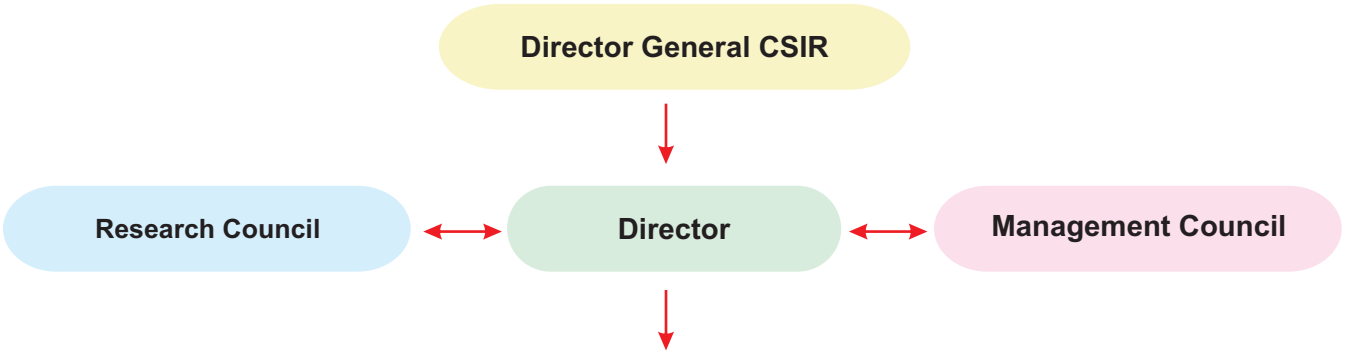
वार्षिक प्रतिवेदन
Annual Report
2009-2010

केन्द्रीय औषधीय एवं सगंध पौधा संस्थान
Central Institute of Medicinal and Aromatic Plants
(Council of Scientific and Industrial Research)
Lucknow - 226 015, India

Organizational Structure



Research Centres

- Research Centre Bangalore
- Research Centre Hyderabad
- Research Centre Pantnagar
- Research Centre Purara

Divisions & Departments

1. **Agronomy & Soil Science**
   a. Agronomy
   b. Soil Science
2. **Biotechnology**
   a. Plant Biotechnology
   b. Molecular Bioprospection
3. **Chemical Sciences**
   a. Analytical Chemistry
   b. Phytochemistry
   c. Process Chemistry & Chemical Engineering
4. **Crop Protection**
   a. Microbial Technology & Entomology
   b. Plant Pathology
5. **Genetics and Plant Breeding**
   a. Genetic Resource Management
   b. Plant Breeding
6. **Plant Biology**
   a. Metabolic & Structural Biology
   b. Plant Physiology
   c. Taxonomy and Pharmacognosy
7. **Information & Project Management**
   a. Biostatistics
   b. Information & Communication Tech.
   c. Knowledge Resource Centre
   d. Project Monitoring & Evaluation
8. **Technology & Business Development**
9. **Human Resource Development**

Support Units

- Administration
- Finance & Accounts
- Stores & Purchase
- Workshop
- Canteen
- Rajbhasha Unit (Hindi Cell)

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Annual Report

2009-2010

With Best Compliments from

Prof. Ram Rajasekharan
Director, CSIR-CIMAP

Central Institute of Medicinal and Aromatic Plants
(Council of Scientific and Industrial Research)
Lucknow - 226 015, India

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CIMAP Scientists for providing timely inputs

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Contents

निदेशक की कलम से

मुझे संस्थान के वर्ष 2009-10 के वार्षिक प्रतिवेदन की प्रस्तवाना प्रस्तुत करते हुए अपार हर्ष हो रहा है, क्योंकि इस वर्ष सीमैप ने अपने द्वितीय स्वर्णकाल में प्रवेश की दिशा में पहला कदम रखा है। इन क्षणों में यह नितान्त आवश्यक है, कि हम अपने पूर्व पचास वर्षों की स्वर्णिम उपलब्धियों पर विहंगम दृष्टि डालते हुए आने वाले वर्षों में विज्ञान एवं तकनीक के क्षेत्र में होने वाले तीव्र बदलावों के प्रति पूरी जिम्मेदारी, उत्साह एवं लगन से कार्यरत रहने के लिए अपनी प्रतिबद्धता बनाये रखें।

विज्ञान के सतत् बदलते धरातल के साथ स्वास्थ्य एवं औषधि के क्षेत्र में हमारी चुनौतियों के आयाम भी सतत् बदल रहे हैं। भविष्य में मानव स्वास्थ्य के लिए बहुऔषधीय प्रतिरोधकता जैसी चुनौतियों के प्रति सीमैप मूकदर्शक होने के बजाय नवीन प्राकृतिक औषधि अणुओं एवं शोध आयामों के द्वारा इन जटिल समस्याओं का निदान पाने के लिए सतत् प्रयासरत रहेगा।

प्रकृतिजन्य सगंध तेलों एवं औषधियों के क्षेत्र में सीमैप का उत्कृष्ट योगदान रहा है। इस क्षेत्र में सीमैप का योगदान उसके द्वारा किये गये पेटेन्ट और प्रकाशनों द्वारा परिलक्षित होता है। अपने सामाजिक दायित्वों का निर्वहन सीमैप कृषकोंन्मुखी केन्द्रित कार्यकलापों से कर रहा है। सीमैप के ग्रामीण विकास एवं बायोविलेज द्वारा सम्पूर्ण देश में संचालित कार्यक्रमों के लाभार्थियों की सूची में उत्तरोत्तर वृद्वि हो रही है। भविष्य में हम अपने इन प्रयासों को जारी रखते हुए औस पौधों से जैव ऊर्जा, ट्रांसक्रिप्टोमिक्स, मॉलिक्युलर ब्रीडिंग और अति संवेदी विश्लेषण तकनीकों जैसे अनछुए आयामों पर भी ध्यान केन्द्रित करेंगे। सामाजिक कटिबद्धता को और तेजी प्रदान करने की दिशा में सीमैप ने देश के विभिन्न राज्यों में अपने प्वाइंट ऑफ प्रजेन्स (उपस्थित बिन्दु) स्थापित किए हैं।

ऐसा कहना निर्रथक न होगा कि बीते वर्ष में हमारी प्रगति प्रशंसनीय थी, विज्ञान एवं तकनीक मंत्रालय ने संस्थान द्वारा विकसित औषधीय एवं सगंध पौधों की प्रजातियों का स्वंय संज्ञान लिया है। इस वर्ष में संस्थान के कई वैज्ञानिकों को विदेशों द्वारा शोध फेलोशिप एवं प्रायोजित परियोजनाएं भी प्राप्त हुई हैं।

पर्यावरण के प्रति अपनी सजगता को साबित करते हुए सीमैप ने कागज प्रयोग में अप्रत्याशित कटौती की है, और उसका उदाहरण यह वार्षिक प्रतिवेदन है। इस प्रतिवेदन की गुणवत्ता को बिना प्रभावित किये हुए इसे सुग्राह्य एवं सीमित करने का प्रयास किया गया है। ऐसा कर सीमैप को अपनी नैतिक एवम् नागरिक जिम्मेदारी निर्वहन करने का गर्व है।

इस अवसर पर मैं अपने सहयोगियों एवं विद्यार्थियों को उनके सतत् और अथक प्रयासों से संस्थान की सफलता में योगदान के लिए धन्यवाद देता हूँ। भविष्य में भी मैं उन सभी को उनके प्रयासों में सफलता की कामना करता हूँ।

राम

(राम राजसेखरन)

From the Director's Desk.....

It gives me immense pleasure to deliver my pleasant duty of writing a foreword to this issue of our Institute's Annual Report. This year marked the first step of CIMAP into its second set of Golden years. While we stop by to take a quick glance of what we have done in the last 50 years in the area of Medicinal and Aromatic Plants (MAPs) and bask in its glory, we also deem it our responsibility to continue with the zeal and enthusiasm we have shown so far, in order to keep pace with the fast evolving area of Science and Technology.

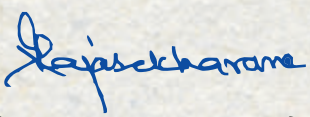
With the ever widening horizon of Science, the multitude of challenges that we are faced with in the area of health and medicine, with the advent of every new multidrug resistant bug that spells a serious threat for the future healthy existence of mankind, we at CIMAP, cannot but think of newer areas and approaches to find newer natural drug molecules that can be a solution to the myriad of problems that we are currently facing.

CIMAP's contribution in the area of natural drug molecules and essential and aromatic oils has been incredible. It has created a niche for itself, which is evident by the very many patents and publications that the Institute has to its credit. CIMAP has also been a society friendly Institute, having the welfare of its farmers as its sole mission. The number of beneficiaries from CIMAP's Biovillage and Rural Development programs is on the rise and is also fast spreading across the length and breadth of the country. While we will continue to work on these aspects, we will also focus on newer and comparatively unexplored areas, like bioenergy from MAPs, transcriptomics, molecular breeding methods and more sophisticated analytical methods. From the Societal point of view, CIMAP is placing its Point of Presence in those States that it had not ventured so far.

As will be seen from the Highlights and the ensuing pages, our performance in the past year was commendable. Needless to say, the institute was also aptly recognized by the Ministry of Science and technology for the new plant varieties it released. Many of our Scientists were awarded fellowships for overseas research; we also had several grant in aid projects, apart from the major laboratory projects.

As a "Go Green" effort, CIMAP is on a drive to cut down on paper usage, a befitting example being this year's Annual Report. We have taken extraordinary efforts to keep this report short and sweet, without compromising on the quality of the same. By this, we at CIMAP feel proud to be responsible citizens.

I take this opportunity to thank each and every one of my colleagues and students who are contributing to the success of the Institute by their continuous effort and unflinching support. I wish them continued success in all their endeavors.



(RAM RAJASEKHARAN)

CIMAP

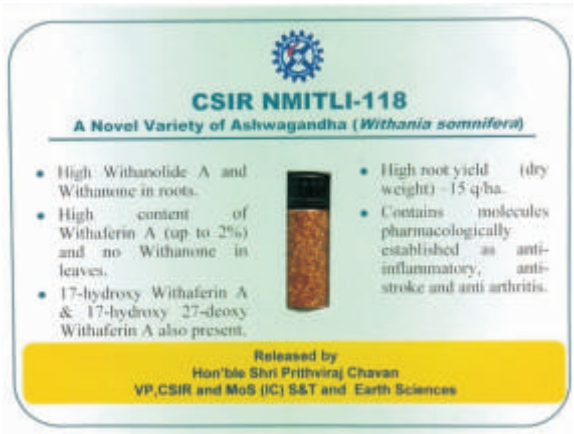
1. Golden Jubilee Celebrations 'AROMED'

This year was very important in the history of CIMAP, as it saw its Golden Jubilee. Fifty years since inception, CIMAP decided to stop by and look at its glorious past and the achievements in the area of MAPs across the world. As a result, an International Conference on Aromatic and Medicinal Plants (AROMED) was held in Lucknow in February 2010. This conference was organized by a group of young scientists, ably supported by the Director and senior scientists. The conference was attended in big numbers and saw enthusiastic participation and deliberations from Scientists, both from within the country and abroad. The conference was received well as was seen from the good feedbacks it received. It is therefore proposed to make this a once-in-two-years event in future. In addition, two National Symposia at Bangalore and Hyderabad Centres were also held as part of 50 year celebrations.

2. New varieties released

2.1. Ashwagandha variety

A new Ashwagandha variety NMITLI-118 was developed and released by Hon'ble Minister of Science (IC) S&T and Earth Sciences, Shri Prithviraj Chavan on Sep. 26th, 2009. This variety has the following features: uniform crop canopy, non-spreading plant architecture (more plants/unit area), high root yield and high withanolide yield per unit biomass, phytochemically uniform and is the first pharmacologically validated variety. (Release function photo on cover III).



2.2. Chamomile var. "CIMAP SAMMOHAK"

A high blue oil yielding variety of Chamomile (*Chamomila recutita* (L.) Rauschert) suitable for North Indian Plains was released. This improved variety has shown dry flower yield of 7.53q/ha and dark blue oil yield of 6.63kg/ha. The dark blue oil was found to contain 12.98% of the active ingredient chemuzuline.

CIMAP SAMMOHAK

2.3. Lemongrass var. "CIMAP SUWARNA"

A high oil yielding variety of lemongrass (*Cymbopogon khasianus*) suitable for rain fed conditions/drought prone areas was released. This variety is highly promising for fast growth, high herbage (50t/ha) and oil yield (200kg/ha) of better quality (citral 80%).

CIMAP SUWARNA

Highlights

2.4. Palmarosa var. "CIMAP HARSH"

A high oil yielding variety of palmarosa (*Cymbopogon martinii* var. *motia*) suitable for North India (U.P, Bihar), M.P, Maharashtra and South India was released. This variety has potential to produce herb yield of 30 t/ha and oil yield of 240kg/ha containing 89% geraniol. The variety has been developed through intensive composite breeding.

CIMAP HARSH

2.5. Menthol Mint var. "CIMAP SARYU"

A high oil yielding variety of menthol mint (*Mentha arvensis* L.) was released. This variety was developed through intensive selection. It has potential to produce 2.74t/ha of herb containing 0.84-1.0% oil with an average oil yield of 265-290 kg/ha against 220- 230 kg/ha oil yield of well established mint variety Kosi. The oil of CIMAP Saryu contains 79-80% menthol.

CIMAP SARYU

2.6. Release of a new interspecific hybrid of Mentha "CIMAP MPH1

An interspecific hybrid between *Mentha arvensis* and *Mentha piperita* that is rich in menthofuran was developed and released. The hybrid combines growth characteristics of *Mentha arvensis* and oil quality unique to both the parents. The hybrid CIMAP/MPH-1 outperformed the menthofuran rich cultivar CIM-Indus of *M. piperita* to the order of 60% in terms of menthofuran productivity.

CIMAP MH-1

Highlights

3. RSP 006 Programs for rural development, women empowerment and tribals

During this year, CIMAP and its research centers organized more than 50 training and rural development programs across the North Indian and South Indian States. Of particular mention is the program run in the tribal villages of Vishakapatnam by our CIMAP Research Center, Hyderabad, in which the tribals have been educated about the importance of aromatic plants like lemongrass, apart from the cultivation and marketing of these plants. Through the RSP 006 programs, CIMAP is working on rural development and women empowerment.

The old and young together trying their hands in making of incense sticks (agarbattis) in their house under women empowerment programme

4. CIMAP Kisan Mela was organized which was inaugurated by HE Governor of Uttar Pradesh Shri BL Joshi

Prof. Ram Rajasekharan welcoming the UP Governor HE Shri BL Joshi

5. Strengthening of CIMAP-JNU program and academy linkages

Starting 2009, the CIMAP-JNU program was strengthened and was able to attract much larger number of students who had cleared their CSIR-JRF. The response from the budding scientists is on rise, with more and more applications coming in. Apart from this, CIMAP has also signed an MoU with Kumaon University by which the Pantnagar Center of CIMAP will get more researchers to work.

6. New Project on Bioenergy

With the global attention moving towards global warming and renewable resources, CIMAP has embarked on a new project to convert its spent biomass (post distillation) to biofuels. Unlike the traditional bioethanol and biobutanol, CIMAP will work on an alternate chemical route to synthesise a compound that can be used as biofuels using green technology.

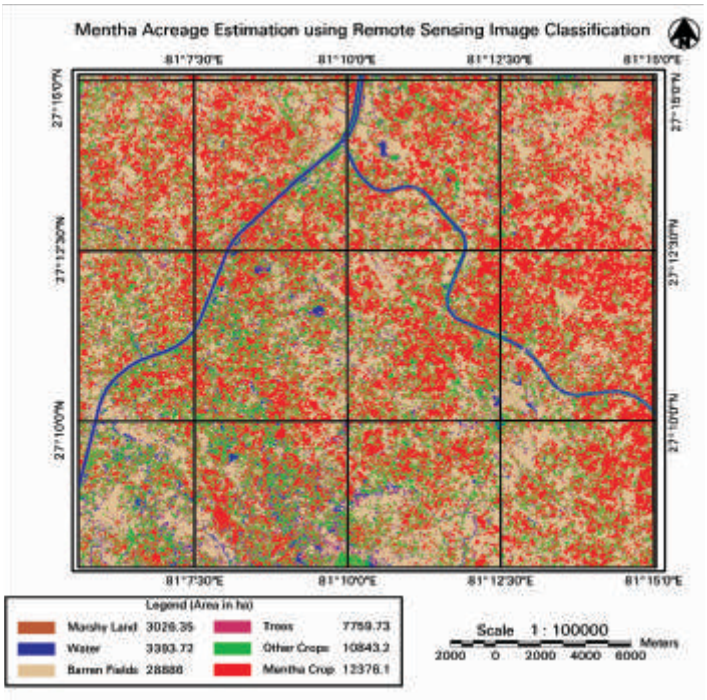
7. Development of customized medicinal plant microarray chips

A high utility small scale (750 target genes) microarray chip of Poppy (*Papaver somniferum*) and containing all the significant alkaloid biosynthesis-related genes has been designed. It can be utilized for comparing poppy genotypes, plant developmental stages, organ specificity of genes, stress responses, G x E effects, disease phenotypes, etc. It has already been used for differentiating the well known poppy genotypes of CIMAP (Sujata and Sampada) that has provided deep insight into the differential gene expression in them. This may be further exploited to characterize the Sujata phenotype in poppy, which has been highly sought after in recent times.

