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वार्षिक प्रतिवेदन
Annual Report
2015 -16

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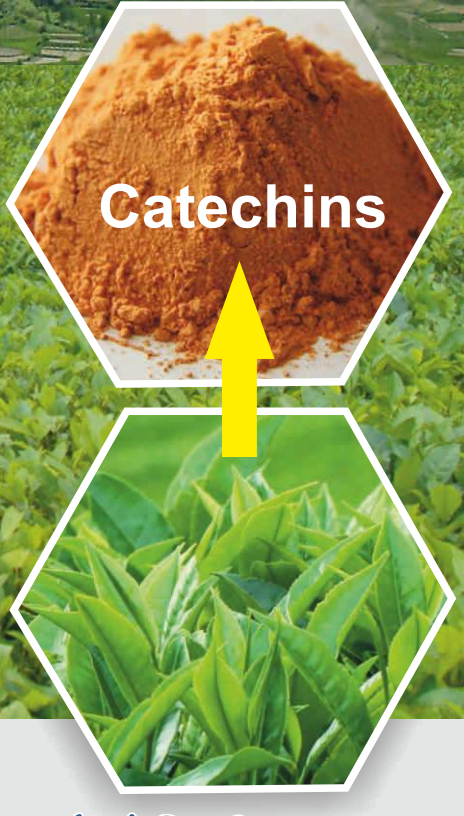
Positioning Catechins For Bioeconomy



सीएसआईआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
CSIR-Institute of Himalayan Bioresource Technology
पालमपुर–हिमाचल प्रदेश
Palampur-Himachal Pradesh

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Annual Report
2015-16

With Best Compliments from
Dr. Sanjay Kumar
Director

CSIR- Institute of Himalayan Bioresource Technology
Palampur (HP)-176061

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MISSION

Committed to develop technologies to boost bioeconomy through sustainable utilization of Himalayan bioresources.

Research areas

- High altitude biology and plant conservation
- Adaptation biology and climate change
- Biotechnology, nanobiology and bioinformatics
- Natural product chemistry and process development
- Agrotechnology and plant improvement
- Plant protection
- Food and nutraceuticals
- Regulatory research

Organization structure

CSIR- Institute of Himalayan Bioresource Technology

Prime Minister of India
President, CSIR

Minister of Science & Technology
Vice President, CSIR

Director General, CSIR

Research Council — **Director** — **Management Council**

R & D Areas

- Agrotechnology of Medicinal, Aromatic & Commercially Important Plants
- Biotechnology
- Food and Nuraceuticals
- High Altitude Biology
- Natural Product Chemistry & Process Development

Support Services

- Planning Project Monitoring & Evaluation
- Engineering Service Unit
- Library
- Business Development and Marketing Unit
- Intellectual Property Management
- Computer Cell
- Instrumentation
- Press & Media Unit

House Keeping

- Administration
- Finance & Accounts
- Store & Purchase
- Security
- Hindi Cell
- Guest House and Hostel
- Farm Management

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FROM THE DIRECTOR'S DESK

Advancing in its mission of developing bio-based economy to boost economic development and national competitiveness, greater diffusion of knowledge and technologies resulting from inventions and innovations on rich Himalayan bioresources was evident this year. MoUs were signed with (i) M/s. Agri Natural India to work on steviosides, (ii) M/s. Root and Flowers for fruit products, (iii) Minocha industries for food products, (iv) M/s. FEEDS, Manipur, (v) M/s. Pushp Biotech and Farms, and (vi) M/s. Model Floriculture Centre. Biotechnology Industry Research Assistance Council (BIRAC) funded a project to our industry partner M/s Baijnath Pharamcuticals for production of catechins from tea leaves. The institute successfully established Common Research and Technology Development Hubs, supported by the Department of Scientific and Industrial Research that was recognized by the ministry of micro, small, & medium enterprises, Government of India as one of the Incubation centres in the state of Himachal Pradesh. Scientific knowledge generated by the scientists, technical staff and research scholars made an impact through 174 research articles published in quality journals and grant/filing of thirteen patents. Aligned with the national needs, the institute identified Fast Track Translational Projects and Mission Mode Projects under the dynamic leadership of our Director General, Dr Girish Sahni. This complied with the true spirit of *Manthan*, (a director's conference held during 12-13 June, 2015 at CSIR-IIP, Dehradun) under the visionary guidance of our Honourable Union Minister for Science & Technology and Earth Sciences, Dr. Harsh Vardhan.

Combating malnutrition is a major challenge for our country and addressing to this, our team developed two innovative products, nutri-bar and nutri-mix, to meet the requirements of iron and calcium using relevant bioresources. Gluten-free-antioxidant rich food items, buckwheat (*Fagopyrum esculentum*) based noodles, flakes and puffed snacks were developed. Advancing in the area of development of nutritive food and nutraceutical products, our teams identified the beneficial effects of Himalayan ethnic cuisine *Kangri Dham* on health attributes. To preserve and promote *Kangri Dham*, several dishes were processed as 'Ready to Serve Food' with shelf-life of more than 6 months at ambient temperature without adding any preservatives.

Adaptation biology is one of niche areas of research at CSIR-IHBT. Analysis of genes and

processes were identified wherein universal stress proteins (USPs) and dehydration responsive elements binding proteins (DREB) plying an important roles in plant adaptation under abiotic stresses. Of the various USPs, a role of *AtUSP17* was analysed using a knock down mutant with T-DNA insertion in *Arabidopsis*. While the detailed analysis is underway, data did suggest AtUSP17 to be a component of stress tolerance mechanism in *Arabidopsis*. Of the various *DREB*s of apple, *Md DREB-076* and *MdDREB-043* were identified to be of critical importance and their functional characterization is underway in tobacco. On biotic stresses, our team identified for the first time that whitefly can also transmit naked viroid RNA from one plant to the other as plant- and whitefly-proteins – complex.

Dissecting the stress adaption pathway in plants, a thermostable superoxide dismutase (SOD) enzyme was identified that could be autoclaved. Since this enzyme has commercial implications, the technology of the production of enzyme was earlier transferred to M/s PhtyoBiotech, Kolkata. During the year, our team successfully deciphered the molecular basis of SOD tolerance to autoclaving. Continuing our research on enzyme prospection, yet another commercially important novel L- asparginase was identified from high altitude flora.

CSIR-IHBT has pioneered research on genome biology of Himalayan bioresources. Transcriptomes of important Himalayan plant species were deciphered on next generation sequencing (NGS) platform that presented a range of deployable genes and processes. Dormancy related genes were identified from apple using transcriptome analysis on next generation sequencing platform, which has implications in modulating the dormancy process. Genomes of important Himalayan microbial species were sequenced to bioprospect relevant industrial enzymes. Genomic resources were created and genetic was characterized for agarwood (*Aquilaria malaccensis*) and bamboos (*Dendrocalamus latiflorus*). Importantly, huge volume of sequencing data led to identification of a regulatory sRNA-9881 as a prominent marker for several cancer types. Also, the first ever comprehensive analysis of *Solanum* genome repeats helped to understand their role in genome regulation. Some of the repeats appeared to influence transcription factor binding site and miRNA. Also, a miReader (85) with potential to identify mature miRNAs directly from NGS read data without the need for genomic sequences or homologous references, was developed.

Monitoring Himalayan bioresources is one of the major thrusts of our institute. The estimated net primary productivity studied for three protected areas using satellite data recorded the highest values with 5.35 t C/ha/yr Great Himalayan National Park. Satellite data was also used to estimate land use and land cover mapping, preparation of digital geo-referenced forest fire maps and spatial distribution maps of important plant species. Work on plant invasion showed the importance of fruiting time and dispersers on the spread of *Sapium sebiferum*. .Yet another important

contribution of the team has been on establishment of long term ecological research plots in protected and unprotected areas in western Himalayas and data was recorded for species abundance, flower traits and soil chemistry.

Work on chemical exploration of bioresources continued with full vigour. Importantly, a new skeleton (14*R*, 17*S*, 20*R*-lupan-3-one) was isolated from *Commiphora wightii*. A new hederagenin based triterpenoid saponin, clematograveolenoside A, along with known compounds were characterized from *Clematis graveolens* roots. These showed potent insecticidal activities. The group identified a new plant source for shikimic acid.

Synthetic and semisynthetic chemistry focused on developing newer catalysts, C-N bond formation, carboxylation , and esterification reactions of alcohols. Method for palladium supported nanoparticle catalyzed carboxylation of aryl halides alkenylsilanes and organoboronic acids was developed. Quinoline derivatives were synthesized via C-H activation/ functionalization for their possible use as anti-malarial compound. In a new initiative, the institute developed a lab scale process for production of textile fibres from bamboos with an aim to upscale the process for industrial use.

The power of nanotechnology is being used to improve the therapeutic importance of biologically active molecules. Stability and solubility of curcumin was improved through nanotechnology approach. Further, biocompatible fluorescent silicon nanoparticle conjugated albumin proteins was found as better cholesterol efflux agent for macrophages *in vitro*. In addition, to search for novel macromolecule based therapeutic nano-devices, dendrimer conjugated podophyllotoxin was found to be an effective inhibitor against skin-tumor formation *in vivo*.

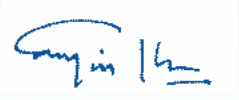
Societal development in the Himalayan region and northern plains has been one of the major thrust of our institute. Our teams have been active on various fronts such as value addition to the underutilized crops, trainings, advisory and extension services in the area of tea, floriculture, medicinal and aromatic crops, supply of virus tested planting material of apple rootstocks, and promotion and utilization of bamboos. Significantly, apple was introduced for the first time in Champhai district of Mizoram.

The institute focused on various activities around commercial crops of commercial significance including in developing new varieties. Five genotypes of gerbera and two of calla lilies, generated through hybridization, showed promising attributes for commercial floriculture. Also, research on orchids and carnivorous plants species was initiated.

Our team promoted cultivation of wild marigold and damask rose in Himachal Pradesh and Jammu and Kashmir, and stevia in Punjab. *Hippophae* germplasm at institute's Centre of High Altitude Biology (CeHAB), Ribling, Lahaul (HP) was enriched with 43 accessions from Uttrakhand and 17 from Sikkim.

The animal house facility was upgraded that got approved by 'The Committee for the Purpose of Control and Supervision of Experiments on Animals, Ministry of Environment, Forest and Climate Change, Government of India, for the trade of laboratory animals for research purpose.

A sprawling culture of innovation, an ecosystem of team work, dedicated human capital, state of art infrastructure, and a powerful communication system to link to stakeholders is exhibiting its positive impact through the scientific knowledge generated and the technologies developed around Himalayan bioresources in a time defined manner. CSIR-IHBT rededicates itself to strengthen and competent the nation through deployment of science and technology.



Sanjay Kumar

निदेशक की कलम से

आर्थिक विकास और राष्ट्रीय प्रतिस्पर्धा प्रोत्साहन हेतु जैव आधारित आर्थिकी को विकसित करने के संस्थान के लक्ष्य को आगे बढ़ाते हुए इस वर्ष हिमालय जैव–संसाधनो पर खोज और नवाचारों के परिणामस्वरुप ज्ञान और प्रौद्योगिकियों का व्यापक प्रसार देखा गया। 1) मै. एग्री नैचुरल इंडिया के साथ स्टीवियोसाइड पर, 2) मै. रूट एण्ड फ्लावर के साथ फल उत्पादों के लिए, 3) मै. मिनोचा उद्योग के साथ खाद्य उत्पाद के लिए, 4) मै. फीड्स, मणिपुर, 5) मै. पुष्प बायोटेक एण्ड फार्म और 6) मै. मॉडल फ्लोरिकल्चर सेन्टर के साथ समझौता ज्ञापन किए गए। जैवप्रौद्योगिकी उद्योग अनुसंधान सहायता परिषद (बीआईएआरसी) ने हमारे एक सहयोगी उद्यम मै. बैजनाथ फार्मास्यूटिक्ल को चाय की पत्तियों से कैटेकिन उत्पादन के लिए परियोजना राशि स्वीकृत की है। संस्थान ने वैज्ञानिक तथा औद्योगिक अनुसंधान विभाग के सहयोग से सामुहिक अनुसंधान और प्रौद्योगिकी विकास केन्द्र की सफलतापूर्वक स्थापना की गई है जिसे सूक्ष्म, लघु एवं मध्यम उद्यम मंत्रालय, भारत सरकार द्वारा मान्यता प्रदान की गई है। वैज्ञानिक एवं तकनीकी स्टाफ और शोधार्थियों द्वारा अर्जित ज्ञान का प्रभाव प्रतिष्ठित पत्रिकाओं में प्रकाशित 174 शोध लेखों तथा पंजीकरण के लिए दायर/अनुमोदित 13 पेटेंट से साफ झलकता है। राष्ट्रीय आवश्यकताओं को ध्यान में रखते हुए संस्थान ने सीएसआईआर के महानिदेशक डा. गिरीश साहनी के गतिशील नेतृत्व में फास्ट ट्रैक ट्रांसलेशनल और मिशन मोड परियोजनाओं को चिन्हित किया है। हमारे माननीय केन्द्रीय विज्ञान एवं प्रौद्योगिकी तथा पृथ्वी विज्ञान मंत्री डा. हर्षवर्धन के दूरदर्शी मार्गदर्शन में 12–13 जून 2015 के दौरान सीएसआईआर–आईआईपी, देहरादून में आयोजित निदेशक सम्मेलन में हुए 'मंथन' का सच्ची भावना के साथ अनुपालन किया गया।

कुपोषण से मुकाबला करना हमारे देश के लिए मुख्य चुनौती है इसी को ध्यान में रखकर हमारी टीम ने प्रासंगिक जैव संसाधनों का उपयोग करते हुए न्यूट्री बार और न्यूट्री मिक्स जैसे दो अभिनव उत्पादों को विकसित किया है ताकि आयरन और कैल्शियम की कमी को पूरा किया जा सके। ग्लुटिन मुक्त एंटीऑक्सीडेंट से भरपूर खाद्य, बक–वीट (*Fagopyrum esculentum*) पर आधारित नूडल्स, फ्लेक्स और पफ्ड स्नैक्स तैयार किए गए हैं। पौषक खाद्य एवं न्यूट्रास्यूटिक्ल उत्पादों को विकसित करने के क्षेत्र में आगे बढ़ते हुए हमारी टीम ने हिमालय क्षेत्र की परम्परागत कांगड़ी धाम के स्वास्थ्यवर्धक गुणों की पहचान की है। कांगड़ी धाम को संरक्षित करने और बढ़ावा देने के लिए कई व्यंजनों को 'रेडी टू सर्व' तैयार किया गया है जो कि सामान्य तापमान पर बिना किसी प्रिज़रवेटिव के 6 माह से अधिक समय तक प्रयोग किए जा सकते हैं।

अनुकूलन जीवविज्ञान संस्थान के लिए एक मुख्य शोध क्षेत्र है। जीन और प्रक्रम के विश्लेषण को पहचाना गया जहां यूनिवर्सल स्ट्रेस प्रोटीन (यू.एस.पी.) और डिहाइड्रेशन रिस्पॉसिव एलिमेंट बाईडिंग प्रोटीन (डी.आर.ई.बी.) का अजैविक दबावों के साथ पादप अनुकूलन में एक महत्वपूर्ण भूमिका है। विभिन्न यू.एस.पी. में से एरोबिडोप्सिस में T-DNA के प्रवेशण के साथ उत्परिवर्ती का प्रयोग करते हुए *AtUSP17* की भूमिका का विश्लेषण किया गया। यद्यपि आंकड़ो का विस्तृत विश्लेषण चल रहा है जिससे पता चलता है कि एरोबिडोप्सिस में *AtUSP17* स्ट्रैस सहनशीलता प्रक्रिया का एक अंग है। सेब के विभिन्न डी.आर.ई.बी. में से *Md DREB-076* और *MdDREB-043* को बहुत ही महत्वपूर्ण पाया गया और उनका कार्यात्मक लक्षणचित्रण तंबाकू में देखा गया। जैविक स्ट्रैस में हमारी

टीम ने पहली बार यह पाया है कि वायरायड आरएनए पौधो–तथा–व्हाइट फ्लाई में प्रोटीन कॉम्प्लैक्स के रूप में पंहुच सकती है।

पैधों में प्रतिबल अनुकूलन क्रमबद्ध मार्ग को विच्छेदित करने के लिए एक थर्मोस्टेबल सुपरॉक्साइड डिस्म्यूटेस (SOD) एन्जाइम को खोजा गया, जो कि उच्च ताप ($121^{0}C$) पर भी स्थिर रहता है। इस एन्जाइम की व्यवसायिक उपयोगिता है, इसकी प्रौद्योगिकी को मै. फाइटो बायोटेक, कोलकाता को हस्तांतरित किया गया है। इस वर्ष हमारी टीम ने आटोक्लेविंग में SOD की सहनशीलता के आण्विक आधार को समझ लिया है। एन्जाइम प्रोसपेक्शन पर अपने शोध को आगे बढ़ाते हुए उच्च तुंगता वाले क्षेत्र की वनस्पति से एक अन्य व्यवसायिक दृष्टि से महत्वपूर्ण नवीन एन्जाइम L- asparaginase की खोज की गई है।

सीएसआईआर–आईएचबीटी ने हिमालय जैवसंपदा की जिनोमिक जीवविज्ञान पर शोध को प्रारंभ किया है। हिमालय के महत्वपूर्ण पादप प्रजातियों के ट्रांसक्रिप्टोम को नेक्स्ट जनरेशन सिक्वेंसिंग (एन.जी.एस.) प्लेटफार्म पर खोजा गया जिसमें प्रयुक्त किए जाने वाले बहुत से जीन और प्रक्रियाओं के विषय में जानकारी उपलब्ध हुई है। इसी प्रकार सेब के ट्रांसक्रिप्टोम विश्लेषण से प्रसुप्तावस्था संबन्धी जीन को खोजा गया जिसमें प्रसुप्तावस्था प्रक्रिया को प्रभावित करना निहितार्थ है। हिमालय की महत्वपूर्ण सूक्ष्मजीव प्रजातियों के जिनोम का संबन्धित औद्योगिक एन्जाइम बनाने के लिए अनुक्रमण किया गया। जिनोमिक संसाधन तैयार किए गए तथा अगरवुड और बांस के आनुवांशिकी को लक्षणचित्रित किया गया। अनुक्रमण आंकड़ो से एक नियामक अनुक्रमण sRNA-9881 की कैंसर के एक प्रमुख मार्कर के रूप में पहचान हुई। इसके अतिरिक्त सोलेनम *Solanum* के प्रथम जीनोम विश्लेषण से व्यापक जीनोम नियमन में उनकी भूमिका को समझने में सहायता मिली। ऐसा प्रतीत होता है कि कुछ जिनोम दोहराव ट्रांसक्रिप्शन फैक्टर के miRNAs के साथ बंधने की प्रक्रिया को प्रभावित करते हैं। इसके अलावा एक miReader (85) जिसकी परिपक्व miRNAs बिना किसी जिनोमिक दृश्यों या मुताबिक संदर्भों की आवश्यकता, सीधे प्रस्तुत एनजीएस डेटा में से पहचानने की क्षमता के साथ विकसित किया गया है।

हिमालय की जैवसंपदा का अनुवीक्षण भी संस्थान का एक प्रमुख कार्यक्षेत्र है। उपग्रह से प्राप्त चित्रों का उपयोग करते हुए तीन संरक्षित क्षेत्रों की कुल प्राथमिक उत्पाकता का आकलन किया गया जिसमें ग्रेट हिमालय नेशनल पार्क में उच्च उत्पादकता 5.35 टन कार्बन प्रति हैक्टेयर/प्रति वर्ष दर्ज की गई। उपग्रह डेटा से भूमि उपयोग एवं आच्छादन का मानचित्रिकरण किया गया। वनों में लगने वाली आग एवं महत्वपूर्ण पादप प्रजातियों के मानचित्र भी तैयार किए गए। पौधों के अनुसंधान कार्य में *Sapium sebiferum* के विस्तार में पुष्पण का समय और पक्षियों का विशेष संबंध उजागर हुआ। पश्चिमी हिमालय में सरंक्षित और असंरक्षित क्षेत्रों में दीर्घकालीन पारिस्थकीय अनुसंधान प्रक्षेत्र की स्थापना करना भी हमारी टीम का एक महत्वपूर्ण योगदान है। इसमें प्रजातियों की बहुलता, पुष्प विशेषता और भूमि की रसायनिकी के आंकड़े दर्ज किए गए हैं।

जैवसंसाधनों के रसायनिक खोज का कार्य भी पूरे उत्साह के साथ जारी है। उल्लेखनीय है कि कोमिफोरा विगटी *Commiphora wightii* से एक नई संरचना (14*R*, 17*S*, 20*R*-lupan-3-one) को विलगित किया गया है। क्लेमेटिस की जड़ों से पहले से ज्ञात यौगिकों के अतिरिक्त एक नए हेडराजेनिन आधारित ट्राईटरपिनॉयड सैपोनिन, क्लेमेटोग्रवेऑलिनोसाइड–A का विश्लेषण किया गया एवं जिसमें कीटनाशक गतिविधि पायी गई है। इस समूह ने शिकिमिक अम्ल के नए पादप स्रोत की पहचान कर ली है।

संश्लेषित एवं अर्धसंश्लेषित रसायनिकी के क्षेत्र में नए कैटालिस्ट, C-N बान्ड फॉरमेशन, कार्बोक्सिलेशन अभिक्रिया एवं एल्कोहल के एस्टरीफिकेशन अभिक्रिया को विकसित करने पर ध्यान दिया जा रहा है। पेलेडियम नैनोकणों को उत्प्रेरक के रूप में एराइल हैलाइडस, एल्कीनाइल सिलेंस तथा काबर्निक बोरोनिक अम्ल का निर्माण करने में उपयोग किया गया। C-H उत्प्रेरण तथा प्रतिरोधात्मकता का अनुसरण करते हुए क्विनोलिन डेरिवेटिवस, मलेरिया प्रतिरोधक अणुओं का निर्माण किया गया। नई पहल के अन्तर्गत संस्थान ने बांस से वस्त्र तंतु बनाने की प्रयोगशाला स्तर पर एक प्रक्रिया को विकसित किया है एवं इस प्रक्रिया को औद्योगिक स्तर पर ले जाने का लक्ष्य भी है।

नैनोतकनीक की क्षमता का उपयोग जैविक सक्रिय अणुओं की रोग उपचार को सुधारने के लिए किया जा रहा है। करकुमिन curcumin के स्थायित्व और घुलनशीलता को नैनोतकनीक से सुधारा गया। इसके उपरान्त जैवअनुकूल फ्लोरोसेंट सिलिकॉन नैनो कण के साथ जुडे हुए एलब्यूमिन प्रोटीन को मेक्रोफेज कोशिकाओं से एक अच्छे कोलेस्ट्रॉल के वहिर्वाह घटक के रूप में स्थापित किया गया। इसके साथ ही नए स्थूल अणुओं का उपयोग करके स्वास्थयकारक सूक्ष्म यंत्रों को विकसित किया गया एवं डेंड्राइमर के साथ जुड़े हुए पोडोफाइलोटॉक्सिन podophyllotoxin को त्वचा के कैंसर रोग के विरुद्ध सक्रिय पाया गया।

हिमालय क्षेत्र एवं साथ लगते मैदानी क्षेत्रों का सामाजिक विकास संस्थान का मुख्य कार्यक्षेत्र है। हमारी टीम कम उपयोग में लाई गई फसलों के मूल्यवर्धन, चाय, पुष्पखेती, औषधीय एवं सगंध फसलों पर प्रशिक्षण, परामर्श और प्रसार सेवाएं, रोगमुक्त सेब के रूटस्टॉक की पादप सामग्री की आपूर्ति और बांस के उपयोग और संवर्धन सहित कई क्षेत्रों में सक्रिय है। उल्लेखनीय है कि मिज़ोरम के चम्पाई जिले में पहली बार सेब के पौधे लगाए गए हैं।

संस्थान नई किस्मों की खोज के साथ व्यवसायकि दृष्टि से महत्वपर्ण फसलों के विकास पर अपना ध्यान केन्द्रित कर रहा है। संकरण द्वारा तैयार जरबेरा की पांच तथा कैला लिलि की दो किस्मों ने व्यवसायिक पुष्प खेती के लिए अच्छी संभावनाएं प्रदर्शित की है। ऑर्किड और कार्निवोरस पौध प्रजातियों पर भी शोध की पहल की गई है।

हमारी टीम ने हिमाचल प्रदेश और जम्मू एवं कश्मीर में जंगली गेंदे तथा पंजाब में स्टीविया की खेती को प्रोत्साहित किया है। संस्थान के उच्च तुंगता जीवविज्ञान केन्द्र, रिबलिंग (लाहौल) हिमाचल प्रदेश में उतराखंड से 43 तथा सिक्किम से 17 हिप्पोफी किस्मों को जर्मप्लाज़म संग्रह में लगाया है।

संस्थान के एनिमल हाउस सुविधा को बढ़ाया गया है जिसे अभी भारत सरकार के पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय की उच्च स्तरीय समिति ने संस्थान को शोध उद्देश्य के लिए प्रयोगशाला में पशुओं के प्रजनन/बेचने के लिए अनुमति प्रदान की है।

न्वोन्मेष की बेहतर संस्कृति, टीम भावना का वातावरण, समर्पित मानवसंपदा, अत्याधुनिक आधारभूत सुविधाएं, सभी भागीदारों के साथ मजबूत संचार प्रक्रिया का प्रभाव समयबद्ध तरीके से हिमालय जैवसंपदा पर आधारित वैज्ञानिक ज्ञान और विकसित प्रौद्योगिकी से साफ झलकता है। सीएसआईआर–आईएचबीटी विज्ञान और प्रौद्योगिकी के माध्यम से राष्ट्र को समर्थ और सशक्त बनाने के लिए अपने आप को पुनः समर्पित करता है।

संजय कुमार

Agrotechnology of Medicinal, Aromatic & Commercially Important Plants

Development of agro-technologies, production of quality planting material and plant protection of medicinal, aromatic and other commercial crops

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Research area: Agronomy of plantation crops and extension

Rural development in the western Himalayan region and adjoining plains through transfer of CSIR-IHBT technologies: CSIR-Institute of Himalayan Bioresource Technology has major goal of rural development in the western Himalayan region and northern plains. During the year the following activities were pursued under CSIR Rural Development programme:

- Advisory and extension services for improving productivity and quality of China hybrid tea
- Transfer of agro-techniques and post-harvest management technology of commercially important cut flower crops
- Production of characterized planting material of industrial and commercial plants for facilitating crop diversification and processing of aromatics and herbals
- Improvement of apple production and quality through training growers, and dissemination of virus tested planting material of apple rootstocks through tissue culture industry
- Demonstration of essential oil extraction technologies
- Promotion and utilization of bamboos for livelihood and environmental benefits
- Value addition to the traditional/underutilized crops of high altitude region

Promotion of tea farm mechanization for combating problems of labour shortage and rising costs in tea plantations: Strengthening of the tea industry in this region by improving crop quality and cost reduction through mechanization of farm operations is prime need of small tea growers in the current scenario of scarcity of farm labour and rising costs.

- Conducted five training programmes and demonstrations on handling of different tea machines and their use
- Organised training and workshop for up-gradation of tea quality and productivity
- Bilingual technical folder on "Tea Farm Mechanization" was released
- Advisory service was extended for improving productivity and quality of Kangra tea and promotion of mechanisation.

Introduction of apple in Mizoram: Apple (*Malus domestica*) is being cultivated since time immemorial. Being a temperate fruit crop, over 80% of the global production is done in Europe. In

other countries apple cultivation is confined in temperate zone as well. Regions with long day-hours, bright sun-shine, cool nights and low humidity during the growing season associated with chilling winter season (temperature <7°C) are essential for apple cultivation. With time, improved cultivars have been developed for growing in regions with low chill requirements. There are varieties now available with wide adaptability, and modern facilities for marketing and transport to ensure apple availability throughout the year.

- Initiated work jointly with Project Director of DRDA, Champhai, Mizoram
- Chose cultivars with low chilling requirement (300-500 hours)
  - Set I: Cultivar Anna and Dorsett Golden, with chilling requirement of below 300 hours.
  - Set II Cultivar Fuji, 3 variants, & Gala, 3 variants, having chilling requirement of nearly 500 hours.
- Demonstration plots were set up at 10 locations, accommodating a total of 210 apple saplings
- Organised training for capacity building of staff of DRDA and farmers
- Besides, imparted training on tea nursery and plantation management to enthusiastic group of farmers who had started tea but were unaware of its technical details.

Promoting cultivation of potential aromatic crops: Traditional farming has never been paying as much in the Himalayan region as in the plains. Wild animal and stray cattle menace has recently emerged as a serious intimidation to the traditional farming, forcing farmers to abandon their fields. Under such a scenario, there is a strong need to diversify agriculture and grow Himalayan friendly preferably native plants with marketable attributes which promise assured returns to the community. Promotion of cultivation of aromatic crops, by providing quality planting material, agrotechnology, processing technology and value addition to the products, holds promise for entrepreneurship development and creating import substitute in the flavour and fragrance sector. Potential of *Tagetes minuta* as high value aromatic crop has already been tried and tested by the Institute.

Keeping in view that cultivation of region specific aromatic crops needs support not only in terms of planting material and processing facilities but also a proper network of quality evaluation and assurance as per market need, survey for introduction of tagetes cultivation in Sainj and Banjar regions of Kullu district, Tissa & Chauri area of Chamba, parts of Kangra, Mandi and Kinnaur districts were conducted. The farmers of these areas were imparted training on cultivation and distillation of the aromatic crops.

Rural Health: Primary Health Centres (PHCs) across the country are the most basic units in the field of medical care in the rural India. Under CSIR 800 programme, conducted survey of the

Primary Health Centres (11 No.) in and around Gopalpur region of Kangra district for compiling a report on their response to common ailments in Kangra district particularly. The survey revealed that through overall response of the PHCs to common ailments is satisfactory, yet lot sources and quality evaluation of drinking water was done in the panchyats. Surveys needs to be done in many PHCs for further improvement. Provision of the latest medical diagnostic kits to the PHCs and frequent training of the medical and paramedical staff on the modern techniques and developments in medical science would make the delivery efficient and convenient to the beneficiaries. IT based approach for diagnosis and treatment of the patient could be a boon to those residing in tough hilly terrains.

Under CSIR-800 course, the AcSIR students also conducted survey and awareness campaign of important diseases in 3 villages panchayats in Kandwari region.

Connecting with societies through electronic and print media: Telecasts on cultivation of stevia, gladiolus, gerbera, tea, *Crataegus*, *Acorus,* bamboo and ferns; conservation needs and quality estimation of medicinal and aromatic plants, plant adaptation under climate change scenario were arranged. Additionally, telecast on importance and mapping of bioresource and database development and role of CSIR-IHBT in socio-economic development through Doordarshan and other channels were organised. Articles on important achievements of the institutes appeared on national and regional print media.

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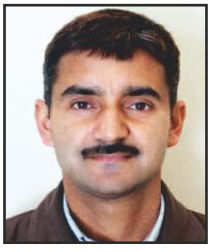
Production of bamboo charcoal using portable kiln: Activities on conversion of bamboo culms into charcoal were continued this year. Different bamboo species were tested to find out their suitability for conversion into bamboo charcoal using portable and brick kilns. A total of five quintals of charcoal was produced after carbonization. As studied earlier, the charcoal has a carbon content of 76-85%. Earlier, 1000 kg of charcoal powder prepared by pulvarizing bamboo charcoal was exported to the cosmetic company, Body Shop in UK @ $5 per kg via Unifect Ltd., UK. In the current year also, a demand for 500 kg has been received from the same company. For this, charcoal has already been prepared and pulverized into a powder of 200 µm. However, attempts are being made to pulverize it further to a range of 50 to 70 µm.

Bamboo Kiln

Portable Kiln

Bamboo Charcoal

Designing of activated charcoal plant for production of biochar and activated charcoal from bamboos: In order to prepare activated charcoal from bamboo culms, a design for upgrading the existing kiln was prepared. The design is expected to cater to a temperature of >800°C and also reduce the obnoxious fumes produced the process of carbonization. The design is presently under the process of being fabricated.



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Stevia breeding: Nine stevia genotypes derived from diverse crosses were selected based on higher proportion of rebaudioside-A than stevioside (Table 1) and involved as parental lines in a polycross through a controlled hybridization programme. The parental lines were grown in isolation and the seeds from individual plants were collected representing half-sib progenies. The half-sib populations have been planted in field and will be evaluated for steviol glycoside profile for further improvement in rebaudioside-A content in stevia.

Table 1. Stevioside and rebaudioside-A content of stevia genotypes used as parental lines in hybridization programme

S. No.	Genotypes	Stevioside content (%)	Rebaudiosie-A content (%)	Ratio (Reb.-A/Stev.)	Ste. + Reb.-A
1.	2A-3-1-10	1.227	1.956	1.59	3.183
2.	5a-8-3-2	2.998	3.465	1.16	6.463
3.	5b-9-5-3	9.837	12.396	1.26	22.233
4.	5b-9-5-9	3.460	4.609	1.33	8.069
5.	6a-10-5-3	12.970	13.015	1.00	25.985
6.	6a-11-1-5	9.810	9.836	1.00	19.646
7.	6a-11-1-10	3.139	3.964	1.26	7.103
8.	7a-15-4-2	0.235	0.378	1.61	0.613
9.	7b-21-3-2	1.978	2.423	1.22	4.401

Calla lily breeding: In *Zantedeschia aethiopica* morphological characterization of calla lily genotypes raised from open pollinated seedling population was undertaken to study the variability with respect to different vegetative and floral traits. Morphological parameters were evaluated for a period of two years and potential selections were identified (IHBT-CL-W1-1, 2-1, 2-5, 4-1, 4-3, 7-5, 8-4, 13-1, 19-3, 29-4, 29-5 and 33-4). These selections are being evaluated for propagation potential under field conditions.

In *Z. elliotiana* hybridization programme in calla lilies was undertaken using two parental genotypes IHBT-CL-Y1 (yellow color) and IHBT-CL-P1 (purple colour). Seeds obtained from hybridization flowered three years after germination and variable colors of calla lilies were obtained which are being further evaluated for flower production potential.

Table 2. Morphological variations among *Z. aethiopica* genotypes under field and polyhouse conditions

Traits	Range (Field)	Range (Polyhouse)	Mean (Field)	Mean (Polyhouse)
Stalk height (cm)	25.2 - 76	29 - 112	38.25	60.5
Leaves no.	13 - 18	36 - 57	7.95	46.4
Largest leaf length (cm)	6.5 - 19.9	19 - 42.5	11.79	32.5
Largest leaf Width (cm)	2.9 - 13.5	9 - 20.5	6.14	15.9
Flower No.	2 - 6	2 - 10	2.6	4.1

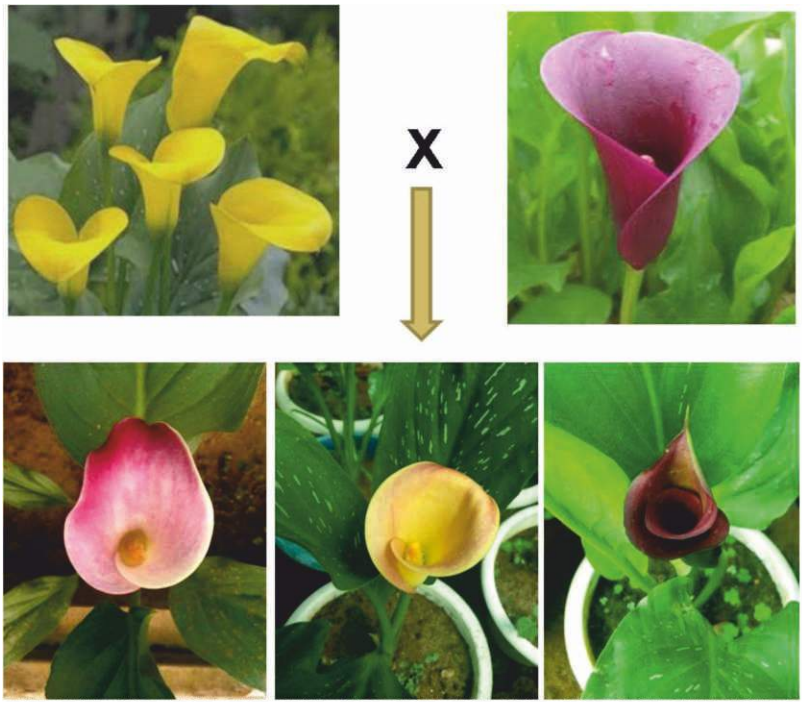

Fig 1. New color variations in *Z. elliotiana* obtained through hybridization programme.

Gerbera breeding: Hybrid F_1 genotypes of gerbera were developed through controlled crossing program and subjected to *in vitro* micro-propagation to achieve quick multiplication. Mature seeds obtained from different cross combinations were used for the establishment of *in vitro* gerbera cultures. Seeds were cultured on MS basal medium and the developing micro-shoots from seeds were further cultured on MS media supplemented with different doses of growth regulators to achieve shoot proliferation. Of the different media, highest number of micro-shoots, number of leaves and leaf length were observed in proliferation medium (MS supplemented with 1mg/l BAP

+ 0.030 mg/l IBA + 0.025 mg/l NAA) which gave best proliferation among the gerbera genotypes. The half strength MS medium supplemented with 0.4mg/l IBA was found best for *in vitro* rooting. Rooted plantlets were successfully hardened in trays filled with moist sand and transferred to sleeves for cultivation in soil. The hybrid F_1 genotypes were morphologically characterized under field conditions with respect to floral traits and evaluated for agronomic performance over a period of two years.

Based on mean performance of hybrid gerbera genotypes compared to respective parents, CSIR-IHBT-Gr-13-1 was superior to parental lines with respect to leaf length (cm) and stalk length (cm), while CSIR-IHBT-Gr-11-6 and CSIR-IHBT-Gr-24-6 were superior to parents for leaf width (cm). CSIR-IHBT-Gr-24-6 was superior to one of the parents for number of flowers per plant in a year but had significantly reduced stalk length (cm) in comparison to the parents. CSIR-IHBT-Gr-29-1 and CSIR-IHBT-Gr-Y-1 were superior to the parents for stalk length.

