaliq
Mr. SK Pandey
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Mr. Gopal Ram
Ms. S Sharda
Mr. PN Gautam
Mr. Joseph M Massey
Mr. Ram Lakhan
Mr. PK Tiwari
Mr. E Bhaskar
Mr. Vinod Kumar

**Sr. Technician (1)**

Mr. Siva Kumar DC
Ms. Raj Kumari

**Technician (2)**

Mr. DPS Meena
Mr. VK Shukla
Mr. Pankaj Kumar Shukla
Mr. Kundan Narayan Wasnik

**Technician (1)**

Mr. Yalla VVS Swamy
Mr. Basant Kumar Dubey

Mr. Vijay Kumar Verma
Mr. Harendra Nath Pathak
Mr. Hemraj Sharma
Mr. Jittendra Kumar Verma
Mr. Pramod Kumar
Mr. Ved Prakash Saini

**Lab Assistant (Gr. I (4))**

Mr. Om Prakash
Mr. Mahesh Prasad
Mr. VK Singh
Mr. Abdul Mabood
Mr. Mohd Amin Khan
Mr. Ram Ujagir
Mr. Subhash Kumar
Mr. Bharat Singh Bisht
Mr. Man Mohan
Mr. Qasim Ali
Mr. Sabhajit
Mr. Mohd Navi
Mr. Munawar Ali
Mr. Hari Pal
Mr. Rajanna
Mr. Nurul Huda
Mr. Surendra Nath

### Lab Attendant (2)

Ms. Pushpa Semwal
Ms. Samundra Devi
Mr. Lal Chand Prasad
Mr. G Appa Rao
Mr. Manish Arya

### Administrative Staff (Group-A)

Mr. BD Vashisth - COA
Mr. MS Mehra - F&AO
Mr. BL Meena, SPO
Mr. Inder Raj, AO

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Mr. Sanjay Kumar
Mr. Hare Ram
Mr. Ankeshwar Mishra
Mr. Vikash Chand Mishra
Mr. AK Sharma
Mr. AK Chauhan
Mr. Sanjay Kumar Ram
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Mr. SP Singh
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Mr. Muneshwar Prasad
Mr. Sant Lal
Mr. Parvez Nasir
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Mr. Rajesh Kumar
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Mr. OP Singh
Ms. Nisha Sharma
Mr. Harish Chandra
Mr. Shiv Kumar
Mr. Suneel Kumar
Mr. AL Sahoo
Mr. Ayush Singhal

### Asstt (S & P) Grade I

Mr. Pankaj Kumar
Mr. Shamiullah Khan
Mr. Anees Ahmad

### Senior Stenographer

Ms. Gaitry Sharda
Ms. P Sabitha
Mr. S.J. Sinha
Ms. Kanchan Lata Thamos

### Asstt Gen Grade-II

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Mr. SB Shah
Mr. Manoj Swaroop Shukla
Ms. Sheela Yadav
Mr. Vijay Kumar Bhartey
Mrs. Preeti Gangwar

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Mr. Kanhaiya Lal
Mr. KS Ali
Ms. KC Nagarathnamma

**Asstt S & P Grade-II**

Mr. SA Warsi

Mr. Ajeet Verma

**Asst F & A Grade-III**

Mr. Pradeep Kumar

Ms. Farzana Hafeez

**Group C (Non-Tech)**

Mr. AK Srivastava

Mr. CS Pant

**Isolated Posts**

Mr. Yograj Singh

Mr. Rohit Khanna

Ms. Sangeeta Tanwar

**Drivers PB-1**

Mr. Ajay Kumar Verma

Mr. Sanjay Kr. Singh

Mr. Sarwesh Yadav

Mr. Chandrapal Verma

Mr. Rajesh Kumar

**Canteen Staff**

Mr. Victor Mukerjee

**Group-D (NT)**

Mr. Mata Prasad

Mr. Sadanand

Mr. Kailash Chandra

Mr. R Algarswamy

Mr. Tula Singh

Mr. Ashok Kr. Pathak

Mr. Mohd Aslam Khan

Mr. Kishan Lal

Mr. P Bhiskapathi

Mr. Ajay Kumar

Mr. RK Gupta

Ms. Nirmala Verma

Ms. Tara Devi

Ms. Nargis Sufiya Ansari

Ms. Sunita Devi

Mr. Santosh Kumar

Mr. Sant Ram

Mr. Harihar

Mr. TP Suresh

Mr. Raja Ram

Mr. Praveen Kumar

Mr. Kishan Ram

Ms. Zarina Bano

Mr. Ram Karan

Mr. Dharam Pal Balmiki

Mr. Abdul Nadir Khan

Mr. Arvind Kumar

Ms. Raj Mati

Mr. Harpal Valmiki

Mr. Kripa Ram

Mr. Sudhir K. Bhattacharya

Mr. Mohd. Shameem

## 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 disease) of exotic-species and also production of authentic high-yielding seeds, leaves and other propagating materials of medicinal and aromatic plants of economic importance
- To encourage cultivation of medicinal and aromatic plants in suitable regions of the country by giving grants-in-aid or loans and other incentives, wherever necessary
- To carry out surveys of resources of medicinal and aromatic plants and to maintain economic statistics of the raw materials as well as the finished products
- To set up and maintain a specialized herbarium and museum of medicinal and aromatic plants of economic importance as well as of products derived therefrom
- To undertake research and to encourage the same in established research institutions, e.g. university laboratories, technological institutions, national laboratories, etc. for schemes relating to improvement, processing and utilization of medicinal and aromatic plants
- To act as a 'clearing house' for collecting techno-economic data relating to medicinal and aromatic plants and products derived therefrom, by scientific ledgering and documentation and to disseminate information through publications of monographs, brochures, books and all other effective means.

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

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