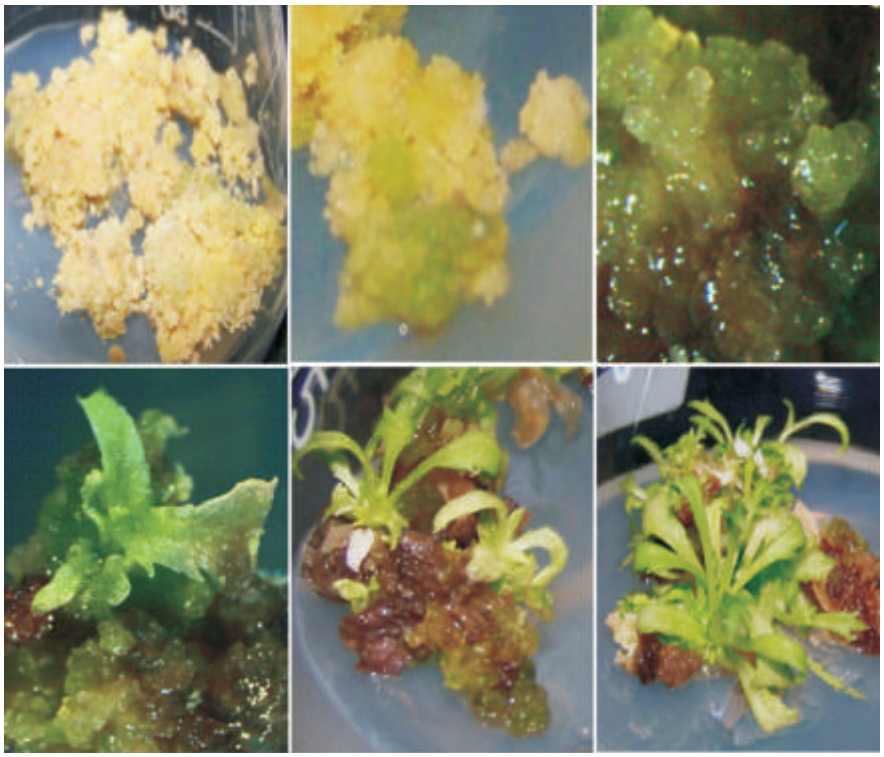
On similar lines, a high utility small scale (750 target genes) microarray chip containing all the significant artemisinin biosynthesis and diversion pathway-related genes in *Artemisia annua* has also been developed.

Highlights

8. Remote sensing and satellite imagery based assessment of medicinal and aromatic crop cultivation and coverage up to village level has been initiated



9. Tissue culture of MAPs: Regeneration protocol for Pyrethrum through callus cultures has been established



Highlights

1. Agronomy and Soil Science

1.1. Optimization of stage of harvest and moisture stress for Indian basil and palmarosa (Saudan Singh)

Results of field experiments conducted at CIMAP, Lucknow during August, 2009 to January, 2010 revealed that harvesting of Indian basil and palmarosa at 75 and 125 days after planting and creating moisture stress up to foliage wilting in the field gave significantly higher essential oil yield 140 and 84 lit /ha, respectively than early or late harvesting either at fully turgid or wilted condition. This practice increased the oil yield from 3.5 – 20.0 and 3.8 – 5.5% of Indian basil and palmarosa respectively.

1.2. Influence of biomass, oil content and oil yield of geranium under integrated nutrient management systems (R.K. Verma)

A study revealed that application of farm yard manure (FYM), vermicompost (VC) and NPK and its combination treatments significantly increased the biomass and oil yield of geranium in comparison to control. Among the treatments, $N_{100}P_{60}K_{60}$ + 5t VC recorded the highest increase of 167.0% in biomass and 168.6% in oil yield over control.

1.3. Yield and economic potential of different peppermint (*Mentha piperita* L.) based cropping systems (D. D. Patra, Muni Ram)

Peppermint planted after the harvest of paddy in January produced maximum (59.0 kg/ha) oil yield. On the other hand planting of peppermint after the harvest of potato and mustard resulted in 30-40 % reduction in oil yield as compared to that after paddy. However, maximum net return of Rs. 70,700/ ha was obtained from sweet basil-potato-peppermint cropping system followed by Rs. 67,500 and 67,100 obtained from maize- potato-peppermint and sweet basil-mustard-peppermint cropping systems, respectively.

1.4. Companion cropping of medicinal plants in orchard *vis-a-vis* evaluation of shade tolerance (H.S. Chauhan)

To utilize the interspace available in orchards, systematic experiments have been conducted to explore the possibility of growing some high value medicinal plants under artificial shade condition. Vacha (*Acorus calamus*), Satawar (*Asparagus racemosus*), Sarpgandha (*Rauvolfia serpentina*) tolerated shade levels well to the extent of 50% without significant effect on growth and yield parameters.

1.5. Integrated nutrient management for the cultivation of *Matricaria chamomilla* (Kambod Singh)

Experimental results revealed that application of different combinations of organic and inorganic fertilizers increased the flower yield by 12.8 to 65.9% over control. Application of 50% inorganic fertilizers + 50% FYM produced significantly higher fresh and dry flower yield (35.0 and 9.8 q ha^{-1}, respectively) over other treatments.

1.6. Influence of tannery waste polluted soil on growth and development of German chamomile (*Matricaria chamomilla)* (M. Anwar, D.D. Patra)

The result revealed that dry flower, shoot and root yield increased significantly over control at combination of 1:3, 1:1 and 3:1 (soil:sludge) ratio. The highest yield in g pot^{-1} of dry flower (13.9), shoot (57.4) and root yield (22.4) of chamomile was observed in sludge alone. This indicates that leather tannery sludge could be utilized for growing German chamomile.

1.7. Influence of foliar and soil application of manganese sulphate on the yield and quality of *Mentha arvensis* (A. Chattopadhyay)

Soil application of 30 and 40 kg/ha of $MnSO_4$ significantly increased the herb and oil yield of *Mentha arvensis* as compared to control soil (without Mn application). Foliar application did not result in significant increase in the oil yield. Maximum menthol content (75.7%) was obtained with the foliar application of 0.5% $MnSO_4$ followed by the soil application of 10kg/ha of $MnSO_4$ (75.0%) as compared to 73.3% in control. Increase in oil yield with soil application of 30 and 40 kg/ha of $MnSO_4$ resulted in lesser menthol with increase in menthyl acetate**.** The results thus suggest that foliar application of 0.5% $MnSO_4$ would be beneficial to produce mint oil with higher menthol content.

1.8. Phytoremediation of heavy metal polluted soils through cultivation of medicinal and aromatic plants. Assessment of tolerance level of lemongrass towards nickel in soil (A. Chattopadhyay)

Results of two harvests taken on the ongoing pot experiment to assess the influence of application of graded level of Ni in soil on yield and quality of lemongrass oil at CIMAP, Lucknow, has revealed a non linear increase in the herb and oil yield of lemongrass(var. Krishna) with the increased availability of Ni in soil.

1.9. Studies on the effects of foliar application of metallic salts on the growth and yield of Japanese mint (Arun Prasad)

The foliar application of metallic salts (0.5% aqueous solution of sodium chloride, calcium chloride, ferrous sulphate, manganese sulphate, zinc sulphate, copper sulphate and nickel sulphate) on the growth, yield and chemical composition of essential oil of Japanese mint (*Mentha arvensis*) variety Kushal revealed that herb and essential oil yield of Japanese mint significantly increased by the foliar application of sodium chloride, manganese sulphate and zinc sulphate as compared to control plants. Therefore, it can be suggested that sodium chloride could be used as an economically cheap fertilizer component to enhance the yield of Japanese mint.

1.10. Studies on the effects of heavy metals (chromium, cadmium, lead and nickel) on the growth and yield of vetiver (Arun Prasad)

The effects of increasing levels viz., 0 (control), 25.0, 50.0 and 75.0 mg kg^{-1} soil) of chromium (Cr), cadmium (Cd), lead (Pb) and nickel (Ni) on the growth and yield of vetiver (*Vetiveria zizanioides*) variety Gulabi was studied in a pot experiment. The root biomass (90g / plant) and oil yield (2 ml/plant) of vetiver significantly increased by the application of Cd.

1.11. Effects of cadmium and nickel on the growth and yield of mint species (Arun Prasad)

The effect of increasing levels (0 (control), 50.0, 100.0, 150.0 and 200.0 mg kg^{-1} soil) of cadmium and nickel application on the yield and quality of essential oil of *Mentha arvensis* and *Mentha piperita* was studied in a pot experiment. The results of the study indicate that the herb and oil yield of *M.arvensis* and *M. piperita* were not significantly affected by the application of 50.0 mg kg^{-1} soil Cd as compared to control, and thereafter the herb and oil yield significantly decreased with the further increase in the level of Cd. The results of this study suggest that both species of mint could be cultivated in Ni contaminated soils. A higher level of Cd in soil presuambly phave deleterious effect on the growth of both the mint species.

1.12. Evaluation of accessions of palmarosa and lemongrass for its growth and yield performance in sodic soil (Arun Prasad, D.D. Patra)

It has been experimentally shown that PRC-1 of palmarosa and Praman variety of lemongrass, have an edge over the remaining varieties in terms of establishment in sodic soils.

1.13. Growth, yield and essential oil quality in Mentha piperita and Ocimum basilicum/ Matricaria chamomilla grown in heavy metal polluted soils vis-à-vis bioremediation (D.D. Patra, M. Anwar)

The results indicate that *Ocimum basilicum* could be a suitable crop to be grown under heavy metal (Cadmium) polluted soil.

1.14. Yield and resource optimization in Kalmegh (*Andrographis paniculata*) (Muni Ram)

One year experimental results indicated that plant population of Kalmegh maintained at 2.22 x 10^5 plants/ ha and application of N at 80 kg/ ha was suitable for achieving maximum biomass production.

2. Biotechnology
(Plant Biotechnology, Molecular Bioprospection)

Plant Biotechnology

2.1. Wound induced transcript and metabolite accumulation response in *Papaver somniferum* (Rakesh K. Shukla).

One hundred twenty two novel wound inducible ESTs in response to wounding have been identified. Two hundred white colonies were sequenced leading to the identification of novel ESTs. These ESTs were further validated through DNA-array hybridization followed by real time expression analysis. Eighty six novel ESTs showing homology with known sequences in database were shown to be induced by more than two fold. Twelve genes of benzyl-isoquinoline alkaloid (BIAs) pathway were analyzed further through real time expression analysis, which shows that nine gene transcripts of BIAs pathway were induced (>2 fold) after 5 hours of wounding. Tissue specific metabolite profiling of morphine, codeine, thebaine, narcotine and papaverine has been performed through HPTLC. The differential accumulation of metabolites after wound need to be further validated through HPLC analysis. Identification and induction of BIAs transcripts after 5 hours wounding reveals that wound plays a major role in regulation of BIA pathway. Further, functional characterization of these wound inducible transcripts will serve as a

useful tool in metabolic engineering of BIA pathway in opium poppy.

2.2. Analysis of differentially expressed genes in contrasting genotypes of *Papaver somniferum* (Ashutosh K. Shukla, A.K. Shasany)

A high utility small scale (750 target genes) microarray chip of *P. somniferum* containing all the significant alkaloid biosynthesis-related genes has been designed. The target genes were selected from over 20000 *P. somniferum* ESTs in dbEST (NCBI), in-house generated 300 ESTs (GR979624-GR979913, GT735891-GT735900) of 'Sampada' genotype and all the known genes of *P. somniferum* in GenBank (NCBI). The chip can be utilized for comparing distinct poppy genotypes, plant developmental stages, organ specificity of genes, stress responses, G x E effects, disease phenotypes, etc. A comparative analysis of 'Sujata' and 'Sampada' genotypes has been carried out at the transcript level using the customized poppy gene chip. 'Sampada' sample was taken as the control and out of the 750 target genes on the chip, 52 genes were found to be down-regulated and 46 genes were up-regulated in 'Sujata' as compared to 'Sampada'. On the basis of a more stringent criterion, 21 genes qualified for the "down-regulated" category and 20 for the "up-regulated" category in 'Sujata' genotypes. Homology-based annotation of these differentially expressed genes broadly classified them into major categories like (i) latex-related, (ii) oil and lipid-related, (iii) cell wall-related, (iv) alkaloid-related, and (v) others. Selected target genes are being taken up for validation through semi-quantitative RT-PCR.

2.3 Isolation of leaf/trichome-specific promoters from *Artemisia annua* (Vikrant Gupta)

In silico analyses of the *Artemisia* ESTs (~85,000) in NCBI database led to identification of homologs of *GLABRA2* and *GLABRA3* of *Arabidopsis*. PCR primers for the amplification of *GLABRA* homologs were designed using the sequence of identified *Artemisia* ESTs. Partial cDNAs of these identified homologs were amplified from *Artemisia annua* by RT-PCR and cloned in pGEM-T Easy vector. Attempts are being made to get the complete cDNA sequence of these genes.

2.4. Pathway engineering and system biology approach towards homologous and heterologous expression of high-value phytoceuticals (Vikrant Gupta)

Sequencing of a trichome-enriched cDNA library of *Artemisia annua* resulted in the generation of 161 good quality ESTs that were submitted to the GenBank. BLAST analysis identified a candidate that showed homology to WRKY proteins in the NCBI database. In order to obtain the complete (full length) *WRKY* cDNA, 5' RACE was carried out. The complete *WRKY* cDNA was found to be 1348 bp long, encoding a putative WRKY protein of 323 aa. The predicted WRKY protein contained a putative WRKY domain. An over expression construct of WRKY is being made in pBI121 binary vector for further characterization.

2.5. Establishing distinct identity of *Mucuna pruriens* progeny with parent cultivar through molecular profiling (Sunita S. Dhawan)

RAPD analysis was carried out to establish distinct identity of selected *Mucuna* progeny compared to other accessions and parent cultivar. Total 408 bands were generated. The data scored on RAPD polymorphism and band sharing was aimed at analyzing the genetic similarity index matrix obtained through multivariant analysis using Nei and Li's coefficient. Analysis of RAPD pattern revealed that primers MAP 01, 02, 18, OPA 03, 04, 16, OPB 09, 17, 20, upon amplification gave upto 100% polymorphism, while MAP 08, 17 and OPA 08 produced about 90 % polymorphic bands. Comparison of the results obtained from different primers demonstrated a high variation and genetic divergence between the progeny and the parental cultivar.

2.6. Assessment of genetic diversity among progeny of *Gymnema sylvestre* using RAPD analysis (Sunita S. Dhawan)

To estimate the level of diversity and genetic relationship among selected progenies of *Gymnema sylvestre* in relation to their parent, 40 random decamer primers were used to amplify the genomic DNAs from all the individuals. Based on the observations it could be concluded that the genetic diversity among the available accessions is low and one accession (S10) showed relatively high divergence from the parent and the other accessions.

2.7. *In vitro* regeneration protocol from Pyrethrum callus cultures (Laiqur Rahman)

In-vitro culture protocol for development of pyrethrum somaclones, using an efficient regeneration protocol from leaf and petiole induced callus was established. Maximum number of shoots were observed on TDZ (Thiadiazuran) containing media. The shoots can be rooted on MS media containing NAA (Napthalene Acetic Acid). The complete plants were initially hardened at culture room conditions followed by their

establishment to glass-house. The plants will be characterized morphologically and chemically for pyrethrins.

2.8. Gene prospection in *Withania somnifera* aerial (leaves) and underground (roots) organs for comparative withanolide profiles. (A.K. Shasany, Ashutosh K. Shukla, M.M. Gupta)

This study used an EST-based approach for gene prospection in *Withania*. Two of the 495 leaf ESTs were converted into full-length genes through RACE, yielding the genes, sterol methyl transferase (*smt1*) and obtusifoliol-14α-demethylase (*odm*), whose products are putatively involved in the sterol biosynthetic pathway leading to withanolides. 1-deoxy-D-xylulose-5-phosphate reductoisomerase (*dxr*) and hydroxy-methylglutaryl-CoA reductase (*hmgr*), were also isolated from 'CIM-Poshita' through RT-PCR. Substractive hybridization was carried out between the leaf and root cDNA populations of genotype WS138, having contrasting leaf and root withanolide profiles, to isolate leaf- and root-specific ESTs, which yielded 36 leaf-specific and 47 root-specific ESTs, of which some showed homology to glucosyltransferases.

2.9. AFLP studies on downy mildew-resistant and-susceptible genotypes of opium poppy (A.K. Shasany, O.P. Dhawan, Ashutosh K. Shukla)

cpDNA AFLP analysis identified 24 Pps-1 (DM-resistant)-specific unique fragments that were found to be maternally inherited in both the crosses, Pps-1 x Jawahar-16 and Pps-1 x H-9. In the case of nuclear DNA AFLP analysis, it was found that 17 fragments inherited from Pps-1 were common to the reciprocal crosses of both - (i) Pps-1 and Jawahar-16 as well as (ii) Pps-1 and H-9. This is the first molecular investigation on the identification of polymorphism between DM-resistant and -susceptible opium poppy genotypes and development of DM-resistant opium poppy genotype-specific AFLP markers. These AFLP markers could be used in future genetic studies for analysis of linkage to the downy mildew resistant traits.