Table 3. Details of floral features of selected gerbera F_1 genotypes

S. No.	Plant No.	Flower colour	Stalk length (cm)	Flower diameter (cm)	Flower head type	Disc colour	Flower type
1.	CSIR-IHBT-Gr-11-6	Light Yellow	43.0	10.2	Double	Green	Standard
2.	CSIR-IHBT-Gr-13-1	Red	46.5	10.5	Double	Green	Standard
3.	CSIR-IHBT-Gr-24-6	Yellow orange	29.6	11.7	Semi-double	Brown	Standard
4	CSIR-IHBT-Gr-29-1	Red bicolour	45.8	10.5	Double	Green	Standard
5	CSIR-IHBT-Gr-Y-1	Yellow	44.5	11.5	Double	Green	Standard

Fig. 2 Potential gerbera genotypes with high *in vitro* proliferation (left to right: CSIR-IHBT-Gr-11-6, CSIR-IHBT-Gr-13-1, CSIR-IHBT-Gr-24-6, CSIR-IHBT-Gr-29-1 and CSIR-IHBT-Gr-Y-1)

Registration of gerbera cultivars: Registration of two gerbera cultivars "Him Glow" (INGR15019) and "Him Peace" (INGR15018) as germplasm at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research.

Publications:

- Singh S, Raja Ram, Kaundal S, Sharma A, Kumar A and Dhyani D (2016) Field performance and differential response of micro-propagated potential F_1 genotypes of *Gerbera jamesonii*. *American Journal of Experimental Agriculture*, 10(1): 1-11.
- Singh S and Dhyani D (2016) Domestication of Wild Gerbera (*Gerbera gossypina* (Royle) Beauved). *International Journal of Plant Science and Ecology* , 2:10-14.
- Singh S, Dhyani D, Nag A and Sharma RK (2016) Morphological and molecular characterization revealed high species level diversity among cultivated, introduced and wild roses (*Rosa* sp.) of western Himalayan region. *Genetic Resources and Crop Evolution*, DOI: 10.1007/s10722-016-0377-0.
- Yadav AK, Kaundal S, Sharma A and Singh S (2015) Chilling Stress tolerance in plants: Physiology and mechanisms. In: *Recent advances in plant stress physiology.* Praduman Yadav and Sunil Kumar (eds.) Astral International (P.) Ltd., India ISBN 978-93-5124-730-2.
- Dhyani D and Singh S (2015) Wild roses of western Himalayas and a catalogue of *Rosa* species. CSIR-IHBT Publication.

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Research Area: Agronomy, medicinal and aromatic plants, climate change

Development of agrotechnologies for medicinal and aromatic plants: Our group is involved in development of production technologies of medicinal, aromatic plants and industrial crops *viz*., damask rose (*Rosa damascena* Mill.), stevia (*Stevia rebaudiana* Bertoni), kutki (*Picrorhiza kurrooa*), ginseng (*Panax ginseng*), *Hippophae* spp. etc. We are involved in studying crop weather relationship of damask rose and also studying the growth and phenology of Himalayan spp. under elevated CO_2 temperature conditions.

While studying the effect of plant spacing (45 cm x 45 cm and 60 cm x 45 cm) and weed management practices (control, weed free, hand weeding, pendimethalin +1 HW and oxyfourfen +1HW) in stevia, it was found that planting stevia at a spacing of 45 cm x 45 cm and spraying with pendimethalin as pre-emergence herbicide followed by hand weeding at 30 days after spray recorded significantly higher stevia dry leaf biomass than other treatments. Steviol glycosides were not affected by the treatments.

To study the effect of environmental conditions on growth and yield of *Hypericum perforatum,* an experiment was initiated during November 2015 under free air carbon enrichment (FACE), free air temperature increase (FATI) and FACE+FATI facility in the institute. At 30 and 60 days after exposure (DAE) to elevated CO_2 and temperature, plant height was significantly higher in FATI as compared to FACE and ambient but remained at par with FACE+FATI (Fig.1). At 30 DAE, significantly higher numbers of leaves were recorded in FATI as compared to other environmental conditions. Number of leaves in FACE+FATI remained at par with ambient but was significantly higher than ambient. At 60 DAE, significantly lower number of leaves was recorded in FACE as compared to three remaining environmental conditions. The latter three

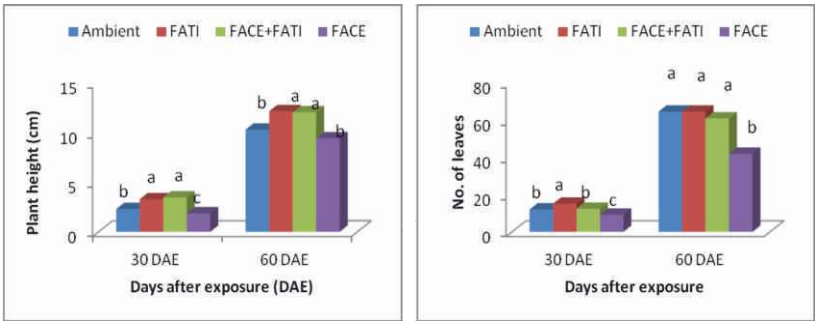

Fig. 1 Effect of environmental conditions on plant height and number of leaves per plant of *Hypericum perforatum* at 30 and 60 days after exposure (DAE).

treatments remained at par with each other (Fig.1).

Germplasm resource centre of Hippophae at Ribling farm, CeHAB, Keylong, Lahaul & Spiti, HP was enriched with collection of *Hippophae salicifolia* from different regions of the country. About 43 accessions were collected from Uttrakhand and 17 accessions from Sikkim.

Growth data was recorded from demonstration plots of Ginseng (*Panax ginseng*) laid out at farmer's field at village Sansha, Tehsil Keylong, district Lahaul & Spiti, HP. Plant height varied from 12 to 38 cm and number of leaves per plant varied from 1 to 5 in 1 to 4 years old plant of ginseng. Likewise plant spread in north –south (N-S) directions varied from 9 to 33 cm whereas in E-W direction it varied from 10 to 30 cm in 1 to 4 years old plant. The demonstration plots of damask rose at district Reasi and *Tagetes minuta* (8 ha) village Batote, district Ramban of Jammu and Kashmir were established.

Publications:

- Kumar R, Sharma S, Kaundal M, Sood S and Agnihotri, VK (2016) Variation in essential oil content and composition of damask rose (*Rosa damascena* Mill) flowers by salt application under mid hills of the western Himalayas. *Journal of Essential Oil Bearing Plants*. 19:2, 297-306.
- Kumar R, Sharma S, Kaundal M, Sharma S and Thakur M (2016) Response of damask rose (*Rosa damascena* Mill.) to foliar application of magnesium (Mg), copper (Cu) and zinc (Zn) sulphate under Western Himalayas. *Industrial Crops and Products*, 83:596-602.
- Sharma S and Kumar R (2015) Effect of temperature and storage duration of flowers on essential oil content and composition of damask rose (Rosa x damascena Mill.) under western Himalayas. *Journal of Applied Research on Medicinal and Aromatic Plants.* DOI: http://dx.doi.org/10.1016/j.jarmap.2015.10.001.
- Sharma S, Walia S, Singh B and Kumar R (2015) Comprehensive review on agro technologies of low -calorie natural sweetener Stevia (*Stevia rebaudiana* Bertoni): a boon to diabetic patients. *Journal of the Science of Food and Agriculture.* DOI: 10.1002/jsfa.7500. 23;96(6):1867-79.
- Kumar, R, Sharma, S, Prasad R and Dubey YP (2015) Bioorganic nutrient source effect on natural sweetener plant stevia and soil fertility in the Western Himalayas. *Communications in Soil Science and Plant Analysis*. 46: 1170-1186. DOI: 10.1080/00103624.2015.1033545.

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Research Area: Entomology; bioprospection of insects, microbes and plants

Bioprospection of microbes from insects: Our group has initiated work for isolation, screening and characterization of microbes from insects for industrially important enzymes. Characterized cellulase producing bacteria *viz*. *Trabulsiella* sp. from termites and *Serratia* sp. from silverfish. Congo red assay showed a zone of clearance, indicating cellulose degrading activities of the isolated microbes.

Development of bio-insecticides: In the direction of developing plant based biopesticides, two accessions of *Acorus calamus*, *viz*., IHBT/AC/7 and IHBT/AC/16, that contain high and low β-asarone content, respectively showed insecticidal activities against 2nd instar larvae of *Spodoptera litura* and *Plutella xylostella*. However, *P. xylostella* larvae were more susceptible (96 h LC_{50}IHBT/AC/7 = 1085 ppm; IHBT/AC/16 = 1200 ppm) than the larvae of *S. litura* (96 h LC_{50}IHBT/AC/7=1756 ppm; IHBT/AC/16=2427 ppm). In IHBT/AC/7 accession, β-asarone is 2.51 times and α-asarone is 6.65 times higher as compared to IHBT/AC/16 accession. LC_{50} results of these two accessions depict that asarones are not completely responsible for the larvicidal activities of the essential oils; other constituents also play their role in rendering toxicities. The essential oils of *A. calamus* can be exploited for the development of plant based insecticides for sustainable management of agriculturally important insect pests.

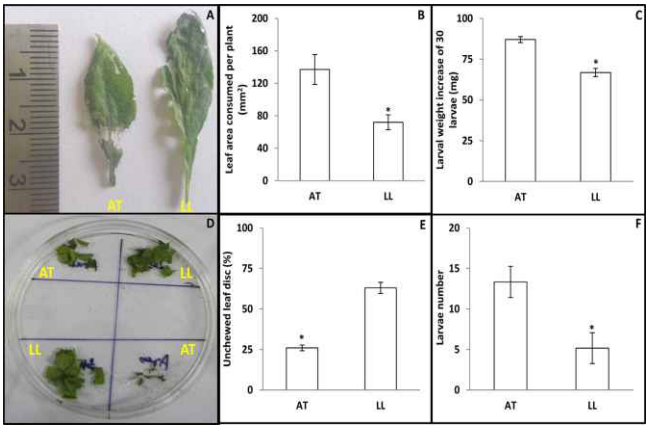

Fig. 1 Non-choice and choice feeding and performance by *P. xylostella* on *Arabidopsis thaliana* (AT) and *Lepidium latifolium* (LL). (A) leaf damage after 48 h of challenge by three 3rd instar larvae; (B) average leaf area consumed by larvae in both plants; (C) increase in weight of larvae after 48 h; (D) representative petri dish showing choice experiment; (E) % unchewed discs in choice experiment; (F) total number of insects found on each plant

DNA barcoding of insects: Initiated work on DNA barcoding of insects and identified different sps. of insects *viz*. *Aphis*, *Archips*, *Aulacorthum*, *Platynus*, *Argyresthia* and *Asaphes*.

Host-insect interaction studies:

Adult moth and larval performance of *Plutella xylostella* were studied on a novel

host *Lepidium latifolium* L. (LL) that has high sinigrin content and was compared with its laboratory host *Arabidopsis thaliana* (AT). Adult moths visit and prefers LL over AT for oviposition. Conversely, LL leaves were not preferred and proved detrimental for *P. xylostella* larvae (Fig. 1). This preference-performance mismatch of *P. xylostella* on LL mediated by glucosinolate pattern suggests that this novel plant could be utilized in *P. xylostella* management.

Advisory services: Advisory services for the management of insect and mite pests of tea besides medicinal, aromatic and other floriculture crops was provided during the year.

Publications:

- Kumari S, Chauhan U, Kumari A and Nadda G (2015) Comparative toxicities of novel and conventional acaricides against different stages of *Tetranychus urticae* Koch (Acarina: Tetranychidae). *Journal of the Saudi Society of Agricultural Sciences*, DOI: 10.1016/j.jssas.2015.06.003.
- Nadda G (2015) Occurrence of root aphid, *Forda orientalis* George on a high altitude plant, *Arenaria festucoides* Benth in Western Himalaya. *Munis Entomology and Zoology*, 10 (2):499-501.
- Nadda G and Kumar S (2015) First report of aphid, *Liosomaphis ornata* Miyazaki, 1971(Hemiptera: Aphididae) from India. *Halteres*, 6:51-55.

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Research area: Agronomy of medicinal and aromatic plants

The medicinal and aromatic plants sector is witnessing sea changes in the recent past due to high demand in the international market and also facing numerous challenges such as lack of agronomic practices and sustainable supply. Thus, the major focus is to develop and standardize the agronomic practices for higher productivity under the western Himalayan conditions. Damask rose (*Rosa damascena* Mill.) is one of the most high-value essential oil bearing plants in the world. However, the flower yield and quality of essential oil of *R. damascena* are largely influenced by the pruning practices and balance supply of plant nutrition. Information about the effect of pruning system and foliar application of $MgSO_4$ on flower yield and secondary metabolites of *R. damascena* is still unsolved. Thus, a field experiment comprising two pruning systems (complete and partial) and five levels of $MgSO_4$ (water spray as control, $MgSO_4$ @ 5.0g L^{-1}, 10.0g L^{-1},15.0g L^{-1}, and 20.0g L^{-1}) was conducted. Overall, the flower yield ranged from 503.66 -1114.47 g $bush^{-1}$ (Fig. 1), while oil content varied from 0.039- 0.046 % of the fresh flower. Irrespective of foliar spray, partial pruning produced significantly ($P \leq 0.05$) higher flower yield (893.02 and 503.66 g $bush^{-1}$) compared with complete pruning system in both the years. Regardless of pruning system, the foliar application of $MgSO_4$ @ 15.0g L^{-1} registered about 26 -38 % higher flower yield as compared to water spray (control). However, the essential oil content in flower was not significantly ($P \geq 0.05$) influenced by pruning system and foliar application of $MgSO_4$ (Fig. 1).

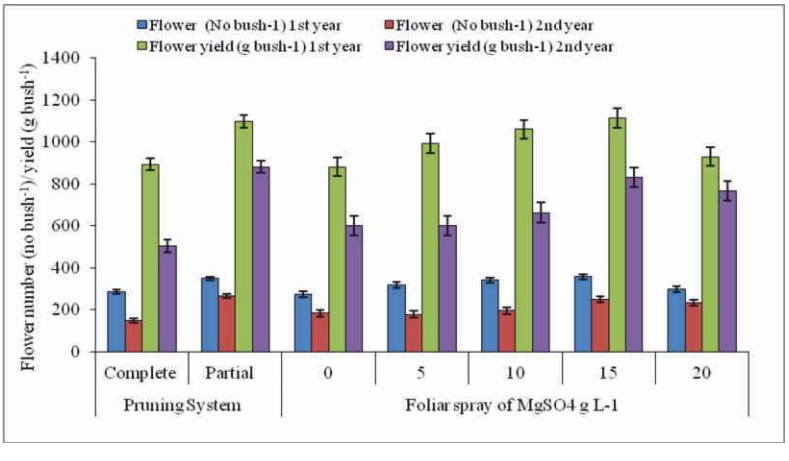

Fig. 1 Effect of pruning system and foliar application of $MgSO_4$ on flower number (No./bush) and yield (g/bush) of *R. damascena.*

Our group is also interested in developing location specific, cost effective and eco-friendly agrotechnologies for higher resource use efficiency and sustaining the productivity and soil health under medicinal crop production system. The effect of conservation of agricultural practice has been evaluated in stevia crop production system under the western Himalayan conditions. The analyzed data revealed that conventional tillage practices significantly ($P \leq 0.05$) increased dry leaf yield (t ha^{-1}) by about 22 and 50 % compared with zero tillage practices during 1st and 2nd cropping season, respectively. However, no significant ($P \leq 0.05$) difference was observed between conventional and zero tillage practices during 3rd cropping season. Organic carbon (OC) content in soil was significantly ($P \leq 0.05$) increased with conventional tillage practices during 2nd and 3rd cropping seasons (Fig. 2). On the other hand, application of mulching (M_1- 5t ha^{-1}, M_2-5t ha^{-1}, M_3-15t ha^{-1}) increased OC in soil as compared to control (M_0-without mulch) during all the cropping seasons (Fig. 2).

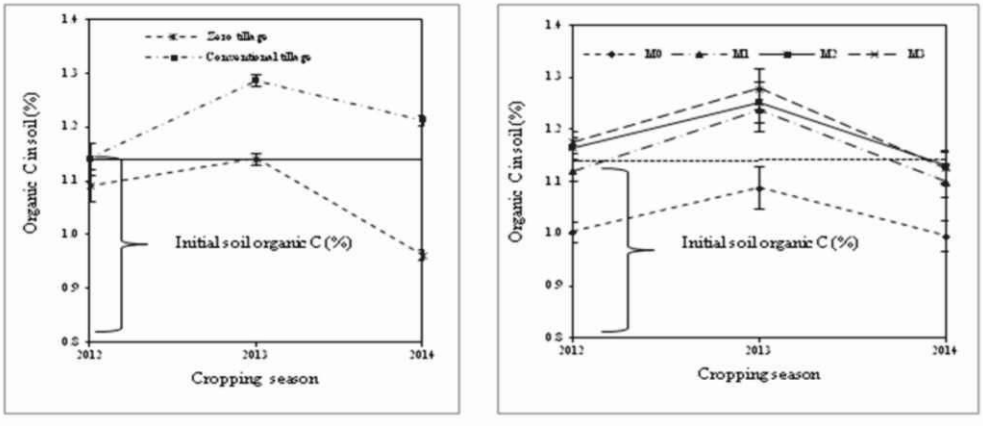

Fig. 2 Effect of tillage practices and mulching on soil organic status under the western Himalayan conditions.

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Research area: Plant breeding

Evaluation of polyploid stevia CSIR-IHBT-ST-03 (C-7-3-4): Tetraploid stevia genotype was developed through treatment of stevia seeds with 0.6% colchicine treatment for 24 h. The polyploid stevia genotype CSIR-IHBT-ST-03 (C-7-3-4) was distinguished from diploid control stevia plant through flow cytometry. Chromosome count in the root tip cells of polyploid stevia CSIR-IHBT-ST-03 (C-7-3-4) confirmed the tetraploid status.

The genotype CSIR-IHBT-ST-03 (C-7-3-4) was evaluated for morphological as well as biochemical traits (Fig. 1; Table 1).

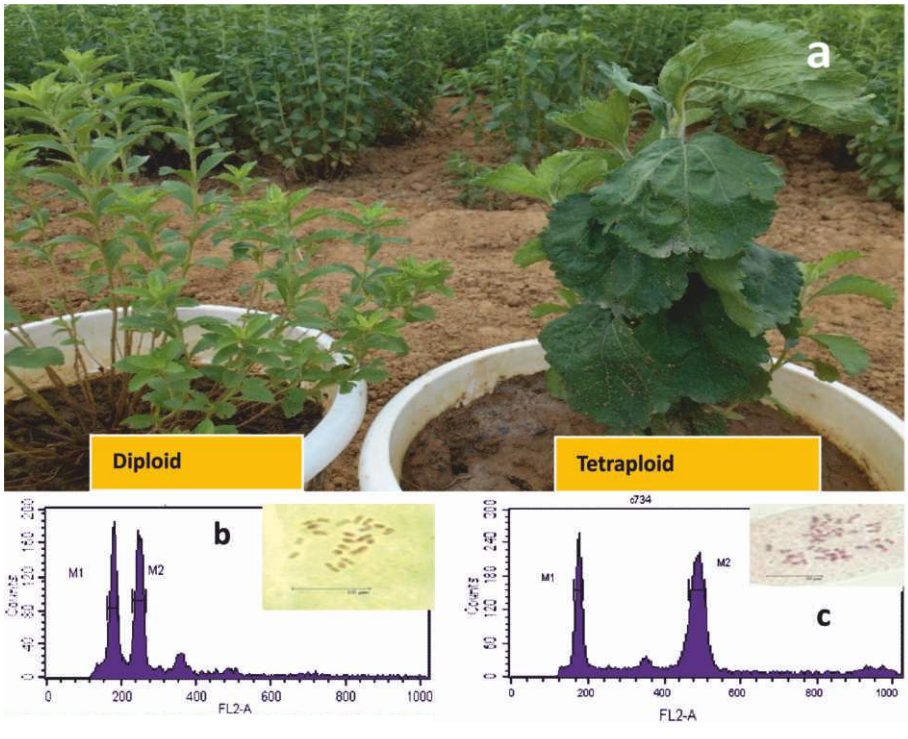

Fig. 1 (a) Diploid (Control) and tetraploid genotype CSIR-IHBT-ST-03 (C-7-3-4) of stevia, (b) Flow-cytometry histogram showing internal reference standard M1 (*Lycopersicum esculentum*) and diploid *Stevia rebaudiana* M2 and (c) Internal reference standard M1 (*L. esculentum* 'Stupicke') and tetraploid CSIR-IHBT-ST-03 (C-7-3-4) *S. rebaudiana* M2. Inset pictures are the chromosome counts from root tips of respective stevia plant.

Table 1 Morphological features of tetraploid stevia genotype CSIR-IHBT-ST-03 (C-7-3-4) in comparison to check at Palampur location .

Character	CSIR-IHBT-ST-03 (C-7-3-4)		Control (Canada-2-3-1)	
	2012-13	2013-14	2012-13	2013-14
Biochemical traits				
Stevioside %	6.35	7.54	7	6.6
Rebaudioside-A%	2.55	2.25	2.1	2.4
Morphological trait				
Plant height (cm)	103.70	97.40	105.50	112.30
Branches/plant (no.)	4.50	12.00	8.00	18.00
Stem thickness (mm)	8.15	6.14	6.41	5.42
Internode length (cm)	5.40	6.10	3.10	3.80
Max. leaf length (cm)	10.24	9.67	6.80	6.84
Max. leaf width (cm)	6.94	7.08	3.80	3.52

Selection and evaluation of potential Calla lily genotypes

The parental genotypes of *Zantedeschia elliottiana* CSIR-IHBT-CL-ZE-1 (light yellow coloured) and CSIR-IHBT-CL-ZE-2 (Red purple coloured) were crossed and variable colours of calla lilies were obtained in the progenies which were morphologically characterized for floral traits. The genotype CSIR-IHBT-CL-Y-1 has been selected for its unique cylindrical trumpet flower shape and attractive bright yellow colour. The genotype along with parents were evaluated for two years with respect to flower production potential and other agronomic attributes *viz*., flower stalk length, stalk diameter, leaf size and numbers, plant height, number of flowers per plant and number of shoots under field and protected conditions.

Fig. 2 Flower and plant of genotype CSIR-IHBT-CL-Y-1 of *Zantedeschia elliottiana*

Table 2. Morphological features of genotype CSIR-IHBT-CL-Y-I under field and polyhouse conditions

Morphological Traits	Protected cultivation		Field condition	
	Mean	Range	Mean	Range
Number of flowers	3.3	1.0-4.0	3.2	1.0-4.0
Flower stalk length (cm)	88.4	44.3-97.6	48.2	37.5-64.3
Flower stalk diameter (mm)	8.6	4.88-10.4	6.7	3.9-8.9
Plant height (cm)	124.5	81.4-134.5	94.3	56.4-102.3
Leaf length (cm)	25.4	18.7-31.5	22.2	15.4-26.2
Leaf width (cm)	17.3	12.4-21.4	12.1	9.3-13.1
Number of shoots	4.6	2.0-5.0	5.0	1.0-6.0
Number of leaves	20.3	16.0-25.0	28.2	5.0-32.0

In *Zantedeschia aethiopica* hybridization programme was undertaken using two parental genotypes CSIR-IHBT-CL-ZA-1 and CSIR-IHBT-CL-ZA-2. Variable floral shapes of calla lilies were obtained in the progenies which were evaluated for agronomic traits under protected and field conditions. The genotype CSIR-IHBT-CL-W-1 has been selected for desirable flower shape and white colour. The evaluation of selection along with parents was done for two years with respect to flower production and agronomic parameters viz. flower stalk length, stalk diameter, leaf size and numbers, plant height, number of flowers per plant and number of shoots.

Fig.3 Flower and plant of genotype CSIR-IHBT-CL-W-1 of *Zantedeschia aethiopica*

Table 3. Morphological features of IHBT-CL-W-1 under field and polyhouse conditions

Morphological Traits	Field condition		Protected cultivation	
	Mean	Range	Mean	Range
Number of flowers	6.7	4.0-10.0	5.0	4.0-6.0
Flower stalk length (cm)	90.3	81.4-104.5	107.5	98.5-118.0
Flower stalk diameter (mm)	10.2	6.9-16.5	13.1	10.1-17.8
Plant height (cm)	62.2	49.0-72.5	85.6	81.5-95.1
Leaf length (cm)	22.7	16.4-28.4	42.5	38.0-45.5
Leaf width (cm)	11.4	7.6-17.5	21.5	17.3-26.2
Number of shoots	10.3	6.0-14.0	12.4	10.0-16.0
Number of leaves	33.0	26.0-37.0	38.0	34.0-45.0

Chrysanthemum breeding: For the genetic improvement of Chrysanthemum, 78 crosses were attempted among the diverse germplasm accessions to generate novel variations for flower colour, shape and size. The F1 Hybrid seeds were sown and hybrid populations were raised. Selection was performed among the hybrid populations for flower colour, shape and size. A total of 16 F1 hybrids were selected for further multiplication and evaluation (Fig. 4).

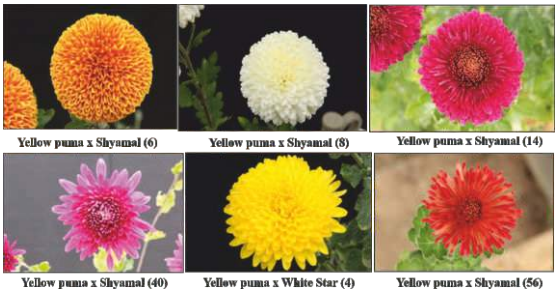

Fig. 4 Selected chrysanthemum F1 hybrids for further multiplication and evaluation.

Marigold breeding: Ninety nine breeding lines of marigold were developed through hybridization and selection approaches. These selected breeding lines were evaluated for morpho-agronomic traits for two seasons during 2014-15 and 2015-16 (Fig. 5; Table 4).

Fig. 5 a) Marigold plant and b) marigold flower

Table 4: Morphological characteristics of marigold breeding lines

S. No.	Morphological parameters	Range	Mean
1	Plant Height (cm)	35 - 98	71.44
2	Flower diameter (cm)	4.6 - 7.6	6.12
3	Flower no./plant	3 - 101	31.0
4	No. of buds	7 - 60	27.4
5	Total flower + buds	18 - 107	57.28
6	Flower wt. (g)	8.57 - 15.12	10.52
7	No. of branches	4 - 15	7.12
8	Plant spread (cm)	35 - 97	61.34

Registration of Germplasm: Registration of two gerbera cultivars "Him Glow" (INGR15019) and "Him Peace" (INGR15018) as germplasm at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research.

Publications:

- Singh S, Ram Raja, Kaundal S, Sharma A, Kumar A and Dhyani D (2016) Field performance and differential response of micro-propagated potential F_1 genotypes of *Gerbera jamesonii*. *American Journal of Experimental Agriculture*,10(1): 1-11.
- Yadav AK, Kaundal S, Sharma A and Singh S (2015) Chilling Stress tolerance in plants: Physiology and mechanisms. In: *Recent advances in plant stress physiology*. Praduman Yadav, Sunil Kumar (eds.) Astral International (P.) Ltd., India ISBN 978-93-5124-730-2, pp.-185-199.

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Research area: Development of bio-pesticides and pest management

The research focus is on isolation and characterization of native strains of entomopathogenic fungi (EPF) from insect cadavers' and soil samples from agricultural, horticultural and forest ecosystem in western Himalayan region for development of microbial biopesticides. We are also targeting Himalayan flora to study their insecticidal properties against target pests i.e. *Plutella xylostella*, *Spodoptera litura* and *Aphis craccivora*. The work is also being done on effect of elevated temperature and carbon dioxide on biology and life cycle of insect pests on target medicinal plants.

Identification of promising native strains of entomopathogenic fungi (EPF) for the development of microbial bio-pesticides for pest management: Field surveys were carried out for isolation of EPF from soil samples of different ecosystems. Two strains showed promising activity/pathogencity against second instar larvae of *P. xylostella* (60-100% mortality) and *A. craccivora* (96-100% mortality) under laboratory conditions. The isolated strains will be further evaluated against target pests under field conditions.

Screening plant extracts/fractions/essential oils/pure compounds/synthetic analogues against target pests for development of formulations: Essential oils of *Acorus calamus*, *Cedrus deodara, Aegle marmelos, Tagetes minuta* and *Murraya koenigii* were screened for their insecticidal properties against *P. xylostella* larvae. *A. calamus* was found more effective against second instar larvae (LC_{50}=0.29 mg/mL) after 72 h followed by *C. deodora* (LC_{50}=1.08 mg/mL) as compared to other essential oils. Feeding deterrence and repellent activity of *A. calamus* and *C. deodara* was more promising (59-71% and 73-86% respectively) against third instar larvae.

Insecticidal and structure activity relationship of cinnamoyl amides from *Zanthoxylum armatum* was studied against *P. xylostella*. The activities of these compounds varied depending on the presence of specific substituents at various positions of the aromatic rings (A and B). Among the tested compounds, 8, *N*-(3-bromo-4-methoxyphenethyl)cinnamamide showed best larvicidal activity (LC_{50}=62.13mg/L) followed by 6, *N*-(3×-bromophenethyl)cinnamamide (LC_{50}=128.49mg/mL) and 2 *N*-(4×-methoxyphenylethyl)cinnamamide (LC_{50}=225.65 mg/mL).

A new hederagenin based triterpenoid saponin, clematograveolenoside A (1) along with three known saponins, tomentoside A (2), huzhangoside D (3) and clematoside S (4) were isolated from the roots of *Clematis graveolens* were screened for their toxicity against *A. craccivora*. Tomentoside A (2) was found more effective against *A. craccivora* with an LC_{50} value of 1.21 and 0.46 mg/L at 72 and 96 h after treatment, respectively.

Publications:

- Reddy SGE, Dolma SK, Koundal R and Singh B (2015) Chemical composition and insecticidal activities of essential oils against diamondback moth, *Plutella xylostella. Natural Product Research*, DOI:10.1080/14786419.2015.1068772.
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- Kumar V, Reddy SGE, Bhardwaj A, Dolma SK and Kumar N (2016) Larvicidal activity and structure activity relationship of cinnamoyl amides from *Zanthoxylum armatum* and their synthetic analogues against diamondback moth, *Plutella xylostella*. *EXCLI Journal*, 15:229-237.
- Reddy SGE, Dolma SK and Bhardwaj (2016) Plants of Himalayan region as potential source of biopesticides for lepidopteron insect pests. In. *Herbal insecticides, Repellents and Biomedicines: Effectiveness and Commercialization* (Eds) Vijay Veer and Reji Gopalakrishnan, Springer India.

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Research area: Protected cultivation of ornamental crops

Floriculture has been the major thrust area for diversification of agriculture in the hills during the recent years. The agro climatic conditions offer excellent opportunities for the development of floriculture to serve the internal off-season market.

Development of agro-technologies for orchids: Orchids have become one of the most important segments in world floriculture market. The orchids symbolize friendship, perfection, elegance and virility. These are grown for cut flowers, pot plant, extraction of bio-molecules and herbal medicines. The flowers and pot plant command highest price in markets due to their incredible range of diversity in size, colour, shape, forms, appearance and long vase life. Keeping in view the potential of Orchids, we are interested in developing agro-technologies, improvement in productivity, quality and commercialization for high value temperate orchids in the Western Himalayas.

Fig. 1 Cymbidium pots in shade net house

Agro technologies for eight hybrids of Cymbidium i.e. 'Pink Clash Moon Venus', 'Winter Beach Sea Green', 'Eushi Kam', 'Sleeping Nymph', 'Soul 'Hunt 6', CM12, CM03, CM02, and CM06 along with other orchids species i.e. *Arundina graminfolia*, *Zygopatalum lutermilium, Cattleya* sp. and *Dendrobium aphyllum* are under development.

Fig. 2 Flowering in Cymbidium varieties (Yellow colour and Yellow colour with brownish spot)

Fig. 3. 1-year-old cymbidium seedlings (CM02 and CM06)

Lilium: Due to increase in demand, year round production of cut flower has become important practice among growers. For control of flowering bulbs and plant are treated with specific temperatures and chemicals to impact their growth and flowering. In this regard, we evaluate lilium LA varieties Pavia and Ercolano in poly house conditions for growth and flowering parameters.

Fig. 4 Flowering in LA lilium cultivar Ercolano in polyhouse

Table 1. Performance of Ercolano and Pavia varieties of LA lilium in protected cultivation

Parameters	Ercolano	Pavia
Plant height	67.85 cm	65.91 cm
No. of leaves	78.2	54.9
Length of leaves	8.54 cm	10.07
Days for flowering	71.3 days	79.3 days
Duration of flowering	9.4 days	8.9 days
Flower diameter	20.13 cm	18.48 cm
No. of buds per plant	3.9	4.4
No. of bulbs harvested/ plant	2	2.5
No. of bulblets/ bulb	5.8	2.5
Weight of bulbs	52 g	45 g
Diameter of bulbs	5.01 cm	4.5 cm

Germplasm conservation and maintenance: Existing germplasm of lilium consisting of ten asiatic cultivars was enriched with eight oriental lilies and two LA cultivars, one calla lily cultivar, eight orchid cultivars, three chrysanthemum cultivars. Twelve wild species namely *Corydalis meifolia, Meconopsis aculata, Rhodolia fastigata, Potentilla atrosanguinea, Polygonum affine, Pedicularis siphonantha, Cremanthodium arnicoides, Swertia paniculata, Senecio raphanifolius, lagotis cashmeriana, Dianthus angulatus* and *Iris kumaonensis* were collected from Rohtang and Lahaul valley of Himachal Pradesh for testing their suitability as a potted plant.

Publications:

- Sharma P , Gupta YC , Dhiman SR, Sharma P and Bhargava B (2015) Effect of planting time on growth, flowering and seed yield in Dianthus barbatus L. *National Academy Science Letters*, DOI 10.1007/s40009-014-0336-2.
- Sharma P, Gupta YC, Dhiman SR, Sharma P and Bhargava B (2016) Variation in growth, flowering and seed yield of satin flower (*Godetia grandiflora*) planted on different date. *Indian Journal of Agricultural Sciences*, 86(2):277-280.
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Biotechnology

Biotechnological interventions for prospection, utilization and conservation of bioresources in Himalaya

- Developing efficient micro-macro propagation systems
- Identification of genome wide makers, metabolic engineering and Nanobiology
- Next-Gen and Third Generation high throughput whole genome and transcriptome sequencing for understanding evolutionary mechanism
- Dissecting abiotic and biotic stresses
- Identification and characterization of novel enzymes/ genes for basic and applied research

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Research area: Plant adaptation and high altitude biology

Himalayas offer large opportunities to bioprospect microbe and plant diversity for identification and sustainable utilization of the relevant components for industrial use. Our group has been involved in bioprospecting genes, enzymes & metabolic pathways, and understanding the adaptation of plants along the altitudes of Himalayas. While prospecting enzymes, our group identified a unique thermostable superoxide dismutase (SOD) from *Potentilla atrosangunia* that was further engineered to improve tolerance to autoclaving and functionality across the wide range of temperature from subzero to 50C. Analysis of amino-acids sequence of SOD showed the presence of a central core that imparts structural stability and catalytic activity to the enzyme. However, a role of sequences flanking the central core was not known. Wet lab as well as bioinformatic-based experiments with the deletion mutants of SOD showed that the flanking sequences are important for the optimal functionality of the enzyme and also to maintain the stability of the enzyme after autoclaving (Fig. 1). Deletion of flanking sequences produced unfavorable geometry of SOD which leads to non-availability of substrate to the active site (Fig. 2).

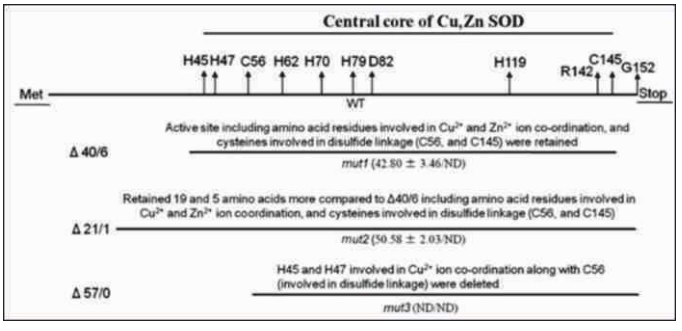

Fig. 1 Deletion experiments carried out with the wild-type (WT) SOD. Important amino acids in the WT are shown by arrow mark. Central core is marked and it has important residues for conferring catalytic activity. N-terminal of the protein is shown by the first encoded amino acid methionine (Met), whereas extreme C-terminus is marked as Stop. Various deletion mutants such as *mut1* (deletion of 40 and 6 amino acids from N and C-terminal, respectively), *mut2* (deletion of 21 and 1 amino acids from N and C-terminal, respectively), *mut3* (deletion of 57 amino acid from N terminus, whereas all amino acids were retained at C-terminus, respectively) created in the study are shown as line diagram. WT and mutant SODs were expressed and purified for estimation of the activity. The per cent activity relative to the maximum activity of WT is given in parentheses below the line diagram of each mutant. Δ, truncation; numerical values before and after slash are the number of amino acids truncated from N- and C-terminal, respectively; nd, activity not detected (adapted from our article published in *J Biomol Struct Dyn*, 34(3): 474-85, 2015).

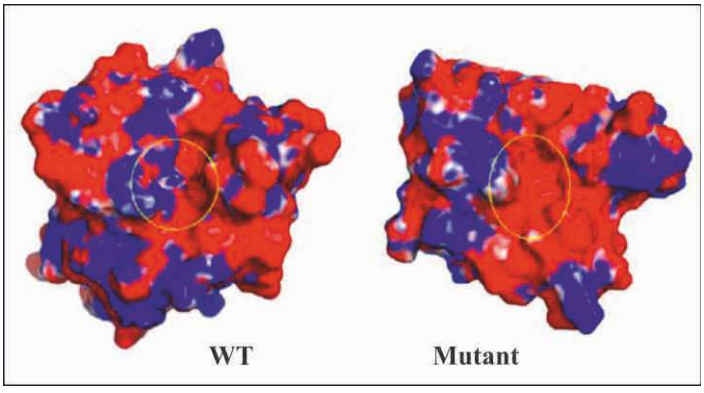

Fig. 2 Comparison of volume and electrostatic potential surface of wild type (WT) and a mutant (deletion of 40 and 6 amino acids from N and C-terminal, respectively) models. Though, we created three different deletion mutants as shown in Fig. 1, data of only one mutant is shown in the above figure. Blue, red and white color represents negative, positive, and neutral charge, respectively. Catalytic pocket region within enzyme is encircled (adapted from our article published in *J Biomol Struct Dyn*, 34(3): 474-85, 2015).