2.10. *In vitro* mass multiplication of disease free mint (Sanjog Thul)

Readily responding tissue culture media for mass multiplication for 11 varieties of *Mentha* was standardized, out of which, 9 varieties of different species of *Mentha* (*M. arvensis, M. spicata* and *M. cardiaca*) were best multiplied on ½ MS medium supplemented with 0.5 mg/L BAP while 2 varieties of *M. piperita* grew best on ½ MS medium without any hormonal supplements. *In vitro* multiplied plantlets of 'Arka' and 'MSS-5' of *M. spicata* were transferred to glass house and showed more than 90% survival. These plants are to be transferred to field for production of disease free plantlets.

2.11. Optimization of asiaticoside production in *Centella asiatica* through biotic and abiotic elicitation (A. Mathur, A. Prasad, N.K. Srivastava, M.M. Gupta, A.K. Mathur)

Biomass production and asiaticoside analysis of four accessions have been successfully done to select the elite accession in terms of higher biomass production and asiaticoside content. The best harvesting period under Lucknow climate for the best accession was found to be July-September. Among the various concentrations of Cu^{++} and Mn^{++} tested to elicit biomass and asiaticoside production and physiological parameters revealed that media devoid of Cu^{++} promoted biomass production, higher chlorophyll content, more number of leaves and increased leaf area. The increase in biomass also correlated with increase in asiaticoside content when Cu^{++} was completely eliminated from the culture medium. In case of Mn^{++}, leaf number was not changed but the leaf area, total chlorophyll content (112.6 cm^2 and 3.28, respectively) and photosynthetic efficiency was more when the Mn^{++} concentration was 0.5µM and decreased on further increase in Mn^{++} concentration.

2.12. Cell suspension culture-based biotransformation of natural compounds (A. Mathur, R.S. Bhakuni)

Successful conversion of artemisinin to deoxyartemisinin using *Catharanthus roseus* and *Lavandula* cell suspensions with more than 78% conversion efficiency has been achieved. The process has also been upscaled to 1.0 g substrate level. Attempts have also been made to convert semisynthetic sesquiterpene - artemether the methyl ether derivative of dihydroartemisinin that has been more effective *in vivo* than artemisinin. Attempts were made to biotransform artemether (both α and β forms) using cell suspension cultures of *G. glabra,* and *Lavandula officinalis.* Both the systems showed efficient bioconversion.

2.13. *In vitro* propagation of *Lagerstroemia speciosa* from nodal explants (S. Banerjee, G.D. Bagchi)

Optimization of hormonal combinations led to rapid *in vitro* propagation through the use of young nodal explants from mature trees of *Lagerstroemia speciosa*. Direct regeneration of multiple shoots

could be obtained on culture of nodal explants on Murashige and Skoog's (MS) medium containing different concentrations of TDZ. Elongation and further maturation occurred on transfer of the regenerated shoots to BAP (Benzyl Amino Purine) containing MS medium. The differentiated shoots were rooted on half strength MS medium with IBA (Indole-3-Butyric Acid).

2.14. Oxido-reductive biotransformation potential of *Atropa belladonna* hairy root clone (S. Banerjee, A. S. Negi, P. V. Ajayakumar, K. Shanker)

Three different aromatic carbonyl compounds i.e. 3,4,5-trimethoxybenzaldehyde (1), 3,4,5-trimethoxya-cetophenone (2) and 3,4,5-trimethoxybenzoic acid (3) were examined for biotransformation through the use of a selected hairy root clone of *Atropa belladonna.* Aldehyde (1) was transformed into its corresponding reduced product, i.e. 3,4,5-trimethoxy benzyl alcohol (4) and oxidized product, i.e. 3,4,5-trimethoxy benzoic acid (5). Ketone (2) was transformed only into its alcohol derivative, i.e. 1- (3,4,5-trimethoxyphenyl) ethanol (6), while, there was no transformation in case of acid substrate (3) under similar conditions. *Atropa belladonna* hairy root culture has shown significantly high efficiency of biotransformation and exhibited a maximum of 32.59% conversion for (4) and 33.61% to (5).

2.15. Field evaluation of *Catharanthus roseus* somaclones developed via direct adventives organogenesis from leaf explants (A.K. Mathur, K. Shanker, G.C. Uniyal)

Sixty five somaclones of three parental genotypes of *C. roseus* (*cv.* Nirmal, Dhawal and Prabal), were evaluated for their field performance. Somaclone DC-56 and DC-58 and N-23 showed higher accumulation of catharanthine in the leaves. Based on the individual plant screening data, twelve selections were advanced to plant-to-row stability trial through their seed-derived progenies. Initial observation has indicated a new flower morphology appearing in somaclone P-39.

2.16. *In vitro* pathway complementation for higher metabolic yield through mixed culture approach (A.K. Mathur, M.M. Gupta)

Results indicate that *Catharanthus roseus + Rauvolfia serpentina* and *C. roseus + Vinca major* when mixed in 1:1 ratio can maintain their individual growth kinetics during the mixed culture mode. Cells of *Glycyrrhiza glabra* because of their very fast *in vitro* proliferation rate did not allow *C. roseus* cells to acquire critical biomass during the 15-20 day culture cycle. *C. roseus + Panax quinquefolium* combination still needs more fine tuning of growth regulators.

2.17. Post-harvest elicitation for pathway modification in *Catharanthus roseus* leaves (A.K. Mathur, M.M. Gupta, G.C. Uniyal)

Results obtained indicated that post harvest treatment with 5MT (5-Methyl Tryptophan) and tryptophan showed an increase in the vindoline recovery. HPLC analysis revealed a marked 10 fold increase in 24 hrs 5MT treated twigs and leaves of 'Dhawal' genotype (9.2 % and 8.6% of crude alkaloid extract, respectively), followed by 'Prabal' line (7.2 % and 6.4% of the crude alkaloid, respectively) and 'Nirmal' genotype (4.2 % crude alkaloid in twigs and leaves both). Elicitation treatment of 24 hrs in general resulted in better vindoline yield than 48 hrs in all the lines.

2.18. *In-silico* analysis of unigene derived microsatellite markers in family Solanaceae (Ashok Sharma)

18,228 unigenes were mined for *Solanum lycopersicum* and SSR repeat motifs were analyzed. Of these, 12,090 showed the presence of simple sequence repeats (SSRs). The average density of SSRs was 1(one) SSR per 1.3 kb of unigene sequence screened. The study of occurrences of different types of SSR repeats revealed that the percentage of occurrence of mono-nucleotide SSR (89.36 %) was the highest followed by tri-nucleotide SSR (6.38 %). Among mononucleotide repeats, polyA/polyT repeats were predominant while polyC/polyG repeats were rare. AT/TA dinucleotide repeats were more frequent, followed by TC/CT and AG/GA combinations.

Primers were designed for PCR amplification of the desired microsatellites using Primer 3.0 software. This study is a step forward towards the utilization of *in-silico* approaches to analyze microsatellites (SSRs) from unigene sequences of plants.

Molecular Bioprospection

2.19. Development of standardized herbal product for bovine mastitis (D. Chanda, D.U. Bawankule, A. Pal)

In-vivo acute of and sub acute oral toxicity study of herbal product developed for bovine mastitis was done alongwith its anti-inflammtory activity study. No morbidity and mortality was observed during the entire experimental period. Majority of the biochemical hematological and gross pathological parameters showed no significant changes. In toxicity experiment, the formulation studied is

well tolerated up to 300 mg/kg in sub acute study and up to 2000 mg/kg in acute study by Swiss albino mice. F-3 combination exhibited the topical anti-inflammatory activity in dose dependent manner against TPA (12-0-Tetradecanoylphorbol-13-acetate) induced mouse ear edema model.

The results indicate that the animals treated with a combination (F3) containing two parts of *Azadirachta* bark along with one part each of *Withania* leaf and stem extracts exhibited the minimum microbial load in the spleen. Same combination was also able to potentiate the anti-inflammatory cytokines while suppressing pro-inflammatory cytokines.

2.20. Safety evaluation of standardized extracts of *Andrographis paniculata*: a commonly used herb of Ayurvedic medicine in Swiss albino mice.

Chemical standardization of acqueous, hydro-alcohlic and alcoholic extracts of aerial parts was done. All the three extracts, in both the acute and sub acute toxicity experiments were well tolerated by the experimental animals and no gross abnormalities were detected in pathological examination including the expression of inflammatory cytokines.

2.21. Molecular mechanism(s) of traditional medicinal plants against rheumatoid arthritis

(D.U. Bawankule, A. Pal, K. Shanker)

Potent *in-vitro* anti-inflammatory leads, coded as IVT-93 and IVT-94 were validated in mice. IVT-93 and IVT-94 exhibited the anti-arthritis activity against the collagen + FCA induced arthritis in mice. IVT-94 treatment showed the gain in body weight when compared to normal control. Significant changes were not observed in hematological parameters.

2.22. Immunological profile of different *Ayurvedic* preparations of *Terminalia arjuna*

(D.U. Bawankule, A. Pal, D. Chanda , D. Mani)

The Ayurvedic preparation of *Terminalia arjuna* were coded as IVT-901 (*sheet ksaya* preparation) and IVT-902 (*Kshirpak* preparation) for *in-vivo* study.

Mice treated with IVT-0901 and IVT-0902 exhibited a significant increase in hemagglutinin antibody titer when compared to normal vehicle control. IVT-0902 was more potent than the IVT-0901 as an immunomo-dulatory agent. Significant difference was not observed in body weight, haematological parameters as well as cell mediated immunity.

2.23. Topical anti-inflammatory effects of *Ocimum basilicum* leaf extract

(N.P. Yadav, A. Pal, D.U. Bawankule, D. Chanda)

In the present investigation, the topical anti-inflammatory property of the extract of *Ocimum basilicum* leaves was carried out in mice model and it was found that *Ocimum basilicum* extract significantly reduced ($p \leq 0.05$) the ear weight variation (difference in the weight of right and left ear of animals), levels of LPO (malonaldehyde), IL-1β, IL-6 and TNF-α when compared with toxin group, which proves the anti-inflammatory effect of *Ocimum basilicum* leaf extract.

2.24. Wound Healing Activity of Stem Bark extract of IVT-22

(N.P. Yadav, A. Pal, D.U. Bawankule, D. Chanda)

Stem bark of IVT-22 is used to treat the wounds in folk medicine in India. Variable extracts A, B and C of stem bark of IVT-22 were used for the study in excision-wound model in swiss albino mice. For evaluation of wound healing potential of IVT-22, various parameters viz. percent wound contraction, hydroxyproline content and DNA content were estimated. Extract (A) significantly ($p \leq 0.5$) increased hydroxyproline content (7.63±0.11 mg/g) and DNA content (47.71±2.09 mg/100g) at wound site, when compared to vehicle control group. The percent wound contraction was also highest in extract (A) treated group of animals (97.65 ± 0.15%) in comparison to vehicle control, positive control, extract (B) and extract (C) treated animals. These findings indicate that extract(A) of stem bark of IVT-22 has significant wound healing property, which substantiate its folklore use to treat the wounds.

2.25. Wound healing potential of different fractions of IVT-18

(N.P. Yadav, A. Pal, D.U. Bawankule, D. Chanda)

Based on our previous lead, IVT-18 was fractionised by various organic solvents and fraction A, B, C and D were obtained. These fractions were subjected for wound healing activity in mice. The wound healing potential of the fractions was evaluated in excision wound model and various parameters viz. hydroxyproline content, DNA content and percent wound contraction were estimated. In conclusion, fraction C is exhibiting higher content of hydroxyproline and DNA in wounded tissue on 16th day, it was also showing greater wound contraction in mice on 12th and 16th day, hence, Fraction C of IVT-18 is having wound healing activity.

2.26. Traditional knowledge based cardiotonic 'Kshirpaka' (D. Mani, K. Shanker, D. Chanda , D.U. Bawankule , A. Pal)

Kshirpak, a traditional knowledge based cardiotonic formulation is well tolerated up to 4000 mg/kg body weight in acute toxicity experiment and up to 180 mg/kg body weight in sub acute experiment in *Charles Foster* rats.

2.27. First report of a labdane diterpenoid from mango ginger (*Curcuma amada*) and its antimycobacterial activity (S. Banerjee, A.S. Negi, D. Saikia)

A labdane diterpene dialdehyde was isolated from the chloroform extract of the rhizomes of *Curcuma amada* labda-8(17), 12-diene-15, 16-dial was found to be the major compound accountable for the anti-tubercular activity. This compound exhibited antitubercular activity (MIC = 500 µg/mL) against *Mycobacterium tuberculosis* H_{37}Rv strain in BACTEC 460 assay. This diterpenoid was further modified to three analogues. Two of its semisynthetic analogues also exhibited antitubercular activity at 250-500 µg/mL. This is the first report on isolation and its antimycobacterial activity of dialdehyde from *C. amada*.

2.28. Prospecting *Nyctanthes arbor-tristis* for possible anti-plasmodial activity and combination therapy for combating drug resistance (A. Pal)

Alcoholic extract of the leaves showed low anti-malarial activity at 1000mg/kg when compared to the positive control at 10mg/kg. A dose dependent experiment was undertaken with doses ranging from 500mg to 2000mg/kg which indicated the optimum dose to be 1500mg/kg in terms of mean survival time, parasitaemia, anemia, Tumour necrosis factor and IL-6 in the treated groups.

2.29. Biological and chemical transformation of plant compound for value added product of therapeutic/aroma value (A. Pal, R.S. Sangwan, D. Mani and K. Shanker)

Immunomodulation of *Arjunarishta* was carried out. The formulation IVT 907 which was simple decoction along with jaggery and the flowers showed the maximum immunopotential effect indicating the role of *Woodfordia fructicosa* in enhancing the biological activity.

2.30. Biological and chemical transformation of plant compound for value added product of therapeutic /aroma value (A. Pal, R.S. Sangwan, R.S. Bhakuni)

Antimalarial activity of the artemisinin derived compound (CPM-1) was examined. A typical dose response related activity was observed with 7.5 mg/kg of the compound and it could render a mean survival time of 28 days in the infected mice.

2.31. Development of bioassay for selected target genes in *Staphylococcus aureus* (M.P. Darokar)

Attempts have been made to clone *ldh* gene from *S. aureus* and its expression in *E. coli* for developing bioassay. The gene has been cloned and the expression of enzyme and its purification are under progress. Simultaneously, an assay has been standardized for screening phytochemicals inhibiting *ldh,* a validated target in bacteria and malaria parasite.

2.32. Antimalarial screening programme *In-vitro* efficacy of extract/pure molecules against *Plasmodium falciparum* (M.P. Drokar, A.S. Negi)

Bioassays (cell based and enzyme based) have been established and put in to use for screening phytochemicals for their antimalarial activity.

Chalcone derivatives on estradiol framework previously reported to have anticancer activity were evaluated for their ability to inhibit the growth and development of the malaria parasite *Plasmodium falciparum* using *in-vitro* assays. Out of twelve steroidal chalcone and one indanone derivatives studied, three compounds were found to have 50% growth inhibitory concentration (IC_{50}) less than 5 µM and concentration inhibiting parasite development to schizont (MIC) as $\leqslant$ 20 µM. Two compounds (7 and 16) did not exhibit cytotoxicity against mammalian cell line Vero which is evident by high selectivity ratio. These observations suggest that steroidal chalcones showing selective activity against *P. falciparum* may be considered antimalarial leads for further study.

3. Chemical Sciences
(Analytical Chemistry, Phytochemistry, Process Chemistry & Chemical Engineering)

Analytical Chemistry

3.1. Development of a validated chromatographic method for quality analysis of *Phyllanthus* spp. (M.M. Gupta, K. Shanker)

An online hyphenated high performance liquid chromatography-photodiode array-mass spectrometry (HPLC–PDA-MS) analytical method was developed for the simultaneous determination of six lignans of therapeutic importance in four *Phyllanthus spp* (*P. amarus*, *P. maderaspatensis*, *P. urinaria and P. virgatus*). Targeted lignans viz. heliobuphthalmin lactone (1), virgatusin (2), hypophyllanthin (3), phyllanthin (4), nirtetralin (5) and niranthin (6). The method was validated following the International guidelines. The described method can be utilized for assays and stability tests of *P. amarus* extracts as well as *Ayurvedic* drugs based on *Phyllanthus* herb.

3.2. Isolation and characterize marker compounds from *Phyllanthus amarus*. (M.M. Gupta, K. Shanker)

Two new lignans 3-(3,4-dimethoxy-benzyl)-4-(7-methoxy-benzo[1,3]dioxol-5-ylmethyl)-dihydro-furan-2-one and 4-(3,4-dimethoxy-phenyl)-1-(7-methoxy-benzo[1,3]dioxol-5-yl)-2,3-bis-methoxymethyl-butan-1-ol were isolated from the leaves of *Phyllanthus amarus* and their structures were established by spectral analysis.

3.3 Micelle-Mediated Cloud Point Extraction and Preconcentration of Secondary Metabolites: An Alternative Eco-friendly Separation Approach (K. Shanker)

The quantitation of andrographolide and neo-andrographolide was carried out using the densitometric reflection/absorption mode at 540nm after post chromatographic derivatization with vanillin-sulphuric acid reagent. A precise and accurate quantification can be performed in the linear working concentration range. The accuracy of the quantitation of diterpenes obtained by HPTLC method was also confirmed by reverse phase HPLC. The micelle-mediated extraction and cloud-point preconcentration (CPE) method offers a convenient alternative to the conventional extraction systems. The extractability of targeted diterpenes using non-organic solvents is comparable. The elution of surfactant in both TLC and HPLC does not interfere in quantitation. The proposed technique is an economic, simple and sensitive method with high cleanup effect devoid of extraction with organic solvents. The method was applied to separate and determine andrographolide and neo-andrographolide from *A. paniculata* respectively.

3.4. Development of binary gradient RP-HPLC method for the quantification of four important marker compounds of *Centella asiatica* (G.C. Uniyal)

An improved binary gradient HPLC-PDA method for the quantification of madecassoside, asiaticoside madecaslic acid and asiatic acid, present in leaf extract of *Centella asiatica,* was developed.

3.5. Enantioselective discrimination of menthol isomers in *Mentha piperita*. (C.S. Chanotiya)

GC separation method for (+/-)-menthol enantiomers was developed by using chiral stationary phase capillary column. Essential oil isolation by Clevenger-type apparatus was done. Separation of oil components by column chromatography; GC-FID, enantio-GC-FID and GC/MS was performed and enantiomeric excess determination of terpenoids by enantioselective-gas chromatography technique was achieved

3.6. Isolation and characterization of antipsychotic agents from plants (S.K. Srivastava, M.M. Gupta, J. Singh)

The bioactive chloroform extract code named MAP-1597 resulted in the isolation of six compounds K001 to K006. All the isolated compounds were characterized on the basis of their 1D, 2D NMR, and MS spectroscopic data. Out of the six compounds, three compounds are new and being reported for the first time from nature. Although all the six isolated compounds were active but compounds K001 and K004 possess significant antipsychotic activity. The antipsychotic activity for all the isolated compounds K001-K006 is being reported by us for the first time.

3.7. Separation of clavine alkaloids from *Ipomoea muricata* by pH-zone-refining (CPC) (S.K. Srivastva)

pH-Zone-refining CPC has been successfully applied in the separation of alkaloids, directly from a crude extract of *Ipomoea muricata which is a good source of lysergol, an important starting material for the synthesis of anti-Parkinson drug Cabergoline.*

From 4 g of crude extract, 210mg lysergol and 182mg chanoclavinewere obtained in 97% and 79.6% purities. Total yield recovery was >95%.

3.8. pH-Zone-refining centrifugal partition chromatography (CPC) for preparative isolation of steroidal glycoalkaloids from *Solanum xanthocarpum* (S.K. Srivastava)

pH-Zone-refining CPC technique was successfully applied in the separation of complex polar steroidal glycoalkaloids of close Rf values, directly from a crude extract of *Solanum xanthocarpum*. Separation of 1 g of crude extract over CPC resulted in two distinct pHzones. The fractions collected in pH-zone i afforded 72 mg of solasonine while the fractions collected in pH-zone ii were slightly impure, hence were purified over medium pressure LC, which afforded 30 mg of solasonine and further 15 mg of solamargine (SM). The steroidal glycoalkaloids, SM and solasonine were isolated in 93.3 and 91.6% purity, respectively. The isolated alkaloids were characterized on the basis of their 1H, 13C-NMR, and ESI-MS data.

PHYTOCHEMISTRY

3.5. Development of a technology for the production of biofuel from spent material of essential oil crops (P.K. Rout)

The work on production of chemicals such as levulinic acid, ethyl levulinate and hydroxymethyl furfural from spent palmarosa biomass in 2 L capacity reactor is under progress. The analysis is being carried out by GC and GC/MS. The process optimisation is under progress.

3.6. Chemical studies on aromatic flora (P.K. Raut)

The study on volatile fragrance composition of live and picked flowers of *Tagetes patula* and *Rosa damascena* by using SPME technique is under progress. The study on adsorptive recovery of water soluble components from Kewda (*Pandanus fascicularis* Lam) distilled water by using polymeric synthetic resins, is being carried out.

3.7. Green chemistry: Isolation and chemical modification of withanolides from *Withania somnifera* (L.N. Misra)

The isolation of withanolides in large amount has been done using chromatographic methods. A convenient route has been developed to introduce N in the withanolides at C-6 position by reaction of amines to yield the respective imines. The significance of the methodology is that it is based on the principles of green chemistry, and the reaction is done in aqueous medium at room temperature. The yields of products range from 30 to 80%. The biological activity evaluations are being carried out.

Attempts have been made to convert the oxirane ring into thiirane ring and to study its effects on the biological activities of the withasteroids. Thiiranes find wide application in pharmaceutical, pesticide and polymer industries.

3.8. Chemotypic studies on the essential oil of *Lantana camara* (L.N. Misra)

Collections from the Dibrugarh region from North eastern India showed the presence of new chemotype with davanone as the major constituent of the oil. This is the second source of this valuable sesquiterpenoid, the first one being Davana.

3.9. Studies in *Callicarpa macrophylla* (A.K. Singh)

Analysis of essential oil from leaves and fruits of *Callicarpa macrophylla* led to identification of more than 45 constituents. The oil was dominated by sesquiterpenoids, the most significant being selinene isomers (41.6% in fruit oil) and dendrolasin, a furanoid perfumery molecule in the oil.

3.9.1 A novel method for estimation of calliterpenone and calliterpenone monoacetate (A.K. Singh, M.M. Gupta, K. Sharma)

Variation in content of calliterpenone and calliterpenone monoacetate in the leaves of plant according to their position on the stem was carried out using novel methods (HPLC/HPTLC) of estimation. Maximum amount of calliterpenone was in top leaves during July (1.2%), while it was minimum during December (0.32%). During the month of July, mononacetate was also in high percentage. Studies suggest that *Callicarpa macrophylla* should be harvested during July for maximum recovery of calliterpenone.

3.9.2. Calliterpenone for enhancing the stability and life of bio formulations

The natural plant growth promoter Calliterpenone, has also been found to increase the rhizobia numbers significantly in aqueous extract of vermicompost which will be beneficial for improving the stability and life of vermicompost-based bio formulations.

3.10. Chemical fingerprinting of various elite cultivars of spearmint developed by CIMAP (A.K. Singh)

The volatile constituents of the essential oils from different elite cultivars of spearmint Arka, MSS-2, MSS-5, Neera, MACS-2 and Mukta scotch type spearmint (*Mentha cardiaca* Gerard) and Indian origin *Mentha spicata* L. *viridis* var. Ganga, Supriya, and Neerkalka (hybrid cultivar) were investigated and characterized by GC and GC/MS. The cultivars are rich in monoterpenoids. *Mentha spicata* L. *viridis* var. Ganga contains piperitenone oxide as major chemical entity which was present in low percentage in oil of *M. viridis* Supriya. The other cultivars *viz.* var. Arka, MSS-2, MSS-5, Supriya, Neera and Neerkalka contain carvone along with limonene as major constituents. High limonene content was observed in Neerkalka, *Supriya* and MSS-5 while significant amount of 1, 8-cineole was noticed in Neera and MSS-2 only. Similarly, *cis*-dihydro carvone was marked higher in Neera, Arka and MSS-2, respectively. The essential oil profile of MACS-2 and Mukta are typical scotch type and are rich in carvone (55.9-61.3%), and limonene (17.6-28.9%) with quantitative differences in major and minor constituents; differences in trace constituents were also recorded in these cultivars. Variations in terms of FID area percent response were observed in all cultivars, thereby making us place these as distinct varieties within spearmint. Complete oil profile in two harvests have been prepared and compared with commercial samples of oil.

3.11. Biosynthesis of andrographolide in *Andrographis paniculata* (A. Akhila)

The biosynthetic route to andrographolide was studied using [1-^{13}C]acetate, [2-^{13}C]acetate and [1,6-$^{13}C_2$]glucose. The peak enrichment of certain carbon atoms in ^{13}C NMR spectra of andrographolide suggested that DXPC De-oxy Xylulose Phosphate) pathway is the major biosynthetic pathway to this diterpene. However, the possible existence of MVA pathway was also indicated because of the crossing over of plastidial wall by some precursors and intermediates.

3.12. Pharmacophore driven synthesis using plant scaffolds (P.K. Chaudhary)

Andrographolide processed in gm quantity was used as a scaffold to study the effects of its γ-butyrolactone moiety and double bond, against the cancer cell lines. A method was developed for an enantioselective reduction of the andrographolide with 95% yield using chemoselective reagent, and the product showed loss of anticancer activity. The reduction product was isolated in a single step by crystallization. One of the functional derivatives of andrographolide showed 100-fold increase of the anticancer activity against MCF-7 cell lines (breast cancer). Two new scaffolds from neoandrographolide were synthesized for their biological study. The structure determination of the scaffolds by spectroscopic means is in progress.

3.13. Natural bioactives and their structural variants for possible health benefits (P.K. Chaudhary)

A method was optimized for the extraction of bioactive saponins from *Centella asiatica*. Further, a bench scale method was developed for the isolation of 50% enriched asiaticoside from 2 kg plant material. Total saponin content of CIMAP plant, *Centella asiatica* is better (5.2%) than the market sample and consequently its asiaticoside content as asiaticoside was the major saponin of the total content. It is useful as nerve tonic and in Dementia. Further purification and confirmation of structures of saponin and sapogenins are in progress.

Process Chemistry and Chemical Engineering

3.14. Up scaling of bench scale process for the isolation of isoxanthochymol and xanthochymol from the fruit rinds of *Garcinia indica* (S.K. Chattopadhyay)

An improved process technology for isolation of iso-xanthochymol and xanthochymol from the fruits of *Garcinia indica* has been developed and the anti-tumor activity has also been tested *in vivo*.

3.15. Chemical transformation of artemisinin and antimalarial evaluation of the products (R.S. Bhakuni)

Several new derivatives of artemisinin were synthesized and analyzed for antimalarial activity. Under a dose dependent study on mice infected with drug resistant strain of *Pyoelii nigeriensis* the new derivative, artecyclopentyl mether was found to reduce the concentration of IFN- γ, IL-10 and NO in serum, TNF- α and lipid peroxidation in brain tissue on the day 6 post infection. The derivative has been found to retain the blood glucose towards the normalcy in the treated mice, thus preventing the condition of hypoglycemia and resulting in 100% survival of treated mice with 7.5mg/kg of the drug.

3.16. Up-scaled isolation of parent molecules targeted for chemical and biological transformation (S. Tandon)

The process parameters were optimized for the extraction and isolation of coumarinolignoids from seeds of *Cleome viscosa* at a pilot scale of 100 kg / batch size. Consumption of solvents was minimized simultaneously, increasing the yield of the product upto1.13%, making the technology more efficient and economical.

Process technology for the extraction and isolation of andrographolides from *Andrographis paniculata* was developed and up scaled to a level of 20 kg / batch.

3.17. Development and scaling up of process technology for the isolation of citral ex lemongrass oil and its synthesis to β-ionone a precursor of vitamin A (S. Tandon)

Fractionation data for the isolation of citral ex. lemongrass oil has been generated at bench scale level.

Conversion of citral to pseudo-ionone with purity up to 89% under different process conditions and concentrations were achieved at level of 100 g / batch size. β-ionone of 72% purity and 78 % yield of citral was obtained from cyclization of pseudo-ionone under different process conditions and acid concentrations.

4. Crop Protection

Microbial Technology & Entomology

4.1. Microbial utilization and useful metabolites (Alok Kalra)

The possibilities of utilizing microbes in developing new growth promoters for medicinal and aromatic plants and source of new value added industrial compounds was explored.

4.1.1. Consortia of AM fungi and N-fixing bacteria

The effect of arbuscular mycorrhizal (AM) fungi, and two free living nitrogen fixing bacteria (NFB)- *Bacillus subtilis* and *Stenotrophomonas sp*. inoculated alone or in combinations on the biomass, nutrient uptake, and content of artemisinin in *Artemisia annua* was studied. Among all the treatments, plants inoculated with *Glomus mosseae* + *Bacillus subtilis* performed better than any other treatment for enhancing growth, biomass yield, and the content of artemisinin.

4.1.2. Endophytes of Catharanthus roseus

An endophytic microbe V3, isolated from leaves of *Catharanthus roseus* improved the growth of the plants and the root and leaf yields both under glass-house and field conditions. Of the various alkaloids, an increase in content of catharanthine in the leaf sample was observed by the application of strain V3, although it reduced the content of vincristine. Analysis of root samples revealed that the content of ajmalicine and serpentine improved by the application of V3.

4.1.3. Trichoderma citrinoviride, an efficient cellulase producing fungus

Cellulase production, using delignified bioprocessings of medicinal and aromatic plants by the six species of *Trichoderma* were comparatively evaluated. *T. citrinoviride* was found to be the most efficient producer of cellulases along with a high level of β-glucosidase compared to pure cellulose. Although *T. virens* produced minimal enzyme and could not produce complete cellulase enzyme complex on any other test waste or pure cellulose, it produced all three enzymes of the complex on marc of *Artemisia.*

4.2. Management of root-knot nematode in MAPs through bio-organics (Rakesh Pandey)

A glasshouse experiment to assess the relative efficacy of bio-organics viz, vermicomposts, neem cake, bioagent *Trichoderma harzianum* strain, *Glomus mosseae* and carbofuran on the reproduction and infection potential of *Meloidogyne incognita* in *Ocimum basilicum* showed that neem cake and *T. harzianum* improved the growth, biomass and oil yield of the plant with reduction in the severity of root-knot disease. Other vermicompost and *G. mosseae* also reduced the nematode reproduction and root galling. Therefore, it is concluded that various organic materials including vermicomposts, neem cake and *T. harzianum* can be used instead of pesticides, for reducing the root-knot disease in *O. basilicum* and enhancing the oil yield.

4.3. Development of integrated pest management strategies in menthol mint (Dwijendra Singh)

Twenty-six menthol-mint genotypes were screened for their resistance potential against attack of sweetpotato whitefly [*Bemisia tabaci* Genn. (Hemiptera: Aleyrodidae)] and *Begomovirus* infection under field conditions. Thirteen mint genotypes were found significantly resistant to pupae and adult of *B. tabaci,* and four to *Begomovirus* infection. Among ten promising medicinal plant extracts prepared in methanol, acetone, and distilled water, two plant extracts designated as DS/NA-Ent/01 and DS/NA-Ent/07,

were found to possess a strong insect growth regulator activity against *Helicoverpa armigera* Hub. (Lepidoptera: Noctuidae).

PLANT PATHOLOGY

4.4. Identification of a new variant of *Streptomyces chattanoogensis* with potential antibacterial, antifungal and bioremediation of heavy metals (M. Alam, D.D. Patra)

The isolation carried out from the soil samples of an industrial area of Jajmau, Uttar Pradesh, India predominantly yielded colonies of actinobacteria designated as *Streptomyces* sp. CIMAP A_2. It produced considerable amount of antibacterial and antifungal compounds as well as cell wall degrading enzymes, proteases, pectinases and cellulases. The strain also produced substantial amount of hydroxymate siderophore and was highly effective in the availability of trace metals/ nutrient elements like Fe, Cu, Mn and Zn and bioremediation of heavy metals like Pb, Cd, and Sn. The strain was identified as *S. chattanoogensis* on the basis of morphological, physiological, biological characteristics and sequence analysis.

4.5. Use of different bioinoculants to increase the root biomass yield and oil content (M. Alam)

4.5.1. Studies in vetiver

Four varieties of vetiver; KS1, Dharni, Keshri, and CIM-Viridhi were treated with eight different bioinoculants (B1, UPS1, UPS2, SGS2, 2A, 2B, Psfi, and B6) and their responses on the root biomass yield and oil content were evaluated after 18 months duration under pot condition. Our results showed that var. Dharni and CIM-Viridhi responded best towards SGS2, while only var. CIM-Viridhi produced similar yield against UPS1. The other two var. KS1 and Keshri performed best towards UPS2. Results also showed that overall performance of B1 and B6 was good for all the varieties tested. These bio-inoculants may be exploited to increase the yield in the commercial fields of vetiver. There was no significant difference in oil content among the treatment and control.

4.5.2. Studies in mulethi (Glycyrrhiza glabra) and Sarpagandha (Rauvolfia serpentina)

Thirteen bioinoculants were tested on root cuttings to evaluate their effect on the sprouting of mulethi and sarpagandha under pot condition. Results showed that 100% germination was recorded in mulethi treated with Psb1, B6, SGS2, B1 and PA1 followed by 66.66% germination in UPS2, AS1, and Psf1, whereas only 33% germination was recorded in control. In case of sarpagandha 75% germination was observed when the root cuttings were treated with B1, 2A, and 2B against 50% germinations in control.

4.6. Identification of new phytoplasma diseases in *Ocimum* and *Stevia* (A. Samad, P.V. Ajayakumar)

Healthy and infected leaf samples from *Stevia rebaudiana* and *Ocimum basilicum* were collected from different locations and used for DNA extraction and PCR. PCR products of expected size were obtained from all symptomatic plants, but not from the symptom-less plants.