Yet another interest of our group is on regulation of secondary metabolites in the medicinal plants of Himalayas. Our previous work deciphered the metabolic pathway leading to the picroside biosynthesis in *Picrorhiza kurrooa* (*P. kurrooa*) and revealed the importance of temperature in regulating the picrosides metabolism. To gain insights into temperature regulatory mechanisms, miRNA libraries were prepared and analyzed from leaf and rhizome tissues of *P. kurrooa* exposed to 15°C and 25°C. The functional validation of micro RNAs and their respective targets showed the importance of phenylpropanoid, stibelinoid, cysteine and methionine metabolism in regulating temperature response of *P. kurrooa*. The outcome from such studies has far reaching implications in the metabolic engineering of plant secondary metabolism and synthetic biology.

Publications:

- Kumar A, Randhawa V, Acharya V, Singh K and Kumar S (2015) Amino acids flanking the central core of Cu, Zn superoxide dismutase are important in retaining enzyme activity after autoclaving. *Journal of Biomolecular Structure & Dynamics*, 34(3):475-85.
- Shafi A, Chauhan R, Gill T, Swarnkar MK, Sreenivasulu Y, Kumar S, Kumar N, Shankar R, Ahuja PS and Singh AK (2015) Expression of SOD and APX genes positively regulates secondary cell wall biosynthesis and promotes plant growth and yield in *Arabidopsis* under salt stress. *Plant Molecular Biology* 87(6):615-31.
- Paul A and Kumar S (2015) An *A20/AN1-zinc-finger domain containing protein* gene in tea is differentially expressed during winter dormancy and in response to abiotic stress and plant growth regulators. *Plant Gene* 1: 1-7.
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Patents:

- Kaachra A, Vats SK, Ahuja PS and Kumar S. An expression construct and process for enhancing the carbon, nitrogen, biomass and yield of plants. Aug 19, 2015 EP2699687 B1.

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Research area: Conservation and genetic improvement of western Himalayan bioresources

Conservation of rare, endangered, critically endangered and threatened medicinal plants of western Himalaya

In our attempt to develop alternative systems of *Nardostachys jatamansi* for valuable physiochemicals, large amounts of callus cultures were developed from leaf explants and screened for important phytochemicals. The calli was found to have a number of important phytochemicals including nardin known for its hair growth promoting property.

In continuation to previous work carried out under the DBT sponsored project 'Preventing extinction and improving conservation status of threatened plants through application of biotechnological tools', *in vitro* repositories were established for 15 accessions of *Dactylorhiza hatagirea* collected from different locales of HP. In a separate study, Plant Growth Promoting Rhizobacteria (PGPR) were isolated from the *in situ* rhizosphere of *Picrorhiza kurrooa* and used for hardening tissue culture raised *P. kurrooa* plants under polyhouse conditions. The biologically hardened plants showed more than 85% survival as compared to no survival of untreated control plants.

Evaluation of growth and reproductive performance of transgenic tea plants developed by the biolistic gun method: Transgenic tea plants developed from leaf explants by the biolistic gun method in an earlier study were maintained under polyhouse conditions for seven years. The growth and reproductive behaviour of the transgenic and nonbombarded control plants were evaluated. Phenotypic similarity was recorded in the transgenic and control plants. Although, the growth parameters were significantly at par, shoot height was found to be significantly lower in the transgenic plants. Abscission of floral buds and flowers, fruit drop and empty seed formation were significantly higher in the transgenics. Viability and germination of the transgenic seeds was also significantly lower and only 3% of the transgenic seedlings survived. Depression in reproductive behaviour of transgenic plants was notable.

Catechin-specific-diazotized sulfanilamide reagent for histo-chemical evaluation of catechins in PEG stressed transgenic tea plants: Presently, there are a number of methods for detection of cellular localization of polyphenols using histo-chemical methods. However, specific detection of catechins in the plant cells has not been possible till date. Therefore, the applicability of the catechins-specific-reagent (CSR) was investigated for histo-chemical detection of cellular

catechins. It was earlier shown that a golden-yellow coloured complex is formed when the diazotized arylamine moiety of the CSR reagent reacts specifically with the Aring of catechins. Based on this principle, the CSR regent is used for spectrophotometric quantification of catechins. In the study, CSR stained microtome sections of leaves and stem of transgenic and nontransgenic tea plants revealed cellular localization of golden yellow coloured catechin globules. The structurally intact and highly turgid transgenic cells accumulated higher levels of catechins after 20% PEG stress, whereas, the non-transgenic cells contained only few catechin globules. The findings corroborated well with spectrophotometric quantification data (Fig. 1).

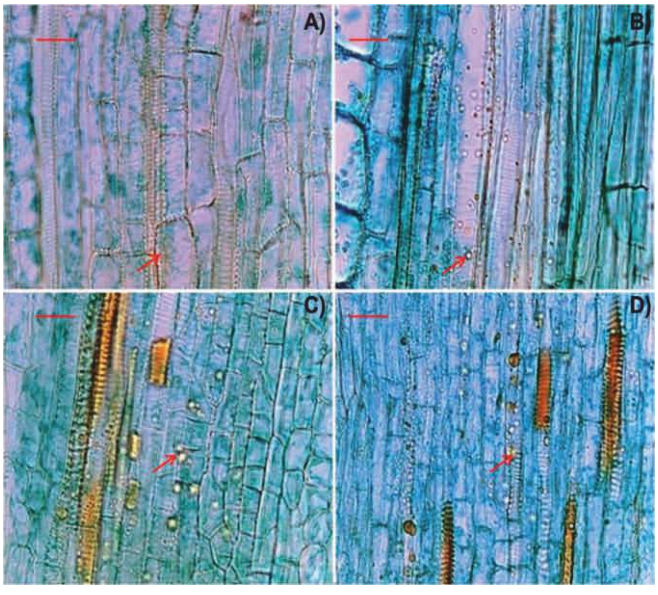

Fig. 1CSR stained longitudinal sections of stem sed untransformed control (UT). B) Untreated transgenic (TR). C) PEG treated UT. D) PEG treated TR. Scale bars- 20 µm.

Identification of markers of floral transition in maggar bamboo (*Dendrocalamus hamiltonii*): While all clonal populations of a bamboo plant remember their age and die *en masse* after gregarious flowering, it is impossible to identify juvenile plants from the ones that will flower gregariously and die. Therefore, the transcriptome approach was employed to identify markers that will differentiate juvenile and about-to-flower plants. The up and down regulation of several floral transition genes and transcription factors homologous to dicot and monocot model plants were recorded and correlated with morphological and biochemical changes in vegetative, about to flower and flowering stages. These changes were able to predict flowering in the *in vitro* system and corroborated well with data obtained from proteomic studies (Fig. 2).

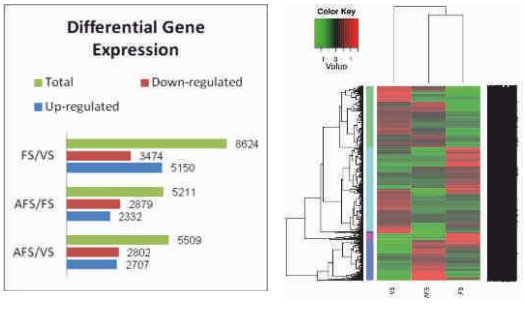

Fig. 2 Heat map of significantly but differentially expressed contigs of three floral transition stages.

Publications:

- Kaur D, Dogra V, Thapa P, Bhattacharya A, Sood A and Sreenivasulu Y (2015) *In vitro* flowering associated protein changes in *Dendrocalamus hamiltonii*. *Proteomics* 15:1291–1306, DOI 10.1002/pmic.201400049.
- Bhattacharya A, Sharma M, Gulati A, Joshi R, Chanda SK and Ahuja PS (2015) Biotechnic & Histochemistry. *The Biological Stain Commission*, 90(1): 45-54.
- Sandal I, Koul R, Saini U, Mehta M, Dhiman N, Kumar N, Ahuja PS, Bhattacharya A (2015) Development of transgenic tea plants from leaf explants by the biolistic gun method and their evaluation. *Plant Cell Tissue and Organ Culture*, 123:245–255.
- Ahmad N and Anis M (2015) *In Vitro* Approaches for Conservation and Sustainable Utilization of *Podophyllum hexandrum* and *Picrorhiza kurroa* - An overview on these Endangered Medicinal herbs of Western Himalaya. In: Plant Tissue Culture: Propagation, Conservation and Crop Improvement. Springer, Singapore.

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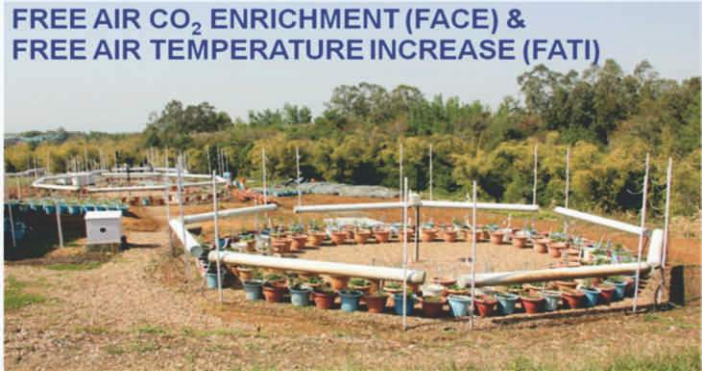
Research area: Adaptive biology and climate change

Studies under free-air CO_2 enrichment and temperature increase facility is a better way of estimating how plant growth will respond to the conditions under climate change scenario. There is an increasing support to the view that such information should be generated from diverse regions as well as ecosystems of the world to account for inherent variability and have representation of diverse groups of plants.



a) Gas exchange studies: During the current year, impact of elevated CO_2 and temperature was studied in the following plant species native to Himalaya *viz. Hypericum perforatum*, *Picrorhiza kurroa, Rumex neplensis, Taraxacum officinale* (low and high altitude populations), and *Valeriana jatamansi*. Changes in physiology, morphology, secondary metabolite composition and biomass partitioning were studied during spring and autumn seasons.

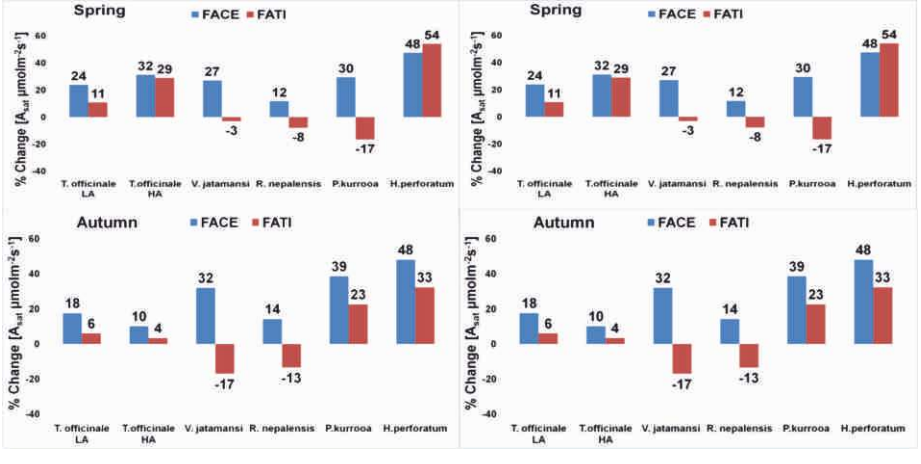


Fig. 1 Percent changes in light saturated photosynthesis (A_{sat}) and stomatal conductance (g_s) in leaf of *Hypericum perforatum, Picrorhiza kurroa, Rumex neplensis, Taraxacum officinale* (low and high altitude populations), and *Valeriana jatamansi* during spring and autumn months under elevated CO_2 (FACE; 550±50 µmol m^{-2} s^{-1}) and elevated temperature FATI; 2.5 ±0.50 ºC).

Under elevated CO_2 (FACE), light saturated photosynthesis (A_{sat}) increased for all species during Spring and Autumn months. The percent change in A_{sat} for *T. officinale* was higher in spring than during autumn. Compared to low altitude (LA) population of *T. officinale*, change in A_{sat} for high altitude (HA) population of the species was more than 3 times higher in spring than during autumn. Change in A_{sat} for under-storey species, *V. jatamansi* and *R. nepalensis*, and HA species *P. kurrooa* was greater during autumn compared to spring.

Stomatal conductance (g_s) decreased invariably under FACE, for all the species and for both the seasons of study. Change in g_s was greater for low altitude species during Spring than autumn. HA species *T. officinale* and *P. kurroa* showed relatively greater decrease during autumn.

Grown under elevated temperature conditions, *T. officinale* showed differential responsive to warming; A_{sat} increased during spring but decreased during autumn. Warming increased A_{sat} in open habitat species *T. officinale* and *H. perforatum* during spring but led to its decrease in under-storey species like *V. jatamansi* and *R. nepalensis* during both the seasons.

P. kurrooa an open habitat species of high altitude distribution showed decrease in A_{sat} under FATI during spring season only. Decrease in g_s was greater during autumn than spring for all species in response to warming.

b) Variation in total polyphenol content under Free Air CO_2 Enrichment (FACE) and Free Air Temperature Increase (FATI):

Under FACE environment, total polyphenol content registered a significant ($P \leq 0.05$) increase in both leaf and root samples of *R. nepalensis*. Under elevated temperature, the content decrease non-significantly ($P \geq 0.05$) in leaves. However, total polyphenol content in root increased significantly ($P \leq 0.05$) as compared to that in leaves grown under control conditions.

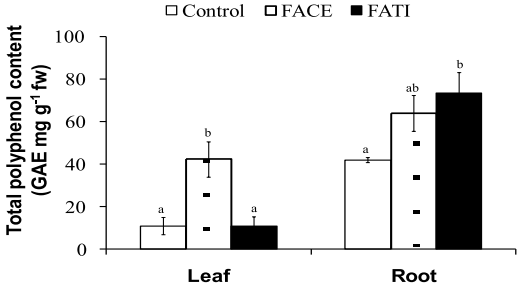


Fig. 2 Total polypenol content in leaf and root of *Rumex nepalensis* grown under ambient CO_2 (Control), elevated CO_2 (FACE), and elevated temperature (FATI) on fresh weight (fw) basis and expressed as gallic acid equivalents (GAE). The data shown indicate means ±SE (n=3). One-way ANOVA was conducted and different letters in superscript show significant difference at $P<0.05$.

C) Variation in total polyphenol content along an altitude: For *ex-situ* studies, populations of *R. nepalensis* were raised from seeds collected from four different altitudes; 800 m amsl, 1300 m amsl, 2200 m amsl, 4000 m amsl and grown under common conditions of greenhouse. For *in-situ* studies, samples were collected from population of the species growing in its native habitat at all the four altitudes as mentioned earlier. In leaves of the species, total polyphenols content showed a curve-linear response as a function of altitude under both *ex-situ* and *in-situ* conditions.

Compared to 800 m, total polyphenol content increased significantly ($P \leq 0.05$) under *ex-situ* and *in-situ* conditions up to 2200 m altitude. Thereafter, total polyphenols content showed a significant ($P \leq 0.05$) decline at 4000 m amsl. Total polyphenol content in roots of *R. nepalensis* showed a significant ($P \leq 0.05$) linear decrease with increase in altitude under both *ex-situ* and *in-situ* conditions.

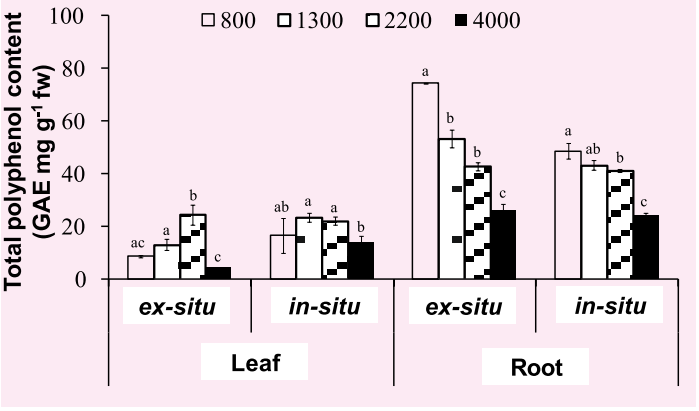
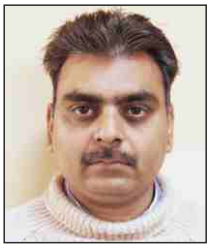


Fig. 3 Total polyphenol content in leaf and root of *Rumex nepalensis* under *ex-situ* and *in-situ* conditions on fresh weight (fw) basis and expressed as gallic acid equivalents (GAE). All the data are mean values ± SE. One-way ANOVA was conducted and different letters in superscript show significant difference at $P<0.05$ (n=3).

Patent:

- Anish Kaachra, Surender Kumar Vats, Paramvir Singh Ahuja, Sanjay Kumar. An expression construct and process for enhancing the carbon, nitrogen, biomass and yield of plants. peoples republic of china (Application No. 201280027891.9; granted 05/11/2015);European patent (No: 269968; granted on 19/08/2015).



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Research area: Plant-virus interactions

Active transmission of *Apple scar skin viroid* naked RNA by the whitefly, *Trialeurodes vaporariorum:* Nucleic acid transfer between plants is a phenomenon which is likely to occur in many ways in nature. Active transmission of Apple scar skin viroid (ASSVd) naked ssRNA species by the whitefly *Trialeurodes vaporariorum* (Tv) was reported for the first time. Not only the viroid RNA, its DNA form was also identified from the insect. The viroid transfer efficiency was enhanced with the help of *Cucumis sativus* Phloem protein 2 (CsPP2), a plant protein known to translocate viroid RNAs. This PP2/ASSVd complex was stably present in the viroid infected cucumber plants (Fig. 1). As viroid-like secondary structures are found in some plant RNAs, and PP2 is known to bind and translocate several RNAs, the results have huge implications in transfer of similar RNA species between plants visited by the whitefly.

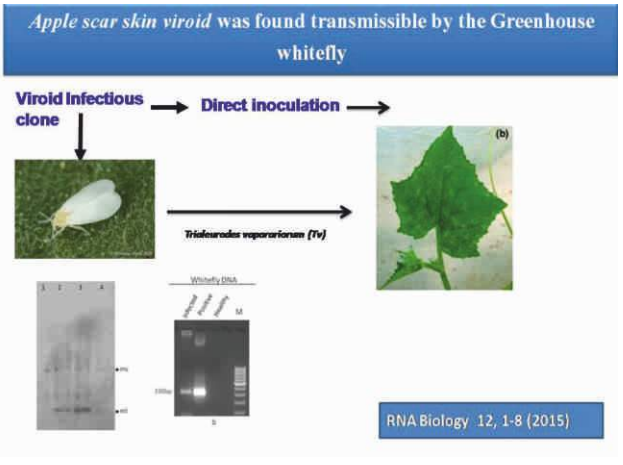

Fig. 1 Viroid RNA replication and conversion into DNA in Tv (RT) The RNA is picked up as a complex involving viroid, phloem protein 2 and ubiquitin ligase

Natural occurrence of *Apple stem grooving virus* on bamboos and *Bauhinia variegata:* *Apple stem grooving virus* (ASGV) is an important and abundant virus in apple orchards. Presence of the virus was confirmed on various Bamboo species and *B. variegata* by molecular means. The identified isolate were 95-98% similar at sequence level. After *Bamboo mosaic virus* and *Cherry necrotic rusty mottle virus*, ASGV happens to be only the third virus to be characterized from bamboo. The trees probably act as a reservoirs of ASGV.

Complete nucleotide sequence of *Ageratum enation virus* and an alphasatellite infecting a new host *Glycine max* in India: Leaf crumpling, yellowing and stunting were observed on soya bean (*Glycine max*) in Himachal Pradesh, India. PCR-based detection confirmed the presence of a begomovirus. The viral genome was amplified by rolling circle amplification, cloned and

sequenced. The complete nucleotide sequence of DNA-A showed highest nucleotide identity to an isolate of *Ageratum enation virus* infecting a weed *Ageratum conyzoides*. In addition, a DNA molecule was found which shared 95% nucleotide identity with an alphasatellite infecting ageratum. Neither beta satellite nor DNA-B were detected in the infected samples.

***Valeriana jatamansi* and *Glycine max* as natural hosts of Begomoviruses and *Cucumber mosaic virus*:** In order to identify natural virome of *Valeriana jatamansi* and *Glycine max*, *V. jatamansi* was found infected with *Cucumber mosaic virus* (CMV) subgroup I isolate. In another study, *V. jatamansi* showing crinkling symptoms and *G. max* showing yellowing and stunting were found associated with *Bhendi yellow vein mosaic virus* and *Ageratum enation virus*, respectively. Results suggest that *V. jatamansi* may act as a reservoir for the above two important viruses of vegetables.

Publications:

- Bhardwaj P, Awasthi P, Prakash O, Sood A, Zaidi AA and Hallan V (2016) Molecular evidence of natural occurrence of Apple stem grooving virus on bamboos. *Trees - Structure and Function*, 1-9, DOI 10.1007/s00468-016-1375-8.
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Research area: Molecular genetics and genomics

Genetic diversity characterization and genomic resource creation in endangered medicinal and commercially important plants

***Aquilaria malaccensis* (Agarwood):** The primary goal of plant conservation is to maintain genetic diversity of endangered species. Among the different genetic resources, home garden plantations are proved to be very efficient for ex- situ conservation of rare/endangered species. The endangered *A. malaccensis* is an important plant with high economic values. *A. malaccensis* Lam. (Thymelaeaceae) is an evergreen, hermaphroditic and an obligate outcross species, commonly known as 'sasi'. It is the main source of agarwood in India. Characterization of genetic diversity and population structure is receiving tremendous attention for effective conservation of genetic resources. Considering important repositories of biological diversity, the genetic relationships of 127 *A. malaccensis* accessions from 10 home gardens of three states of northeast India were assessed using amplified fragment length polymorphism (AFLP). Of the 1153 fragments amplified with four AFLP primer combinations, 79.4% were found to be polymorphic. Polymorphic information content (PIC) and marker index (MI) of each primer combination correlated significantly with the number of genotypes resolved. Overall, a high genetic diversity (avg. 71.85%) was recorded. Further, high gene flow (Nm: 3.37), low genetic differentiation (FST: 0.069) and high within population genetic variation (93%) suggested that most of the genetic diversity is restricted within population. Neighbour joining (NJ), principal coordinate analysis (PCoA) and Bayesian-based STRUCTURE grouped all the accessions in two clusters with significant intermixing between populations. This revealed that two genetically distinct gene pools are operating in the *A. malaccensis* populations cultivated in home gardens (Fig. 1). Based on the various diversity inferences, five diverse populations (JOH, FN, HLF, DHM and ITN) were identified, which can be potentially exploited to develop conservation strategies for *A. malaccensis.* Further to enhance the genomic resources, the publicly available transcriptome was mined for SSR identification. A total of 7,072 SSRs was identified from 125,479 sequences.

Current inferences on genetic diversity and population structure will allow developing appropriate sampling strategies for optimization and implementation of ex situ conservation in *A. malaccensis* genetic resources. AFLP-based high within population genetic diversity in *A. malaccensis* home garden populations revealed that the current study can be potentially utilized

for implementation of conservation strategies in the northeast India.

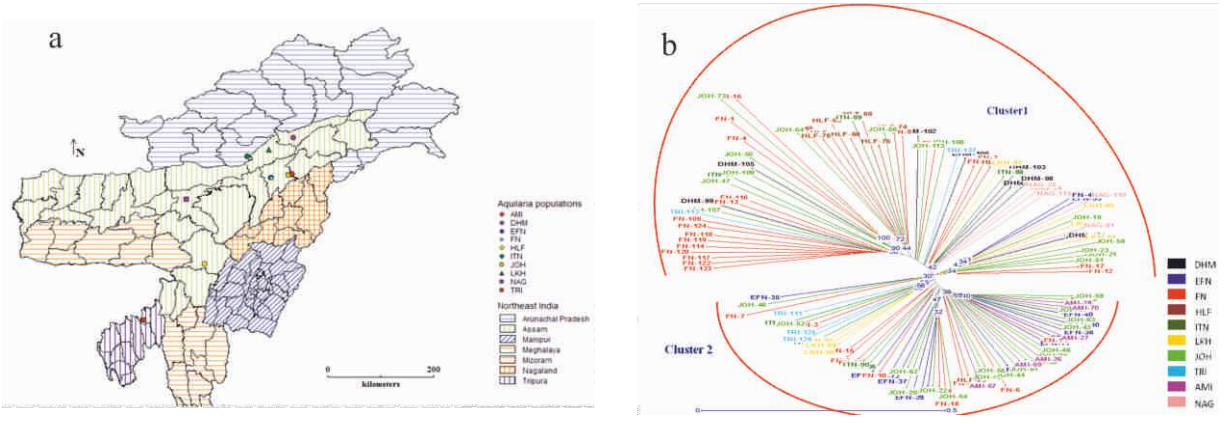

Fig. 1 Genetic diversity of 127 *Aquilaria malaccensis* . (a) Map displaying the location of *A. malaccensis* collected from different home gardens of northeast India (b) Bootstrapped neighbour–joining (NJ) tree of 127 *A. malaccensis* accessions based on AFLP analysis.

Genomic resources creation in bamboo: Bamboo is one of the most essential forest resources. Microsatellites have important role in genome, and are preferred over other molecular markers. For the first time, we exploited public transcriptome data of *Dendrocalamus latiflorus* for identification and characterization of 12,028 potential genic microsatellite markers in the species. Frequency of SSRs was found to be 1 per 4 Kb. Tri-repeats were found to be the most abundant (47.7 %) (Fig. 2). Among them, GC rich repeat motifs namely, CCG/ CGG (24.18 %) and AGG/CCT (22.29 %) were predominantly identified. Of these, 92 % were class II type. Interestingly, 100 % markers showed cross transferability across 14 related bamboo species, and were utilized for establishing phylogenetic relationships. Unique set of developed genic SSR (DLTGMS) markers were deposited to NCBI's probe database under accessions Pr032396515 to Pr032408542 and available at institution web page (http://www.ihbt.res.in/GR/Bamboo/DL

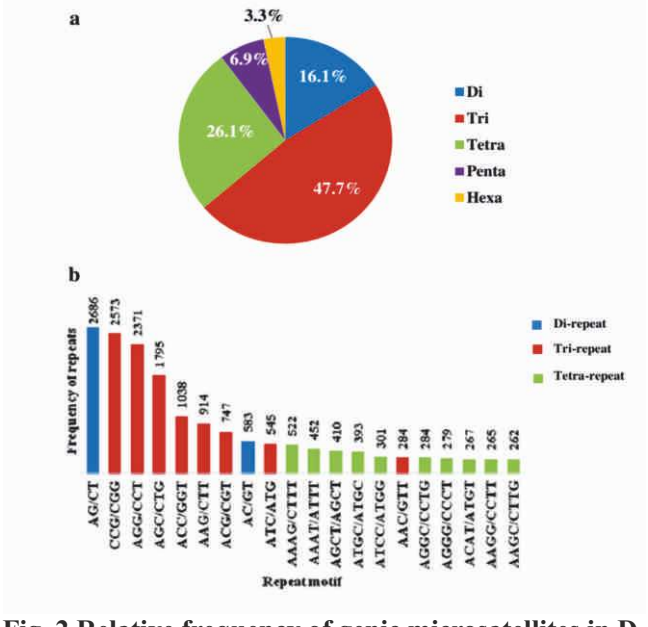

Fig. 2 Relative frequency of genic microsatellites in D. latiflorus transcriptome (a) Repeat types; (b) Frequency of top 20 repeat motifs.

TGMS_MarkerResource.xls). Genic SSR markers developed herein would assist in genetic diversity, evolutionary and association mapping studies in bamboo. Similar efforts are under progress in Tea, Stevia, bamboo and other important medicinal plants .

Publications:

- Unamba CI, Nag A and Sharma RK (2015) Next Generation Sequencing technologies: The doorway to the unexplored genomics of non-model plants. Front. *Plant Science*, 6:1074. doi: 10.3389/fpls.2015.01074.
- Kumar V, Bhandawat A, Sharma H, Nag A and Sharma RK (2015) Novel microsatellite markers identification and diversity characterization in *Pteris cretica* L. *Journal of Plant Biochemistry and Biotechnology*, DOI 10.1007/s13562-015-0316-8.
- Bhandawat A, Singh G, Raina A, Kaur J and Sharma RK (2015) Development of genic SSR marker resource from RNA-Seq data in Dendrocalamus latiflorus. *Journal of Plant Biochemistry and Biotechnology*, DOI 10.1007/s13562-015-0323-9
- Singh P, Nag A, Parmar R, Ghosh S, Bhau BS and Sharma RK (2015). Genetic diversity and population structure of endangered Aquilaria malaccensis revealed potential for future conservation. *Journal of genetics,* 94(4), 697-704.
- Kumar R, Kuldip, Ahuja PS and Sharma RK (2015) Status and Opportunities of Molecular Breeding Approaches for Genetic Improvement of Tea. Spinger International Publishing Switzerland, V.R. Rajpal et al. (eds.), Molecular Breeding for Sustainable Crop Improvement, *Sustainable Development and Biodiversity*, 11, DOI 10.1007/978-3-319-27090-6_5.

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Research area: Transgenics, plant developmental and seed biology

Seed biology of high altitude plants

Re-analysis of protein data reveals the germination pathway and up accumulation mechanism of cell wall hydrolases during the radicle protrusion step of seed germination in *Podophyllum hexandrum*- a high altitude plant: *Podophyllum hexandrum* Royle is an important high-altitude plant of Himalayas with immense medicinal value. Earlier, it was reported that the embryo of the seed is surrounded by thick walled, multi layered endosperm tissue and thick testa and these protective layers create a physical barrier to the water uptake and provide a constraint against radicle emergence during seed germination. It was also identified that the cell wall hydrolases were up accumulated during radicle protrusion step of Podophyllum seed germination. Presently, Podophyllum germination protein interactome network (PGN) was constructed (Fig. 1) by using the differentially accumulated protein data set of Podophyllum during the radicle protrusion step of seed germination with reference to Arabidopsis protein–protein interactome network (*At*PIN). The developed PGN is comprised of a giant cluster with 1028 proteins having 10519 interactions and a few small clusters with relevant gene ontological signatures. In this analysis, a germination pathway related cluster which is also central to the topology and information dynamics of PGN was obtained with a set of 60 key proteins. Among these, 8 proteins which are known to be involved in signalling, metabolism, protein modification, cell wall modification and cell cycle regulation processes were found commonly highlighted in both the proteomic and interactome analysis. The systems-level analysis of PGN identified the key

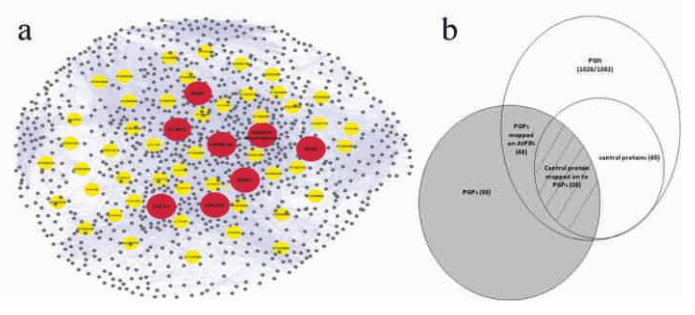

Fig. 1 (a) Podophyllum Germination Network (PGN) representing molecular mechanisms underlying Podophyllum seed germination. The giant component comprising of 10466 interactions among 1028 proteins was used for the network analysis. Key proteins identified by network analysis which were relevant for the germination are highlighted in yellow. Proteins overlapped with initial proteomics based dataset are highlighted in red, b)Venn diagram depicting the strategy used for the identification of germination relevant key proteins from Podophyllum germination interactome analysis.

proteins involved in radicle protrusion step of seed germination in Podophyllum.

Xyloglucan endo-transglycosylase/hydrolase (XET/H) gene is expressed during the seed germination in *Podophyllum hexandrum*: a high altitude Himalayan plant: In earlier studies on seed germination in Podophyllum, accumulation of Xyloglucan endo-transglycosylases/hydrolases (XET/Hs) transcripts was recorded. XET/Hs belong to glycosyl hydrolase family 16, which play an important role in endosperm weakening and embryonic expansion during seed germination. The study confirmed its possible role in determining the fate of seed for germination. Full length cDNA of a membrane bound *Ph*XET was cloned from the germinating seeds of Podophyllum. Analysis of nucleotide sequence revealed *PhXET* with an open reading frame of 720 bp encoding a protein of 239 amino acids with a molecular mass of 28 kDa and pI of 7.58. *In-silico* structure prediction of *PhXET* showed homology with that of *Populus tremula* (1UN1). *Ph*XET was predicted to have a potential GPI-anchor domain and was located in plasma membrane (Fig. 2). It was found that the exogenously applied phytohormones (GA and ABA) regulate the expression of *Ph*XET. The obtained data showed that the *Ph*XET regulates seed germination in Podophyllum by supplementing its activity along with other endosperm weakening and embryo expansion genes.

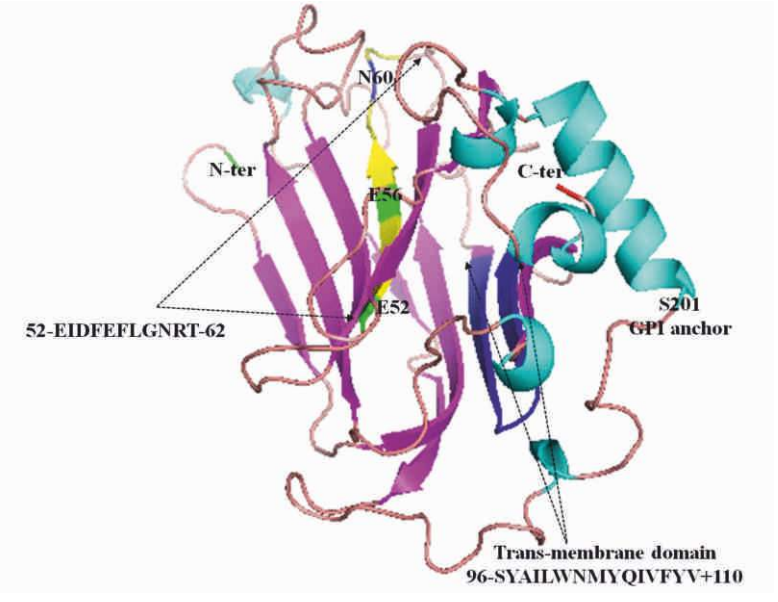

Fig. 2 Predicted tertiary protein structure of the *Ph*XET. Helices are represented by round cyan arrows, β-sheets by flat magenta arrows and loops linking secondary structures are represented in tint. Predicted N-linked (N60) glycosylation sites and signature motif of Glycosyl hydrolases family 16 (52-EIDFEFLGNRT-62) are indicated (yellow) with arrows. Two active sites E52 and E56 are marked in green. Trans-membrane domain (96-SYAILWNMYQIVFYV-110) is highlighted in blue. Potential GPI anchor site (S201) is also marked.

Publications:

- Dogra V, Bagler G and Sreenivasulu Y (2015) Re- analysis of protein data reveals the germination pathway and up accumulation mechanism of cell wall hydrolases during the radical protrusion step of seed germination in *Podophyllum hexandrum* – a high altitude plant. *Frontiers in Plant Science,* 6:874.

- Dogra V, Sharma R, Sreenivasulu, Y (2016) Xyloglucan endo-transglycosylase/hydrolase (XET/H) gene is expressed during the seed germination in *Podophyllum hexandrum*: a high altitude Himalayan plant. *Planta,* DOI 10.1007/s00425-016-2520-8 .

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Research area: Plant metabolic engineering, epigenetics and nanobiology

Protein-Protein Interactome of Horse Gram: Global protein-protein interactome (PPI) map was constructed for horse gram (*Macrotyloma uniflorum*), a highly drought-tolerant legume. Large-scale studies of PPIs and the constructed database has provided the rationale behind the interplay at cascading translational levels for drought stress-adaptive mechanisms in horse gram. Using a bidirectional approach (interolog and domain-based), a high-confidence interactome map and database for horse gram was constructed. Available transcriptomic information for shoot and root tissues of a sensitive (M-191; genotype 1) and a drought-tolerant (M-249; genotype 2) genotype of horse gram was utilized to draw comparative PPI subnetworks under drought stress. High-confidence 6804 interactions were predicted among 1812 proteins covering about one-fourth of the horse gram proteome. The highest number of interactions (33.86%) in horse gram interactome matched with Arabidopsis PPI data. The top five hub nodes mostly included ubiquitin and heat-shock-related proteins. Higher numbers of PPIs were found to be responsive in shoot tissue (416) and root tissue (2228) of genotype 2 compared with shoot tissue (136) and root tissue (579) of genotype 1. Characterization of PPIs using gene ontology analysis revealed that kinase and transferase activities involved in signal transduction, cellular processes, nucleocytoplasmic transport, protein ubiquitination, and localization of molecules were most responsive to drought stress. Hence, these could be framed in stress adaptive mechanisms of horse gram. Being the first legume global PPI map, it would provide new insights into gene and protein

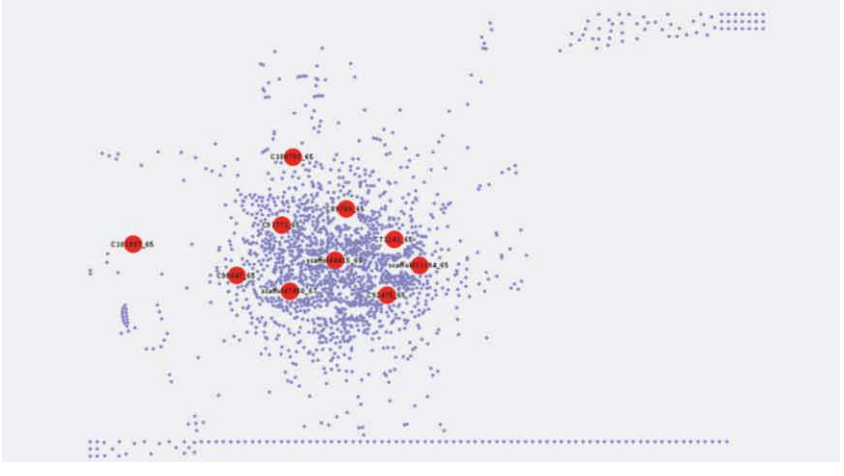

Fig. 1 Predicted protein-protein interactome consisting of 6804 interactions among 1812 proteins. Hub nodes common to both methods used are depicted in bold and red color.