Selected clones were sequenced and BLAST comparisons of the sequenced data showed matching of *S. rebaudiana* clones only. The 16S rRNA sequences of phytoplasma detected in *S. rebaudiana* showed the highest similarity of 98% with sorghum bunchy shoot phytoplasma (Accession No. AF509322). Phylogenetic analysis also confirmed the *Stevia* little leaf phytoplasma as sorghum bunchy shoot phytoplasma -related strain. This is the first report of phytoplasma infection on *S. rebaudiana* and *O. basilicum.*

4.7. Identification of new viral disease on ashwagandha (A. Samad)

An outbreak of viral disease was observed on ashwagandha and disease incidence was recorded to be 25-30% in the severely infected field at CIMAP, Lucknow. Infected plants exhibited typical mosaic and vein clearing/bandings symptoms.

Total genomic DNA was extracted from healthy and infected ashwagandha leaves and indexed by PCR using begomovirus CP gene-specific primers. A product of 771 bp in size was amplified from infected but not from healthy plants. It seems that disease is caused by begomovirus.

4.8. Evaluation of genotypes (Rye and related accessions) for susceptibility to artificial infection by *Claviceps purpurea* leading to high ergot yield (H.N. Singh, M. Alam)

Eight accessions of rye sown at 11 dates from mid October to first week December at the intervals of 5 days were artificially inoculated twice using needle board and pad puncture method. The mature sclerotia were collected manually and yield/accession was recorded. Maximum average sclerotial yield was 17g/M^2 in R-3 and SR-14 followed 15 g/M^2 in SR-12 and SR-13, respectively. Rye-7 and R-Lko yielded 13g/M^2. In other accessions yields were less than 10g/M^2.

4.9. Influence of various bioinoculants and composts on the productivity of *Mentha piperita* under pot conditions (H.N. Singh, Alok Kalra)

Experiments on interactive effect of siderophore producing microbes and various organic manures indicated that siderophore producing microbe, SD-22 alone was ineffective but along with manures its application increased the herb yield of *M. piperita.* However, siderophore producing bacteria SD-22 worked synergistically with vermicompost. Thus, it can be exploited to be used with vermicompost for increasing the yield of this crop.

Another experiment on interactive effect of siderophore producing microbe, SD-22 with four species of mycorrhizal fungi, *Glomus aggregatum, G. fasiculatum, G intraradices and G. mosseae* and *Trichoderma harzianum* on the herb yield of *M. piperita* was carried out. Results indicated that microbe SD-22 in combination with *G. aggregatum* improved the yield of plant significantly, showing synergism in between SD-22 and AM fungi. *T. harzianum* alone was effective in improving the plant growth and yield but with SD-22 , it was not so.

4.10. Natural stored grain protectant (A.K. Tripathi)

Eight spices were evaluated, singly and in combination for their contact and fumigant toxicity, repellence and effects on progeny development against the cowpea weevil (*Callosobruchus maculatus* F.) and rust red flour beetle (*Tribolium castaneum* Herbst). The powders of large cardamom, cinnamon and clove caused complete inhibition of progeny production in *C. maculatus* and *T. castaneum* at a dose of 5 g/100 g. A 1:1 mixture of green cardamom and turmeric showed both contact and fumigant toxicity against *C. maculatus*, while a mixture of clove and large cardamom showed repellency and inhibited progeny development in *T. castaneum.*

5. Genetics and Plant Breeding
(Plant Breeding, Genetic Resource Management)

5.1. Genetic enhancement of aromatic grasses, *Cymbopogons* through genomic and genetic manipulation (U.C. Lavania, R.K. Lal)

5.1.1. Genomic manipulation in Cymbopogons: Two morphologically differing clones of Palmarosa (*Cymbopogon martinii*), and clone "Suwarna" of Lemongrass (*C. khasianus*) were changed to tetraploid state. Former is stabilized for their cytogenetic purity. The latter is under cytological screening for progressive stabilization.

One of the two clonal autotetraploids realized in *C. martinii*, is of the clone "Vaishnavi" that has morphologically distinct unique drooping type inflorescence.

5.1.2. Development of improved variety in Lemongrass (Cymbopogon khasianus) : An improved high yielding variety with better quality of essential oil having production potential of oil yield 200 kg / ha and 80 % citral content has been developed in Lemongrass – *Cymbopogon khasianus,* and released for commercial cultivation as variety "Suwarna" . This variety is suitable for rain fed condition and drought prone areas.

5.1.3. Development of improved variety in Palmarosa (Cymbopogon martinii): Based on rigorous population selection followed by composite breeding, an improved variety rich in essential oil and high geraniol content has been developed and released for commercial cultivation under the variety name "Harsh".

5.2. Molecular taxonomy and basic studies in MAPs (U.C. Lavania)

5.2.1. Chromosomal localization of rDNA and DAPI bands in Hyoscyamus niger L.

The standard karyotype prepared from metaphase spreads in *Hyoscyamus niger* L. (Family : Solanaceae, 2n=34) was further used to elucidate further linear chromosome differentiation combined with DAPI (4' 6-diamidino-2-phenylindole) banding patterns and localization of rDNA loci. Observations based on two colour simultaneous fluorescence *in situ* hybridization with rDNA probes reveal two prominent 45S rDNA and one weak 5S rDNA site in the chromosome complement of *Hyoscyamus niger*. DAPI banding pattern observed on the same metaphase reveal that 15 of the 17 chromosomes have DAPI positive bands. 13 chromosomes show DAPI positive bands in the telomeric region of short arm. The two chromosomes that support secondary constriction had only weak DAPI positive bands in their centromeric region, but their 45S rDNA chromosomal sites show DAPI negative bands. The chromosomes 4 and 17 do not show any DAPI band. Taken in conjunction with the karyomorphology, the two 45S rDNA sites could be

correlated to one site each in the secondary constriction region of chromosomes 5 and 10, and 5S rDNA site in the intercalary region proximal to secondary constriction region of chromosome 5.

5.3. Breeding strategies for newer opportunity MAPs : *Stevia, Centella* and *Withania* (R.K. Lal, H.O. Misra, U.C. Lavania)

5.3.1. Isolation of high yielding strain RK-1 of Mandukparni (Centella asiatica): From half sib family selection a high yielding strain RK-1 with fresh biomass/dry herb yield of 101.5q/10.9q/ hectare respectively, and asiaticoside content ranging from 4.8 to 6.9% on dry herb basis has been identified in *Centella asiatica*.

5.4. Breeding and characterization of *Mentha species* (J.R. Bahl, S.P. Singh, V.R. Singh, Birendra Kumar)

5.4.1. Development of high yielding variety of Menthol mint (Mentha arvensis)

A new improved variety named 'CIM Sarayu' has been developed though intensive half sib seed progeny selection from variety 'Shivalik', The new variety has higher biomass, oil content, oil yield and menthol content over the existing varieties. It has been released for commercial cultivation. This variety holds productive potential of 27.4 tons/ha biomass, 265-290 kg. oil/ha, and 0.84 to 1.00 % oil content with 80% menthol. The variety could be differentiated on the basis of distinct morphological features and characteristic RAPD profile.

5.5. Genetic studies for improvement of periwinkle, *Catharanthus* (R.N. Kulkarni, K.V.N. Sathya Srinivas, K.V. Syamasundar, Tripta Jhang)

5.5.1. Genetic linkage between mutant traits

Genetic linkage was detected between flower size (*fs*), leaf size (*ls*), plant height (*dw*) and stem colour (*r*) in the cross, dwarf mutant (EMS 24-17-1), with green stem, small flowers & small leaves x PS-1, with normal plant height & purple stem, and linkage map r 0.22 fs 0.11 dw 0.23 ls

5.5.2. Inheritance of a new mutant

Inheritance of a new mutant with caducous flower buds (premature flower bud abscission) was studied. After several attempts of hybridization, its inheritance could be studied. The mutant trait was found to be inherited as a recessive trait. The mutant appears to be potentially useful for possible development of a cleistogamous genotype to facilitate maintenance of genetic purity in periwinkle.

5.6. Development of improved variety in Chamomile, *Chamomilla recutita* (R.K. Lal)

Following intensive mutation breeding efforts, an improved variety named "CIMAP-Sammohak" promising high flower production and high oil yield of better quality has been developed. This variety holds the production potential of dry flower yield of 7.53 q/ha dark blue oil yield of 6.63 kg/ha containing 12.98% chemuzuline.

5.7 Breeding for genotype designing in *Asparagus*, Vetiver and *Curcuma* (Ashok Kumar Singh, RK Lal, HP Singh, UC Lavania)

5.7.1. Identification of high yielding superior clones of khus (*Vetiveria zizanioides*): Eighty six clo-lines developed out of polycross progenies were under evaluation for their performance with respect to fresh root yield and oil content. Fresh root yield and oil content ranging from 0.5 – 50.7gm/plant and 0.2 – 3.5 percent have been recorded, facilitating identification of promising clones with over 2 % oil content..

5.7.2 Identification of High Rhizome and high curcumin yielding clones in *Curcuma*: Based on Pilot Scale field evaluation trial of sixteen selected clones of *Curcuma*, two high rhizome and high curcumin clones have been identified. Clone UNK/PST-1 yielded highest rhizomes (40.6 q / ha) and curcumin content 7.8 %, and Accession No. TUR-4/PST-2 yielded rhizomes to the order of 34.7 q / ha and curcumin content 7.7 %.

5.8. Gene bank utilization strategies: conservation to bio-prospecting genes/ molecules/ products (A.K. Gupta)

5.8.1. Genetic variability in Tagetes erecta germplasm

A set of 50 germplasm accessions of *Tagetes erecta* (African marigold) was evaluated for genetic variation in their xanthophyll content and other morphological traits. Large variation was observed for morphological and chemical parameters. Based on Nei's similarity matrix, 50 germplasm accessions were classified into five major clusters. Largest cluster was cluster II with twenty five accessions with 90% similarity among the accessions. The second largest cluster was cluster V with twelve accessions with more than 95% similarity followed by cluster I containing nine and cluster IV with three accessions.

5.8.2. Chemotyping of Withania somnifera germplasm collected from different geographical locations of India

Germplasm accessions of *Withania somnifera* were characterized for root and chemical

characterisitcs. Root length among collection varied from 7 to 110 cm. Majority of the accessions (30 Nos.) were having a root length of 31-40 cm and one accession produced roots of less than 10cm length. Longest roots (110 cm) were recorded in CWS-98, collected from Bharatpur and minimum (7 cm) in CWS-67 from Krishnanagar (West Bengal).

SN	Secondary metabolites	Range (%)
1	Total alkaloid in roots	0.14-0.90
2	Withanoloids in roots	0.19-0.90
3	Withaferin A in roots	0.00-1.718
4	Withanoloide A in roots	0.00-1.574
5	1-2 Deoxywithastramonolide in roots	0.00-0.35
6	Total alkaloid in leaves	0.12-0.70
7	Withanoloids in leaves	0.10-0.72
8	Withaferin A in leaves	0.00-0.019
9	Withanoloide A in leaves	0.00-0.277
10	1-2 Deoxywithastramonolide in leaves	0.00-0.45

5.9. Optimization of seed rate for commercial cultivation of seed propagated Palmarosa (*Cymbopogon martinii*) crops (Birendra Kumar)

Germination percentage in various Palmarosa varieties ranged from 7.75-10.25 in Vaishnavi, 9.5-15.75 in Tripta, 25.50-34.25 in PRC-1, and 26.0-34.25 in Trishna, under different controlled constant (15^{O}C, 20^{O}C & 25^{O}C) and uncontrolled (minimum 27^{O}C – Maximum 39^{O}C) temperatures with 2nd day as first count and 5th day as final count under uncontrolled and 3-4th day as first count and 6-7th day as final count under controlled constant temperature.

5.10. Molecular marker development and genetic cataloguing for building up of core collection in *Withania* (Tripta Jhang)

Total 72EST –SSR markers in *Withania* have been developed out of which 24 were validated. Besides, a set of 59 promising chemotypes and morphotypes of *Withania somnifera* selected from the CIMAP germplasm repository based on 24 characters of phenome and 3 phytochemical markers (Withaferrin A, Withanolide A and 12–deoxywithastramonolide) were characterized for their molecular diversity on the basis of EST derived SSR, ISSR and Universal rice primers. Phylogentic analysis by DARwin 5.0 programme revealed 60 % genetic diversity present in the set of 59 accessions studied i.e. 41 tall, red berry Kashmiri type(Red); 12 short, yellow berry, Nagore type(Yellow); 5 yellow berry tall type(Green). One accession each from *Lycopersicum esculentum* and *Capsicum annuum* were screened to test cross-transferability of these markers.

6. Plant Biology
(Metabolic & Structural Biology, Plant Physiology, Taxonomy & Pharmacognosy)

Metabolic & Structural Biology

6.1. Metabolic clustering of a core collection of Ashwagandha (*Withania somnifera*) (R.S. Sangwan)

A core collection of 12 accessions/ experimental lines including discrete chemotypes of the plant was comparatively analyzed for their withanolide profiles *vis-a-vis* molecular marker aided genetic diversity and patterns of multiple molecular forms (isozymes) of certain broad function enzymes.

A comparison of phylogenetic trees developed based on the parameters of DNA markers, phytochemicals and isozymes, revealed them to be quite variable. The phytochemical pattern based phylogenetic relationship better matched that on the isozymic pattern basis, although the window of variation within the scale was obviously narrower in the latter case.

6.2. A novel β-glucosidase identified and characterized from *Andrographis paniculata* (R.S. Sangwan)

A gluconolactone inhibition insensitive β-glucosidase from *Andrographis paniculata* (Acanthaceae) leaves has been isolated, purified to homogeneity and characterized for its physico-kinetic properties. The enzyme has monomeric structure with native molecular weight of about 60 kDa. The pH optimum of the enzyme was acidic (5.5), as also its pI (4.0). The enzyme with meso-thermostability and high temperature optimum (55 ºC) for catalytic activity had an activation energy of 6.8 kCal.Mol^{-1}. The substrate saturation kinetics of the enzyme for pNPG revealed Michaelis-Menten constant (K_m) and catalytic efficiency (K_{cat}/K_m) as 0.25 mM and 52,400 $M^{-1}.s^{-1}$, respectively.

Substrate specificity of the enzyme was restricted to β-linked gluco-, manno- and fuco-conjugates. The gluconolactone inhibition insensitivity was evident from its very low inhibition at millimolar inhibitor concentrations (50% inhibition at 10 mM concentration).

6.3. Bioconversion of artemisinin to its non-peroxidic derivative de-oxyartemisinin through suspension cultures and enzymatic extracts of *Withania somnifera* Dunal (N.S. Sangwan)

Biotransformation of artemisinin was investigated using different cell suspension culture lines of *W. somnifera*. The cell lines exhibited potential to

transform artemisinin to its non-peroxidic analogue, de-oxyartemisinin, by losing the peroxo bridge of artemisinin. For the bioconversion of artemisinin, two cell lines (L1, and L2) of *W. somnifera* were selected, both of which converted artemisinin to de-oxyartemisinin. Different types of cell culture lines of *W. somnifera* led to the diverse profile of product formation. Single dose feeding of artemisinin to the cell cultures of *W. somnifera* resulted in production of three types of different compounds as product. In order to explore the ability of cells to transform artemisinin into its derivative compounds, different time-course incubation was carried out for maximum conversion.

6.4. QSAR models for biological activities of phytochemicals (Feroz Khan)

Anti-malarial, anti-inflammatory, immuno-modulatory QSAR models have been developed for artemisinin and its derivatives, artemisinic acid, ursolic acid, coumarinolignoids and betulinic acid.

6.5. QSAR model for anti-cancer activity of indanone derivatives (Feroz Khan)

The results indicated that despite very similar geometrical structures of some of the compounds large differences in the locations and the relative energies of HOMO and LUMO were observed.

6.6. Comparative genomics approach for drug targets identification (Feroz Khan)

Search of similarity of *Plasmodium falciparum* genome/proteome with the human counterpart has been performed through comparative genomics approach. Of the 5269 *P. falciparum* genes scanned against human genome, 4518 showed similarity and of the remaining 751 unique genes, 141, 241 and 368 genes were known, unknown and hypothetical, respectively.

6.7. Identification of novel steroidal anti-estrogenic targets through rational drug designing approach (Abha Meena)

Ninetysix molecules were designed, 40 of which violated Lipinski's *Rule of Five*. Remaining 56 molecules when tested for their docking with estrogen related receptors like ER α, ER β, ER γ, and ER receptor displayed significant affinities for ER β.

Plant Physiology

6.8. Dose and duration dependent effect of elicitation by Cadmium (Cd) on post harvest recovery of total alkaloids from leaves and roots of *Catharanthus roseus* (N.K. Srivastava)

Cd brings about different degrees of response on recovery of alkaloids from leaves and roots. However, a dose of 20mM Cd uniformly positively elicited alkaloid recovery when treated for 24h duration.

6.9. Post harvest studies during leaf processing on the recovery of total alkaloids in *Catharanthus roseus* (N.K. Srivastava)

Post harvest drying of leaves at 40^{O}C for 12, 24 & 48h uniformly resulted in higher recovery of total leaf alkaloids, although Sun drying of the leaves for 48h also resulted in higher alkaloid recovery.