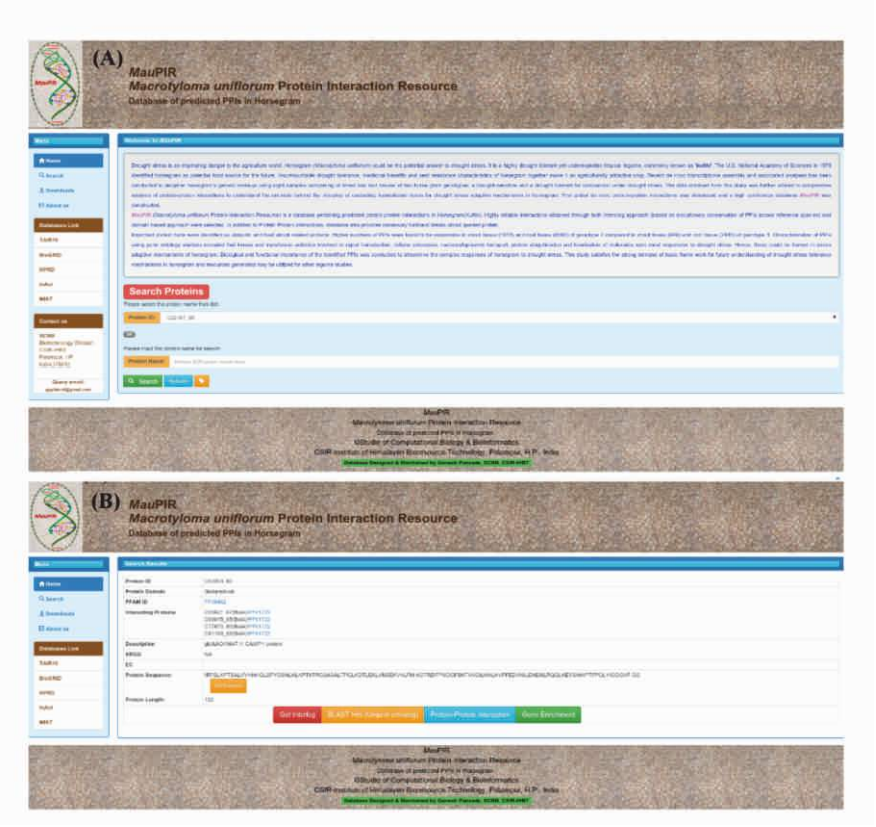

Fig. 2 Screenshot of front page of *Mau*PIR database showing (A) homepage of the database and (B) Functional description of a protein query.

Epigenetic regulation of genes encoding enzymes of flavonoid biosynthesis and antioxidant pathways during salt stress in transgenic tobacco: Epigenetic changes have been identified as regulators of developmental events in plants during normal growth as well as environmental stress exposures. Flavonoid biosynthetic and antioxidant pathways play a significant role in plant defense during their exposure to environmental cues. The aim of this study was to unravel whether genes encoding enzymes of flavonoid biosynthetic and antioxidant pathways are under epigenetic regulation, particularly DNA methylation, during salt stress. For this, a repressor of silencing from Arabidopsis, AtROS1, was overexpressed in transgenic tobacco. Generated transgenics were evaluated to examine the influence of AtROS1 on methylation status of promoters as well as on coding regions of genes encoding enzymes of flavonoids biosynthesis and antioxidant pathways. Overexpression of AtROS1 increases the demethylation levels of both promoters as well as coding regions of genes encoding chalcone synthase, chalcone isomerase, flavanone 3-hydroxylase, flavonol synthase, dihydroflavonol 4-reductase, and anthocyanidin synthase of the flavonoid biosynthetic pathway, and glutathione S-transferase, ascorbate peroxidase, glutathione peroxidase, and glutathione reductase of the antioxidant pathway during control conditions. The level of demethylation was further increased at promoters as well as coding regions of these genes

during salt-stress conditions. Transgenic tobacco overexpressing AtROS1 showed tolerance to salt stress that could have been due to the higher expression levels of the genes encoding enzymes of the flavonoid biosynthetic and antioxidant pathways.

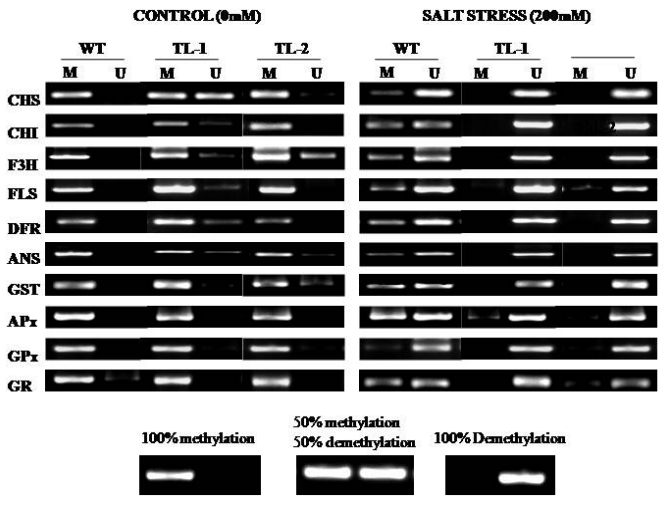

Fig. 3 Methylation pattern of coding regions of genes encoding enzymes of the flavonoid and antioxidative pathways by methylation-specific PCR in wild-type and transgenic tobacco lines under normal and salt stress conditions. Methylation pattern of coding regions of genes encoding enzymes. M, methylated; U, unmethylated.

Nanobiocomposites of bamboo cellulose nanocrystals and silver nanoparticles for accelerated wound healing: Cellulose nanocrystals (CNCs) isolated from *Dendrocalamus hamiltonii* and *Bambusa bambos* leaves have been used for impregnation of *in situ* synthesized silver nanoparticles (AgNPs) from leaf extract mediated reduction of $AgNO_3$ to form nanobiocomposites (NCs) in two forms film and ointment. This work document the use of plant CNCs as an alternate to bacterial cellulose for wound dressings. NCs possessing water absorption capacity and strong antibacterial activity showed synergistic effect on *in vivo* skin wound healing and documented faster and significant wound closure in treated mice. NCs exhibited lesser inflammation and early vasculogenesis at day 3 coupled with increased fibroblasts and collagen content at day 8 leading to faster neo-epithelization by day 14. Highly effective,

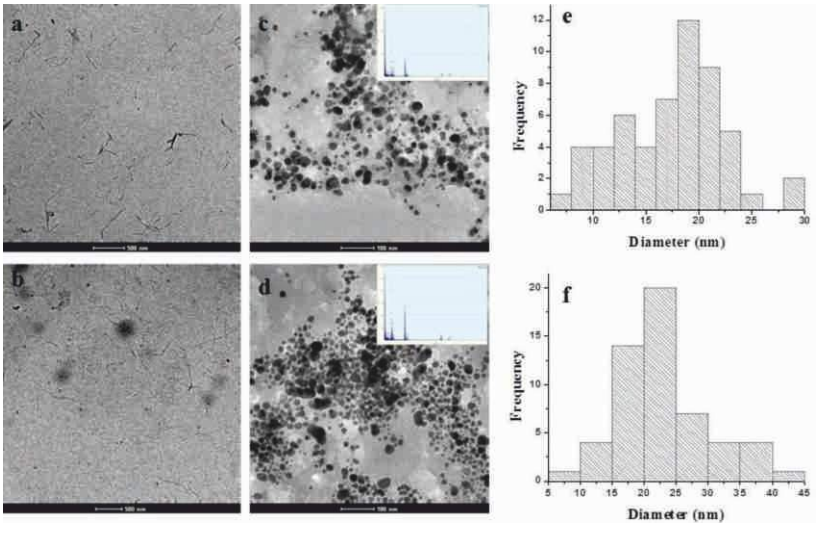

Fig. 4 TEM micrographs of various nanocomposites. (a) DH-CNCs, (b) BB-CNCs, (c) DH-CNC-Ag, and (d) BB-CNC-Ag. Histograms representing the size distribution of AgNPs in NCs: (e) DH-CNC-Ag, and (f) BB-CNC-Ag. TEM-EDS as inset figures in (c) and (d) show the presence of Ag peaks in NCs.

biocompatible, and easy to apply NCs wound dressings (ointment and films) containing lesser amounts of Ag (0.05±0.01 wt%) are potential candidates for effective skin repair.

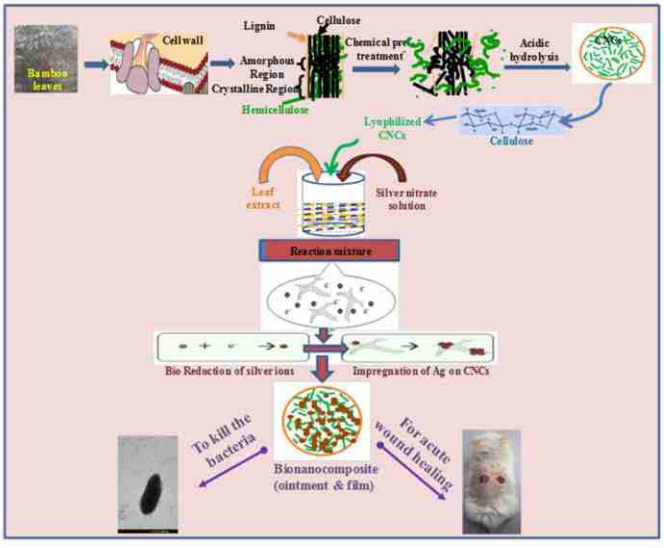

Fig. 5 Schematic presentation of the process of synthesizing nanocomposites and their use as antimicrobial and wound healing agents.

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- Bhardwaj J, Gangwar I, Panzade G, Shankar R and Yadav Sudesh Kumar (2016) Global De Novo Protein-Protein Interactome Elucidates Interactions of Drought-Responsive Proteins in Horse Gram (*Macrotyloma uniflorum*). *Journal of Proteome Research*, 15(6):1794-809.
- Guliani Anika, Kumari Avnesh, Kumar Dharmesh and Yadav Sudesh Kumar (2016) Development of nanoformulation of picroliv isolated from *Picrorrhiza kurroa. IET Nanobiotechnology*, 10: 114-119
- Bharti P, Mahajan M, Vishwakarma AK, Bhardwaj J and Yadav Sudesh Kumar (2015) AtROS1 overexpression provides evidence for epigenetic regulation of genes encoding enzymes of flavonoid biosynthesis and antioxidant pathways during salt stress in transgenic tobacco. J Exp Bot. 66: 5959-5969.
- Guleria Praveen, Masand Shikha and Yadav Sudesh Kumar (2015) Diversion of carbon-flux from gibberellin to steviol biosynthesis by overexpressing SrKA13H induced dwarfism, abnormality in pollen germination and seed set behaviour of transgenic Arabidopsis. J Exp Bot. 66: 3907-3916.
- Kumar Ajay, Vishwakarma,Vihan Aprajita, Sharma Nity and Yadav Sudesh Kumar (2016) DNA methylation status in leaf, root and rhizome of *Valeriana jatamansi*. *J Global Agri Eco* 4(1): 36-44.

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Research area: Value addition of western Himalayan bioresources

Value addition of western Himalayan bioresources

Value addition of apple pomace for products like dietary fibre and polyphenol extraction will help in sustainable industrial growth, besides providing potential human health supplements. Dietary fibres are mainly cell wall polysaccharides, resistant to hydrolysis by digestive enzymes in the human body. The dietary fibre consumption have various positive health effects, especially in management of gastric and cardiometabolic disorders. Fibres also have preventive role in world's widely spreading diseases like obesity and diabetes. The polyphenol extracted from pomace was found to be rich in quercetin, phloretin and phloridizin metabolites. Pholridizin is known to have good antidiabetic properties. In addition, a prototype was developed to separate the seeds at industrial scale. The seed separator was patented in major apple producing countries. The group also focused on western Himalayan MAPs for their improvement or value addition through screening of arrays of biological activities. In continuation to previous research work on bioactives of western Himalayan plant resources, screening is under progress to develop biopreservatives to enhance the shelf-life of perishables.

Isolation of dietary ingredient from apple pomace: Phenolic compounds possess wide-range of biological properties including free radical scavenging antioxidant activities and playing a significant role in stabilizing lipid peroxidation. Quercetin, phloretin and phloridizin are the major polyphenol isolated from apple pomace (Fig. 1). The total phenolics (TPC) yield was approximately 7-10 mg gallic acid equivalent (GAE)/g of dry pomace, whereas flavonoids ranged

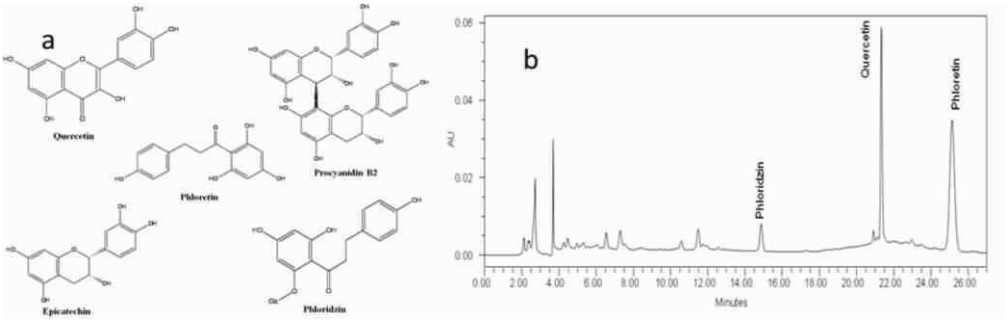

Fig 1. Apple pomace polyphenolic profile a) Isolated phenolic compounds and b) HPLC profile

between 1.5 to 2.0 mg quercetin equivalent (QE)/g of dry pomace (Fig 2a). The total dietary fiber (TDF) contents were more than 65% with a ratio of 1:4 between soluble and insoluble fibre (Fig. 2b). The apple pomace mainly consists of cell wall polysaccharides and thus showed good functional properties such as swelling, water retention and fat adsorption capacity. The results also revealed better hydration properties of freeze dried fraction. Thus it has potential as a low caloric bulk ingredient in dietary fiber enrichment of variety of food products.

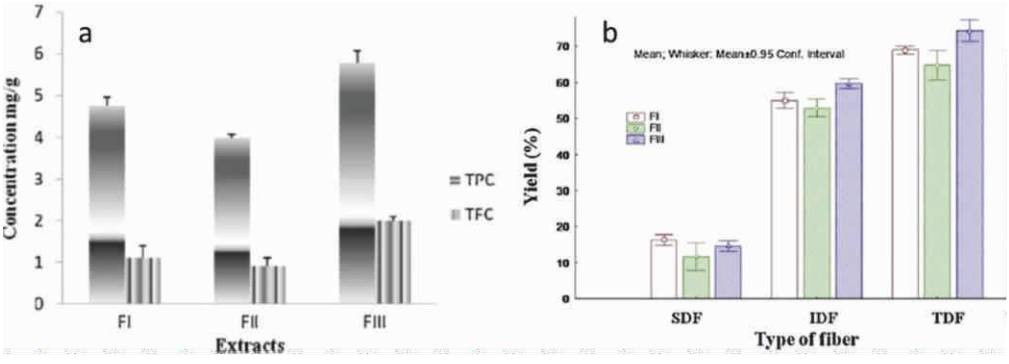

Fig. 2 Apple pomace bioactive constituents a) Total Polyphenol (TPC) & Flavonoids Contents (TFC) and b) Soluble (SDF), insoluble (IDF) and total dietary fiber (TDF) content

Publications:

- Rana S, Kumar S, Rathore N, Padwad Y and Bhushan S (2016) Nutrigenomics and its impact on life style associated metabolic diseases. *Current Genomics*, 17(2):261-278.
- Rana S and Bhushan S (2015) Apple phenolics as nutraceuticals: assessment, analysis and application. *Journal of Food Science and Technology*, DOI: 10.1007/s13197-015-2093-8.
- Rana S, Gupta S, Rana A and Bhushan S (2015) Functional properties, phenolic constituents and antioxidant potential of industrial apple pomace for utilization as active food ingredient. *Food Science and Human Wellness*, 4:180-187.
- Bhushan S (2016) Conceptual editorial - sustainable management and value addition of western Himalayan plant bioresources. *International Journal of Food and Fermentation Technology*, 5(2).

Patents:

- Shashi Bhushan, Sakshi Gupta, Garikapati Dyva Kiran Babu, Mohit Sharma, Paramvir Singh Ahuja. Method and apparatus for the separation of seeds from fruit pulp/slurry/pomace, US Patent No. 9,011,942 B2, dt. 21/04/2015.

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Research area: Structural bioinformatics

The work focused on different aspects of structural bioinformatics by adopting multidisciplinary approaches where first-principle physics was combined with the analysis of biological systems such as 3-dimensional structure of proteins, protein-drug complex and nucleic acids. Attempt was made to ascertain mutations that alter the dynamics behavior of proteins and its interaction with other molecules.

Protein engineering of industrial important proteins/enzymes for improving bio-physiochemical properties: In the initial phase of this project, the potential mutation information conceived from wetlab and presently the conformation behaviour of protein is being studied at different levels in simulation conditions.

Target identification of natural compounds obtained from western Himalayan bioresources: Work was initiated on target identification of 40 natural lead molecules available at CSIRIHBT.

TRAF Protein-protein interaction and simulations studies: The wet and dry-lab studies were carried out to explore the phenotypic changes occurring due to mutation in MATH 2 domain. A novel MATH 2 mutation severely affected the normal function of the protein and its phenotype as compared to wild type. The altered phenotype characteristics of the mutant protein was further rationalized with dry-lab studies. Long term (~200 ns) molecular dynamics simulation (MDS) were conducted for wild and mutant TRAF proteins. The atomic alteration related with the mutant protein were useful in elaborating the changes in structural conformations coupled with the MATH 2 mutation.

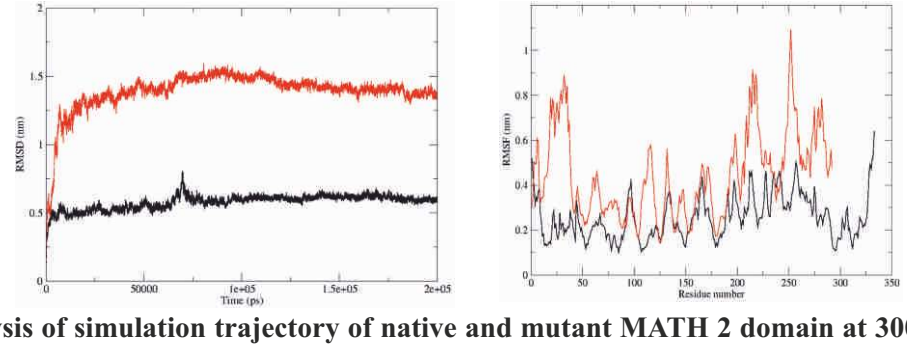

Fig. 1 Analysis of simulation trajectory of native and mutant MATH 2 domain at 300K. (a) Time evolution of backbone RMSD as a function of time (b) RMSF of the Cα atoms. The colour scheme is as follows: native: black and mutant: red.

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Research area: Molecular and microbial biology

Bioprospection and adaptation of novel microbes from Himalayan regions: Extreme climatic conditions and topography of higher altitude affect both microbes and plants. In particular, we are interested in the functional genomics of higher altitude microbes with the major focus on enzymes of industrial relevance. In addition to unlock the microbial diversity of unexplored regions in the western Himalayas (Fig. 1), we are trying to harness the richness of novel microorganisms for the biotechnological applications. It is expected that higher altitude microbes have evolved a resistance mechanisms that facilitate their survival under harsh and stress full conditions. It is also possible that they could have evolved in a different direction than similar microbes from other regions. Currently, we are targeting therapeutic proteins and industrially relevant enzymes from higher altitude microbes (Fig. 2). Our strategy includes multi-dimensional approaches such as whole genome sequencing, molecular, proteomics, genetics, and bioinformatics to develop a bioprocess for the industrial use.

Fig. 1 Isolation of microbes for industrially important enzymes

Fig. 2 Screening of microbes for industrially important enzymes

Publications:

- Himanshu, Swarnkar MK, Singh D, Kumar R (2016) First complete genome sequence of a species in the genus *Microterricola*, an extremophilic cold active enzyme producing bacterial strain ERGS5:02 isolated from Sikkim Himalaya. *Journal of Biotechnology*, 222: 17–18.
- Kumar R, Singh D, Swarnkar MK, Singh AK and Kumar S (2016) Complete genome sequence of *Arthrobacter alpinus* ERGS4:06, a yellow pigmented bacterium tolerant to cold and radiations isolated from Sikkim Himalaya. *Journal of Biotechnology*, 220: 86–87.
- Kumar R, Singh D, Swarnkar MK, Singh AK and Kumar S (2015) Complete genome sequence of *Arthrobacter* sp. ERGS1:01, a putative novel bacterium with prospective cold active industrial enzymes, isolated from East Rathong glacier in India. *Journal of Biotechnology*, 214:139-140**.**
- Kumar R, Singh D, Swarnkar MK, Singh AK and Kumar S (2015) Genome assembly of *Chryseobacterium polytrichastri* ERMR1:04, a psychrotolerant bacterium with cold active proteases, isolated from East Rathong glacier in India. *Genome Announcements*, 3(6):e01305-15.

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Research area: Computational biology and bioinformatics

A legion of potential regulatory sRNAs exists beyond the typical microRNAs microcosm: Post ENCODE, regulatory sRNAs (rsRNAs) like miRNAs have established their status as one of the core regulatory elements of cell systems. However, large number of rsRNAs are compromised due to traditional approaches to identify miRNAs, limiting the otherwise vast world of rsRNAs mainly to hair-pin loop bred typical miRNAs. A huge volume of sequencing data from 4997 individuals and 25 cancer types to report 11,234 potentially regulatory small RNAs was analyzed. The rsRNA-target interactions were studied and validated using experimental data from AGO-cross linking, DGCR8 knockdown, CLASH, proteome and expression data. A subset of such interactions was also validated independently in the present study using multiple cell lines, by qPCR. Several of the potential rsRNAs emerged as critical cancer biomarkers controlling some important spots of cell system (Fig. 1). The entire study has been presented into an interactive info-analysis portal handling more than 260 GB of processed data. The possible degree of cell system regulation by sRNAs appears to be much higher than previously assumed. The rsRNA and their biology have been archived at a dedicated database: The "Mythology of "micro"-RNAs" is available at SCBB software page: http://scbb.ihbt.res.in/SCBB_dept/Software.php.

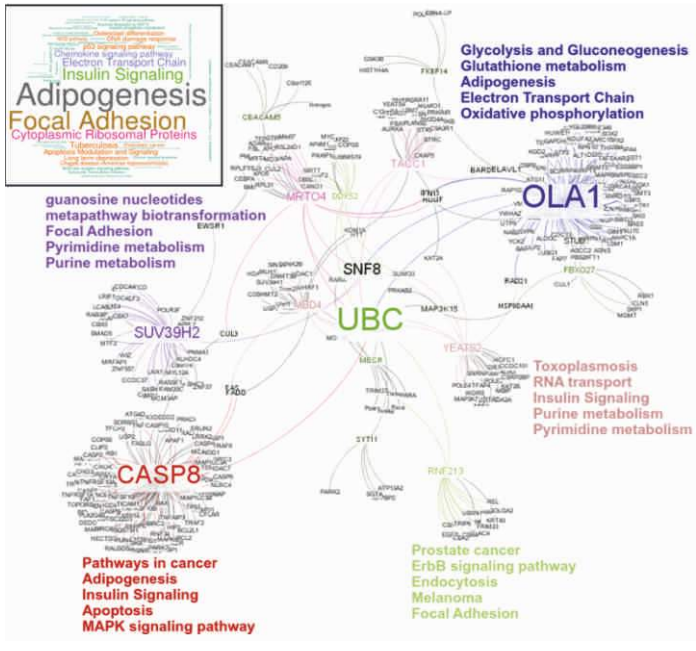

Fig. 1 rsRNA-9881 emerges as a prominent marker of several cancer types. One of those 11,237 rsRNAs, rsRNA-9881 appeared in almost all cancer conditions. From its network analysis, it emerged out that it is deeply involved with pathways and genes critical in cancer, and Adipogenesis and Focal adhesion related genes emerged mostly associated with this rsRNA. Using these rs-RNAs one could also characterize the cancer cases.

Decoding of Solanum genome repeats: Repetitive elements have lately emerged as key components of genome, performing varieties of roles. It has now become necessary to have an account of repeats for every genome to understand its dynamics and state. Recently, genomes of two major *Solanaceae* species i.e. *Solanum tuberosum* and *Solanum lycopersicum* were sequenced. However, there is a reasonable gap in information about repetitive elements and their possible roles in genome regulation for these species. The present study was aimed at detailed identification and characterization of complex repetitive elements of the genomes of these species and assess the possible transcriptionally active repetitive elements. About 50–60% of genomes of *S. tuberosum* and *S. lycopersicum* was found to be composed of repetitive elements and complex repetitive elements were found associated with >95% of genes in both species. The genomes of both species are mostly composed of LTR retrotransposons. Two novel repeat families very similar to LTR/ERV1 and LINE/RTE-BovB were reported for the first time. A reasonable amount of regulatory components like transcription factor binding sites and miRNAs appear to be under the influence of these complex repetitive elements in these species, while several genes appeared to possess exonized repeats (Fig. 2).

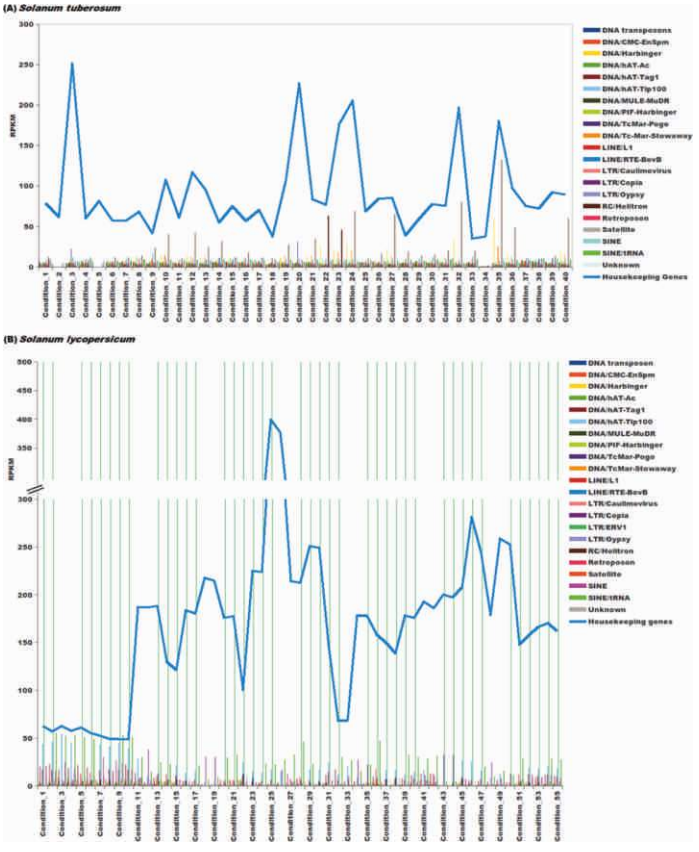

Fig. 2. Several repeats were found actively transcribing in Solanum genome.

Role of antioxidant enzyme in secondary cell wall biosynthesis and plant growth under salt stress: Abiotic stresses cause accumulation of reactive oxygen species (ROS), such as hydrogen peroxide (H_2O_2) in plants. Sophisticated mechanisms are required to maintain optimum level of H_2O_2 that acts as signaling molecule regulating adaptive response to salt stress. CuZn-superoxide dismutase (CuZn-SOD) and ascorbate peroxidase (APX) constitute first line of defense against oxidative stress. In the present study, *PaSOD* and *RaAPX* genes from *Potentilla atrosanguinea* and *Rheum australe*, respectively were overexpressed individually as well as in combination in *Arabidopsis thaliana.* Interestingly, *PaSOD* and dual transgenic lines exhibit enhanced lignin

deposition in their vascular bundles with altered S:G ratio under salt stress. RNA-sequence analysis revealed that expression of *PaSOD* gene in single and dual transgenics positively regulates expression of lignin biosynthesis genes and transcription factors (NACs, MYBs, C3Hs and WRKY), leading to enhanced and ectopic deposition of lignin in vascular tissues with larger xylem fibres and alters S:G ratio, as well. In addition, transgenic plants exhibit growth promotion, higher biomass production and increased yield under salt stress as compared to wild type plants. Results suggest that in dual transgenics, ROS generated during salt stress gets converted into H_2O_2 by SOD and its optimum level was maintained by APX. This basal level of H_2O_2 acts as messenger for transcriptional activation of lignin biosynthesis in vascular tissue, which provides mechanical strength to plants. These findings reveal an important role of *PaSOD* and *RaAPX* in enhancing salt tolerance of transgenic *Arabidopsis* via increased accumulation of compatible solutes and by regulating lignin biosynthesis.

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- Mehra M, Gangwar I and Shankar R (2015) A Deluge of Complex Repeats: The Solanum Genome. *PLoS One*, 10(8): e0133962.
- Shafi Amrina, Chauhan Rohit, Gill Tejpal, Swarnkar Mohit K, Sreenivasulu Yelam, Kumar Sanjay, Kumar Neeraj, Shankar Ravi, Ahuja Paramvir Singh and Singh Anil Kumar (2015) Expression of SOD and APX genes positively regulates secondary cell wall biosynthesis and promotes plant growth and yield in Arabidopsis under salt stress. *Plant Molecular Biology*, 87(6): 615-631.

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Research area: Functional nanomaterials for biomedical applications, nanoparticle-cell/protein interactions, nanomaterials based detection of biomolecules/analytes

Functional nanomaterials (FNM) as cellular imaging probe: Clinical imaging of anatomical details at disease sites is of utmost importance in the modern era of medical diagnosis because it allows the detection of disease sites at very initial stages of growth and plays an integral part in medical diagnosis. However, the development of suitable molecular diagnostic systems for cellular and sub-cellular imaging has remained a dream in medicine. Thus, nanoparticles (NPs) continue to receive attention in the field of medical imaging for their potential as specific contrast agents in vitro and in vivo. In this respect, our group is involved in designing novel nanomaterials which can be utilized for specific cancer cell targeting studies. The chemical conjugation of folic acid on such hybrid nanomaterials surface suggested receptor mediated endocytosis process being responsible for the intracellular localization of NPs (Fig. 1 & Fig. 2). These studies indicated that the prepared nanocomposites have the potential to be used as delivery agent for magnetic and fluorescent materials towards folic acid receptor over-expressing cells and thus can find application in the field of in vitro imaging diagnosis. Further, the intraperitoneal administration of one of the nanoformulations to Wistar rats suggested deposition of these nanocomposites in the lungs. The hematological, biochemical and histopathological analysis confirmed that these nanocomposites are safe to use as a novel dual mode imaging material.

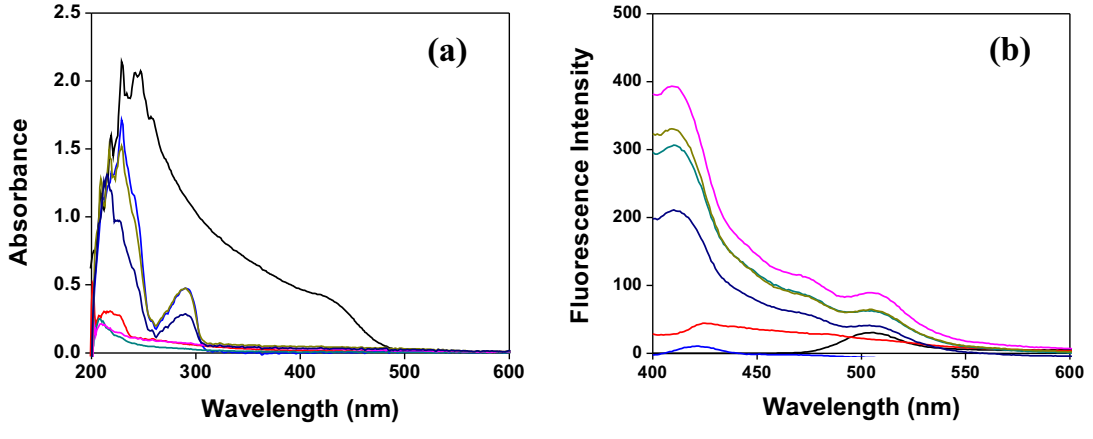

Fig. 1 Absorption (a) and fluorescence (b) spectra of CdS NPs ( ), CSNPs ( ), PD ( ), A ( ), B ( ), C ( ) and D ( ). The excitation wavelength for fluorescence was 380 nm in all the cases.

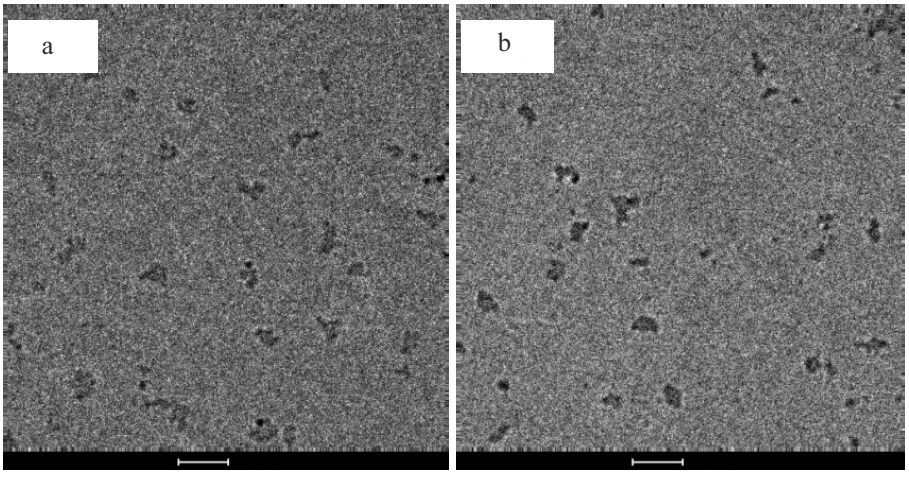

Fig. 2 TEM images (a) and (b) of the prepared nanocomposites. The dark spots inside the spheres correspond to CdS-IONPs. The scale bar is 200 nm for both the cases.

Nanoparticle based detection of biomolecules/toxic warfare agents: The development of nanomaterials-based sensors for biomolecules or chemical warfare agents is expected to increase the specificity while lowering the detection limit of individual analytes. Nanosensors provide rapid and easy detection of the target analytes and are thus cost effective. In this respect, our group has developed glutathione coated fluorescent CdS NPs for sensing dicofol. TEM, SEM and DLS data suggested aggregation of NPs in presence of the same. Similar studies carried out with gold NPs resulted in colorimetric recognition of pesticide dimethoate. These results suggested that the synthesized nanomaterials are very selective and sensitive towards specific pesticides. Such studies are expected to provide new molecular approaches for further development of novel nanosensors for targeted analytes.

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- Walia S, Sharma S, Kulurkar PM, Patial V and Acharya A (2016) A bimodal molecular imaging probe based on chitosan encapsulated magneto-fluorescent nanocomposite offers biocompatibility, visualization of specific cancer cells in vitro and lung tissues in vivo. *International Journal of Pharmaceutics*, 498(1-2):110-118.
- Acharya A, Rawat K, Bhat KA, Patial V and Padwad YS (2015) A Multifunctional Magneto-fluorescent Nanocomposite for Visual Recognition of Targeted Cancer Cells. *Materials Research Express*, 2(11): 115401.

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Research area: Computational functional genomics and system biology

Machine learning and system biology approaches to prioritize drug targets from plant derived molecules of Himalayan region: a case study in oral cancer: Systems-biology inspired identification of drug targets coupled with machine learning-based screening of small molecules that modulate their activity have the potential to revolutionize modern drug discovery by complementing conventional methods. To utilize the effectiveness of such pipeline, the dysregulated gene pairs between control and tumor samples were first analyzed and then implemented as ensemble-based feature selection approach to prioritize targets therapeutic exploration. Based on the structural information of known inhibitors of *CXCR4*—one of the best targets identified in this study—a feature selection was implemented for the identification of optimal structural features (molecular descriptor) based on which a classification model was generated. Furthermore, the *CXCR4*-centered descriptor-based classification model was developed for the first time and was utilized to screen a repository of plant derived small-molecules to obtain potential inhibitors from Himalayan plant species.

Computational identification raises a riddle for distribution of putative NACHT NTPases in the genome of early green plants: NACHT NTPases and AP-ATPases belongs to STAND (signal transduction ATPases with numerous domain) P-loop NTPase class, known to be involved in defense signaling pathways and apoptosis regulation. The AP-ATPases (also known as NB-ARC) and NACHT NTPases are widely spread throughout all kingdoms of life except in plants, where only AP-ATPases were extensively studied in the scenario of plant defense response against pathogen invasion and hypersensitive responses (HR). In the present study, a genome-wide survey (using stringent computational analysis) of 67 diverse organisms' viz., archaebacteria, cyanobacteria, fungi, animalia and plantae were employed to revisit the evolutionary history of these two STAND P-loop NTPases. This analysis divulged the presence of NACHT NTPases in the early green plants (green algae and the lycophyte) for the first time which had not been previously reported. These NACHT NTPases were known to be involved in diverse functional activities such as transcription regulation in addition to the defense signaling cascades depending on the domain association. In *Chalmydomonas reinhardtii*, a green algae, WD40 repeats were found to be at the carboxyl-terminus of NACHT NTPases suggesting probable role in apoptosis regulation. The presence of NACHT NTPases in the early green plants and phyletic patterns resulting from this study raises a quandary for the distribution of this STAND P-loop NTPase with

the apparent horizontal gene transfer from cyanobacteria (Fig. 1). The details of our lab can be accessed at https://sites.google.com/site/vishalfunctionalgenomics/

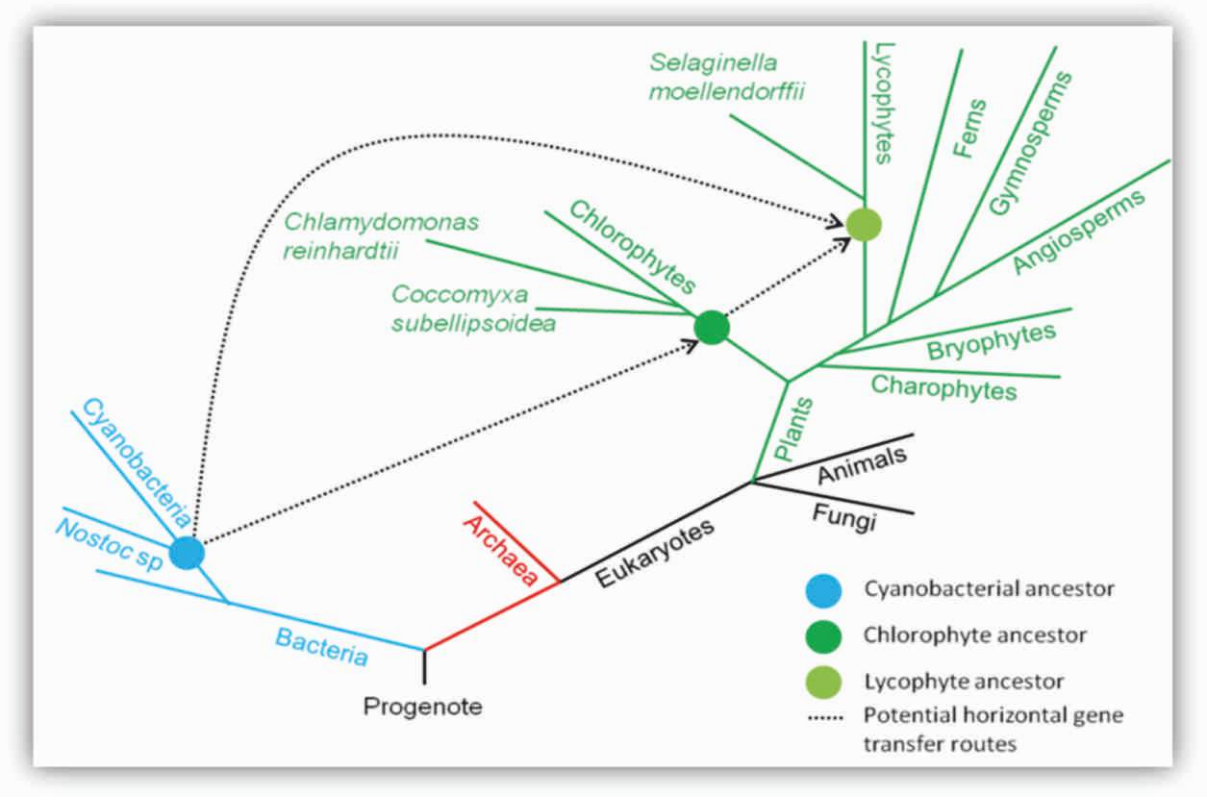

Fig. 1. Hypothetical pictorial representation of horizontal gene transfer of NACHT NTPase genes in early green plants (Source : Arya & Acharya, PLoS One, 2016).

Publications:

- Arya P and Acharya V (2016) Computational identification raises a riddle for distribution of putative NACHT NTPases in the genome of early green plants. *PLoS One*, 11(3): e0150634.
- Kumar G, Arya P, Gupta K, Randhawa V, Acharya V and Singh AK (2016) Comparative phylogenetic analysis and transcriptional profiling of MADS-box gene family identified *DAM* and *FLC*-like genes in apple (*Malus* x *domestica*). *Scientific Reports*, 6:20695.doi: 10.1038/srep20695.
- Randhawa V, Singh AK and Acharya V (2015) A systematic approach to prioritize drug targets using machine learning, a molecular descriptor-based classification model, and high-throughput screening of plant derived molecules: a case study in oral cancer. *Molecular BioSystems,* 3362-3377.

- Randhawa Vinay and Acharya Vishal (2015) Integrated network analysis and logistic regression modeling identify stage-specific genes in Oral Squamous Cell Carcinoma. *BMC Medical Genomics*, 8:39, DOI: 10.1186/s12920-015-0114-0.
- Pathania Shivalika and Acharya Vishal (2015) Computational analysis of "-omics" data to identify transcription factors regulating secondary metabolism in *Rauvolfia serpentina*. *Plant Molecular Biology Reporter*, DOI: 10.1007/s11105-015-0919-1.

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Research area: Plant microbe interaction and molecular plant pathology

Mining differentially expressed apple genes and *in-planta* induced fungal genes during apple fungal pathogen interactions: India is the fifth largest producer of apple worldwide and in India (FAO, 2013) and it is a major crop in western Himalayan region. Every year, farmers incur huge losses due to fungal diseases. Among them apple scab caused by *Venturia inaequalis* is one of the most devastating disease, causing huge losses during epidemic season. Our group is interested in understanding the biology of apple-*Venturia* interaction. A transcriptomic approach was utilized to identify the 9407 genes from apple and venturia showing differential expression during compatible interaction. All the transcripts were further assessed through *in silico* approach to identify the putative secretome. A total of (~450) putative secretory proteins have been identified using this approach (Fig. 1).

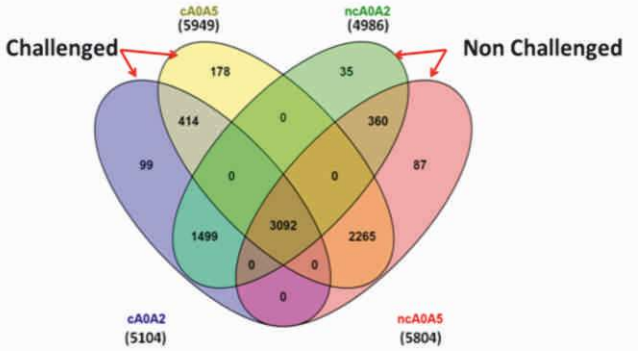

Fig. 1 Genes differentially expressed during compatible apple- venturia interaction

Their further characterization will help in identification of important virulence factors and effectors from pathogen. Simultaneously, we have tried to elucidate the transcripts that expressed in apple during compatible interaction. Computational analysis suggested differential expression of 5104 transcripts during compatible challenge, two day post inoculation. To confirm the result of computational approach, expression of few selected transcripts was analyzed through quantitative real time PCR analysis. Our results validated the expression pattern obtained through FPKM analysis (Fig. 2).

Analysis of *Trichoderma* sp. induced resistance in tomato (*L. esculentum* Mill.) during interaction with pathogen *Fusarium oxysporum*: Previously few selected proteins were identified through 2DE analysis of tomato proteome with *Fusarium oxysporum lycopersici* (*Fol*) infected sample after treatment with *Trichoderma* sp. A few selected genes are under further characterization for their role in tomato- *FOL* interaction.

Characterization of saffron microflora of rhizosphere associated with saffron with a target to develop consortia of beneficial microbes: The project was initiated with the aim to develop 'fail-safe' microbial inoculants through the selection of widespread genotypes of rhizobacteria with multiple plant growth promoting activities with the consortia partners for improving growth and productivity in saffron. Antagonism towards wilts and corm rot pathogens along with abiotic stress tolerance were analyzed. Ten efficient rhizobacteria were selected among 2,401 isolates on the basis of the multiple plant growth promoting attributes and the abiotic stress-tolerance. Evaluation of PGPR for growth promotion in saffron plants under controlled conditions revealed enhanced growth as compared to the control (Fig 3). When one of the novel rhizobacteria *Chryseobacterium* sp. strain IHBB 17019 isolated and analyzed through complete genome sequencing, a circular chromosome of 4.07 Mb with an extra chromosomal DNA of 5.5 kb, and an average 35.91% G+C content was revealed. The annotation predicted gene-coding clusters for phosphate solubilization, auxin biosynthesis, siderophore production and ACC-deaminase activity. At present pot and field trials are ongoing in Pampore,

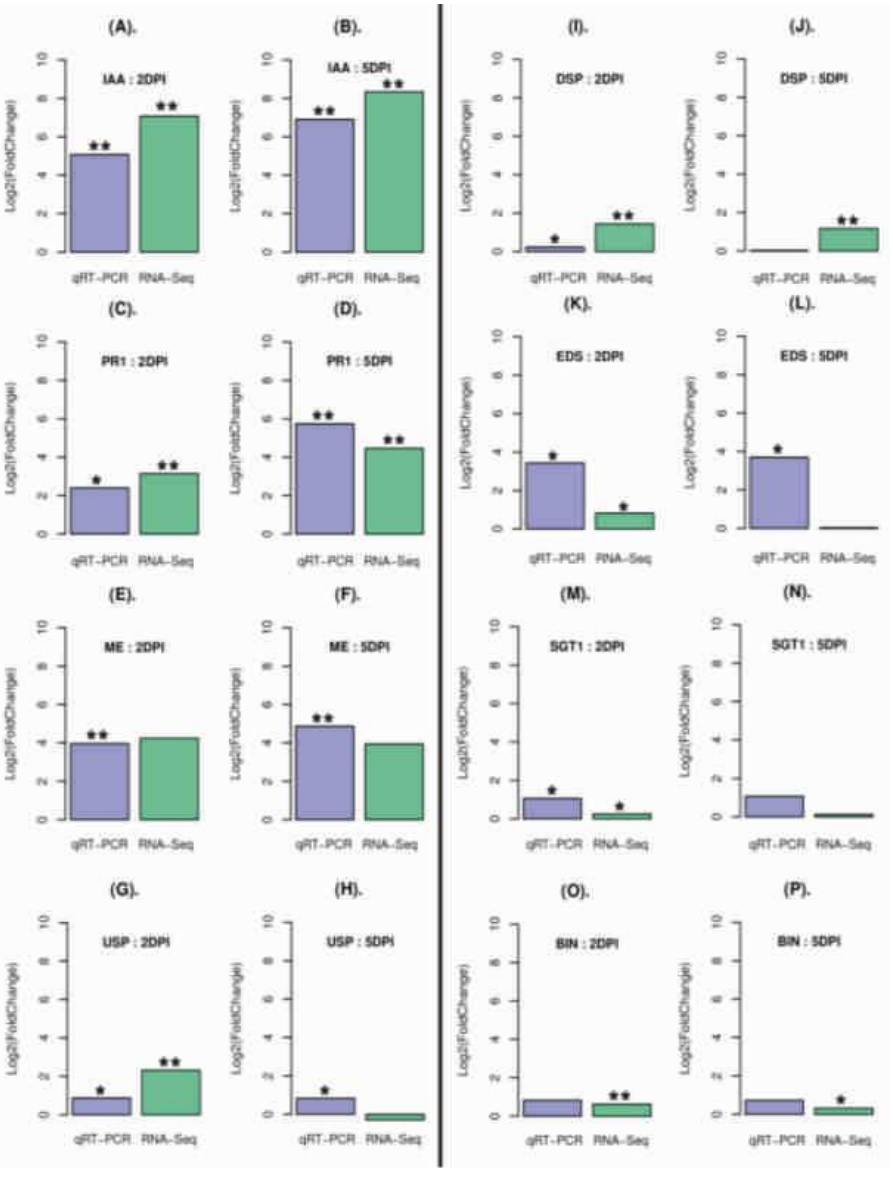

Fig. 2 Expression profile obtained through RNA seq data was validated by Real-Time quantitative PCR for few selected genes.

Fig. 3 Growth promotion shown by efficient PGPRs as compared to control in saffron.

Jammu & Kashmir, to assess the effectivity of selected rhizobacteria for their role in growth promotion of saffron.

PGPRs tools for improving crop productivity in stressed agricultural systems: Stress conditions limit growth and yield in crops. The plant hormone ethylene is involved in evoking physiological responses in plants exposed to a variety of stresses, including salinity, flooding, drought, temperature, presence of heavy metals, pesticides and phytopathogens. PGPRs produce ACC-deaminase which cleaves ACC, the immediate precursor of ethylene, thus preventing the effects of high levels of ethylene on plants. So, the work was aimed at developing formulation of ACC-deaminase PGPRs which can be more economical, environment friendly and beneficial for soil and plant system for the development of stress-tolerant plants. Evaluation of six efficient PGPRs for growth promotion in maize under field conditions in the saline-sodic soils at Banthra experimental fields of CSIR-NBRI revealed enhanced growth as compared to the control. One of the rhizobacterium *Halotalea alkalilenta* Strain IHB B 13600 was analyzed for the complete genome sequence. The gene-coding clusters predicted the genes for auxin production, phosphate solubilization, siderophore production, ACC-deaminase activity and stress-response genes. At present, field trials are under progress in Bajaura, Kullu (H.P.) to evaluate the effect of selected rhizobacteria on growth promotion of different crops such as potato, garlic, wheat and pea.

Biopospecting microbial endophytes and their natural products from some medicinal plants of Indian trans-Himalayas: Among 1184 isolates screened in agar overlay assay against a panel of test organisms, 85 cultures showed antimicrobial activity in well diffusion assay against one or more test organisms. Twenty-five microbial cultures, including 21 endophytes and 4 soil microorganisms, selected for antimicrobial activity have been submitted for structure elucidation of the antimicrobial compounds to the CSIR-Institute of Microbial Technology. These microbial cultures belong to *Bacillus aryabhattai*, *B. amyloliquefaciens* subsp. *plantarum*, *B. cereus*, *B. pumilus*, *B. thuringiensis*, *B. weihenstephanensis*, *Brevibacterium halotolerans*,

Micromonospora sp., *Nigrospora sphaerica*, *Nigrospora* sp., *Paenibacillus peoriae*, *Penicillium* sp., *Serratia plymuthica*, *S. proteamaculans Streptomyces cirratus S. pseudovenezuelae*, *S. spororaveus*, *S. misawanensis*, *S. olivochromogenes* and *Variovorax paradoxus*.

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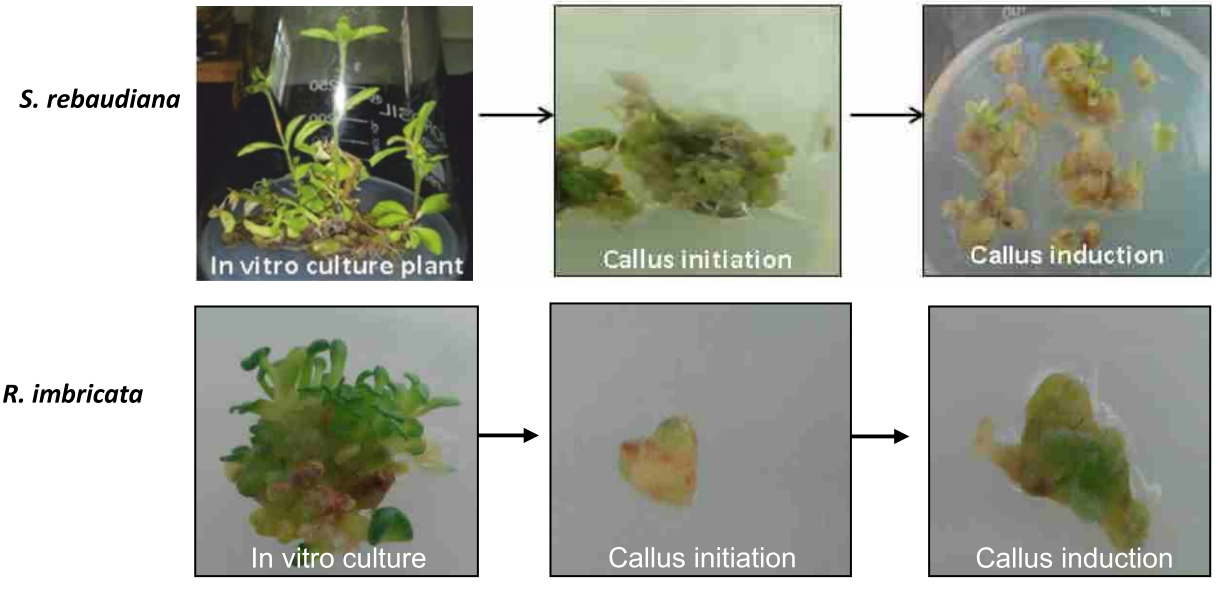
Research area: Plant cell & tissue engineering

In vitro production of secondary metabolites

The group is working on the development of plant cell and organ culture systems for *in vitro* production of secondary metabolites from the commercially important plant *Stevia rebaudiana* (stevia) and *Rhodiola imbricata* (rhodiola). While stevia is known for steviosides and rebaudiosides for use as natural sweeteners, rhodiola contains salidrosides which are used as adaptogenic and nerv-tonics. There is a huge demand for these compounds in the national and international markets. In this regard, callus proliferation protocol and cell suspension cultures have been standardized for large scale production of targeted metabolite.



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Research area: Plant stress biology

Exploring the adaptative mechanism across elevational gradients of high altitude medicinal plants: The extreme environmental conditions across altitudinal gradients in Himalayas affect the extremely complex and dynamic proteome of plants. Many of these plants are extensively used in traditional health care systems and pharmaceuticals. *Picrorhiza kurroa*, a perennial herb that grows at 2700-5000 m amsl, is a rich source of glycosides as well as picroside-I and picroside- II having wide medicinal properties. In order to explore the adaptive mechanism of this plant under stress conditions, a comparative proteomic approach has been used to decode different aspects of plant functions. In this direction, total protein were separated on 2DE (11cm, pH 4-7, 200µg) followed by mass spectrometric identification of proteins (Fig. 1).

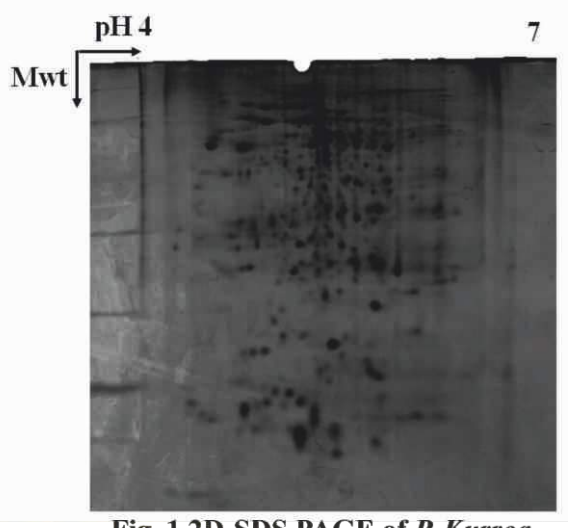

Fig. 1 2D-SDS PAGE of *P. Kurroa*

Identification of novel proteins in response to elevated temperature and CO_2 in *Picrorhiza kurroa* using proteomic approach: Environmental factors are continuously affecting the climate and plant growth which need to be studied for the understanding of plant adaptation and their growth regulation. We addressed *P. kurroa* responses for proteome grow at elevated CO_2 (550 ± 5 ppm) and elevated temperature (2-3°C above ambient) by using analytical and statistical methods. Using 2-DE combined with mass spectrometry leads to identification of thirty five non-redundant differentially expressed proteins. All of these proteins were grouped into five functional categories viz. metabolic process, signal transduction and transport, biosynthetic process, nuclear and metal binding, gene expression and unknown according to gene ontology (Fig. 2). The identified proteins and the associated biological processes can be utilized for improving plant performance in *Picrorhiza* under elevated temperature and elevated CO_2.

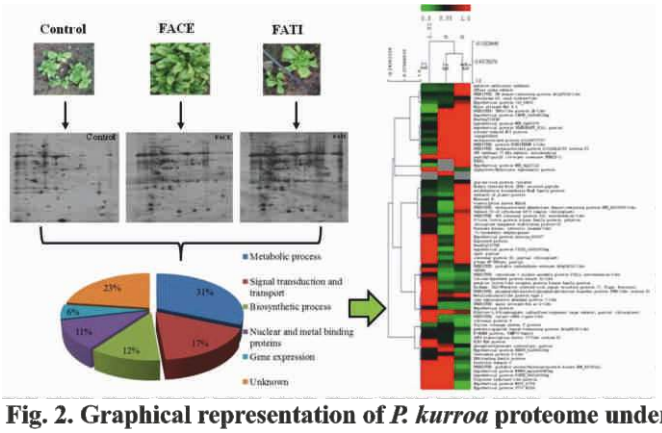

Fig. 2. Graphical representation of *P. kurroa* proteome under free air CO_2 enrichment (FACE) and free air temperature increase (FATI) conditions

Food and Nutraceutical

Development of nutritive food and nutraceutical products of high commercial standards from Himalayan bioresources, and quality evaluation complying with internationally acceptable standards

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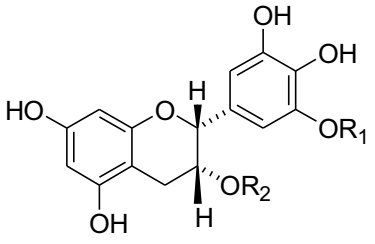
Research area: Tea chemistry and product development

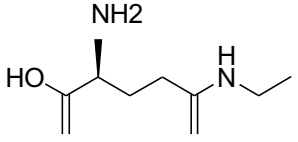
Continuing with the work on characterization of Indian teas, aroma components of teas from lower Darjeeling region were characterised this year. The aroma constituents were extracted by simultaneous distillation extraction and beverage method to get the complete aroma profile of the infused tea. The major components recorded in aroma profiles were geraniol, linalool, nerol and hexanoic acid, while the minor compounds included 3,6-Dimethyl-2H-pyran -2-one, α- and β-ionones, citral and furfural. Interestingly, the GC profiles of these teas did not record presence of methyl salicylate and pyrazines which are present as major compounds in profiles of Kangra orthodox teas and responsible for the nutty flavour.

Sensory profile of orthodox black tea from lower Darjeeling region

Method for detection and quantification of theanine and catechins was standardized using HPTLC and validated for its accuracy and reliability. Theanine and catechins were identified and quantified in different tea samples using HPTLC. NMR based metabolomic studies were also done for the comprehensive metabolite profiling and qualitative assessment of theanine and catechins along with caffeine in tea samples.



Catechin



Theanine

Pilot scale production technology of purification of catechins from tea shoots: In pilot scale study, production of catechins was optimized at 40 kg fresh tea shoots per batch. An industry-academia interface project has been sanctioned to the Institute in association with M/s. Baijnath Pharmaceuticals Pvt. Ltd. as industrial partner for up-gradation of catechins purification at 100 kg fresh tea shoots per batch.

Studies on biotransformation of glutamine to theanine: More than 220 microbial isolates collected from the tea rhizosphere were screened for enzymatic synthesis of L-theanine from glutamine. Seven isolates showing high conversion to theanine (40-55%) were taken for further optimization using different parameters (temperature, pH, substrate concentration etc.).

Chemical profiling of purple tea shoots: Cyanidin-3-glucoside, cyanidin-3-O-*β*-D-(6-(E)coumaroyl) glucopyranoside, delphinidin-3-O-*β*-D-(6-(E)-coumaroyl)-glucopyranoside and cyanidin-3-O-(2-O-*β*-xylopyranosyl-6-O-acetyl)-*β*-glucopyranoside were the anthocyanins characterized from purple tea shoots by comparing their MS data with published data. Anthocyanin biosynthesis in plants takes place via phenyl propanoid pathway and controlled by the transcription level of corresponding genes. Therefore, expression of five genes encoding anthocyanidin reductase (*Cs*ANR), dihydroflavonol-4-reductase (*Cs*DFR), anthocyanidin synthase (*Cs*ANS), flavonol synthase (*Cs*FLS) and leucoanthocyanidin reductase (*Cs*LAR) was analyzed in both the normal and purple coloured cultivars growing in Kangra valley. The expressions of *CsDFR*, *CsANR*, *CsANS* were upregulated, while *CsFLS* and *CsLAR* genes of anthocyanin biosynthesis were downregulated in purple coloured tea shoots as compared to normal tea shoots.

Detection of organic acids produced by plant growth promoting rhizobacteria from tea rhizosphere: Phosphorous is an essential macronutrient available in soil. Soils contain approximately 95-99% of total phosphorous. But most of the phosphorous occurs in insoluble form as Fe and Al phosphates in acidic soils and Ca phosphate in alkaline soils. Several rhizobacteria possess the ability to solubilize insoluble inorganic phosphate and make it available to plants. Abudance of aluminium and iron in tea soils makes phosphorus unavailable to the plants by forming insoluble free oxides and hydroxides of Al and Fe which are known to fix phosphorus.

The phosphate solubilization is usually due to the production of organic acids by these microbes. In this context, HPLC analysis of the culture filtrates was done to identify and quantify the organic acids produced during the solubilization of tricalcium phosphate (TCP), aluminium phosphate and iron phosphate under abiotic stress (pH, desiccation, salinity and Fe, Al and Ca salt) by *Bacillus altitudinis* IHB B 1045, *Pseudomonas frederiksbergensis* IHB B 1059, *Pseudomonas mohnii* IHB B 7048, *Bacillus aryabhattai* IHB B 7024, *Bacillus subtilis* subsp. *inaquosorum* IHB B 7075, *Viridibacillus arenosi* IHB B 7171 and *Serratia marcescens* IHB B 7064. The organic acids were quantified by comparing the peak areas with reference to authentic standards. All strains exhibited the production of oxalic acid. In TCP solubilization, strains showed the production of oxalic acid, formic acid, malic acid, succinic acid and propionic acid. The production of other organic acids was restricted to some strains. During ferric phosphate and aluminium phosphate solubilization the production of oxalic and succinic acid was detected for all the strains. Of all the acids, oxalic acid (230-313 µg/ml), succinic acid (38-89 µg/ml), and propionic acid (30-183 µg/ml) were the major organic acids produced by the microbes during solubilization of different phosphates.

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Research Interest: Functional food and nutraceuticals

Ethnic Foods of Himachal Region

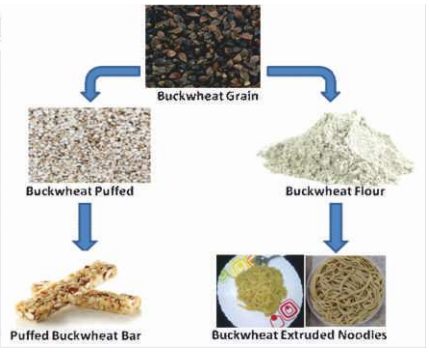
Traditional foods have unique taste and palate because of their regional cooking style and ingredients. Variety of Ready-To-Eat (RTE) foods are available in the market, however traditional ethnic foods like Kangri Dham prepared and served during marriages, family occasion and religious events are not yet available. CSIR-IHBT has developed an indigenous technology for commercial production of Kangri Dham with shelf life up to six months at room temperature without any chemical preservatives that are not yet available. Patent for the developed technology has been filed.

Kangri Dham developed by CSIR-IHBT, Palampur

Functional Foods: Buckwheat is a traditional crop of the high altitude Himalayan region having potential health benefits. Puffed buckwheat is rich in protein, fat and carbohydrate as well as rutin content. Some puffed buckwheat products have been developed and launched at Tribal Fair at Keylong (Lahaul and Spiti). Food processing facility for buckwheat has been established at CeHAB, Keylong (Lahaul and Spiti) and demonstrated to the local inhabitants, progressive entrepreneurs, NGOs and SHGs of the region.

Table Nutritional composition of buckwheat and product

Composition in (%)	Buckwheat Grain	Puffed Buckwheat
Moisture	8.67±0.02	2.96±0.01
Protein	13.22±0.08	7.63±0.04
Fat	3.90±0.05	2.85±0.08
Carbohydrates	58.50 ±0.04	77.69±0.09
Dietary Fiber	13.36 ±0.02	6.52±0.03
Ash	1.98 ±0.08	2.15±0.02



Nutrition for Health: Nutritionally enriched food products to combat malnutrition particularly calcium and iron deficiencies were developed using low cost affordable technology. Fruit bar and nutri mix were developed by incorporating underutilized bioresources to meet 40 and 60% RDA (recommended daily allowances) of iron and calcium.

Around two hundred women's from Gopalpur (Distt. Kangra), CSIR-IHBT Tech-village were selected and screened for their nutrition profile. Results revealed more than 95% female volunteers under this survey were anaemic.

Fruit Bar

Nutri Mix

Publications:

- Agrawal H, Joshi R and Gupta M (2016) Isolation, purification and characterization of antioxidative peptide of pearl millet (*Pennisetum glaucum*) protein hydrolyzate. *Food Chemistry*, 204: 365–372.
- Gupta M, Sharma P, Ghosh MA, Patial V and Singh D (2015) Dwindling of cardio damaging effect of isoproterenol by *Punica granatum* L. peel extract involve activation of nitric oxide-mediated Nrf2/ARE signaling pathway and apoptosis inhibition. *Nitric Oxide Journal*, 50:105-113.
- Kumari M, Swarnkar MK, Kumar S, Singh AK and Gupta M (2015) Complete Genome Sequence of Potential Probiotic *Lactobacillus* sp. HFC8, Isolated from Human Gut Using PacBio SMRT Sequencing. *Genome Announcements*, 3(6): e01337-15.
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- Sood A and Gupta M (2015) Extraction process optimization for bioactive compounds in pomegranate peel. *Food Bioscience*, 12:100–106.

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Research Area: *In vitro* and *in vivo* pharmacology

Anticancer and immunomodulatory potentials of *Tinospora cordifolia*: The plant is widely used in various traditional medicinal systems including "Ayurveda" for the treatment of jaundice, rheumatism, urinary disorder, skin diseases, diabetes and anaemia. The phytoconstituents present in the plant belongs to different class of compounds such as alkaloids, diterpenoids lactones, glycosides, steroids, phenol, aliphatic compounds and polysaccharides. With this background, present study addressed the isolation, structure elucidation, quantification and evaluation of anticancer and immunomodulatory potential of secondary metabolites.

The anti-cancer activities of different extracts, fractions and isolated compounds were evaluated on four different human cancer cell lines, KB (human oral squamous carcinoma), CHOK-1(hamster ovary), HT-29 (human colon cancer) and SiHa (human cervical cancer).

Immunomodulatory potential was determined on murine primary splenocytes (Fig.1).

All extracts and fractions were active against KB and CHOK-1 cells, whereas, palmatine was active against KB and HT-29; tinocordiside against KB and CHOK-1 and yangambin against KB cells. However, N-formylannonain and 11-hydroxymustakone showed immunomodulatory activity.

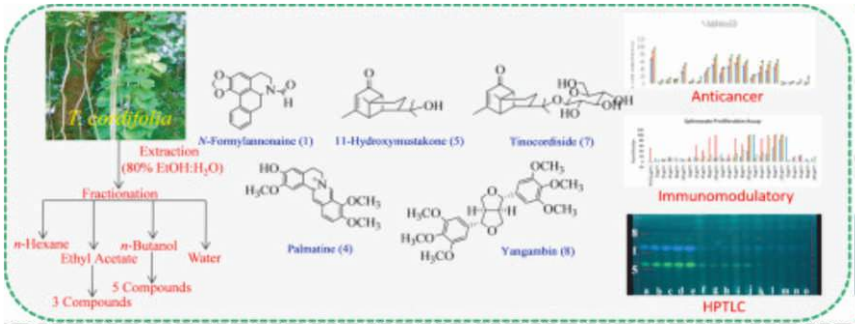

Fig.1. Phytochemical profiling, *in vitro* anticancer and immunomodulatory activities of *Tinospora cordifolia.*

Publications:

- Koundal R, Kumar D, Walia M, Kumar A, Thakur S, Gopichand, Padwad YS and Agnihotri VK (2016) Chemical and *in vitro* cytotoxicity evaluation of essential oil from *Eucalyptus citriodora* fruits growing in the Northwestern Himalaya, India. *Flavour Fragrance Journal,* 31:158–162.

- Rana S, Kumar S, Rathore N, Padwad YS and Bhushan S (2016) Nutrigenomics and its Impact on Life Style Associated Metabolic Diseases. *Current Genomics,* 2016, 17 (6).
- Sharma S, Rana S, Patial V, Gupta M, Bhushan S and Padwad YS (2016) Antioxidant and hepatoprotective effect of polyphenols from apple pomace extract via apoptosis inhibition and Nrf2 activation in mice. *Human and Experimental Toxicology*, DOI: 10.1177/0960327115627689.
- Patial V, Mahesh S, Sharma S, Pratap K, Singh D, Padwad YS (2015) Synergistic effect of curcumin and piperine in suppression of DENA-induced hepatocellular carcinoma in rats. *Environmental Toxicology and Pharmacology*, 2015, 40: 445–452.
- Acharya A, Rawat K, Bhat KA, Patial V and Padwad YS (2015) A multifunctional magneto-fluorescent nanocomposite for visual recognition of targeted cancer cells. *Material Research Express*, 2: 115401 doi:10.1088/2053-1591/2/11/115401.

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Research Area: Toxicopathology and animal pathology

Regulatory and efficacy studies

Our lab is involved in the safety /toxicity and efficacy evaluation of natural drug molecules, nutraceutical and nanomaterials. In regulatory studies conducted as per standard guidelines, steviol glycosides (SG) showed safety up to 5g/kg bw dose in acute study, whereas, no toxicity up to 2g/kg bw dose in sub-acute.

In efficacy studies, the synergistic effect of curcumin and piperine against chemical induced hepatocellular carcinoma in rats was found. Piperine as a bio-enhancer increased the bioavailability of curcumin and thus enhanced its anticancer effect.

The antioxidant and hepatoprotective effect of apple pomace polyphenols was studied using CCl_4 . induced live injury in rats (Fig.1). It was found that the hepatoprotective effect is mainly due to inhibition of apoptosis and activation of antioxidant factors in the cells.

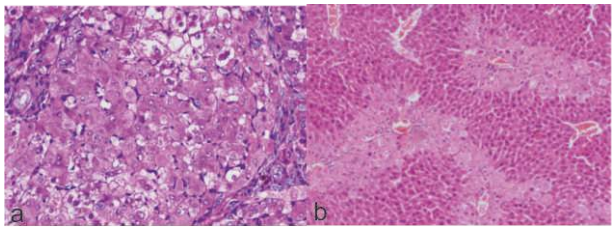

Fig. 1 a) Hepatocellular carcinoma in rat liver, b) CCl4 induced liver necrosis

In collaborative work, the acute toxicity of fluorescent nanocomposites was studied in the rats. The nanocomposites were found safe to use as a novel dual mode imaging material. Diabetic wound healing activity of nanoformulation formed by combining plant cellulose nanocrystals and green silver nanoparticles was studied in Swiss albino mice. Diabetes was induced in the mice using streptozotocin and later mechanical wounds were created on which the healing effect of nanoformulation was studied. We were also involved in the evaluation of cardioprotective effect of *Punica granatum* L. peel extract through activation of nitric oxide-mediated Nrf2/ARE signalling pathway and apoptosis inhibition in isoproterenol induced cardiac damage in rats.

Publications:

- Sharma S, Rana S, Patial V, Gupta M, Bhushan S and Padwad YS (2016) Antioxidant and hepatoprotective effect of polyphenols from apple pomace extract via apoptosis inhibition and Nrf2 activation in mice. *Human and Experimental Toxicology*, DOI: 10.1177/0960327115627689.

- Walia S, Sharma S, Markand KP, Patial V and Acharya A (2016) A bimodal molecular imaging probe based on chitosan encapsulated magneto-fluorescent nanocomposite offers biocompatibility, visualization of specific cancer cells *in vitro* and lung tissues *in vivo*. *International Journal of Pharmaceutics*, 498:110-118.
- Patial V, Mahesh S, Sharma S, Pratap K, Singh D and Padwad YS (2015) Synergistic effect of curcumin and piperine in suppression of DENA-induced hepatocellular carcinoma in rats. *Environmental Toxicology and Pharmacology*, 40: 445–452.
- Acharya A, Rawat K, Bhat KA, Patial V and Padwad YS (2015) A multifunctional magneto-fluorescent nanocomposite for visual recognition of targeted cancer cells. *Materials Research Express*, 2(11):115401
- Gupta M, Sharma P, Mazumder AG, Patial V and Singh D (2015) Dwindling of cardio damaging effect of isoproterenol by *Punica granatum* L. peel extract involve activation of nitric oxide-mediated Nrf2/ARE signaling pathway and apoptosis inhibition. *Nitric Oxide: Biology and Chemistry*, 50 : 105-113.

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Research area: Neuropharmacology

Cardioprotective effect of *Punicagranatum* L. peel

The aim of our research work is to explore, validate the therapeutic potential and identify active principles in plants of western Himalayan region using experimental animal models. Further, to study the therapeutic benefits and safety of developed food products is another core area of our research group. In this regard, cardio protective effect of *Punica granatum* L. (Punicaceae) peel was studied. The peel comprising around 50% of the total weight of the fruit is often considered as a waste, in spite of its high bioactive metabolite composition. It is a rich source of phenolic antioxidants like punicalagin, gallic acid, epicatechin etc. The peel was extracted (PGE) and analysed for its secondary metabolite profile. PGE showed presence of punicalagin, gallic acid and epicatechin. The effect of PGE was studied in rat model of isoproterenol (ISO)-induced acute myocardialinfarction (MI). The electrocardiographic alterations with increased heart weight and cardiac tissue damage (Fig. 1) signifying MI was observed following ISO administration (150 mg/kg; *s.c.*), twice at 24 ± 1 h interval. Marked attenuation of the said parameters (Fig. 2), along with reduction in serum creatine kinase-MB, lactate dehydrogenase, alanine transaminase and aspartate aminotransferase was observed with PGE pretreatment at 50, 100 and 200 mg/kg; *p.o.* doses. Moreover, PGE treatment decreased lipid peroxidation and increased cardiac tissue superoxide dismutase activity, reduced glutathione and nitrite levels. There wasdose-

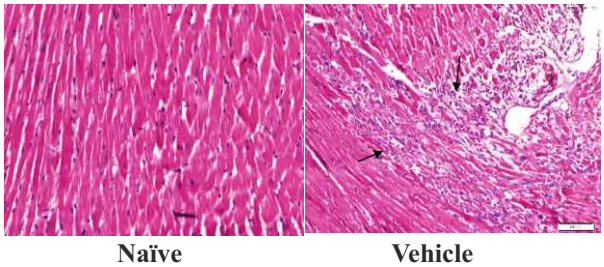

Fig. 1 Histopathological finding showing myocardial tissue damage in isoproterenol administered vehicle control group

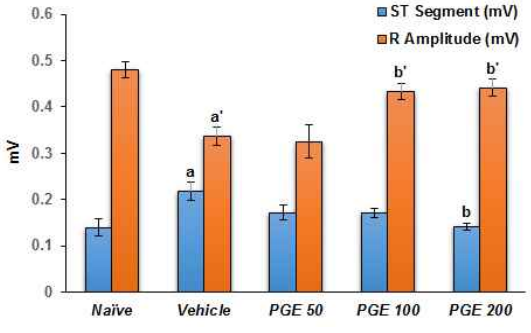

Fig. 2 Effect of *Punicagranatum* L. (Punicaceae) peel extract on isoproterenol-induced alteration in ST segment and R amplitude. [a]P< 0.05 indicates ST segment as compared to naïve group; [b]P< 0.05 indicates ST segment as compared to vehicle control group.[a']P< 0.05 indicates R amplitude as compared to naïve group; [b']P< 0.05 indicates R amplitude as compared to vehicle control group

dependent increase in endothelial nitric oxidesynthase, Bcl-2 and nuclear factor erythroid 2-related factor 2 (Nrf2), and decrease in Bax proteins expression in the myocardium of the extract treated rats. It was concluded that PGE increases myocardial expression of endothelial nitric oxide synthase that leads to nitric oxide-mediated Nrf2activation thus upregulateantioxidant mechanisms, which ultimately leads to inhibition of apoptosis (Fig. 3).