Taxonomy & Pharmacognosy

6.10. Seasonal variation of guggulsterone in *Commiphora wightii* plants (G.D. Bagchi, R.K. Verma)

Guggulsterone content was estimated in its oleo-gum resin throughout the year to determind its suitability for cultivation at sub-tropical conditions. Study showed that at this conditions, total guggulsterone content ranges between 0.50-2.36% which is almost at par with the naturally growing desert plants, while guggulsterone-E and -Z contents in oleo-gum resin range between 0.01-0.33% and 0.1-2.27% respectively. This shows that at subtropical conditions, guggulsterone-Z content increases considerably than the naturally growing plants. High total guggulsterone and guggulsterone-Z contents were particularly observed during spring and autumn seasons in contrast to the plants growing in natural conditions, where plants are tapped for higher yield of oleo-gum resin during winter season. Increase in guggulsterone-Z content in oleo-gum resin increases its value since guggulsterone-Z has been reported to possess better activity than it's E-isomer.

6.11. A new temperate Artemisia species (*Artemisia myriantha* var. *pleiocephala*), domesticated at sub-tropical conditions, was evaluated for commercial cultivation (G.D. Bagchi, S.C. Singh)

Artemisia myriantha var. *pleiocephaia* is a rare new variety, collected from Garhwal Himalayas, was evaluated at sub-tropical conditions for commerical cultivation. Essential oils of both natural and domesticated sub-tropical plants were analyzed and studied for the first time. Considerable changes were observed in theoil constituents after domesticiation. Oil of natural plants mailny contained chrysanthenone (7.3%) followed by o-cardinene (5.7%) and 1,8, cineole (5.3%) during flowering. After domestication at sub-tropical conditions, although the major oil

constituent remained chrysanthenone but its quantity increased considerably during flowering (15-29%) along with an important constituent limonene (6-15%). However, during vegetative stage, commercially important camphor (74.9%) was its major constituent.

6.12. Survey and inventorization of medicinal and aromatic plants resources of Madhya Pradesh (S.P. Jain, J. Singh, S.C. Singh)

Survey of Chhindwara and Seoni districts was conducted and an inventory of 125 MAPs from Chhindwara and129 medicinal plants from Seoni districts were prepared. Ethno-medico-botanical survey of Seoni district and Pench National Park revealed folklore information on about 45 plants used in the treatment of various diseases by the local tribal /inhabitant were collected, collated and compiled. Some of the important medicinal plants and their uses are as follows:

Anogeissus latifolia (stem bark, root bark) hydrocele; *Aristolochia indica* (root) snakebite; *Cassia fistula* (fruit pulp) scorpion sting; *Dioscorea hispida* (rhizome and gum) contraceptive; *Cissampelos pareira* (root) ostalagia and snakebite; *Gardenia turgida* (root) tumor; *Hibscus rosa-sinensis* (leaves) spermatorrhoea; *Leea asiatica* (root) snakebite; *Oroxylum indicum* (fruits) paralysis; *Smilax zeylanica* (root) with *Terminalia bellirica* (stem bark) in bone fracture; *Soymida febrifuga* (stem bark) malarial fever; *Wrightia tinctoria* (stem bark) malarial fever; *Ventilago denticulata* (bark, root) malarial fever.

6.13. Collection of herbarium and crude drug specimens

Over 560 MAPs herbarium specimens were collected, processed and deposited in the MAPs herbarium of CIMAP. Twenty crude drug samples were added in the crude drug repository

6.14. Supply of plant species (S.C. Singh)

Plant species were collected and their dried parts were provided to different divisions of the CIMAP for R&D work related to Major Lab Projects and Network Projects of CSIR.

7. Research Centre, Bangalore

7.1. Generation of genetic variability through somaclonal variation and induced *in vitro* mutagenesis for improvement of rose-scented geranium, an exclusively vegetatively propagated aromatic plant (R.N. Kulkarni)

Fifty-three potentially useful somaclones selected from SC_2/VM_2 generation, from 262 somaclones that regenerated after with or without *in vitro* mutagenesis with NMU, in varieties Bourbon and Narmada, were evaluated in SC_3/VM_3 for their true breeding behaviour. These 53 clones consisted of about 10 somaclones in each of the two varieties Bourbon and Narmada, selected for herb yield and oil content. Three somaclones (two from Bourbon and one from Narmada) had higher contents of isomenthone while two from Bourbon and nine from Narmada were selected for higher content of 6, 9-guaidiene. Of the somaclones tested, three selected for oil content did not breed true. No somaclone showed improved quality.

7.2. Development of a high leaf and root alkaloid content variety of periwinkle. (R.N. Kulkarni, K.V. Syamasundar, K.V.N. Sathya Srinivas)

One of the mutants (No. 7) which had higher content of total and specific alkaloids in leaves and roots than parental variety Dhawal was re-evaluated. It showed higher content of total alkaloids in leaves (1.53%) and in roots (2.67%) than variety Dhawal (1.31 and 2.26% respectively). The contents of vinblastine, vincristine and ajmalicine in the mutant were also found to be more than the parental variety.

7.3. Processing of medicinal and aromatic plants for isolation of lead drug molecules (K.V.S. Syamasunder, K.V.N. Satya Srinivas)

Bioactive marker compounds Withaferin A from *Withania somnifera*, andrographolide from *Andrographis paniculata,* aloe emodin and aloin from *Aloe vera* and vindoline from *Catharanthus roseus* were isolated in pure form for use as reference compounds for the use in HPLC anlaysis. The structures of these compounds were confirmed by NMR spectral studies. A bench scale processing method for simultaneous extraction of colchicine and colchicoside from *Gloriosa superba* was standardized and the biomarker compounds were isolated at 3 kg plant material level. (94-95% purity, 84% yield). Enrichment of forskolin content in the roots of Coleus was achieved by conversion of isoforskolin and 6, 7-deacetyl forskolin to forskolin by chemical reaction.

8. Research Centre, Hyderabad

8.1. Biomass yield, essential oil content and composition changes during leaf ontogeny of palmarosa (B.R.R. Rao)

A field experiment conducted during rainy season to investigate the influence of leaf ontogeny on palmarosa revealed that leaf biomass yield increased with leaf age up to 8th leaf (from 29 to 513 mg/leaf). Young and expanding leaves produced more essential oil (1.1-1.6%) than mature, old leaves (0.8-0.99%). The gearniol content increased with leaf age up to 7th leaf (from 85.2 to 92.2%). Mature, older leaves contained higher geraniol concentration (>92%) than young, expanding leaves.

8.2. Agrotechnology development for MAPs for SAT (semi-arid tropics) under resource constraint conditions (K.P. Sastry)

8.2.1. Integrated nutrient management in Cassia angustifolia

An experiment was conducted during February to July,2010 to study the influence of different combinations of organic and inorganic nutrients. It is observed that application of organic : inorganic nutrients in the ratio 60:40 resulted in higher leaf yield.

8.2.2. Influence of organic nutrients in vetiver

In an experiment conducted during May,2009 to March,2010 to study the influence of different doses of vermicompost on the root and essential oil yield in vetiver it was observed that application of 3 tons of vermicompost resulted in higher root yield.

8.2.3. Influence of different combinations of coir peat, gypsum and vermicompost on the herb and oil yield of lemongrass

In an experiment conducted during May,2008 to March,2010 to study the influence of different combinations of coir peat, gypsum and vermicompost on the herb and oil yield of lemongrass it was observed that application of 3 tons of vermicompost one ton of gypsum in combination with 100 g of coir peat /pit resulted in higher herb and essential oil yield of lemongrass planted in a pit system of planting.

8.3. Characterization of different morphotypes for morphological, agronomical and chemical traits in Ashwagandha (R. Ramesh Kumar)

Agronomic and chemical performance of 9 different morphotypes identified in the population of Poshita revealed that WSP-10 (8.27 g/plant) and WSP-3 (7.49 g/plant) are the highest dry root yielding genotypes and the dry root yield were on par with each other. WSP-3 with high root yield and better root physical quality (starch-fiber ratio, 0.42) was identified to be superior morphotype followed by WSP-10.

Yield and root quality evaluation of 7 different Nagore morphotypes showed that WSN-4 with high root yield (1.23 g/plant) and high starch-fiber ratio can be considered promising.

Estimation of genetic parameters and yield association measures indicated that component traits – root diameter, root length, number of secondary roots/plant and leaf area to be reliable traits for indirect selection for higher root yield in Ashwagandha.

Starch content was found to be negatively correlated with total alkaloid content and positively correlated with fiber content and starch-fiber ratio. Starch-fiber ratio was found to be positively correlated with starch content and negatively correlated with crude fiber, which shows that for better root physical quality high starch and low fiber is essential.

Dry root yield showed relatively high positive genetic correlation with crude fiber in comparison to starch content, indicating that the fiber component in the roots are more important for root weight. The starch-fiber ratio (root physical quality parameter) and root yield were found to be negatively correlated. Statistical studies on influence of plant morphological traits on root physical quality *i.e.* Starch-Fiber Ratio revealed that morphotypes with wavy leaf margin, faint leaf veins and yellow orange/ orange berry colour had significantly high starch-fiber ratio.

8.4. Studies on dry root yield and root physical quality parameters at different growth intervals in Ashwagandha (R. Ramesh Kumar)

Dry root yield increased with the crop duration (45 - 150 DAS) from 0.05 to 4.23 g/plant in Poshita and from 0.08 to 2.23 g/ plant in Nagore. Thereafter, root yield significantly declined and registered 42% and 31% reduction in Poshita and Nagore, respectively at 165 DAS indicating 150 days to be the ideal stage of harvest. CIMAP's variety Poshita gave higher root yield over local cultivar Nagore.

The starch-fiber ratio was high (1.32) at early stage of the crop (45 DAS), gradually declined, moderately increased at 120 DAS (0.51) and again declined with crop duration. The trend was similar

in both the varieties. Nagore (0.72) had higher starch-fiber ratio than Poshita (0.56).

Starch content accumulation pattern in Ashwagandha roots was similar to starch-fiber ratio. The starch content was high at 45 DAS (17.44 %), decreased gradually up to 105 DAS (11.11%), and significantly increased at 120 DAS (15.30%). After 120 DAS the starch content declined with the age of the crop (Figure: 3). Poshita had significantly higher starch content (16.14%) than Nagore (12.53%). The re-accumulation of starch content was high at 120 DAS in Poshita (16.39%), whereas in Nagore maximum re-accumulation was at 135 DAS (14.35%).

Crude fiber content in the roots increased gradually with crop growth and reached maximum at 165 DAS (35.65%) (Figure: 4). Poshita had significantly higher fiber content (30.49%) than Nagore (22.44%). The high fiber content in Poshita led to low starch-fiber ratio leading to poor physical quality. The accumulation of fiber content in roots of Poshita was significant up to 60 DAS, whereas in Nagore significant increase of root fiber was up to 135 DAS.

9. Research Centre, Pantnagar & Purara

9.1. Chemical investigation of medicinal & aromatic plants for new source of aroma chemicals/ essential oils (R.C. Padalia, R.S. Verma, V. Sundaresan)

9.1.1. *Chemical Diversity in the genus Alpinia (Zingiberaceae): Comparative composition of four Alpinia species grown in northern India*

The essential oil compositions of different plant parts viz. leaves, flowers and rhizomes of *Alpinia galanga* (L.) Willd., *Alpinia calcarata* Rosc., *Alpinia speciosa* K. Schum., and *Alpinia allughas* Rosc. were examined and compared. The clustering pattern revealed significant similarity in root oils composition of *A. galanga* (sub tropical) with *A. calcarata* and *A. speciosa*; all of which were dominated by fenchane skeletons. On the basis of the present findings as well as the findings from previous studies it is reasonable to state that the fenchyl derivatives could be used as chemotaxonomic markers of the genus *Alpinia*, at least three species viz. *A. galanga*, *A. calcarata* and *A. speciosa* and pinene in *A. allughas*.

9.1.2. *Volatile constituents of three invasive weeds of Himalayan region*

The essential oil of *Lantana camara* L. was dominated by sesquiterpenoids (70.8%) represented by sesquiterpene hydrocarbons (68.7%) with germacrene D (27.9%), germacrene B (16.3%), -caryophyllene (9.6%), -selinene (6.2%), α-humulene (5.8%) as major constituents.

9.1.3. *Essential oil composition of two Plectranthus species from Uttarakhand*

The GC and GC-MS analysis showed the presence of 45 constituents constituting 91.3% and 93.6% of their oil composition. Sesquiterpene hydrocarbons viz. -caryophyllene (36.2%), germacrene D (25.2%), -humulene (6.6%) are the major constituents in *P. rugosus*. On the contrary, the essential oil obtained from *P. incanus* was dominated by monoterpenoids (74.4%) represented by piperitenone oxide (44.2%). terpinolene (14.5%) and piperitone (8.6%) as major constituents.

9.1.4. *Chemical evaluation and biological activity of Aromatic spices of Uttarakhand*

The volatile constituents extracted from some common aromatic spices viz. *Curcuma*, *Zingiber*, *Coriander*, *Cinnamomum*, *Murraya*, *Anethum* and *Foeniculum* etc. were studied by GC and GC-MS. The qualities of some of the oils with the marketed spice were evaluated and compared. Two different chemo-variants were noticed in *Cinnamomum* with eugenol and (E)-cinnamaldehyde as major constituents. The leaf and seed oil of *Coriander* have been compared with (*E*)-2-dodecenal and linalool as major constituents. Sabinene and carvone were reported as the major constituents in *Murraya* and *Anethum*. The detailed analysis and biological activity evaluation is in progress.

9.2. Phytochemical investigation of lesser known MAPs of North India (R.S. Verma, R.C. Padalia)

9.2.1. *Chemical diversity in Indian Oregano (Origanum vulgare L.)*

The yield of essential oil of *Origanum vulgare* L., populations collected from different locations of Uttarakhand were found to vary from 0.07% to 0.80% in different populations. Based on the marker constituents, six chemo-variants were noticed in different populations of *O. vulgare* L. with significant variations in their terpenoid profile. All seventeen populations could be grouped in six clusters, two with solitary populations; two with double; one with triple and last one having eight populations.

9.2.2. Comparative essential oil composition of different vegetative parts of Hedychium spicatum Smith

A total of 39 constituents accounting for 78.7 % - 96.4 % of the oils were identified. The roots and rhizomes essential oils were marked by the presence of high amount of oxygenated monoterpenoids (60.9% and 65.9%, respectively). The most abundant oxygenated monoterpenoid of these oils was 1,8 cineole (48.7% and 64.0%, respectively). However, leaf oils obtained from two distinct locations viz. 'Song' and 'Bhowali' was rich in monoterpene hydrocarbons (β-pinene 40.9%, α-pinene 9.6%) and oxygenated monoterpenoids (1,8 cineole 34.2%), respectively.

9.2.3. Essential oil composition of Aralia cachemirica from Uttarakhand

A total of 25 constituents, representing 91.36% in leaf essential oil and 26 components, representing 96.54% in root essential oil were identified. Both leaf and root oils were characterized by the presence of α-pinene (41.02%, 52.72%) and β-pinene (35.07%, 13.61%) as the major constituents.

9.2.4. Volatile terpenoid composition of Coleus aromaticus from Uttarakhand

A total of 44 constituents representing 85.98% - 98.68% of the oil composition were identified. Major components of these oils were thymol (57.74% - 66.40%), γ-terpinene (5.81% - 11.74%), *p*-cymene (4.07% - 14.19%), β-caryophyllene (2.61% - 3.59%), caryophyllene oxide (1.32% - 1.53%) and 1-octen-3-ol (1.03% - 1.77%).

9.2.5. Aroma profile of Majorana hortensis as influenced by harvesting height

An experiment was conducted to observe the influence of harvest cut height on essential oil yield and composition of sweet marjoram (*Majorana hortensis* Moench) cultivated in Kumaon region of western Himalaya. Three different cuts viz. top 1/3; top 2/3 and whole plant were carried out in respective plants. Essential oil yield was highest in the top-1/3 (0.47%) followed top-2/3 (0.38%) and whole herb (0.33%). A total of 35 constituents representing 94.56% - 98.31% of the total oils were identified by GC and GC-MS.

9.3. Comparative chemical composition of decanted and recovered volatile oils of Cymbopogon distans (R.S. Verma & R.C. Padalia)

The freshly harvested herb of *Cymbopogon distans* was hydro-steam distilled in field distillation unit. The 'primary' essential oil was decanted from receiver after completion of distillation process and 'secondary' oil was recovered from hydrosol (distillate water) with the help of organic solvent. These volatiles fractions were analyzed by gas chromatographic techniques. Monoterpene hydrocarbons and esters were found to be higher in 'primary' oil, while monoterpene alcohols were recorded higher in 'secondary' oil.

9.4. Investigation of chemotypic variation in *Ocimum* spp. grown for medico-religious purposes in Kumaon Himalaya (R.S. Verma & R.C. Padalia)

Ocimum species has been collected from Takula (Almora), Garur (Bageshwar), Vajulla (Bageshwar), forest nursery (Baijnath), Kausani (Almora) and Dehradun. The *Ocimum* species collected from Dehradun was rich in methyl chavicol (64.51%) and linalool (27.07%). The major components of the *Ocimum* species collected from forest nursery (Baijnath) were linalool (74.26%), eugenol (4.77%), germacrene D (4.38%) and -terpinol (3.32%). The *Ocimum* species collected from Garur (Bageshwar) was found to be rich in eugenol (75.90%) and β-elemene (18.02%).