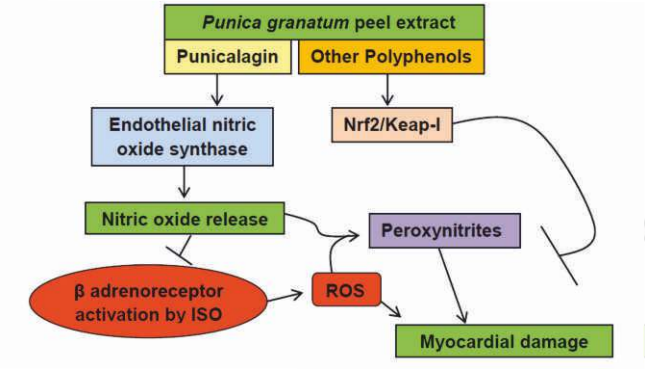

Fig. 3 Proposed cardioprotective mechanism of *Punica granatum* L. ((Punicaceae) peer extract.

Curcumin as a bioenhancer for hepatocellular carcinoma

Phenolic compounds in medicinal plants are major bioactive metabolites found to be effective against several pathological conditions. However, poor pharmacokinetics parameters restrict the clinical use of these bioactive metabolites. Current research is in progress to develop add-on therapies to improve the kinetics of active metabolites. Curcumin is a phenolic compound that has been found to be efficacious against oxidative stress related diseases. Interestingly, due to poor absorption it has been found to be less efficacious *in vivo* as compared to *in vitro*. Hence, to improve its efficacy its effect was studied in combination with piperineagainst diethylnitrosamine (DENA)-induced hepatocellular carcinoma in rats. The combined treatment of curcumin with piperine showed significant improvement of hepatocellular carcinoma in comparison to curcumin *per se* and vehicle control group.

Other work in process

The effect of bioactive components of medicinal plants of western Himalayan region including *Crocus sativus*, *Ginkgo biloba* and a few others being used in traditional medicine for neurological disorders were also studied in chronic experimental animal models.

Publications:

- Gupta M, Pallavi S, Mazumder AG, Patial V and Singh D (2015) Dwindling of cardio damaging effect of isoproterenol by *Punica granatum* L. peel extract involve activation of nitric oxide-mediated Nrf2/ARE signaling pathway and apoptosis inhibition. *Nitric Oxide: Biology and Chemistry*, 50:105-113.
- Patial V, Mahesh S, Sharma S, Partap K, Singh D, Padwad YS (2015) Synergistic effect of curcumin and piperine in suppression of DENA-induced hepatocellular carcinoma in rats. *Environmental Toxicology and Pharmacology*, 40: 445-452.

- Singh P, Singh D, Goel RK (2015) Protective effect on phenytoin-induced cognition deficit in pentylenetetrazol kindled mice: a repertoire of *Glycyrrhiza glabra* flavonoid antioxidants. *Pharmaceutical Biology*, (DOI: 10.3109/13880209.2015.1063673).

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Research Area: Animal model development and preclinical toxicology

Animal breeding and housing facility: Contribution of laboratory animals in the field toxicology is well known. No compound/molecule/drug can reach to human clinical trials without making it through the pre-clinical experimentation on laboratory animals. Thus animal studies play vital part of this research process.

Development of laboratory animal models for various clinical conditions/diseases: In the process of development of beneficial product for human or animal use, raw formulation/molecule is tested *in vitro* using tissues and isolated organs initially, but before human use, legally and ethically, it has to be tested in a suitable animal model before clinical trials in humans can take place. Humans and animals share hundreds of illnesses, and thus animals can act as models for the study of human illness. From such models we learn mechanism/pathogenesis of disease progression and how the immune system responds during the disease progression. Development of animal models for learning this mechanism and finding potential cure is important for betterment of human health. Presently, we target to develop of animal models for carcinogenicity studies by chemical induction as well as humanised xenograft translation. We aim to study chemical induction of mammary tumors by N-methyl-n-nitrosourea (NMU), or 7,12-dimethylbenz[a]anthracene (DMBA) and also study of lung cancer using N-nitroso-tris-chloroethylurea (NTCU) or N-nitroso-methyl-bischloroethylurea

Pre-clinical assessment of lead molecules from western Himalaya region: Once an animal model is developed for a particular disease/clinical condition, animals are used to test potential therapies as part of the applied research process. New medicines/compounds are required be tested in order to assess the beneficial and the harmful effects of a compound on a whole organism. Preclinical assessment of such different formulations/lead molecules from western Himalayan region following norms of national and international regulatory authorities is our service support for testing of various compounds.

High Altitude Biology

- Survey, mapping and classifying bioresources
- Documenting species and ecosystem responses to climate change
- Documentation of traditional knowledge
- Development of database
- Societal services

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Research areas: Ethnobotany, taxonomy and plant conservation

Documentation of Ethnobotanical Knowledge: Ethnobotanical studies were carried out among the *Gaddis* and *Gujjars* inhabiting the remote forest areas of Bharmour and Tisa subdivisions of Chamba district, HP. Information on around 50 plant species used by these ethnic groups in their daily life were recorded through on spot personal interactions and interviews with several knowledge holders in the field. Among the plants reported to be used in curing different ailments were *Aconitum heterophyllum, Angelica glauca, Arnebia benthamii, Dactylorhiza hatagirea, Picrorhiza kurrooa, Podophyllum hexandrum, Rabdosia rugosus, Swertia paniculata* etc. Plants like *Swertia petiolata*, *Rheum emodi* and *Aconitum heterophyllum* are being used for stomach ache cure, whereas roots of *Angelica glauca* is given in joint pain. *Dactylorhiza hatagirea* tuber is used for snake bites. Plants like *Betula utilis, Valeriana jatamansi, Juniperus communis* and *Jurinea dolomiaea* are used in different rituals performed during various occasions.

An interesting process of drying of herbs by the local people was observed in the field, particularly the roots of *Kadu* (*Picrorrhiza kurrooa*) were dried with the help of fire smoke in the field (Fig. 1).

Fig. 1 Drying of roots of *Picrorhiza kurrooa* in the field

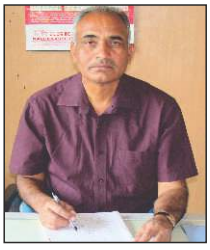
Enrichment of herbarium: In order to enrich the existing herbarium through extensive field explorations, around 500 plant specimens were collected from different locations. Of the total 500 specimens collected, around 100 voucher specimens were selected, processed, identified and deposited in the herbarium for future reference. Voucher specimens added as new to the herbarium included *Arabidopsis* spp., *Gymnema sylvestre*, *Trollius acaulis, Aquilegia nivalis, Allium semenovii, Primula macrophylla, Paraquilegia microphylla, Pedicularis oederi, Cardamine macrophylla* and *Fritillaria roylei*.

S & T Services:

- On a request made by the official of M/s Wah Tea Estate, Rajpur (Palampur), of Kangra (HP), an official site visit was organized in the month of July 2015 to suggest some ornamental ferns for decoration and landscaping of the area. After visiting the site, an ornamental fern, Adiantum species was suggested to be suitable for the proposed site.
- Identified around 155 plant specimens including 32 specimens of pteridophytes received from local R&D organizations like Department of Veterinary Pathology, College of Veterinary and Animal Sciences, CSKHPKV and IVRI Regional Station Palampur for authentication.
- Around 250 INSPIRE students were enlightened about importance of MAPs, biodiversity and its conservation. Further, 50 XIth standard students from Jawahar Navodaya Vidyalaya, Paprola were made aware about the conservation and sustainable utilization of biological diversity and also collection and preservation herbarium samples.

Publications:

- Singh KN, Gopichand, Lal B and Todaria N P (2016) Ecological status and conservation of rare plants in high altitude landscapes of Indian western Himalaya. *Global Journal of Research on Medicinal Plants & Indigenous Medicine*, 5 (1): 01–18.
- Rana S, Rawat K, Mahendru M, Padwad YS, Pakade YB, Lal B and Bhushan S (2015) Screening of bio-constituents and in vitro cytotoxicity of *Clematis gouriana* leaves. *Natural Product Research*, 29 (23): 2242–2246.
- Stappen I, Ali A, Tabanca N, Khan IA, Wanner J, Gochev VK, Singh V, Lal B, Jaitak V, Kaul VK, Jirovetz S and Jirovetza L (2015) Antimicrobial and repellent activity of the essential oils of two lamiaceae cultivated in western Himalaya. *Current Bioactive Compounds*, 11: 23-30.
- Stappen I, Tabanca N, Ali A, Wedge DE, Wanner J, Kaul VK, Lal B, Jaitak V, Gochev VK, Jirovetz Schmidt E and Leopold (2015) Chemical composition and biological activity of essential oils from wild growing aromatic plant species of *Skimmia laureola* and *Juniperus macropoda* from western Himalaya. *Natural Product Communications*, 10(6): 1071-1074.
- Lal B and Kumari A (2015) Report on national conference modern approaches to pteridophytes: Biology, biodiversity and bioresource, organized at CSIR-IHBT Palampur, during 20-21 December. *Indian Fern Journal*, 32: 1-10.



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Research area: Crop physiology and agrotechnology of medicinal, aromatic and other economic plants.

Survey, cultivation, domestication, characterization and standardization of agro-techniques of bioresource of western Himalaya

(A) *Valeriana jatamansi*: Screening of elite plants by chemical characterization and identification of suitable tree species for their intercropping in western Himalaya was carried out (Fig. 1A). More than twenty field surveys were conducted to collect different accessions of *V. jatamansi* from HP, Sikkim (Gangtok) and West Bengal (Darjeeling and Kalimpong).

In HP, forest regions such as Dhauladhar, Chhota and Bada Bhangal, Barot, Mandi, Kullu, Manali, Sainj valley, Garsha valley, Manikaran valley and Barshani region were surveyed. Besides, Kafnoo, Nichar, Reckongpeo, Sangla and Bhavanagar regions of district Kinnaur was also surveyed for the collection of *V. jatamansi*. The details of these surveys are mentioned in Table 1.

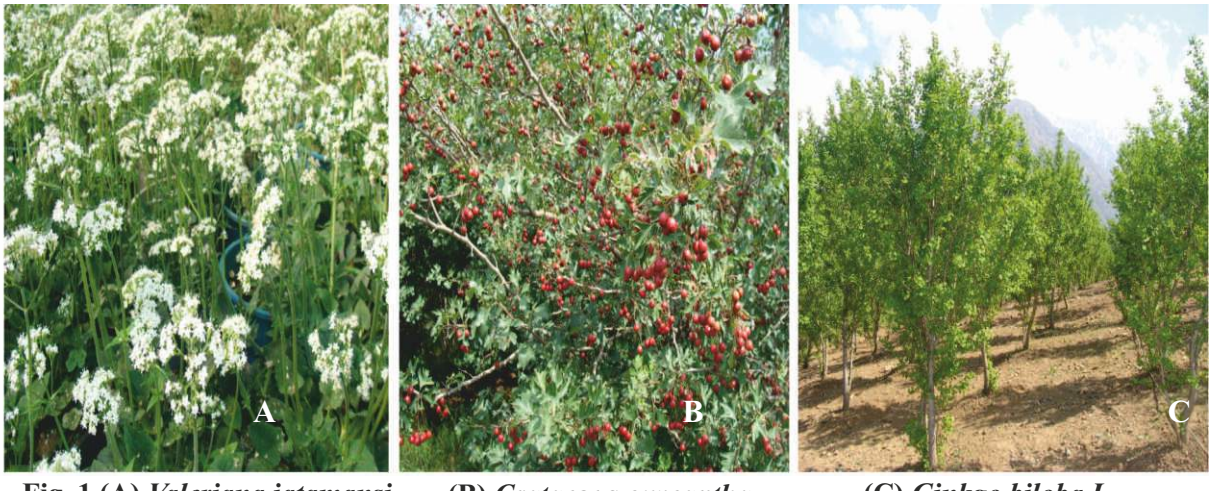

Fig. 1 (A) *Valeriana jatamansi* **(B) *Crataegus oxycantha*** **(C) *Ginkgo biloba L.***

Table 1 Detail of surveyed areas for the collection of accessions of *V. jatamansi*

S.no.	Location	Altitude (m amsl)	Latitude	Longitude
1	Birni-1(Palampur)	2704	32°09'22.232N	76°34'35.071E
2	Birni-2 (Palampur)	2883	32°09'35.820N	76°34'39.094E
3	Birni-3 (Palampur)	2548	32°09'18.534N	76°34'22.126E
4	Birni-4 (Palampur)	2274	32°08'47.745N	76°33'42.865E

5	Kukurgunda	2625	32°07.659N	76°45.577E
6	Plachack-1	2681	32°08.911N	76°45.705E
7	Plachack-2	2769	32°08.105N	76°45.521E
8	Kandi (Mandi)	1961	31.82083°N	77.07694°N
9	Kafnoo(Kinnaur)	2700	31.63912°N	78.00453°N
10	Ranipani (Kullu)	2448	31.58222°N	77.48194°N
11	Barshaini	2075	31°59'52.8N	77°26'37.3E
12	Shilagarh	2123	31°52'14.1N	77°20'09.6E
13	Rahla	2221	31°47'22.4N	77°18'34.7E
14	BSI (Sikkim)	1671	27°20'21.2N	088°36'52.0E
15	UBKVKC (Kalimpong)	1076	27°04'07.4N	088°28'36.8E
16	Darjeeling	2038	27°02'38.4 N	088°15'48.3 E

Result of soil analysis: The pH of the soil was acidic in nature in all the sites. The maximum nitrogen kg/ha was estimated in Darjeeling (437.53 kg/ha) and minimum in Kukurgunda (73 kg/ha). The available P was observed maximum in soil of Kalimpong and minimum in Kukurgunda. Available K was found maximum in Kafnoo and minimum in soil of Kukurgunda.

Mass multiplication: The seeds of *V. jatamansi* were collected, dried in shade and nursery was raised in polyhouse under controlled conditions. After 15-18 days, when the seeds started germinating, agronet was removed. After three months, the Valeriana seedlings were ready for the transfer in the sleeves and field. The field trial was laid out in the month of August, 2015 to study the growth and biomass production under different tree shades. All the meteorological parameters including minimum and maximum temperature, humidity, rainfall, wind velocity, bright sunshine and evaporation rate were also recorded every day from January, 2015 to March, 2016. The soil samples were collected for analysis of its physical and chemical properties from all three tree shades. On the basis of morphological variations two clones of *V. jatamansi* were selected and chemically characterized. In the plantation, the selection criteria were based on the leaf structure such as Valeriana dark green color of leaves (VDG) for one clone. The second clone was Valeriana light green color of leaves (VLG) with small leaf in comparison to the first clone leaf.

(B) *Crataegus oxycantha:* In order to standardize agro-techniques for cultivation of *C. oxycantha*, a field trial was laid down in different plots (Fig. 1B). Among different growth hormones, Indole Butyric Acid (IBA, 1000mg/L) gave highest percentage of sprouting (78.35%) as compared to . control (32.43%) the sprouting.

© *Ginkgo biloba* L: The study on growth and yield of *G. biloba* leaves under high density plantation was conducted at different FYM levels (15-60t/ha). The data for last three year revealed an increment of 25-35% yield of fresh as well as dried leaves (Fig. 1C)

Re-vegetation of dumping sites of Himalaya Region: Ten dumping sites (1403 m to 2221 m amsl) were targeted for re-vegetation in three valleys namely Sainj, Manikarn and Garsa in Kullu district. Eleven different tree species, planted during 2010 to 2012, showed specificity to plantation sites. Among them, *Aesculus indica* gained maximum growth at DS-02, *Ailanthus* at DS-06, while *Cedrus deodara* and *Robinia* at DS-16 site.

Publications:

- Koundal R, Kumar A, Thakur S, Agnihotri VK, Gopichand and Singh RD (2015) Seasonal variation in phytochemicals of essential oil from *Juniperus communis* needles in western Himalaya. *Journal of Essential Oil Research*, 27 (5): 406 –411.
- Gopichand and Meena RL (2015) Standardization of propagation and agro techniques in *Ginkgo biloba* L. - A medicinally important plant. *Journal of Medicinal Plant Studies, 3*(4): 6-15.
- Koundal R, Kumar D, Walia M, Kumar A, Thakur S, Gopichand, Padwad YS and Agnihotri VK (2016) Chemical and *in vitro* cytotoxicity evaluation of essential oil from *Eucalyptus citriodora* fruits growing in the Northwestern Himalaya, India. *Flavour Fragrance Journal*, 31:158-162.
- Singh KN, Gopichand, Lal Brij and Todaria NP (2016) Ecological status and conservation of rare plants in high altitude landscape of Indian Western Himalaya. *Global Journal of Research on Medicinal Plants and Indigenous Medicine*, 5 (1): 01-18.

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Research Area: Biodiversity, ecology and resource use

In continuaton to work on plant invasion, time of fruiting and role of dispersers was found to play an important role in the spread of *Sapium sebiferum*. Further, work on the traits of *Trifolium repens* revealed that flower recurving is an important strategy that helps the species in augmenting reproduction. Studies on host-epiphyte relationships are meager in the Himalayan region and therefore, occurrence of *Pyrrosia flocculosa*, an epiphytic fern on *Eucalyptus globulus* was studied. Further, work on long term ecological research plots and addition of information to the plant database continued.

Plant invasion studies: Spread of invasive species is a contemporary ecological issue. Recent studies have documented advancement of such species in the Himalayan biodiversity hotspot. *S. sebiferum* is one amongst them that has serious ecological implications. We have been monitoring a stand of *S. sebiferum* to document its phenology and seed dispersal patterns. Unlike majority of the plant species in the western Himalaya which fruit during monsoon, fruits of *S. sebiferum* mature and dehisce during November-December. This being winter season in the Himalaya, wherein resources are scarce, *S. sebiferum* is able to attract a large number of frugivorous birds which increase the chances of wider seed dispersal (Fig. 1).

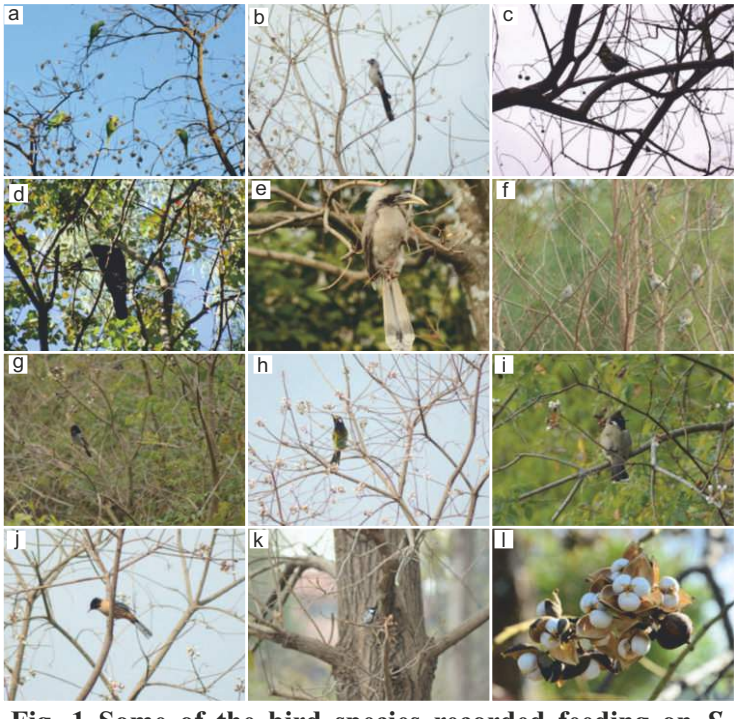

Fig. 1 Some of the bird species recorded feeding on *S. sebiferum* a: Rose ringed parakeet, b: Rufous tree pie, c: Black lored yellow tit, d: Jungle crow, e: Indian Grey Hornbill, f: Gold finch, g: Red vented bulbul, h: Great barbet, i : Himalayan bulbul, j: Rufous sibia, k: Great tit, and l: dehisced fruits of *S. sebiferum* exposing the seeds)

Thus, late fruiting seems to be of much advantage for this species and possibly one of the reasons for its success in the Himalayan foothills.

Recurving as an effective reproductive strategy of *Trifolium repens* L.: Recurving refers to bending of a structure or an organ in the direction opposite to that of its growth. Flowers of *T. repens* showed recurving. We, therefore, studied whether recurving is an effective strategy employed by *T. repens* to maximize chances of fertilization and thereby seed production. For this, fifty individuals of *T. repens* were identified and tagged in wild. Of these, twenty were control (growing as such) and twenty were constrained from recurving. The remaining ten plants were covered with net to limit cross pollination (Fig. 2). All these plants occupied the same habitat and grew in the same natural environment. No significant difference in the number of flowers per inflorescence between control and constrained plants was found. However, a significant difference ($p<0.001$) in the number of seeds produced by control (68.35±3.92) and constrained plants (22.25.±1.35) was observed. Three times more seeds, without compromising on seed mass ($p>0.05$), were produced in the control plants. No seeds were produced in the flowers that were netted. Thus, recurving appears to help *T. repens* in reproduction.

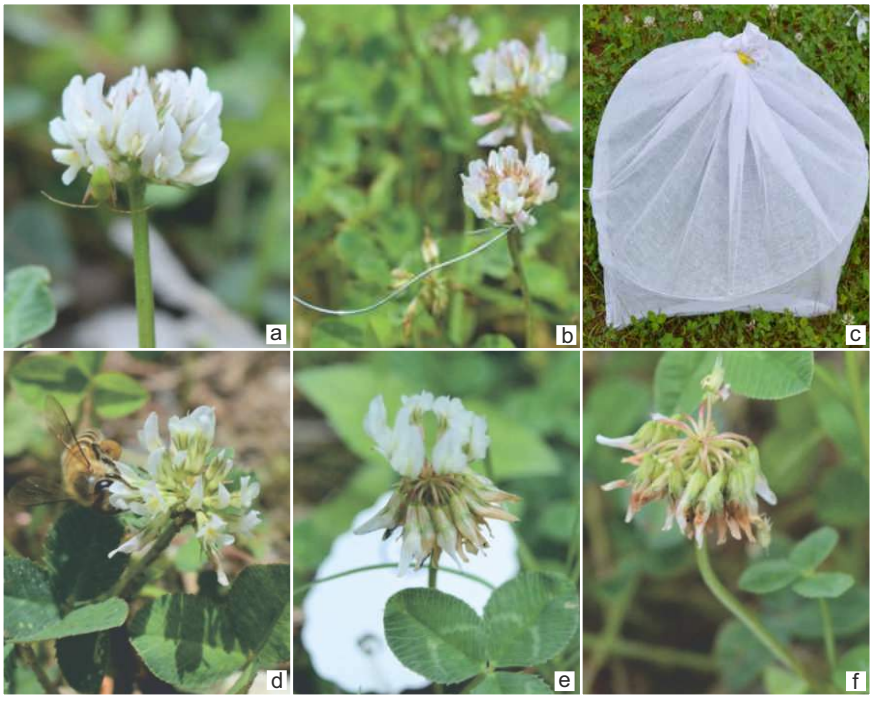

Fig. 2 Inflorescence of *T. repens* (a- compact inflorescence with flower pointing upwards, b- a constrained flower, c- pants covered with net to deter pollination, d-a pollinator on the peripheral mature flower, e- half of the flowers have recurved while the ones yet to be fertilized face upwards, f- inflorescence completely recurved with fruit formation in the process)

Epiphyte-phorophyte studies: Bark characteristics of the phorophyte such as, thickness, rugosity and water holding capacity define host suitability for epiphytes. Little is known about the epiphytic ferns and phorophytes from the Himalayan region. For this, 200 trees of *E. globulus* were sampled and information on girth, fern location and inclination of phorophyte was recorded (Fig. 3). Additionally, bark samples were also analyzed.

Fig. 3 Sampling of phorophytes and collection of bark samples

Ferns were observed growing on 48% of the sampled trees. The distribution of fern increased with increasing girth of the phorophyte. Maximum percentage of the trees in which ferns were present with respect to the total trees present in that girth category was in the 125-145 cm girth class (Fig. 4). With increase in tree girth, outer layer of the bark gets fissured and also its thickness increases. All the trees that hosted ferns had inclination and were associated with mosses. None of the straight trees hosted ferns.

Long term ecological research monitoring plots: Documenting ecosystem responses and species redistribution is an important aspect of climate change studies. For this permanent long term ecological research monitoring plots have already been established in the field. During this year four more plots having automated dataloggers were established and species abundance, flower traits, and soil data was collected from these sites (Table 1).

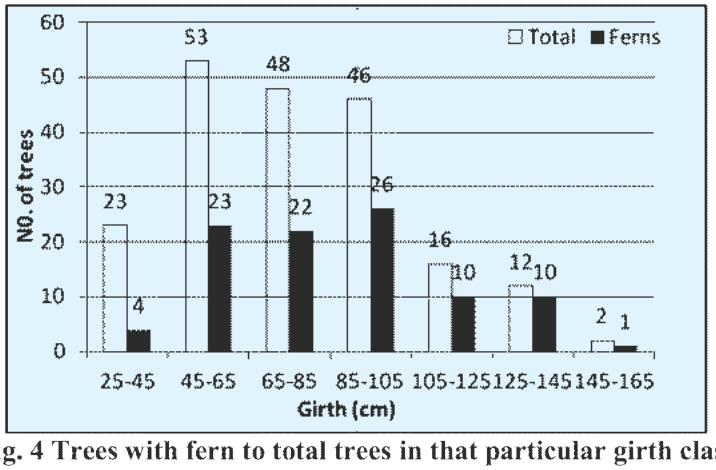

Fig. 4 Trees with fern to total trees in that particular girth class

Table 1. Physico-chemical characteristics of the soil collected from LTERS located along an elevation gradient

Elevation	pH	Electrical Conductivity	Total Nitrogen	Total Phosphorous	Total Potassium
3000	5.04±0.22	0.09±0.00	0.58±0.03	0.09±0.00	1.10±0.03
3100	5.76±0.19	0.12±0.00	0.63±0.03	0.13±0.00	1.60±0.06
3200	5.17±0.07	0.12±0.00	0.63±0.03	0.11±0.00	1.68±0.01
3300	4.37±0.02	0.17±0.00	0.60±0.03	0.15±0.01	0.97±0.01
3400	5.35±0.10	0.11±0.00	0.82±0.05	0.18±0.00	1.02±0.02

Database on floral resources of Himachal Pradesh: Continuing with the development of plant database, information on morphological characteristics, distribution, taxonomy and uses of 1000 plant species were added. This My Sql database consists of 12 tables pertaining to distribution, life form, population, local name, taxonomy, image, uses, conservation status and alien species. The tables are linked to one another by one-to-one and one-to-many linkages.

Publications:

- Ahmad M and Uniyal SK (2016) Is recurving an effective strategy of *Trifolium repens* L. to augment reproduction? *Scientifica*, Article ID 4741086, dx.doi.org/10.1155/2016/4741086.
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- Sood A, Alpy and Uniyal SK (2016) Biodiversity characteristics of the Western Himalaya. *In.* Das and Bera (Eds). *Plant Diversity in the Himalaya Hotspot Region*.

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Research area: Geospatial mapping and database development on bioresources in western Himalaya.

Different factors responsible for forest fires and the regions sensitive to such fires were identified in Kangra district of Himachal Pradesh. A digital geo-referenced forest fire map was also prepared for Dehra forest division of Himachal Pradesh. Maps depicting spatial distribution of targeted Pteridophytes in western Himalaya were also prepared. The temporal pattern of Net Primary Productivity of Great Himalayan National Park (GHNP), Rupi-Bhabha Wildlife Sanctuary (RBWS) and Pin Valley National Park (PVNP) of Himachal Pradesh during 2000 to 2014 was also estimated using satellite data. The land use/ land cover map of Chamba district (HP) was prepared using Landsat image, which provided latest ground conditions. An E-Inventory of 45 medicinal plants of the Indian Himalayan Region (IHR) was prepared from the data compiled from published sources.

Identifying triggers for forest fire and assessing fire susceptibility of forests: A study to identify fire prone sites was carried out in Kangra (HP). For this, geographical coordinates of the recorded fire locations were overlaid on various thematic layers such as elevation, slope, aspect, mean annual temperature and fuel map of the region. The 10.7 % of the forest cover in the study area was categorized as 'very high' and 'high' forest fire-prone area (Fig. 1). The 14.02 % villages of the region were identified as 'high' forest fire prone. The *Pinus roxburghii*, mixed forest species, Khair forest (*Acacia* spp.) and oak forest (*Quercus* spp.) were identified as fire-sensitive forest types of the region.

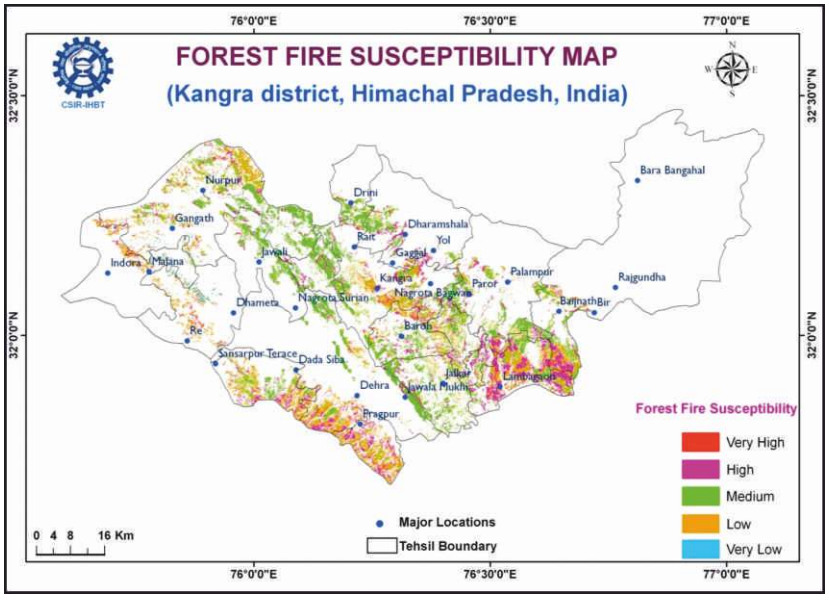

Fig. 1 Prioritized forest fire-prone regions in Kangra district, Himachal Pradesh

Sanctuary (RBWS) and Pin Valley National Park (PVNP) of Himachal Pradesh were calculated from the period 2000 to 2014 using temporal Terra/MODIS NPP satellite data acquired from National Aeronautics and Space Administration Earth Observations (NASA). The average NPP of GHNP, RBWS and PVNP from 2000 to 2014 were 5.35 tC/ha/yr; 4.35 tC/ha/yr and 0.46 tC/ha/yr, respectively (Fig. 3).

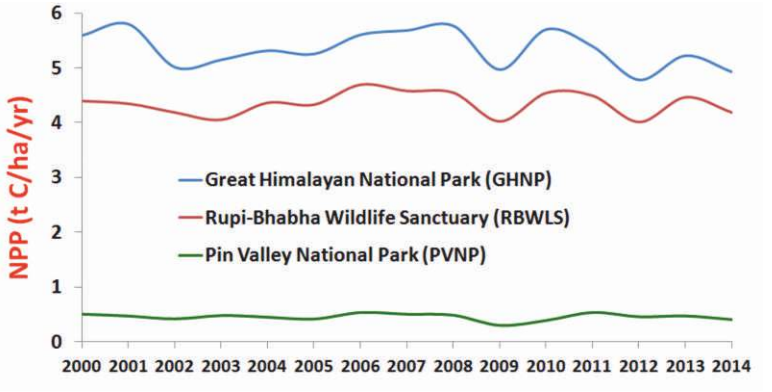

Fig. 3 Mean annual Net Primary Productivity of GHNP, RBWLS and PVNP

Land use/ land cover mapping: Chamba represents one of the interior and biologically rich districts of Himachal Pradesh**.** Mapping of the district was, therefore, carried out using LANDSAT MSS satellite images (Fig. 4A). The results identified nine major land use/ land cover classes in the area (Fig. 4B). Among these classes, forests occupy the largest area (42.26 %) followed by scree slopes (17.09 %), agricultural land (10.36 %), alpine area (10.18 %), scrub/grass land (9.15 %), snow cover (8.47 %), stony/barren area (0.96 %) and built-up areas (0.06 %).

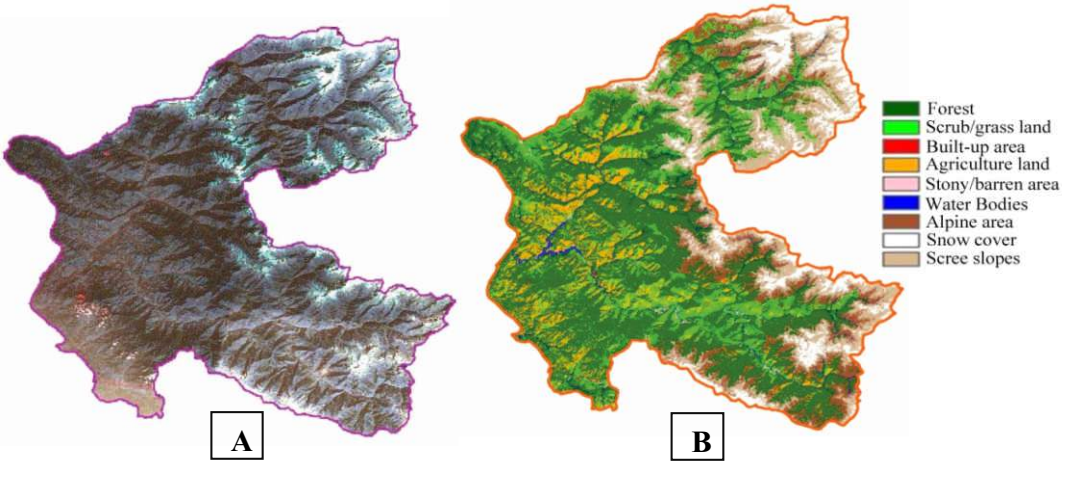

Fig. 4 (A) Landsat image, (B) Land use land cover map of Chamba district of HP

The *P. roxburghii* forest, low elevation, high temperature, high slope, south-west facing aspect, and anthropogenic disturbances were identified as major factors responsible for forest fire in the region.

Preparation of digital geo-referenced forest fire map: In order to provide S&T services to Himachal Pradesh state forest department, a digital geo-referenced forest fire map was prepared for Dehra forest division in GIS environment. The map depicted locations of occurrences of forest fires during the years 2008 to 2014.

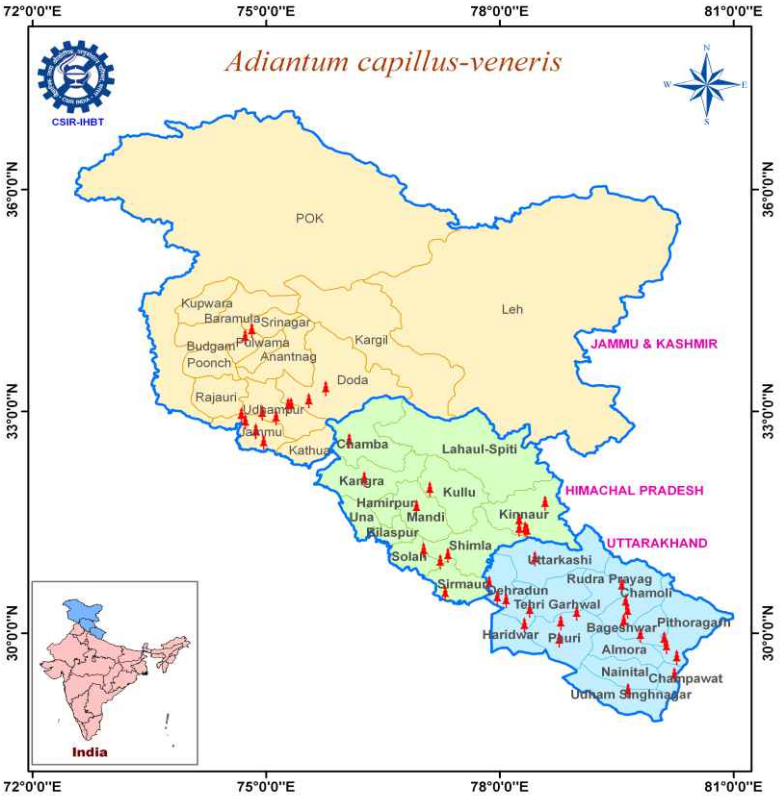

Fig. 2 Maps depicting geographical distribution of one of the targeted fern species in western Himalaya

Preparation of spatial distribution maps on Pteridophytes: Maps depicting distribution of fern species belonging to six targeted genera (Adiantum, Asplenium, Cheilanthes/ Aleuritopteris, Diplazium, Pteridium, Equisetum) represented by six species in the western Himalayan regions (Himachal Pradesh, Uttarakhand, Jammu & Kashmir) have been prepared (Fig. 2). Information on locations of occurrence of target species of Pteridophytes in the western Himalaya was recorded from secondary (published) sources and plotted on the administrative map of western Himalaya in Geographic Information System (GIS) environment.

Field surveys: The ground truthing of Nagrota Bagwan, Khaniara and Dhramkot areas of Kangra district of Himachal Pradesh were carried out in June, 2015. The field survey to Chanshal area of Shimla district of Himachal Pradesh was conducted in the month of August, 2015. The vegetation data was recorded following GLORIA measurement protocols from long term ecological plots named as HIMADRI site.

Estimation of Net Primary Productivity of protected areas in Himachal Pradesh: Annual Net Primary Productivity (NPP) of Great Himalayan National Park (GHNP), Rupi-Bhabha Wildlife

Development of E-Inventory on medicinal plants of Indian Himalayan Region: E-Inventory of 45 medicinal plants of Indian Himalayan Region (IHR) was prepared (Fig. 5). The database contains information of these plants on medicinal usage (traditional, unani, ethno-botanical, modern medicine, ayurvedic and siddha), their systematics, diseases cured, parts used, photographs and maps depicting their general distribution in IHR. The graphic user interface of this E-Inventory allows querying the database on the basis of plant name, family name, part of plant used and diseases cured by the plants.

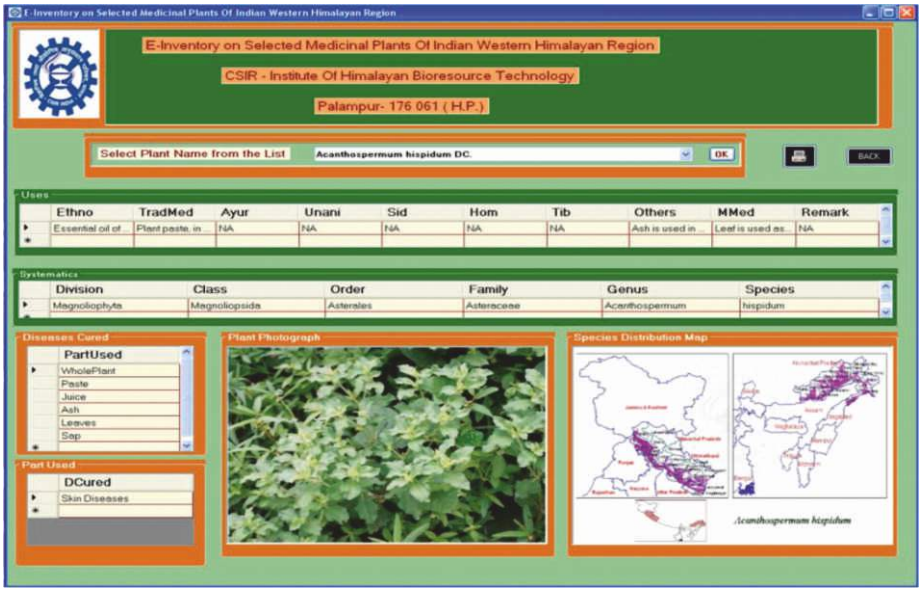

Fig. 5 GUI of E-Inventory of medicinal plants of IHR

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- Kumar S, Meenakshi, Bairagi GD, Vandana and Kumar A (2015) Identifying triggers for forest fire and assessing fire susceptibility of forests in Indian western Himalaya using geospatial techniques. *Natural Hazards*, 78: 203–217.
- Kumar A and Deshmukh B (2015) A Review on 'Geo-ecological studies - an interdisciplinary approach for evaluation and sustainable management of 'Geo-ecosystems. *Journal of Geological Society of India*, 89: 605-612.
- Kumar A, Chauhan VK, Kumar S and Singh RD (2015) Relevance of satellited derived net primary productivity data in monitoring of protected areas in Indian Western Himalaya. *Asian Journal of Geoinformatics*, 15(4): 1-24.
- Verma A, Kumar S, Ahmed M, Kumar A and Uniyal SK (2015) HIMADRI site in Himachal Pradesh (Chansal). *ENVIS Newsletter on Himalayan Ecology*, 12(2): 5.

Anil Kumar Singh, Scientist

Research area: Plant adaptation

Over group page is involved in understanding plant response to environmental stress in both abiotic and biotic stresses negatively affect the yield and quality of economically important crops. Plants have to constantly cope with different abiotic stresses such as drought, salinity, high or low temperature, oxidative stress etc. To counteract these stresses, plants have developed stress tolerance and avoidance mechanisms to overcome the challenges posed by surrounding environment.

Continuing working on plant adaptation, universal stress proteins (USPs) and *DREB* were identified that are likely to play important roles in plant survival under abiotic stresses. Of the various USPs, a role of *AtUSP17* was analysed using a knock down mutant with T-DNA insertion in *Arabidopsis*. While the detailed analysis is under progress, data did suggest that AtUSP17 is a component of stress tolerance mechanism in *Arabidopsis*. Of the various *DREB*s of apple, *Md DREB-076* and *MdDREB-043* were identified to be critical and their functional characterization is underway in tobacco.

Previous work in the institute identified superoxide dismutase (SOD) to be associated with imparting stress tolerance in plants. However, the mechanism imparting stress tolerance has not been adequately deciphered. Our data on transgenic *Arabidopsis* showed that overexpression of SOD along with ascorbate peroxidase (APX) enhanced stress tolerance through lignification of vascular tissues (Fig. 1), a novel mechanism reported for the first time. In addition, transgenics exhibited growth promotion, higher biomass production and increased yield under salt stress as compared to the wild type.

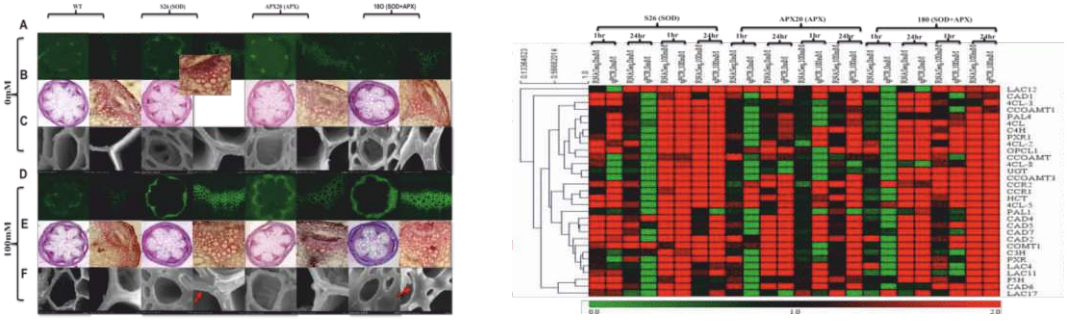

Fig.1 Genes of lignin biosynthetic pathway were upregulated in transgenic *Arabidopsis* overexpressing SOD and APX as compared to the wild type (adapted from our article published in *Plant Mol Biol*, 87(6): 615-31, 2015).

Amit Chawla, Scientist
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Research area: Ecology, plant adaptation strategies and biodiversity conservation in high altitudes of western Himalaya

Study of plant diversity and their functional traits in the high altitude Himalaya: Five transects were laid in the southern aspects in high altitude zone, representing elevation range from 3000m to 5000m and encompassing subalpine forests, treeline zone, alpine and nival zones. Plant sampling was performed to understand the species range and variation in plant functional traits (PFTs) such as plant height, specific leaf area (SLA), succulence, pubescence, spinescence, root/shoot ratio, flower colour, growth form and life form. It was observed that plant diversity is low along with dominance of annuals and higher upper growing limit of species occurrence in the southern aspects than that in the northern aspects. Further, higher treelines of *Juniperus polycarpos* were found in the region.

Assessment of habitat preference of *Dactylorhiza hatagirea*, a threatened medicinal terrestrial orchid of Himalaya: Plant is commonly called as *'Hath Panja*' or *'Salem Panja*' or '*AngmoLakpa*'. Tubers are known to have wound healing and aphrodisiac properties. It is facing extinction risks due to habitat loss and illegal extraction from wild. A study was undertaken to assess its habitat specificity, community structure and challenges in its conservation in HP. A total of twenty five *D. hatagirea* dominated communities were sampled in the region (elevations ranging from 2900-4250m). Among the different traits studied, plant height, root: shoot ratio, basal area and above ground plant biomass are highly variable and these variations serve as proxy for fitness and helps in plant survival (Fig. 1).

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Fig. 1 (A) Study area, (B) *Dactylorhiza hatagirea* uprooted plant, and (C) in wild

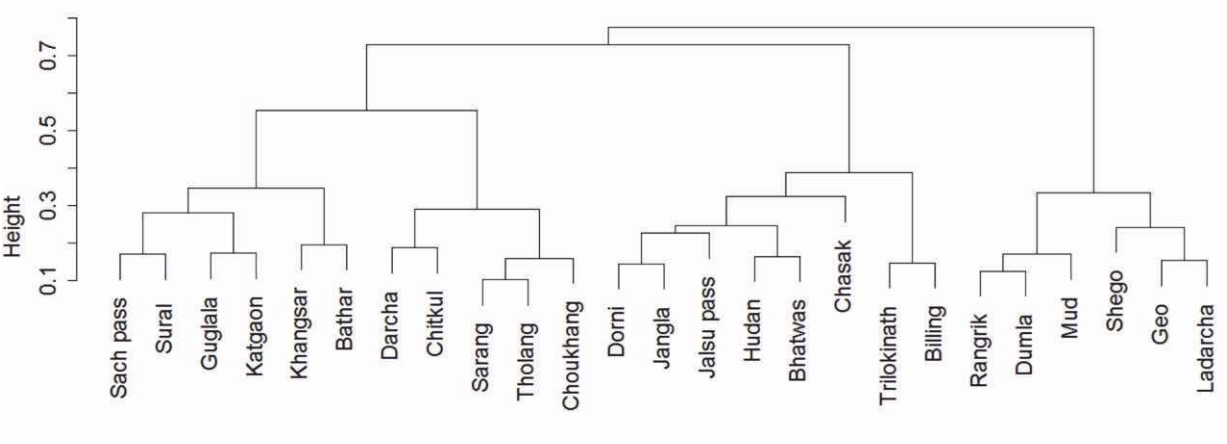

Fig. 2 Dendrogram of studied sites based on soil physico-chemical characteristics.

The co-occurring species in *D. hatagirea* dominated communities were identified and it was found that among a total of 171 species, Asteraceae (18 genera) was the most dominant family followed by Poaceae (16 genera), Fabaceae (12 genera), Rosaceae (10 genera) and Apiaceae (10 genera). Ordination analysis was performed to delineate the main environmental factors explaining distribution of species in the region and variation in PFTs that helps in adaptation. The results indicated that this species, occurs in isolated and small patches in marshy and wet meadows. (Fig. 2).

Manoj Kumar, Scientist
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Research area: Crop modelling and carbon dynamics

Physicochemical properties of forest soil in Dhauladhar wildlife sanctuary: Soils are one of the largest sink of carbon and play a vital role in global carbon (C) cycle. The C stock/ density in soils is affected by vegetation, soil types, climatic conditions, and topography particularly on mountains. Therefore, present study was designed to analyze the physico-chemical properties and C - density of temperate forest soil under canopy of different tree species in Dhauladhar wildlife sanctuary (DWS), HP. The study area was dominated by *Quercus semecarpifolia, Picea smithiana* and *Taxus baccata.* The soil was clay and acidic in nature under all tree canopies. The variation in potassium content was non-significant, however, the total nitrogen was two times higher under *T. baccata* tree canopy as compared to *Q. semecarpifolia*. The soil organic C was 26 % higher under *Q. semecarpifolia* canopy as compared to *P. smithiana* with maximum mean soil C – density (25.6 to 32.0 t ha^{-1}) upto 10 cm depth . In this study, the temperate forest soil showed enormous potential to sequester atmospheric carbon.

Herbaceous diversity of Dhauladhar wildlife sanctuary: The herbaceous vegetation plays a significant role for terrestrial ecosystems, affect nutrient cycling, primary productivity and energy flow in these ecosystems. The herbaceous diversity of temperate forest under open and different dominant tree canopy at DWS, HP revealed about 50 different herbaceous species varying from 17 to 22 at the five locations of DWS. Spruce forest had least diversity indices of herbaceous species; possibly due to allelopathic effect of its needle leaves that restricted the growth and development of floral species. Species like *Fragaria indica* and *Athyrium* were found in shaded region, whereas *Trifolium repens* occurred in open canopy area. It reveals that the herbaceous biomass is significantly affected by various tree canopy, light condition and soil properties.

Simulation studies on *Picrorhiza kurrooa* : *P. kurrooa* is an endangered medicinal plant species and has high demand in pharmaceutical industries. A simulation model is being developed by collecting and estimating various model input data from published literature and actual experiments. The plants kept under different environment conditions viz. Ambient, Free Air CO_2 Enriched (FACE), Free Air Temperature Increased (FATI) and FACE ×FATI conditions are being monitored for various morphological and ecophysiological parameters *e.g.* plant height, no. of leaves, root: shoot length, leaf area, stolon no./plant, biomass allocation, photosynthesis, stomatal conductance, transpiration boundary layer conductance etc.

Ashok Singh, Scientist
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Research Area: High altitude biology (biodiversity conservation and management)

In nature, rapid decline of high value medicinal plants has been reported. Surveys for the collection of threatened plant species were carried out in the cold desert regions of HP. Thirty- four threatened plant species that include *Dactylorhiza hatagirea*, *Aconitum heterophyllum*, *Podophyllum hexandrum*, *Rheum australe* and *Picrorhiza kurrooa* were collected and their *ex-situ* conservation in herbal garden has been initiated. The herbal garden is located in the premises of CSIR-Centre of High Altitude Biology, Ribling, Lahaul and Spiti at an altitude of 3400 masl.

A germplasm resource centre for sea buckthorn (Hippophae spp.) has also been set up at CSIR-Centre of High Altitude Biology. It presently has 300 plants of different genotypes from Leh-Ladakh, Himachal Pradesh and as far as Russia.

Recognising the water limitations in the area, an indigenous snow water harvesting technology has been developed. Further, underground green houses have also been developed at CSIR-Centre of High Altitude Biology.

Natural Product Chemistry and Process Development

Phytochemical investigation of Himalayan bioresources for novel molecules, semi-synthesis for value addition and up-scaling of lab scale developed process.

Bikram Singh, Chief Scientist
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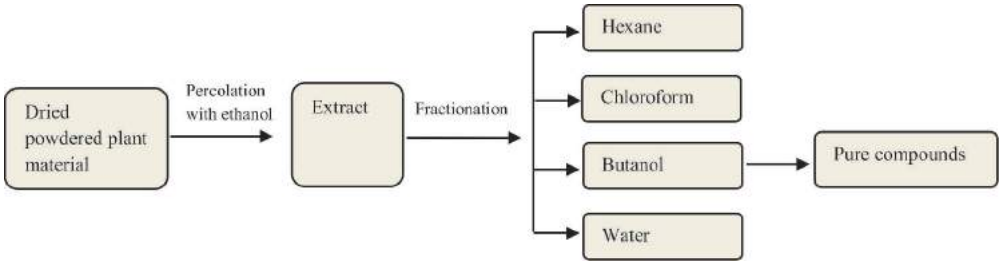
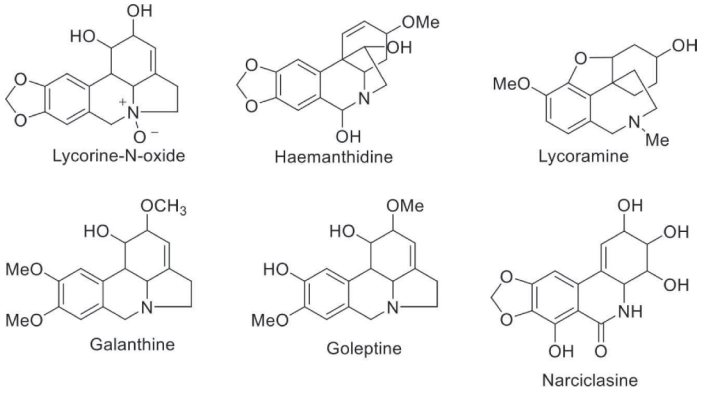
Research area: Natural products chemistry, synthetic modification & methodology development

Prospecting Himalayan flora for potential novel molecules: The research interest includes chemical prospection and profiling, development and scale up process for important molecules, synthesis of natural as well as natural like molecules from medicinal and aromatic plants of Himalayan region. We place a special emphasis on characterization of novel molecules from traditionally important plants growing in Himalayan region. This year we have investigated many medicinal and aromatic plants growing in western Himalayan region viz. *Zephyranthes grandiflora, Narcissus tazetta, Crinum latifolium, Tinospora cordifolia* and few conifers species.

Zephyranthes grandiflora*, *Narcissus tazetta and ***Crinum latifolium*** are traditionally known for ear and chest ailments, tumors. The ethanolic extract of bulbs and leaves of these plants were prepared and subjected to fractionation. Eleven pure compounds from *Zephyranthes grandiflora*, nine compounds from *Narcissus tazetta* and five compounds have been isolated from *Crinum latifolium.* The extracts, fractions and pure compounds from *Zephyranthes grandiflora* and *Narcissus tazetta* were also evaluated for *in-vitro* anticancer activity.



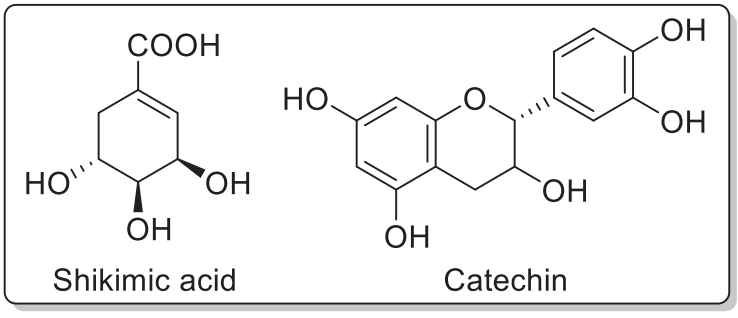
Along with spectral analysis, the UPLC method development for quantification of seven standards in *Narcissus tazetta*



has also been developed.

Structures of some isolated alkaloids from these plants are shown below.

Quantification of conifers from different region of Himalayas: Four conifers *Abies pindrow*, *Cedrus deodara, Picea smithiana* and *Pinus walichiana* from four different locations of different altitude in Himachal Pradesh were screened for presence of shikimic acid. *C. deodara* (2000 m) shows highest percentage of shikimic acid (4.8%).



Hydrodistillated oil from conifers *Abies pindrow*, *Picea smithiana, Cedrus deodara* from three different locations Chamba, Manali, Dharamshala was analysed. Further isolation from MeOH: H_2O (80: 20) extract of needles of *P. smithiana* led to isolation of a pure catechin.

Tinospora cordifolia (Menispermaceae) is widely used in the Indian system of medicine for the treatment of various diseases. Plant material extracted with hot water. After removal of solvent white powder was collected. A part of plant material was extracted with ethanol: water (70:30). The extract was dried under vacuum and subjected to HP-20 resin column for purification.

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- Kumar D, Kumar R, Singh B and Ahuja PS (2015) Reproducible Reversed-Phase High-Performance Thin-Layer Chromatography-Based Quality-Control Method for the Endangered Medicinal Plant *Picrorhiza kurroa* Royle Ex Benth. *Journal of Planar Chromatography*, 28(3), 256–261.
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- Sharma R, Bala M, Verma PK and Singh B (2015) Water mediated synthesis of Benzozole and Thiourea motifs by reacting naturally occurring isothiocyanate with amides. *Synthetic Communications,* 45 (18) 2106-2114.

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Research area: Process design and development in the field of natural products, supercritical CO_2 extraction

Volatile composition of *Lavandula angustifolia* produced by different extraction techniques: The quantitative and qualitative characteristics of volatile fractions from lavender flowers (*Lavandula angustifolia*) produced by different extraction techniques was studied. Water distillation (WD) produced highest product yields (1.2%) followed by water-steam distillation (WSD) (1.12%), solvent extraction (SE) (0.8%) and supercritical CO_2 extraction (SCE) (0.5%). Linalyl acetate, the most important and major ester that determines the quality of lavender aroma, was recorded to be in higher amount in the volatile fraction produced by SCE (51.8%) followed by SE and WSD (31.4%, in each) and WD (26.8%) (Fig. 1-4). On contrary, linalool was found to be highest in the volatile fraction produced by WD (30.9%) followed by SCE (23%), WSD (20.5%) and SE (17.3%). Coumarin and 7-methoxycoumarin, the undesired chemical constituents in the lavender aroma were present in substantial amounts in SE (20.5% and 11.2%, respectively), but were absent in the hydro-distilled oils. Studies on sequential evolution of chemical constituents during WSD and the comparative distillation kinetics (Fig. 5) revealed that the distillation process should be continued up to 2 hours to obtain optimum oil yields with better quality. The foregoing studies disclosed that the SCE produced better quality extracts compared to other conventional techniques that may find potential applications in food and pharmaceutical products.

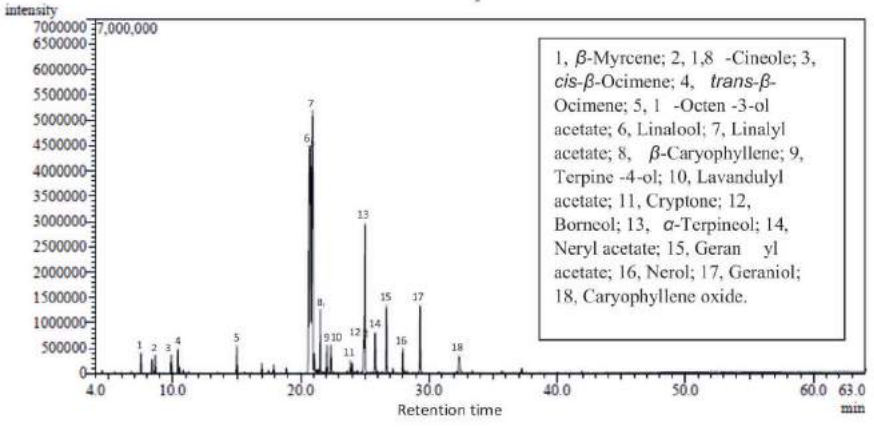

Fig. 1 Gas chromatogram of essential oil isolated from Lavender (*Lavandula angustifolia*) by water distillation (WD) technique.

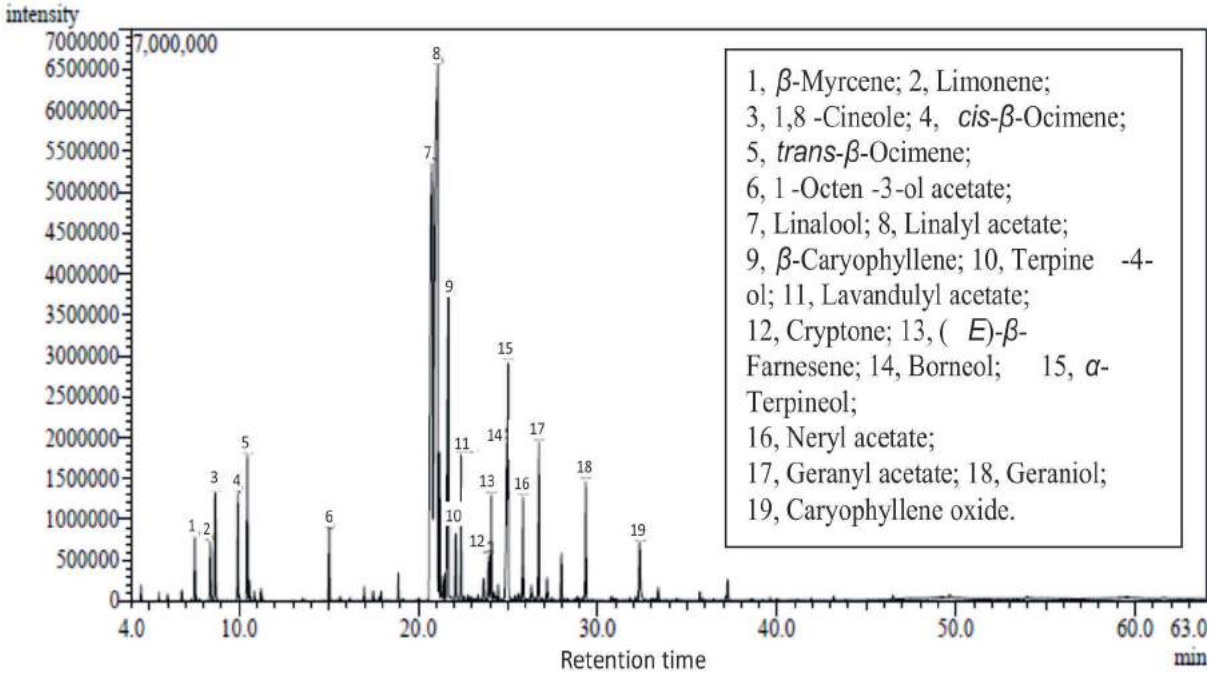

Fig. 2 Gas chromatogram of consolidated Lavender oil produced from *Lavandula angustifolia* by water-steam distillation (WSD) technique.

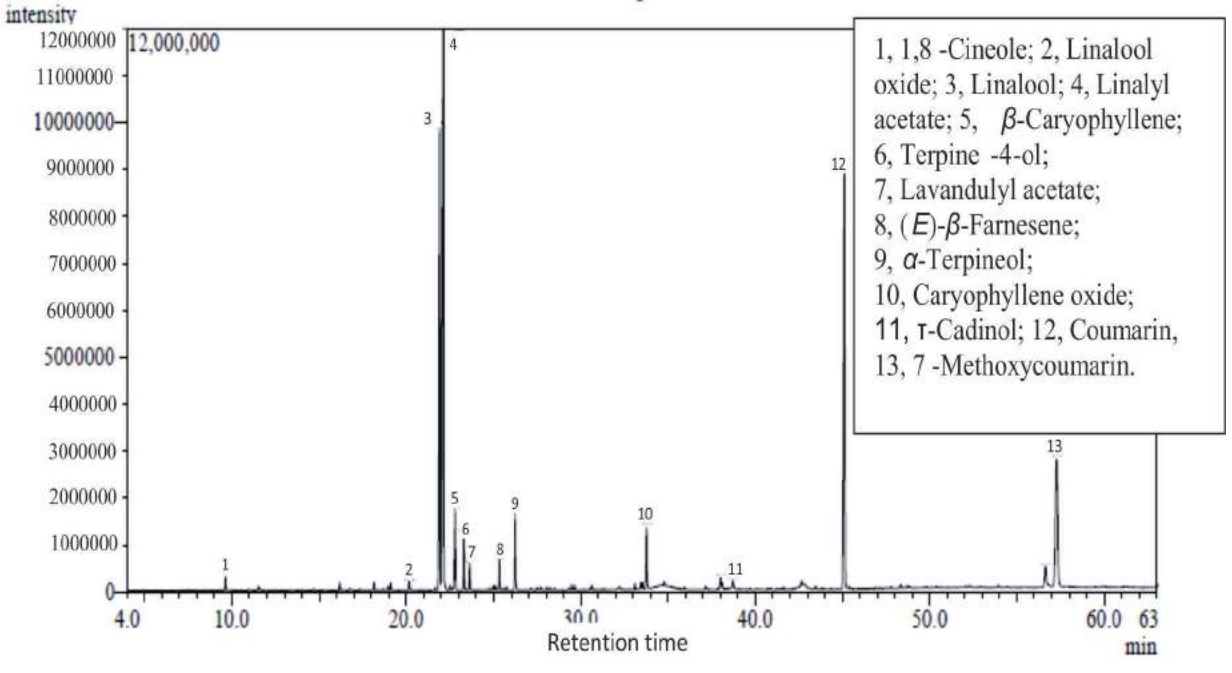

Fig. 3 Gas chromatogram of Lavender absolute produced from *Lavandula angustifolia* by solvent extraction (SE) technique.

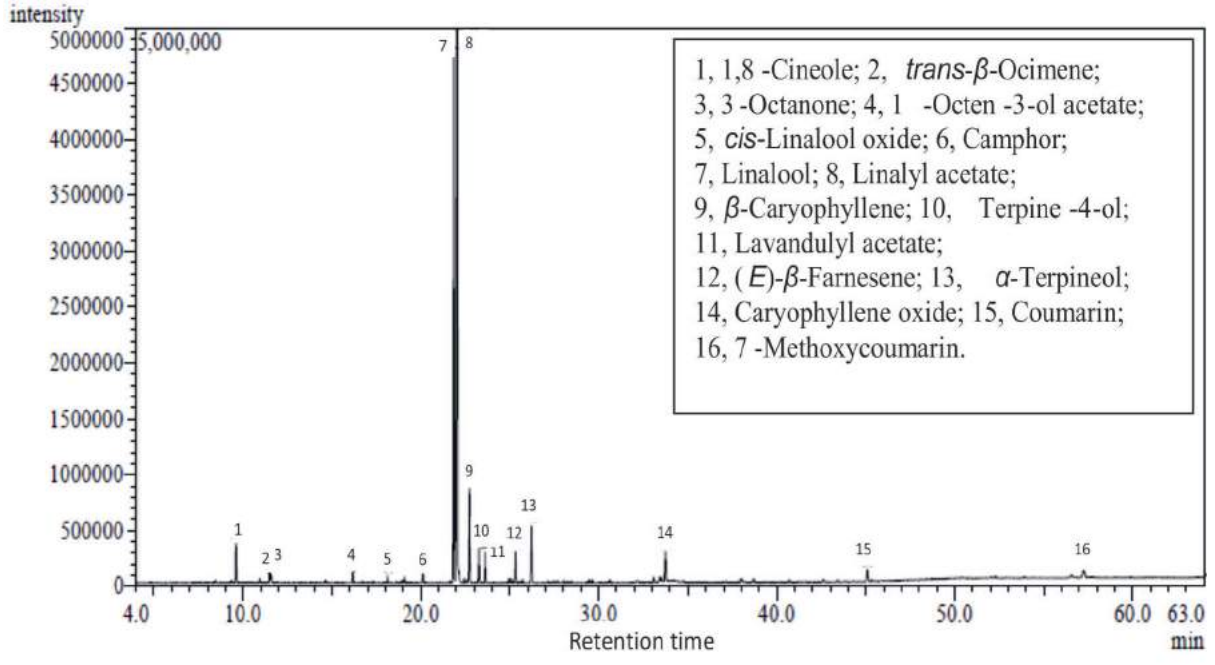

Fig. 4 Gas chromatogram of Lavender aroma produced from *Lavandula angustifolia* by supercritical CO_2 extraction (SCE) technique.

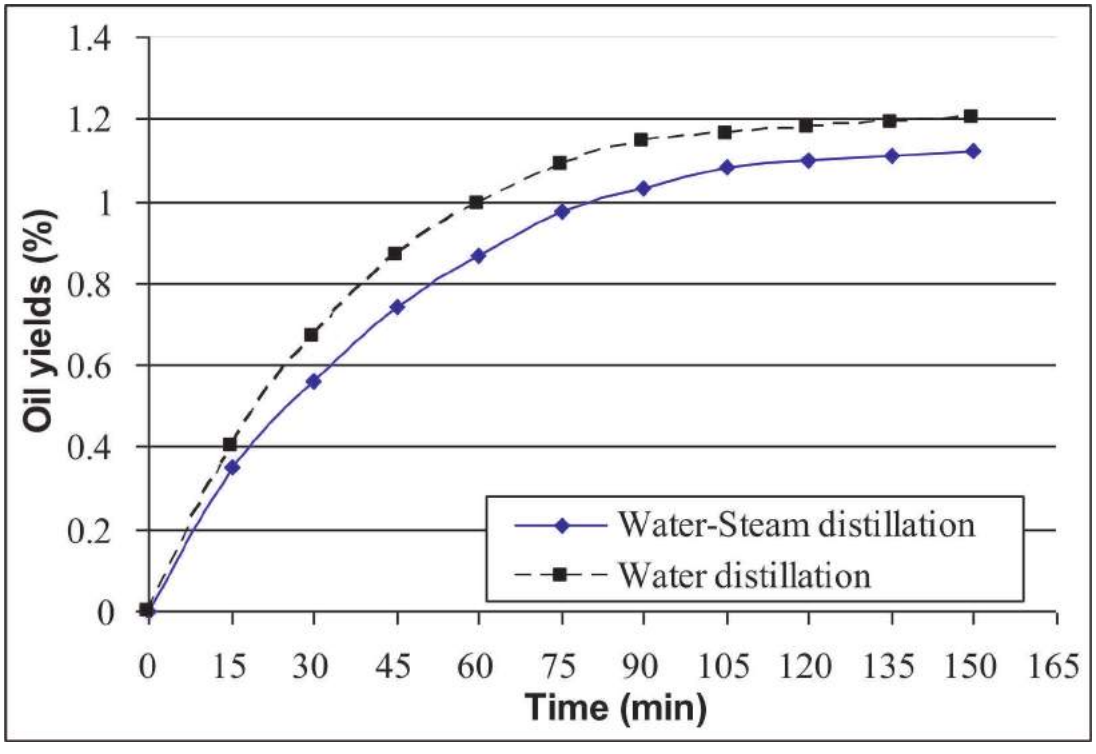

Fig. 5 Comparison of kinetics of lavender oil produced by water distillation (WD) and water-steam distillation (WSD)

Chemical Composition and *in vitro* Cytotoxicity of Essential Oils from Leaves and Flowers of *Callistemon citrinus* from Western Himalayas: Hydrodistillation of *Callistemon citrinus* leaves produced higher oil yields (0.54%) than the flowering tops (0.12%) (Table 1). The GC and GC-MS analysis of essential oils produced from the leaves and flowers of *C. citrinus* revealed that the leaf oil contained high content of α-pinene (32.3%), limonene (13.1%) and α-terpineol (14.6%); whereas the flower oil was dominated by 1,8-cineole (36.6%) followed by α-pinene (29.7%). In general, the leaf oil possessed higher concentration of monoterpene hydrocarbons (52.1%) and sesquiterpenoids (15.9%) than the flower oil (44.5% and 1.2%, respectively). On contrary, the flower oil was predominate in oxygenated monoterpenes (43.5%). Although both leaf and flower oils showed highest cytotoxicity on A549 cells (61.4%±5.0 and 66.7%±2.2, respectively), only 100 µg/mL of flower oil was significantly active against C-6 cells (69.1%±3.1). Interestingly, no toxicity was recorded on normal cells. Higher concentration of 1,8-cineole and/or synergistic effect of the overall composition were probably responsible for the efficacy of flower and leaf oils against the tested cells. These oils may form potential source of natural anti-cancer compounds and play important role in human health.

Publications:

- Kumar D, Sukapaka M, Babu GDK and Padwad Y (2015) Chemical Composition and i*n vitro c*ytotoxicity of essential oils from leaves and flowers of *Callistemon citrinus* from western Himalayas. *PLoS One*, 10(8): e0133823. doi:10.1371/ journal.pone.0133823.
- Babu GDK, Thakur V and Singh B (2016) Variability in the composition of *Lavandula angustifolia* extracts due to extraction methods. *Journal of Herbs Spices and Medicinal Plants,* 22(2): 173-182.
- Babu GDK, Sharma A and Singh B (2016) Volatile composition of *Lavandula angustifolia* produced by different extraction techniques. *Journal of Essential Oil Research* (http://dx.doi.org/10.1080/10412905.2016.1162210).

Patents:

- Shashi Bhushan, Sakshi Gupta, Garikapati Dyva Kiran Babu, Mohit Sharma, Paramvir Singh Ahuja. Method and apparatus for the separation of seeds from fruit pulp/slurry/pomace, US Patent No. 9,011,942 B2, dt. 21/04/2015.
- Agnihotri Vijai Kant, Bikram Singh, Garikapati Dyva Kiran Babu, Gopi Chand, Rakesh Deosharan Singh, Paramvir Singh Ahuja. Process for the modification of *Curcuma aromatica* essential oil. US Patent No. 9,068,141 B2 dt. 30/06/2015

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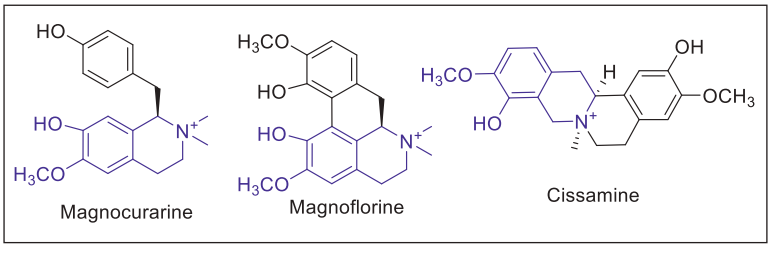
Research Area: Synthetic organic & medicinal chemistry, chemical biology

The driving force for drug discovery is to find molecules that will be effective and tolerated by human body. To find such molecules; systematic exploration of the biologically relevant chemical space is required. Natural products (NPs) have proven track record of being successful drugs however, availability of natural products and other factors make it limiting to develop them as drugs. Furthermore, natural resource may not be available for longer duration therefore; novel synthetic methodologies for the efficient synthesis to produce molecules with significant hit rate are challenging yet essential.

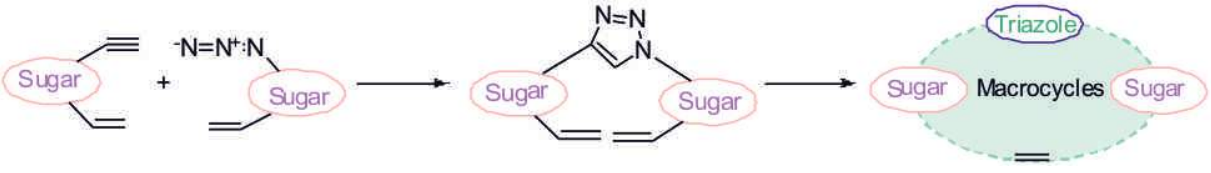
Natural product synthesis and medicinal chemistry: *Tinospora cordifolia* and *Cissampelos pareira are* medicinal plants used as traditional medicine in India for the treatment of various ailments. Extensive and systematic studies on these plants are attributed to tremendous therapeutic potential of these plants in traditional medicine which have led to isolation of protoberberine and several other aporphine alkaloids. For example, magnoflorine, magnocurarine and palmatine have been isolated, have shown tremendous activities of therapeutic interest including anti-cancer, immunomodulator and inflammation. For the generation of most potent molecules; synthesis and extensive SAR studies for these natural products and their analogues is required. Accordingly, we are developing novel synthetic methodologies for the synthesis of these therapeutically important bioactive molecules and their analogs.