10. Information and Project Management
(Information and Communication Technology, Bio-statistics, Project Monitoring)

10.1. Remote sensing and satellite imagery assessment of mint crop coverage at village level (LISS-IV) (Manoj Semwal, Rakesh Tiwari)

Base GIS data layers have been prepared for the study area from remote sensing data; reconnaissance surveys have been conducted for pre and post field data collection and classification studies have been done. Maps have been prepared for mentha acerage estimation using remote sensing classification.

10.2. Leveraging ICT to Rural Development Program – eAgro Advisory services (Alok Kalra, Rakesh Tiwari, Manoj Semwal, Amit Mohan, Sanjay Singh)

Under Rural Development program, a digital database of farmers for providing eAgro advisory services through SMS has been developed. The application is undergoing its beta testing. Bilingual (Hindi – English) eAgro portal for MAPs is being

created to supplemnt the initivative for disseminating the information on the varieties, cultivation, processing and crop protection of medicinal and aromatic plants.

10.3. Leverating ICT technologies for digitization of MAPs herbarium and virtual conservation of MAPs biodiversity. (Rakesh Tiwari, Manoj Semwal, Amit Mohan, Sanjay Singh)

Application for the digitization and data mining to store and retrieve the virtual herbarium of MAPs has been developed. The application is undergoing testing and data entry phase.

10.4. Information and communication technology interventions for science and technology support (Rakesh Tiwari, Manoj Semwal, Amit Mohan, Sanjay Singh, Jitendra Verma)

Online workflow application for in house project submission was implemneted. Web based application for PME indent tracking and web portal and database for e-management of user registration, abstract submission and accommodation arrangements for the international symposium on aromatic and medicinal plants was done.

10.5. Comprehensive Traditional Knowledge and Digital Library (Rakesh Tiwari, G.D. Bagchi, Manoj Semwal, Sanjay Singh)

Data collection, validation and entry of pharmo-cognostical, chemical and bibliographic data on 500 selected medicinal plants was done.

10.6. Upgradation of ICT Backbone and setting up of server farm (Rakesh Tiwari, Manoj Semwal, Amit Mohan, Sanjay Singh, Jitendra Verma)

The ICT core infrastructure was upgraded with a) installation of Layer III Core switch b) installlation of Layer II 10 Gig enabled Edge swithces and upgradation of Internet bandwidth from 3 Mbps to 4.5 Mbps. A new server farm set up has been created at a relocated central position with inrow dedicated cooling and stabilised power supply. The efforts are in direction of making CIMAP ready for National Knowledge Network (NKN).

10.7. Facilitating computational Support (H.P. Singh)

To provide computational support to our scientist in their experimental work during the year a new software-Agrobase Gen II of Agronomix was added and more than twenty scientists availed the facility and got analysed their data in various experimental designs.

11. Technology and Business Development

Medicinal and aromatic plants (MAPs) related technology transfer and business development (A.K. Singh, V.K.S. Tomar, Alok Krishna, R.P. Bansal, Sanjay Kumar, Ram Suresh, Dinesh Kumar, R.P. Yadav, A.P. Dhiman, P.P. Singh, Indra Rautela, P.N. Gautam, Man Mohan, SJ Sinha, Rajesh Kumar, R.D. Ram)

Training programs, exhibition and surveys conducted under technology and business development programme are tabulated below:

11.1. Training programmes on cultivation and processing of economically viable medicinal and aromatic plants

S.N.	Place	Dates	No. of participants	Sponsoring agency
1	Kanpur	7-9 July, 2010	25	SIDBI
2	Lucknow	8-11 March, 2010	97	SIDBI
3	Lucknow	21-23 Dec., 2009	19	UP Sainik Kalyan Board
4	Lucknow	18-21 Jan., 2010	29	UP DASP
5	Lucknow	17-20 March, 2010	30	UPDASP

11.2. Participation in exhibitions / fairs / expositions

S.N.	Title	Date	Location
1.	ASSOCHAM Herbal – Expo	20-21, June, 2009	Pragati Maidan, New Delhi
2.	Herbal – Expo	13-16, August, 2009	Singapore
3.	Kisan Mela	3-6, October, 2009	CSA University, Kanpur
4.	Nutraceutical Summit and Expo	28-30, October, 2009	Hotel 'The Lalit' New Delhi
5.	Exhibition 'Indian Science Congress-2010	3-7 January, 2010	Trivandrum
6.	Exhibition in Golden Jubilee Kisan Mela	31 January, 2010	CIMAP,Lucknow
7.	Science –Expo	28 Jan.to1 Feb., 2010	Regional Science Centre , Lucknow
8.	Flower show	20-21 Feburary, 2010	Governor House, Lucknow
9.	Exhibition in International Symposium- AROMED	21-24 February, 2010	Indira Gandhi Pratisthan, Lucknow
10.	Handicraft Exhibition and Expo	8-10 March, 2010	Sangeet Natak Akadami, Lucknow
11.	Innovation –Expo and Exhibition	13 and 14 March, 2010	Rashtrapati Bhawan, New Delhi

11.3. Surveys conducted

Area	Date	Technology intervention required / outcome
Talbehat / Balabehat, Lalitpur, Uttar Pradesh	28/08/2009	The crops like Tulsi and Aswagandha suitable for rainfed areas can be introduced in the farmers' fields. Some of the hilly part of Balabehat can be suitable for geranium and rose cultivation.
Chirgaon/Bauasagar/ Moth, Jhansi, Uttar Pradesh	18-20/09/2009	Two self help groups (SHGs) were identified for taking up lemongrass demonstrations. Nineteen farmers were encouraged to take up demonstration in the area of 200 Sq.m. each. Out of nineteen farmers, fifteen farmers were trained at CIMAP Lucknow on 1st February, 2010.
Thanaitpur,Barabanki,Uttar Pradesh	05/01/2010	There were 19 farmers growing vetiver var.KS-1 in the area of about 20 acres. The production of herbage in one acre was found to be about 12 quintals of fresh roots.The farmers requested for a distillation facility to facilitate the distillation of the vetiver roots produced by them.
Raipur, Chhattisgarh	21-24/01/,2010	On the invitation of Chhattisgarh State Medicinal Plants Board (CGSMPB), a visit to the various places in Raipur was undertaken to explore the possibility of setting up point of presence (PoP) there with the funding support of the state government. Looking at the immense possibility of promoting the cultivation of medicinal and aromatic plants, the CGSMPB requested CIMAP to submit the project in this regard. CIMAP submitted the project on 17th March, 2010

11.4. CIMAP Kisan Mela-2010

CIMAP Golden Jubilee Kisan Mela was organised on 31st January 2010 which was attended by about 1500 participants hailing from different states such as UP, MP, Maharashtra, Bihar, Haryana, Punjab, Chhatisgarh and Andhra Pradesh. The Kisan Mela was inaugurated by His Excellency Governor of Uttar Pradesh Shri BL Joshi. The Governor also released two improved varieties of aromatic plants - 'CIMAP Saraya' of Mentha and 'CIMAP Harsha' of palmarosa developed by CIMAP scientists.

Training programmes conducted under Rural Development Programme (RSP 006) in various parts of India

Title of the program	Dates		Location	Resource Persons/Centre
	From	To		
Cultivation and processing of MAPs	21 July 2009	23 July 2009	Ranchi, Jharkhand	V.K.S. Tomar, Ashok K. Singh, H.P. Singh, Jamil Ahmad, S.P. Singh, Alok Kalra
Cultivation and processing of MAPs	4 Nov. 2009	6 Nov. 2009	Bhubaneswar, Orissa	V.K.S. Tomar, Ashok K. Singh, H.P. Singh, Jamil Ahmad, S.P. Singh, Saudan Singh, Alok Kalra
Cultivation and processing of MAPs	3Feb. 2010	5 Feb. 2010	Raipur, Chattisgarh	V.K.S. Tomar, Ashok K. Singh, Jamil Ahmad, S.P. Singh, Alok Kalra
Cultivation and processing of MAPs	16 Feb. 2010	18 Feb. 2010	Purnea, Bihar	V.K.S. Tomar, Ashok K. Singh, Jamil Ahmad, Saudan Singh, R.K. Lal
One day Awareness Programme on MAPs	29 Dec. 2010	29 Dec. 2010	Mau, Uttar Pradesh	Ashok K. Singh, H.P. Singh, V.K.S. Tomar
One day Awareness Programme on MAPs	30Dec. 2010	30 Dec. 2010	Azamgarh, Uttar Pradesh	V.K.S. Tomar, Ashok K. Singh, H.P. Singh
One day Awareness Programme on MAPs	31Dec. 2010	31 Dec. 2010	Sultanpur, Uttar Pradesh	V.K.S. Tomar, Ashok K. Singh, H.P. Singh
One day Awareness Programme on MAPs	13 Feb. 2010	13 Feb. 2010	Bihar Shareif, Bihar	V.K.S. Tomar, Ashok K. Singh, H.P. Singh
One day Awareness Programme on MAPs	14 Feb. 2010	14 Feb. 2010	Vaishali, Bihar	V.K.S. Tomar, Ashok K. Singh, H.P. Singh
One day Awareness Programme on MAPs	19 Feb. 2010	19 Feb. 2010	Bihariganj, Bihar	V.K.S. Tomar, H.P. Singh
One day Awareness Programme on MAPs	4 Aug. 2009	4 Aug. 2009	Madurai, Tamilnadu	CIMAP, Bangalore
One day Awareness Programme on MAPs	5 Aug. 2009	5 Aug. 2009	Tirunelvelli, Tamilnadu	CIMAP, Bangalore
One day Awareness Programme on MAPs	6 Aug. 2009	6 Aug. 2009	Kanyakumari, Tamilnadu	CIMAP, Bangalore
One day Awareness Programme on MAPs	18 Aug. 2009	18 Aug. 2009	Coonoor, Tamilnadu	CIMAP, Bangalore
One day Awareness Programme on MAPs	19 Aug. 2009	19 Aug. 2009	Chamarajanagar, Karnataka	CIMAP, Bangalore
Cultivation of Medicinal Plants	03 June 2009	03 June 2009	Kalwakurthy, Mahaboobnagar district, AP	B.R. Rao, K.P. Sastry
Cultivation of Lemongrass	20 Aug 2009	20 Aug. 2009	Kolaput, Arakuvalley, Visakhapatnam district, AP	K.P. Sastry
Marketing of Lemongrass	21 Aug 2009	21 Aug. 2009	Kolaput, Arakuvalley, Visakhapatnam district, AP	K.P. Sastry
Marketing of Ashwagandha	16 Jan. 2010	16 Jan. 2010	Gunthakal, Anathapur district, AP	K.P. Sastry
Marketing of Ashwagandha	17 Jan. 2010	17 Jan. 2010	Emmiganoor, Kurnool district, AP	K.P.Sastry
Cultivation of *Catharanthus*	25 Jan. 2010	25 Jan. 2010	Virudhunagar, Tamil Nadu	K.P.Sastry, V. Sundaresan, S. Bhaskaran
Cultivation of Senna	26 Jan. 2010	26 Jan. 2010	Puliyampatti Tuticorin district, Tamil Nadu	K.P.Sastry, V. Sundresan, T.N.Parameswaran, C.T. Gopinath, S. Bhaskaran

Title of the program	Dates		Location	Resource Persons/Centre
	From	To		
Cultivation practice, improved distillation methods and recycling of agri wastes	21 May 2009	21 May 2009	Uttara Koppa, Kolegeri, Kachhodi, Bhatkal Taluk, Karnataka	CIMAP Bangalore
Demonstration of land preparation and planting methods in khus	6 July 2009	9 July 2009	Uttara Koppa, Kolegeri, Kachhodi, Bhatkal Taluk, Karnataka	CIMAP Bangalore
Vermicompost technology	23 Sep. 2009	24 Sep. 2009	Uttara Koppa, Kolegeri, Kachhodi, Bhatkal Taluk Karnataka	CIMAP Bangalore
Disease management	21 Oct. 2009	23 Oct. 2009	Uttara Koppa, Kolegeri, Kachhodi, Bhatkal Taluk Karnataka	CIMAP Bangalore
Demonstration of activation of vermicompost pits	29 Nov. 2009	30 Nov. 2009	Uttara Koppa, Kolegeri, Kachhodi, Bhatkal Taluk Karnataka	CIMAP Bangalore
Soil conservation practices	2 Feb. 2010	3 Feb. 2010	Uttara Koppa, Kolegeri, Kachhodi, Bhatkal Taluk Karnataka	CIMAP Bangalore
Demonstration of recycling of vetiver biomass to produce vermicompost	27 March 2010	28 March 2010	Uttara Koppa, Kolegeri, Kachhodi, Bhatkal Taluk Karnataka	CIMAP Bangalore
Cultivation practice, harvesting & post harvesting methods in khus	25th May 2009	25th May 2009	Arasinagere, Hulihonda, Mundgod Taluk, Karnataka	CIMAP Bangalore
Nursery preparation in patchouli	16 July 2009	16 July 2009	Arasinagere, Hulihonda, Ugginakere, Thattihalli, Mundgod Taluk, Karnataka	CIMAP Bangalore
Demonstration of land preparation in patchouli	7 Sep. 2009	7 Sep. 2009	Arasinagere, Hulihonda, Ugginakere, Thattihalli, Mundgod Taluk, Karnataka	CIMAP Bangalore
Scientific cropping method in patchouli	2 Oct. 2009	2 Oct. 2009	Hulihonda, Ugginakere, Mundgod Taluk Karnataka	CIMAP Bangalore
Demonstration of harvesting and post-harvesting method in patchouli	31 Oct. 2009	31 Oct. 2009	Hulihonda, Ugginakere, Mundgod Taluk Karnataka	CIMAP Bangalore
Disease management in patchouli	22 Dec. 2009	23 Dec. 2009	Hulihonda, Ugginakere, Mundgod Taluk Karnataka	CIMAP Bangalore
Vermicompost technology	4 Feb. 2010	4 Feb. 2010	Hulihonda, Ugginakere, Mundgod Taluk Karnataka	CIMAP Bangalore
Demonstration of activation of vermicompost pits	6 March 2010	6 March 2010	Hulihonda, Ugginakere, Mundgod Taluk Karnataka	CIMAP Bangalore

Publications

Research Papers

1. Ahmad A., Sahoo D., Ahmad J. and Tandon S. 2009. Asian Journal of Chemistry, 21: 4643-4647.
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Book Chapters

1. Khanuja S.P.S., Jhang T. and Shasany A.K. 2010. Medicinal and aromatic plants: A case example of evolving secondary metabolome and biochemical pathway diversity. In: Sharma VP (Ed.) Nature at work: Ongoing saga of evolution at play, pp. 355-368, Springer Verlag, USA.
2. Tiwari R. 2010. The trade in commercially important Cymbopogon oils. In: Essential oil - bearing grasses: the genus Cymbopogon, Medicinal and Aromatic Plants - Industrial Profiles v. 46, pp.151-165, CRC Press (Taylor and Francis), USA.

Plant varieties released

Plant Name	Variety Name	Release Date	Nodal Scientist	DUS Characters
Lemongrass *(Cymbopogon khasianus)*	CIMAP-Suwarna	22.9.2009	RK Lal	Open, erect plants, light green long leaves, white powdery accumulation on leaf base and stem, very tall, very vigorous and fast growth, high herb and essential oil yield with high citral content, suitable for rain-fed conditions. Oil yield 200 kg/ha with 80% citral content.
Palmarosa *(Cymbopogon martinii* Roxb. (Wats.) var Motia)	CIMAP - Harsh	22.12.2009	RK Lal	Tall, leaf dark green, early maturing, high yield of essential oil and geraniol, oil yield 240 Kg/ha with 89% geranial, suitable for drought prone areas.
Chamomile *(Chamomila recutita* (L.) Rauschert.	CIMAP - Sammohak	22.12.2009	RK Lal	Tall, semi close, dark blue oil, bright big flowers chemuzuline content 12.98 percent, high dry flower (7.5 ql/ha) and blue essential oil yield (6.63 kg/ha), medium maturity.
Menthol mint (*Mentha arvensis* L.)	CIMAP - Sarayu	30.1.2010	SP Singh	Habit – erect, Leaf colour – green, Flower colour – pinkish white, Leaf length – 6.0-7.5cm, Leaf width – 2.5-3.0cm, Sucker colour –white , Sucker thickness – medium, Biomass yield –27.4 tones/ha Oil content – 0.84-1.0%, Oil yield – 265-290kg/ha Menthol content – 79-80%

Patents filed

Title	Inventors	Country	Filing date
A synergistic formulation for the treatment of malaria	SPS Khanuja, Sangeeta Dhawan, Anirban Pal, DU Bawankule, RS Bhakuni, MP Darokar	India	22.6.2009
Synergistic oral formulation for the treatment of arthritis and related disorders	Dayanandan Mani, SPS Khanuja, DU Bawankule, Anirban Pal, NP Yadav Debabrata Chanda, Karuna Shanker, MP Darokar	India	22.6.2009
Antipsychotic agents and standardized antipsychotic fractions from *Rauwolfia tetraphylla* and process of their isolation	SK Srivastava, AK Agarwal, SC Singh VK Khanna, Janardan Singh, Chandeshwar Nath, MM Gupta, Shikha Gupta, RK Verma, Anirban Pal, DU Bawankule, Dharmendra Saikia AK Gupta, Anupam Maurya, SPS Khanuja	PCT	31.3.2010

Patents Granted

Title	Inventors	Country	Patent No.	Date granted
Process for the isolation of andrographolides from *Andrographis paniculata.*	DC Jain, Shiwani Singh, BR Tyagi, Sudeep Tandon	India	233817	9.4.2009
Antibiotic pharmaceutical composition with lysergol as bio-enhancer and method of treatment.	SPS Khanuja, JS Arya, SK Srivastava, AK Shasany, TRS Kumar, MP Darokar Sushil Kumar	India	233906	20.4.2009
Improved process for the isolation of 'calliterpenone' a natural plant growth promoting phyllocladane diterpenoid from genus *Callicarpa.*	AK Singh, SPS Khanuja, Sudeep Tandon, Alok Kalra, Deeptanjali Sahoo, AP Kahol, MM Gupta, RK Verma, AK Kukreja, Mansoor Alam, GD Bagchi, RP Bansal, MP Darokar, AK Gupta	US	7,527,814	5.5.2009
Single pot conversion of artemisinin into artesunic acid.	RS Bhakuni, Tarun Singh, AP Kahol, SPS Khanuja	India	234269	14.5.2009
Single pot conversion of artemisinin into arteether.	RS Bhakuni, Amit Tiwari, Tarun Singh, SPS Khanuja	India	234267	14.5.2009
Improved anti-dermatophytic preparation and use thereof.	SPS Khanuja, Pushplata Chaturvedi, AK Singh, AK Shasany, VK Agarwal, VK Gupta, SC Gupta, AK Tripathy, Anirban Pal, Dharmendra Saikia, MP Darokar, KK Agarwal, RP Bansal	India	234314	20.5.2009
Process for the preparation of arteethers from DHA.	AK Bhattacharya, DC Jain, SPS Khanuja	India	234334	25.5.2009
Herbal disinfectant compositions.	SPS Khanuja, MP Darokar, TRS Kumar, AK Shasany, KK Agarwal, Atique Ahmed, Pushplata Chaturvedi, V K Gupta, Alok Krishna, AK Singh, JR Bahl, RP Bansal, Dinesh Kumar	Japan	4316388	29.5.2009
Primers and a screening method for identification of artemisinin producing plants.	SPS Khanuja, Shilpi Paul, AK Shasany, MP Darokar, AK Shukla, MM Gupta, Anuruddha Kumar	India	234832	17.6.2009
A new nitrile glycoside useful as a bioenhancer of drugs and nutrients and the process of its isolation from *Moringa oleifera.*	SPS Khanuja, JS Arya, TRS Kumar, Dharmendra Saikia, HS Kaur, Monika Singh, SC Gupta, AK Shasany, MP Darokar, SK Srivastava, MM Gupta, SC Verma, Anirban Pal	India	234974	23.6.2009
Process for isolating brevifoliol.	SK Chattopadhyay, Sachin Srivastava, AS Negi, TRS Kumar, Ankur Garg, SPS Khanuja	India	235045	24.6.2009
A New and distinct somaclonal variety of rose scented geranium.	Gauri Saxena, Suchitra Banerjee, Laiq ur Rahman, M Gopal Rao, Srikant Sharma, SPS Khanuja, Sushil Kumar	US	PP20,149	7.7.2009
A process for artemisinin isolation from its natural source, *Artemisia annua* plant populations.	Sushil Kumar, SK Gupta, Digvijay Singh, MM Gupta, DC Jain, AP Kahol, SPS Khanuja, Govind Ram	Japan	4339699	10.7.2009
A novel plant growth promoting naphthophenone derivative from gallic acid.	SPS Khanuja, MP Darokar, Ankur Garg, Togarrati Padmapriya, AK Shasany, A S Negi, SK Chattopadhyay, Sachin Srivastava, AK Bhattacharya	China	200380110950.x	29.7.2009
An improved process for the production of brevifoliol from *Taxus wallichiana.*	SK Chattopadhyay, Sachin Srivastava, AS Negi, TRS Kumar, Ankur Garg, SPS Khanuja	US	7579491	25.8.2009

Title	Inventors	Country	Patent No.	Date granted
A process for one pot conversion of artemisinin into artesunic acid and 10-esters of DHA.	RS Bhakuni, Tarun Singh, AP Kahol, SPS Khanuja	Korea	10-0891641	1.9.2009
Use of cow urine distillate (go-mutra) as bioenhancer of anti-infective and anticancer agents.	SPS Khanuja, Sushil Kumar, AK Shasany, JS Arya, MP Darokar, Monika Singh, Prachi Sinha, Soumya Awasthi, SC Gupta, VK Gupta, MM Gupta, RK Verma, Sweta Agarwal, SB Mansinghka, SH Dawale	China	ZL200510114047.1	9.9.2009
A novel plant growth promoting naphthophenone derivative from gallic acid.	SPS Khanuja, MP Darokar, Ankur Garg, Togarrati Padmapriya, AK Shasany, A S Negi, SK Chattopadhyay, Sachin Srivastava, AK Bhattacharya	Japan	4382041	2.10.2009
Unique DNA marker for tagging high artemisinin yield in *Artemisia annua* and use of method to screen high yielding plants.	SPS Khanuja, Shilpi Paul, AK Shasany, MP Darokar, AK Shukla, MM Gupta, Anuruddha Kumar	Australia	2003290404	29.10.2009
A process for the preparation of 4-aryl-2-butanols from *Taxus wallichiana.*	SK Chattopadhyay, RP Sharma, Sushil Kumar	Germany	19937019	29.10.2009
A novel antifungal/ anticancer composition.	SPS Khanuja, TRS Kumar, VK Gupta, Preeti Chand, Ankur Garg, SK Srivastava, SC Verma, Dharmendra Saikia, MP Darokar, AK Shasany, Anirban Pal	India	238637	15.2.2010
An analgesic and refreshing herbal composition useful as dentrifrices.	AK Singh, RL Bindra, Rashmi Gupta, YN Shukla, Sushil Kumar	India	239740	31.03.2010

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Suresh Ram
Thul Sanjog Tarachand
Verma Ram Swaroop
Yadav Narayan Prasad

Group III
Agarwal VK
Ahmad Ateeque
Ahmad Jamil
Bhaskaran K
Bhukya Balakishan
Chand Sukhmal
Chandrashekar RS
Chauhan Amit
Dhiman AP
Gopal Krishna
Gopinath CT
Gupta Anju
Gupta Namita
Husain S Tahir

Khan AM
Krishna Vinay
Kumar Dushyant
Kumar A Niranjan
Kumar Dinesh
Kumar Sushil
Kushwaha SK
Maurya Anil Kumar
Mirza Mehdi
Mohan Amit
Patel RP
Prajapati Manju
Prakash Shiv
Pravesh Ram
Rajput DK
Ram Dasha
Ram Govind
Ravindra NS
Saini RK
Sattar Abdul
Singh AK
Singh Anand
Singh Anil Kumar
Singh HP
Singh Kundan
Singh Man
Singh PP
Singh Prem
Singh Rakshpal
Singh Sanjay
Singh SC
Singh UB
Singh Vikram
Sisodia Brijesh Singh
Srivastava AK
Srivastava SK
Tripathi RS
Verma RK
Yadav Anju Kumari
Zaim Mohd

Group-II
Baig Salim
Behari Shyam
Bhaskar E
Chandra Phool
Chandra Ram
Dubey Basant Kumar
Gautam PN
Gupta JP
Khaliq Abdul
Khan MR
Kidwai AR
Kumar Pramod
Kumar Raghubind
Kumar Siva DC
Kumar Vijay
Kumar Vinod
Kumari Raj
Lakhan Ram
Massey Joseph M
Meena DP Singh
Pandey OP
Pathak HN
Prasad Durga
Prasad Pawan
Rakhwal VP
Ram Gopal
Ram Raja
Ram RD
Rao Y Shiva
Rautela IV
Rawat RL
Reddy HR
Selveraj S
Sharda S
Sharma Hemraj
Sharma SK
Shukla Pankaj
Shukla VK
Siddiqui FA
Singh JP
Singh Rana Pratap
Singh Sulakhan
SK Pandey
Srivastava AK
Subramani SS
Suresh N
Swamy VVS
Tiwari PK
Verma Jitendra Kumar
Verma Vijay Kumar
Wasnik Kundan Narayan
Yadav Ajai Kumar
Zaidi SAI

Group-1
Ali Munawar
Ali Qasim
Arya Manish
Bisht Bharat Singh
Chand Lal
Chandra Subash
Devi Samundra
Huda Nurul
Khan Mohd Amin
Kumar Subhash
Mabood Abdul
Mohan Man
Nath Surendra
Navi Mohd
Pal Hari
Prakash Om
Prakash Om
Prasad
Prasad Mahadeo
Prasad Mahesh
Rajanna
Ram Dhani
Rao G Appa
Sabhajit
Semwal Pushpa
Singh VK
Ujagir Ram
Verma RC
Verma RK

ADMINISTRATIVE STAFF

GROUP-A
Chongloi Henkholien
Kumar Mohinder
Panicker OO
Rawat US

Group-B (Gazetted)
Dixit IB
Kumar Sanjay
Kushwaha SM
Mishra Kanak Lata
Prasad Neelambuj Shankar

Ram Hare
Sharma KP
Vaish Manju Rani
Yohannan Baby

Group-B (Non-Gazetted)
Abraham TV
Ali KS
Bhartey Vijay Kumar
Chandra Harish
Chaturvedi PK
Dubey KP
Hafeez Farzana
Kandpal CS
Khan Shamiullah
Kirmani Sufia
Kishore Kaushal
Kumar Anil
Kumar Pankaj
Kumar Pradeep
Kumar Rajesh
Kumar Shiv
Lal Bhikhu
Lal Kanhaiya
Lal Sant
Manjunatha S
Mishra US
Nagarathnamma KC
Nasir Parvez
Nath Prem
Prakash Ravi
Prasad Muneshwar
Rao K Viswanatha
Sabitha P
Sahu AL
Seth KS
Shah SB
Sharda Gaitry
Sharma AK
Sharma Nisha
Shivakant
Shukla Manoj Swaroop
Shukla Siddharth
Singh OP
Singh SP
Sinha Srikar Ji
Srinivas P
Srivastava SK
Thomas Kanchan
Thomas KG
Verma Ajeet
Verma Preeti
Warsi SA
Yadav Sheela

Group C (Non –technical)
Khanna Rohit
Pant CS
Singh Yograj
Srivastava AK
Tanwar Sangeeta

Drivers
Kuamr Rajesh
Singh Sanjay
Verma Ajay Kumar
Verma Chandrapal
Yadav Sarwesh
Canteen Staff
Mukerjee Victor
Shamim Mohd
Thankappan Y

Group-D (Non-technical)
Algarswamy R
Ansari Nargis Sufia
Balmiki Dharam Pal
Bano Zarina
Bhattacharya Sudhir Kumar
Bhiskapathi P
Chandra Kailash
Devi Sunita
Devi Tara
Gupta RK
Harihar
Kali Ram
Karan Ram
Khan Abdul Nadir
Khan Mohd Aslam
Kumar Ajay
Kumar Praveen
Kumar Santosh
Kumar Shri Arvind
Lal Kishan
Mati Raj
Pathak AK
Prasad Mata
Ram Kishan
Ram Raja
Ram Sant
Sadanand
Singh Ram Baksh
Singh Tula
Suresh TP
Valmiki Harpal
Verma Nirmala
Verma RY
Yusuf Mohd

CIMAP Budget at A Glance 2009-10

RUPEES IN LAKHS	
PAY & ALLOWANCES	2299.482
CONTINGENCIES (P-04)	207.651
H.R.D. (P-05)	2.836
LAB. MAINTENANCE (P-06)	100.590
STAFF QRS. MAINTENANCE (P-701)	17.512
CHEMICALS/CONSUMABLES & OTHER RESEARCH EXPENDITURES (P-07)	314.134
WORKS & SERVICES (P-50)	96.200
APP. & EQUIP/COMPUTER EQPTS (P-50)	180.000
OFFICE EQUIPMENTS (P-50)	7.225
FURNITURE & FITTINGS (P-50)	8.388
LIBRARY BOOKS (P-50)	3.088
LIBRARY JOURNALS (P-50)	63.304
STAFF QRS (CONSTRUCTION) (P-702)	22.575
CSIR NETWORK PROJECTS (NWP)	443.220
TOTAL	**3766.205**
PENSION (P804)	699.778
EMR (P81)	68.108

External Budgetary Resource

LAB RESERVE FUND (LRF)	69.043
EXTERNAL CASH FLOW (ECF)	240.297

Research Council

Chairperson

Dr. (Mrs.) Manju Sharma
Former Secretary to the Govt. of India, Department of Biotechnology
President & Executive Director, Indian Institute of Advanced Research Chairperson

Member

Prof. Debi P. Sarkar
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Lucknow- 226021

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Dr P.G. Rao
Director,
North-East Institute of Science & Technology,
P.O. Jorhat- 785006

Dr B.S. Sajwan
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National Medicinal Plant Board,
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New Delhi- 110001

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New Delhi- 110001

Director
Central Institute of Medicinal and Aromatic Plants
Kukrail Picnic Spot Road, P.O. CIMAP, Lucknow- 226015

Management Council

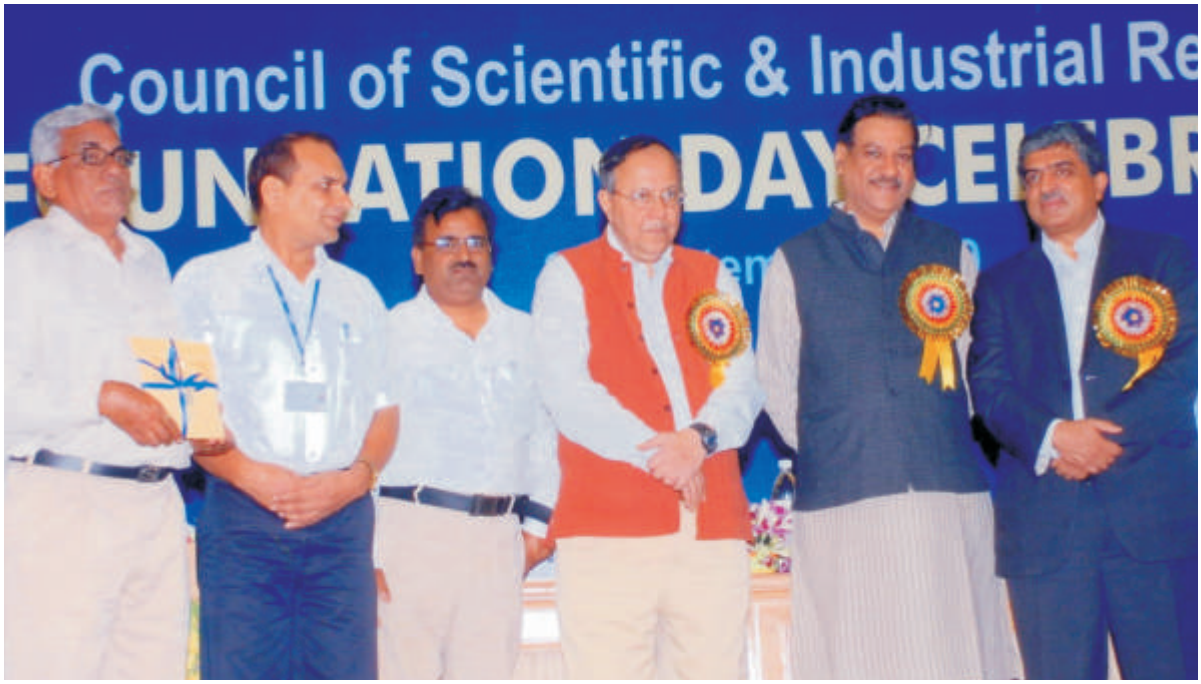
Dr. S.P. Singh, Scientist - F
Dr. A.H.A. Farooqui, Scientist - F
Dr. E.V.S.P. Rao, Scientist -F
Dr. Ashok Sharma, Scientist - F
Dr. A.K. Singh, Scientist - F
Dr. Suchitra Banerjee, Scientist - E II
Shri Birendra Kumar, Scientist - E I
Dr. S.C. Singh, T. O.
FAO
AO

International Symposium on Current Status and Opportunities in Aromatic & Medicinal Plants (AROMED) February 21 – 24, 2010

As a part of Golden Jubilee celebration of CIMAP, an International symposium on AROmatic and MEDicinal plants (AROMED) was held during 21-24, February 2010. A total of 575 scientists, researchers and students from all over the country and abroad participated in the symposium. There were 298 abstracts in five sessions out of which, 28 were short lectures and 270 were poster presentations. Thirty invited lectures (including 10 foreign) on different themes of the symposium were delivered.

AROMED - Inaugural Proceedings

Prof. Ram Rajasekharan, Director CIMAP addressing the gathering during inaugural session of AROMED.
Looking on dias are : (from L to R : Dr. SPS Khanuja, Dr. Manju Sharma, Dr. Akhtar Husain and Dr. RS Thakur



Release function of new Aswagandha variety NMITLI-118 by Hon'ble Minister of Science (IC) S&T and Earth Sciences, Shri Prithviraj Chavan on Sep. 26th, 2009

Central Institute of Medicinal and Aromatic Plants

(Council of Scientific and Industrial Research)
Kukrail Picnic Spot Road, Lucknow-226 015