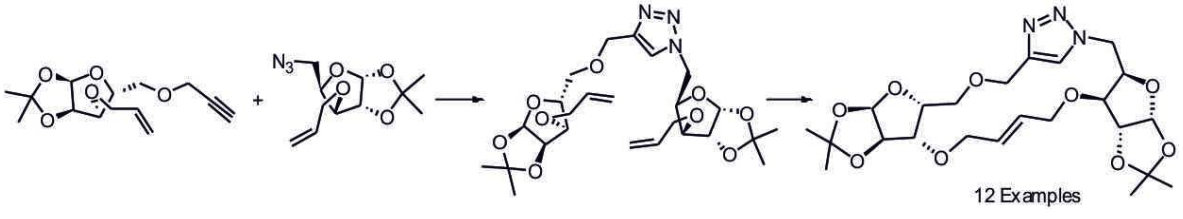
Diversity Oriented Synthesis and Chemical Biology: In order to exploit the advantages of the

small molecule probes to understand unique insights in cell biology small molecules need to be diverse, selective in binding and economical. Nature makes an amazing display of structural diversity in its secondary metabolites and often they are structurally complex. Complex structures are likely to interact with macromolecules (proteins) more selectively than flat and simple molecules. The approach can clarify the role(s) of specific proteins in disease, whilst, in addition, providing a lead molecule for therapeutic intervention strategies.

Our group is involved in the development of synthetic approach for the preparation of polycycles, macrocyles and natural-product like small molecules with multiple scaffolds and stereogenic centres, and huge potential for substitutional variation. In our group we are synthesizing novel macrocyclic small molecules using build/couple/pair approach.



Various building blocks were synthesized utilizing carbohydrates which were assembled via triazole using click reactions (coupled phase). Further various cycloadduct were paired via RCM reaction to furnish macrocyclic compounds.



Build/Couple/Pair (BCP) approach for the synthesis of macrocycles

Late Dr. Neeraj Kumar

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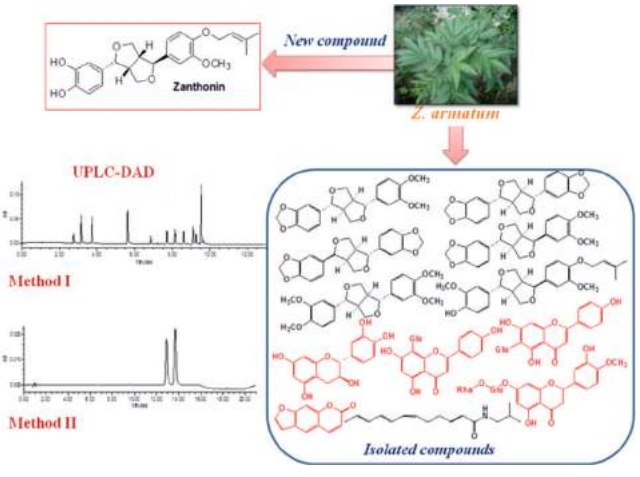
Research area: Natural products and Bio-organic chemistry

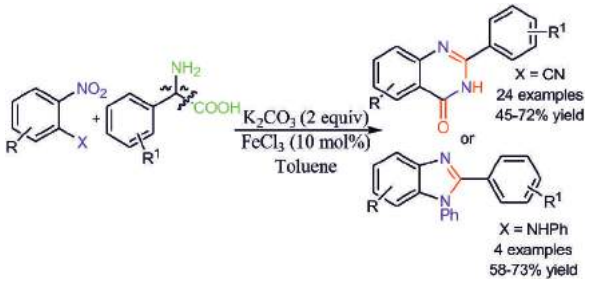
Bioprospection of Himalayan flora, new methodology development with focus on Lewis acids and organocatalysis

Bioprospection of Western Himalayan flora: Himalayan region with varied topological characteristics provide richest reservoirs of biological diversity that host variety of medicinal plants and offer great opportunity to have novel bioactive molecules. The bioprospection of different medicinal plants viz, *P. veticellatum, H. rhamnoides,* Z. *armatum and A. vasica* from Western Himalayan region was done. A new compound zanthonin along with thirteen known compounds including, flavonoids, furofuran lignan, amides, alkaloid and coumarin have been isolated and characterized from *Z. armatum*. The chemical profiling and simultaneous quantification of biologically important flavonoids, furofuran lignans, coumarin and amides in *Z. armatum* by UPLC-DAD-ESI-QTOF–MS/MS was also done. Significant variation based on five chemotypes representing *β*-phellandrene/2-undecanone; linalool/2-undecanone; linalool; 2-undecanone; 2-undecanone /1,8-cineol in the different population of Himachal Pradesh.



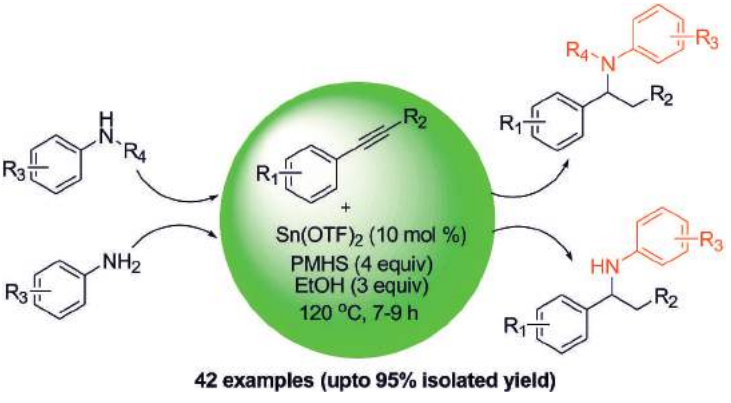
Lewis acid catalyzed C-N bond formation:

1. Iron(III) chloride-catalyzed decarboxylative–deaminative functionalization of phenylglycine: a tandem synthesis of quinazolinones and benzimidazoles: The first iron(III) chloride-catalyzed decarboxylative–deaminative functionalization of phenylglycine with *o*-substituted nitroarenes was achieved for the synthesis of 4(3*H*)-quinazolinones and benzimidazoles. The reaction of 2-nitrobenzonitrile/2-nitro-*N,N*-diphenylamine with phenylglycine at 120 °C in the presence of potassium carbonate as a base in toluene generated the products with 45–87% yields. In this tandem approach, involvement of transfer hydrogenation of the nitro functionality with *in situ* generated ammonia,

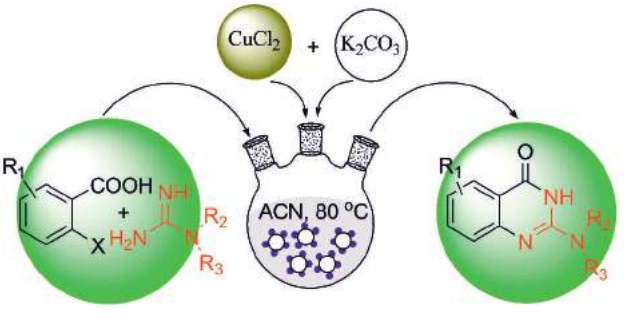


imination, nitrile hydration to amide and oxidative cyclization sequences have been established. The process avoids the use of an external hydrogen source, costly catalysts as well as the isolation of amine and amide intermediates.

2. Tin-catalyzed selective reductive hydroamination of alkynes for the synthesis of tertiary amines: A unique preference of tin(II) for aniline activation is disclosed. The mechanistic study revealed the involvement of two steps in one pot wherein alkyne reduces to corresponding alkene in presence of PMHS as reducing agent followed by hydroamination of alkene. A broad range of alkynes transformed into tertiary amines with good to excellent yield. This method is equally applicable in synthesis of secondary amines



3. **Rapid and efficient cascade synthesis of 2-amino-4(3 *H*)-quinazolinones over an *In Situ*-generated heterogeneous $CuCO_3$–K_2CO_3 Nanocomposite:** A green, recyclable, *in situ* generated, heterogeneous $CuCO_3$–K_2CO_3 nanocomposite-catalysed cascade reaction between 2-halobenzoic acids and guanidines is described for the synthesis of 2-amino-4(3*H*)-quinazolinones. The reaction is rapid and proceeds efficiently in air without the addition of a ligand or additive. This protocol is equally applicable to amidines for the synthesis of 2-alkyl- and 2-phenyl-4(3*H*)-quinazolinones.



Publications:

- Nayal OS, Thakur MS, Kumar M, Sharma S and Kumar N (2016) Tin-catalyzed selective reductive hydroamination of alkynes for the synthesis of tertiary amines. *Advanced Synthesis & Catalysis*, 358 (7): 1103–1109.
- Thakur MS, Nayal OS, Bhatt V, Sharma S and Kumar N (2016) Rapid and efficient cascade synthesis of 2-amino-4(3 *H*)-quinazolinones over an in situ-generated heterogeneous $CuCO_3$–K_2CO_3 nanocomposite. *Asian Journal of Organic Chemistry*.doi: 10.1002/ajoc.201600113.
- Kumar M, Richa, Sharma S, Bhatt V and Kumar N (2015) Iron(III) chloride-catalyzed decarboxylative–deaminative functionalization of phenylglycine: A tandem synthesis of quinazolinones and benzimidazoles. *Advanced Synthesis & Catalysis*, 357 (13): 2862–2868.

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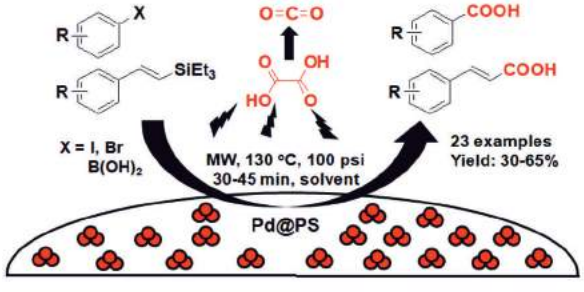
Research area: Supported nano-catalyst and organic synthesis

Research on supported nanoparticles as a catalyst and total synthesis of bioactive molecules

Carboxylation reaction using oxalic acid as C_1 source: Polystyrene-supported palladium(0) (Pd@PS) nanoparticles as a heterogeneous catalyst have been developed for caboxylation of aryl halides, alkenylsilanes, and organoboronic acids to produce the corresponding carboxylic acids with minor quantities of corresponding aldehydes using bench-stable and inexpensive oxalic acid as the C_1 source under focused microwave irradiation. The close vicinity of oxalic acid to Pd@PS maintained through ionic bonding helped to produce CO_2 over the catalytic surface that concurrently participated in the carboxylation reaction (Scheme 1 & Fig. 1).



Scheme 1 Carboxylation reaction using oxalic acid as C_1 source

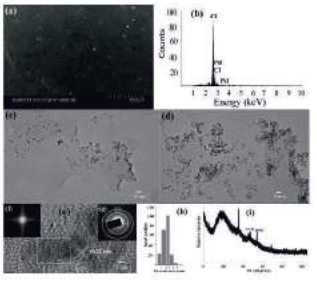
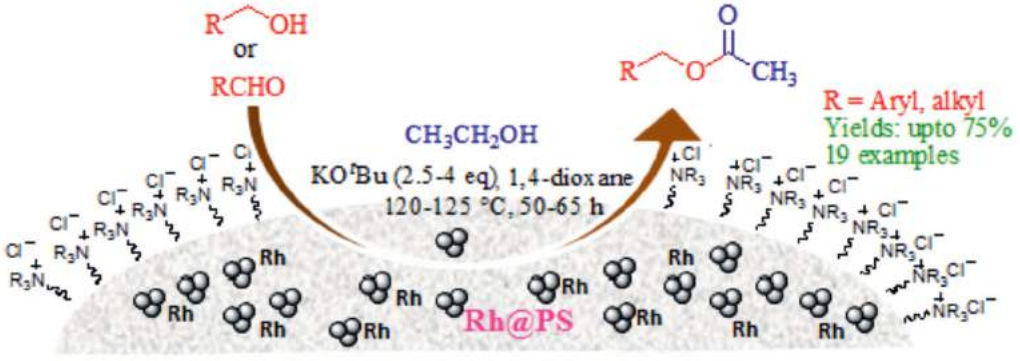


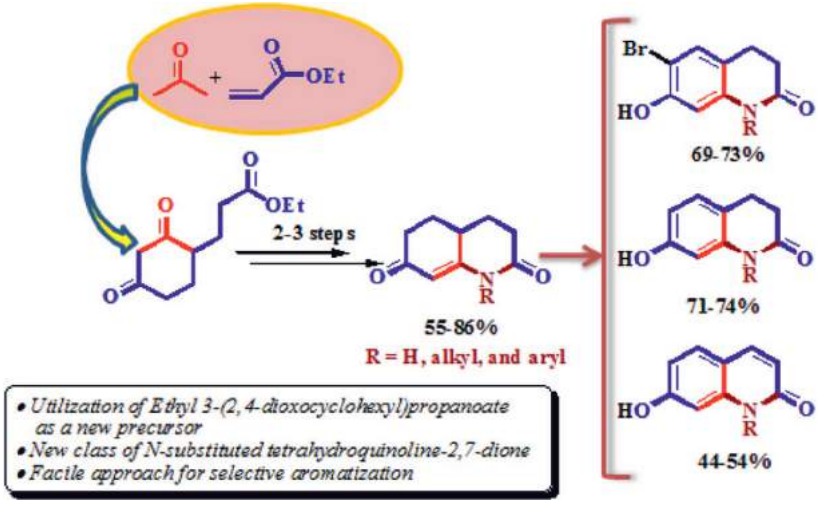
Fig. 1 Characterization of Pd@PS by SEM, EDS, TEM, HRTEM, FFT, particle size and XRD

Oxidative esterification reaction of alcohols: A very unusual role of polystyrene stabilized rhodium (Rh@PS) nanoparticles as a supported catalyst is described for "reverse-esterification" of ethanol with benzyl/alkyl alcohols or aldehydes. Faster and selective oxidation of ethanol to acetaldehyde and H_2 under Rh@PS catalyzed conditions which restricted further oxidation of benzyl/alkyl alcohols and their *in situ* reaction gave the corresponding acetate esters following the dehydrogenative coupling approach. A hitherto redox dehydrogenative-coupling of ethanol and aldehydes has also been explored for the same acetate ester synthesis under Rh@PS catalyzed conditions (Scheme 2).



Scheme 2 Oxidative esterification reaction of alcohols

Tetra- and dihydro-hydroquinolinone synthesis: Ethyl 3-(2,4-dioxocyclohexyl)propanoate has been explored as a precursor for the synthesis of N-substituted 4,4a,5,6-tetrahydroquinoline-2,7(1*H*,3*H*)-diones following conventional protection, selective amidation, and deprotective-cyclization approaches. Moreover, a facile process for the selective dehydrogenative aromatization of these diones was developed to afford the corresponding *N*-substituted-3,4-dihydro-7-hydroxyquinolin- 2(1*H*)-ones and N-substituted 7-hydroxyquinolin-2(1*H*)-ones under mild conditions (Scheme 3).



Scheme 3 Total synthesis of tetra- and dihydro-hydroquinolinone

Publications:

- Shil AK, Kumar S, Reddy CB, Dadhwal S, Thakur V, Das P (2016) Supported Palladium Nanoparticle-Catalyzed Carboxylation of Aryl Halides, Alkenylsilanes, and Organoboronic Acids Employing Oxalic Acid as the C_1 Source. *Synfacts* 12(2): 0217.

- Shil AK, Kumar S, Reddy CB, Dadhwal S, Thakur V, Das P (2015) Supported Palladium Nanoparticle-Catalyzed Carboxylation of Aryl Halides, Alkenylsilanes, and Organoboronic Acids Employing Oxalic Acid as the C_1 Source. *Organic Letters,* 17 (21): 5352–55.
- Thakur V, Sharma D and Das P (2016) Ethyl 3-(2,4-dioxocyclohexyl)propanoate as a novel precursor for *N*-substituted 4,4a,5,6-tetrahydroquinoline-2,7(1*H*,3*H*)-diones and their corresponding 3,4-dihydro-7-hydroxyquinolin-2(1*H*)-ones and 7-hydroxyquinolin-2(1*H*)-ones synthesis. *Molecular Diversity*, 20: 29–40.
- Guha NR, Sharma S, Bhattacherjee D, Thakur V, Bharti R, Reddy CB and Das P (2015) Oxidative "reverse-esterification" of ethanol with benzyl/alkyl alcohols or aldehydes catalyzed by supported rhodium nanoparticles. *Green Chemistry*, 18: 1206-1211.

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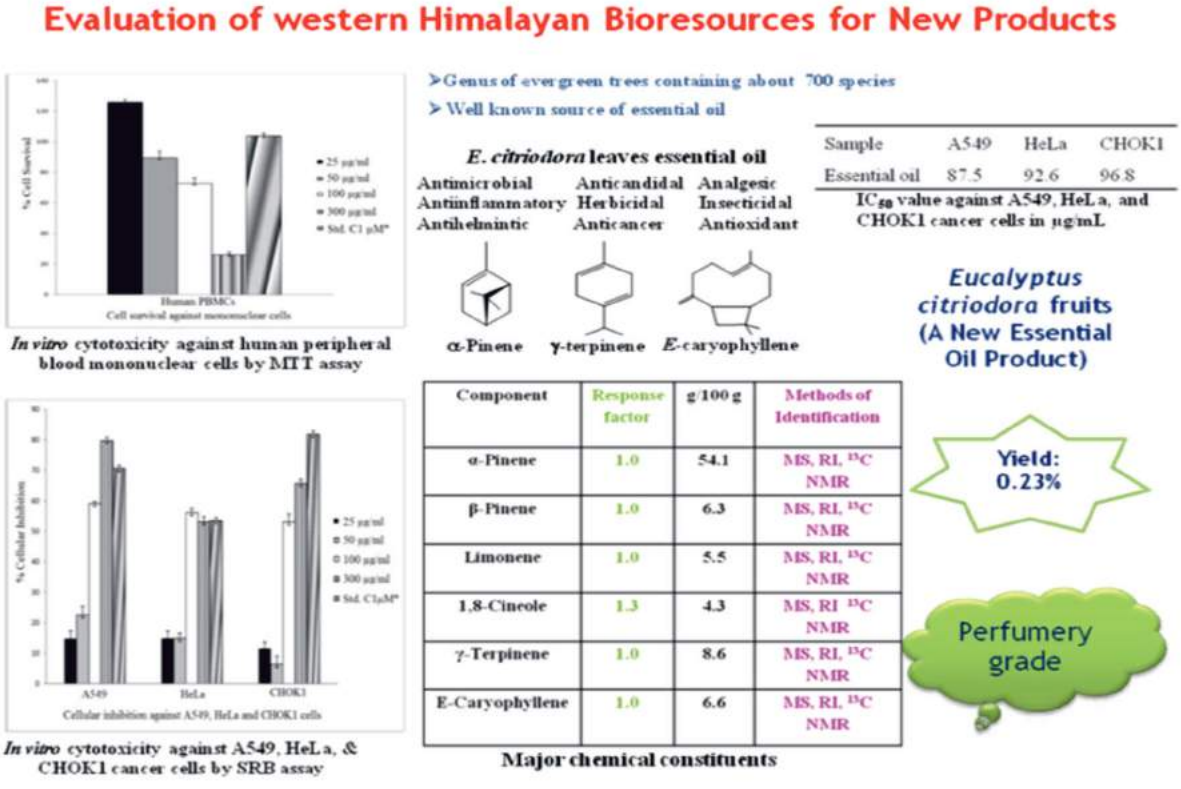
Research area: Natural products and essential oils bioprospection

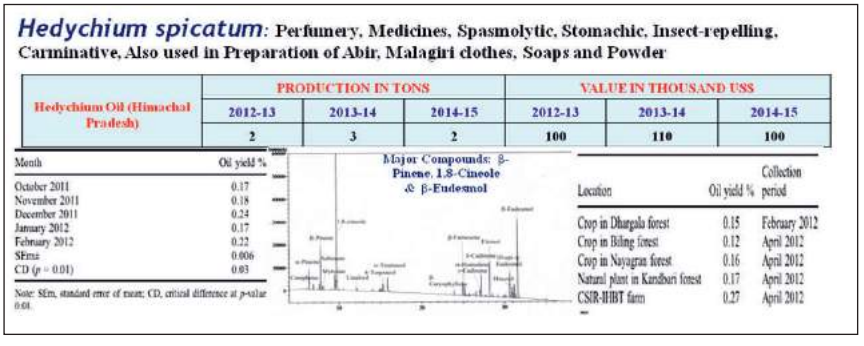
Study of Himalayan bioresources for standardization and utilization: During the present year, a new skeleton (14*R*, 17*S*, 20*R*-lupan-3-one) from *Commiphora wightii* was isolated. In edition, apple leaves were found as a promising source of an important secondary metabolite i.e. phloridzin.

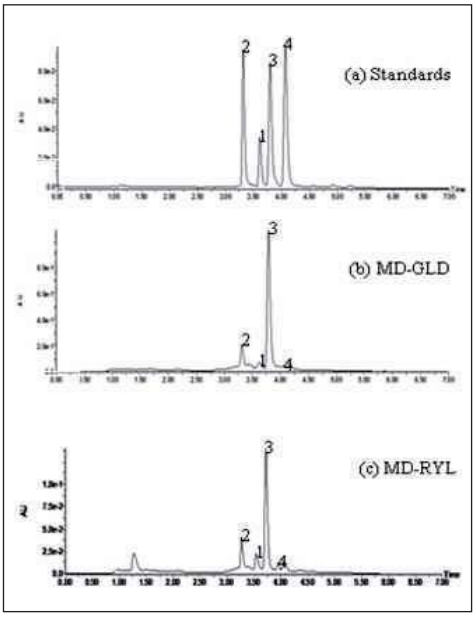
***Eucalyptus citriodora*:** Essential oil was extracted from the fruits of *E. citriodora* by hydrodistillation method in clevenger type apparatus (yield 0.23%). Essential oil was found to be a complex mixture of mono- and sesqui-terpenoids. The major chemical constituents identified were α-pinene (54.1 g/100 g), γ-terpinene (8.6 g/100 g), *E*-caryophyllene (6.6 g/100 g), β-pinene (6.3 g/100 g), limonene (5.5 g/100 g) and 1,8-cineole (4.3 g/100 g). *In vitro* cytotoxicity analysis revealed IC_{50} value of the essential oil between 87.5 to 96.8 μg/mL against A549, HeLa and CHOK1 cells. The toxicity of isolated essential oil was also assessed against human lymphocytes by *MTT assay.*



***Crocus sativus* Linn.:** This is a perennial bulbous herb and valued for its yellow-orange coloured tripartite stigmas that constitute the spice saffron. The reported life zone of *Crocus* in the world extends through latitude 30-45˚ N and longitude 0˚ to 90˚ E at temperature ranging from 4 to 23˚ Celsius at an annual precipitation of 0.1 to 1.1 meter and a soil pH of 5.8 to 7.8. The crop grows best in well-drained soils of medium fertility. Principally saffron is grown in Spain, India, Turkey, Greece, Austria, Belgium, France, Germany, Holland, Hungary, Italy, Japan, Norway, Russia, Switzerland, Turkey, Persia and the People's Republic of China. *Crocus sativus* L. is famous for its diversified pharmacological activities. Hence, species was extensively studied with the view of its pharmacological importance.

***Hedychium spicatum*:** The essential oil of *Hedychium spicatum* rhizome is used in perfumery and medicines. For studying seasonal variation of its volatiles composition, the rhizomes of *H. spicatum were* collected from CSIR-IHBT, Palampur, Himachal Pradesh, India. To study the spatial diversity in essential oil content and composition, the rhizomes were collected from five different locations of Himachal Pradesh. Essential oils were evaluated for their chemical composition by GC and GC/MS analyses. Twenty-two compounds were identified from the rhizome oil with major components as 1,8-cineole, *β*-eudesmol, *β*-pinene and 10-*epi*-*γ*-eudesmol. The essential oil extracted from the rhizomes collected from Biling had highest antioxidant activity.





***Juniperus communis*:** Essential oil from *Juniperus communis* needles were examined in three different seasons (spring, rainy and winter) throughout the year for the analysis of yield and chemical composition. The essential oil yield in all the seasons was not significantly changed and was found 0.29% (rainy), 0.3 (winter) and 0.33% (spring). The major class of compounds identified in essential oil was monoterpene hydrocarbons (51.9-63.7%) with sabinene (30.1-37.1%) as the major constituent. In present experiment, winter was found to be most suitable time for the isolation of sabinene and limonene.

***Malus domestica*:** Apple leaves are less explored source of phenolic compounds. A simple, rapid and sensitive UPLC-DAD quantification method was developed for quantification of phenolics. Four compounds namely, rutin (1), 3-hydroxyphloridzin (2), phloridzin (3) and quercetin-3-*O*-arabinoside (4) were identified by UPLC in golden (MD-GLD) and royal (MD-RYL) apple leaves . The separation was achieved in less than 7 min. This study showed that apple leaves of both varieties contain considerable amount of polyphenols, flavonoids and also phloridzin.

Publications:

- Agnihotri VK (2015) *Crocus sativus* Linn.: an informative eview. *Aperito Journal of Advanced Plant Biology*, 1:1, 29.
- Koundal R, Rawat K, Agnihotri VK, Meena RL, Gopichand, Singh RD and Padwad YS (2015) Temporal and spatial variation in quality of essential oil of *Hedychium spicatum* and evaluation of its antioxidant activity. *Journal of Essential Oil Research, 27(3): 217-224.*
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- Abiodun OO, Sood S, Osiyemi OA, Agnihotri VK, Gulati A, Ajaiyeoba EO and Singh B (2015) In vitro antimicrobial activity of crude ethanol extracts and fractions of *Terminalia catappa* and *Vitex doniana*. *African Journal of Medicine and Medical Sciences*, 44(1): 21-26.
- Koundal R, Kumar D, Walia M, Kumar A, Thakur S, Gopichand, Padwad YS and Agnihotri VK (2016) Chemical and in vitro cytotoxicity evaluation of essential oil from *Eucalyptus citriodora* fruits growing in Northwestern Himalaya (India). *Flavour and Fragrance Journal*, 31: 158-162.
- Kumar R, Sharma S, Kaundal M, Sood S and Agnihotri VK (2016) *Variation* in essential oil content and composition of damask rose (*Rosa damascena* Mill) flowers by salt application under mid hills of western Himalayas. *Journal of Essential Oil Bearing Plants*, 19(2): 297-306.
- Mayanka W, Shiv K, Agnihotri VK (2016) UPLC-PDA quantification of chemical constituents of two different varieties (golden and royal) of apple leaves and their antioxidant activity. *Journal of the Science of Food and Agriculture*, 96: 1440-1450.
- Kamal Kant, Vijai Kant Agnihotri, Manik Ghosh, 2015. Antioxidant Guided Chemical Investigations of *Picrorhiza kurroa.* LAP LAMBERT Academic Publishing (OmniScriptum GmbH & Co. KG), Saarbrücken, Germany, pp. 68.

Patent(s) Granted

- US Patent No. 9068141 B2. Agnihotri, Vijai Kant, Singh, Bikram, Kiran Babu, Garikapati Dyva, Chand, Gopi, Singh, Rakesh Deosharan, Ahuja, Paramvir Singh. Process for the Modification of *Curcuma aromatica* Essential Oil. PCT application number PCT/IB2012/050962, dated 01-03-12, U.S. National application number US14/000539, Filing Date: August 20, 2013, Priority Publication date 12-12-2013, Publication No. US2013/0331467 A1, Priority date: 29.3.2011, Date of Patent 30.6.15.

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Research area: Process equipments design and process scale up for natural products.

Our group is involved in developing process know how and technology transfer of industrially important bioactive natural products including process development and scale-up of laboratory processes on pilot plant. Generally extraction processes are carried out on various medicinal and aromatic plants such as Steviol glycosides from *Stevia rebaudiana*, tea catechins from green tea shoots, rose oil from damask rose and other important aromatic crops. These extraction processes are scaled-up from gram level laboratory-scale to kilogram on pilot plant and optimization of the process to improve the yield. Major areas of research activities of the Division are: Process Development and equipment and plant design; Process Monitoring, Optimization, Membrane Technology; and evaluation of process techno economic feasibility. The pilot plant is also equipped with a wide range of pilot plant equipment and lab scale facilities for carrying out research and development for processing of medicinal and aromatic plants.

Processing of Damask rose flowers on pilot plant: About 4858.5 kg fresh Damask rose flowers were processed on pilot plant and produced 1373.9 g rose oil with an average rose oil yield of 0.028 % (w/w) during the season. Besides the production of rose oil, 1500 L rose water was also produced for sale and as well as complimentary samples.

Optimization of coagulant dose for removing colour impurities from crude Stevia extract: Studies were conducted on laboratory scale for evaluating coagulation efficiency of coagulant calcium hydroxide for removing colouring impurities from crude stevia extract at different doses viz. 4, 6 and 8% weight of dry stevia leaf with respect to different coagulation temperatures 30, 50 and 70°C. Precipitates formed were separated through filtration and precipitates were weighted. Highest coagulation efficiency in terms of precipitation of colour impurities was observed at low temperature i.e. 30°C and 8% coagulant dose as shown in Fig. 1. These same parameters will be applied on pilot scale for further validation.

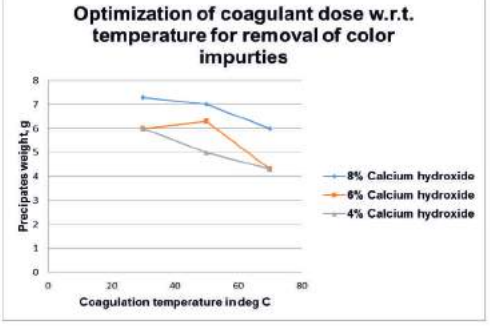

Fig. 1 Variation of precipitate weight with coagulation temperature at different coagulant dose and temperature

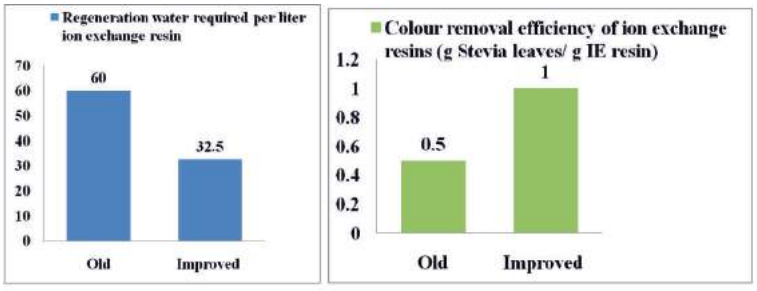

Fig. 2 Comparison of old and improved decolourization method in terms of a) Regeneration water requirement/L ion exchange resin; b) Decolourization efficiency of ion exchange resin

Production of steviol glycosides on pilot scale and optimization of water consumption: Dry leaves of *S. rebaudiana* were extracted in seven batches on pilot scale at 20kg/batch capacity to produce steviol glycoside. The yield of the final product was 8% having purity ranging from 90-96% total steviol glycosides and found devoid of pesticides. Decolourization of stevia extract is achieved by using ion exchange resin, which is a water consuming step as it requires high quantityof water for regeneration of exhausted resin to bring them back to their corresponding ionic form. Process improvement studies resulted in reduction of water requirement during regeneration of ion-exchange resins up to 54% and the doubled the uptake of impurities.

Process improvement and scale up of tea catechin production from green tea shoots: Process improvement and scale up studies were conducted on pilot scale and the process was scale up to 40 kg/batch green tea leaf processing. Demonstration of the entire process was shown to M/s Baijnath Pharmaceuticals, Paprola and the BIRAC team of DBT (Govt. of India) for project funding on technology transfer to industry (Fig. 3).

Fig. 3 Process up-scaled up to 40 kg per batch green tea leaves processing

State of the art facility at pilot plant: Pilot scale purification columns made up of stainless steel and mild steel with food grade rubber lining for purification of natural products were designed, fabricated and commissioned. These columns are useful for purification of bioactive molecules by ion exchange or adsorption process in co-current and counter-current operations on pilot scale. A Schott Duran Glass agitated reaction vessel having volumetric capacity of 50L for carrying out

corrosive chemical synthesis reactions was also designed, fabricated and installed at pilot plant (Fig. 4)

Fig. 4 Process equipment design and installation at pilot plant

Design, fabrication, installation & commissioning of multipurpose essential oil distillation unit at CeHAB, Keylong: Multipurpose essential oil distillation unit having biomass holding capacity of 200 kg per batch was successfully designed, fabricated, installed and commissioned at CeHAB, Keylong (Fig. 5). Design, fabrication, installation & commissioning trial was done on by distilling *Artemisia maritima* plant material. This unit was installed in the DST sponsored project CODER and will be used for standardizing distillation process for other important aromatic crops in the region.

Fig. 5 Multipurpose essential oil distillation unit

Dinesh Kumar, Scientist
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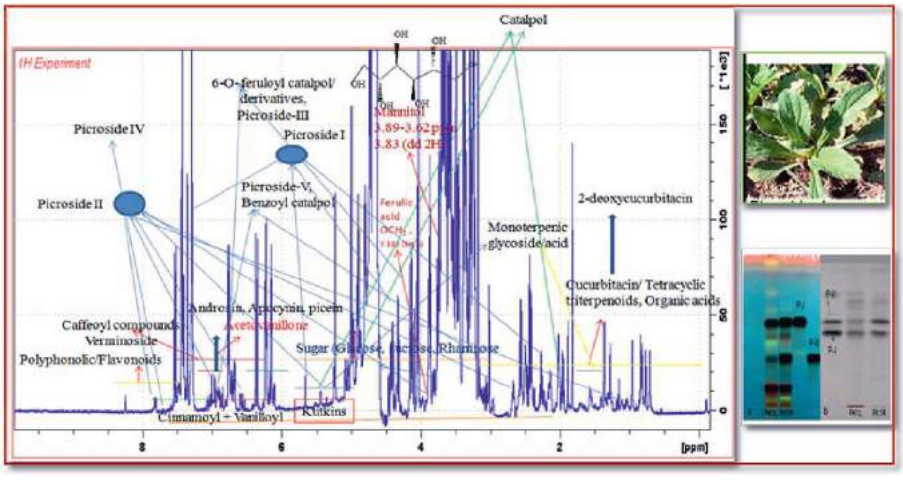
Research area: Nuclear magnetic resonance spectroscopy, metabolomics and natural product chemistry

Metabolomics and quality control of Himalayan bioresources and their derived products: From the primitive age, plants and marines have been used to cure serious complications of human health and are still very significant. Their derived products are used either as such or template in the discovery of new drugs. Several biologically active secondary metabolites have been used for their medicinal values. Hence, understanding the chemistry, metabolite composition and alterations in plant, marines and biofluids, along with quality profile and quality control are the need of hour. Our group is currently working on metabolite profiling, and quality control of some medicinally important plants of western Himalayan region using NMR, UPLC-MS/MS and HPTLC techniques. Moreover, we are also working on *Crataegus oxyacantha* to find out its mechanistic role in toxicity/safety in cardiac disorders especially myocardial tissue through lipidomics and metabolomic studies. Search for bioactive principles from bioresources is also one of the objective.

Picrorhiza kurroa: Metabolite profiling of *P. kurroa* Royle ex Benth using 600 MHz NMR, UPLC and HPTLC techniques was performed successfully. Whereas, primary and secondary metabolites were identified along with a new report of monoterpenic glycoside (1-*β-D-glucopyranosyl)-8-hydroxy-3,7-dimethyl-oct-2(E),6(E)–dienoate*).

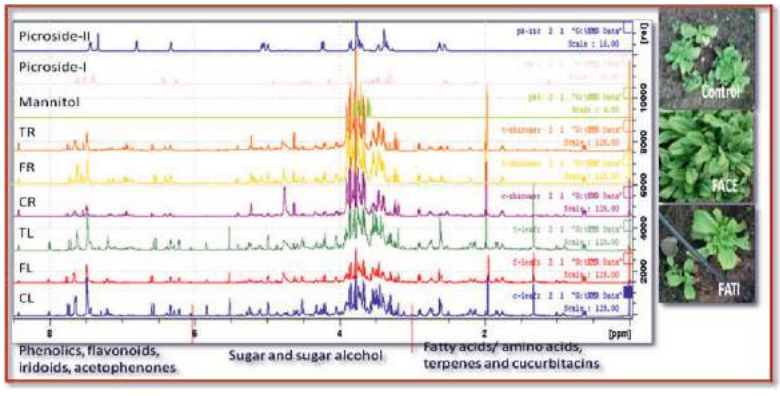


Metabolic profiling of *P. kurroa* Royle ex Benth

Significant differences were noticed between the leaves and rhizomes tissues with respect to secondary metabolites yield. Leaves contained more cucurbitacins and flavonoids, while iridoids

were present more in rhizomes.

The metabolomic study in *P. kurroa* (leaves and rhizomes) using NMR, HPTLC and UPLC techniques under control, elevated temperature and CO_2 conditions was also conducted to understand impact of changing climate. A significant difference was noticed among the qualitative as well as quantitative profile of metabolites. Similar alteration in P-I and P-II picrosides was observed irrespective of analytical technique used. Hence, change in climatic conditions (CO_2 and temperature) found to alter metabolic profile of *P. kurroa*.



Metabolomic study of P.Kurroa under control elevated temperature and CO_2 conditions using NMR, HPTLC and UPLC.

Camellia sinensis: It is used to make special tea and also getting recognized as a raw material for dietary supplements, health foods, and cosmeceuticals. Theanine (amino acid) and catechins (polyphenol) are most abundantly found in tea leaves and are responsible for taste and flavour of tea products along with therapeutic and nutritional values. An economical, rapid, and highly reproducible HPTLC method for quantification of theanine and catechin is developed and validated from quality control perspectives. Moreover, NMR based metabolomic studies were also used for the comprehensive metabolite profiling and quantitative estimation of theanine and catechin along with other important metabolites in *C. sinensis* samples (Fig. 1)

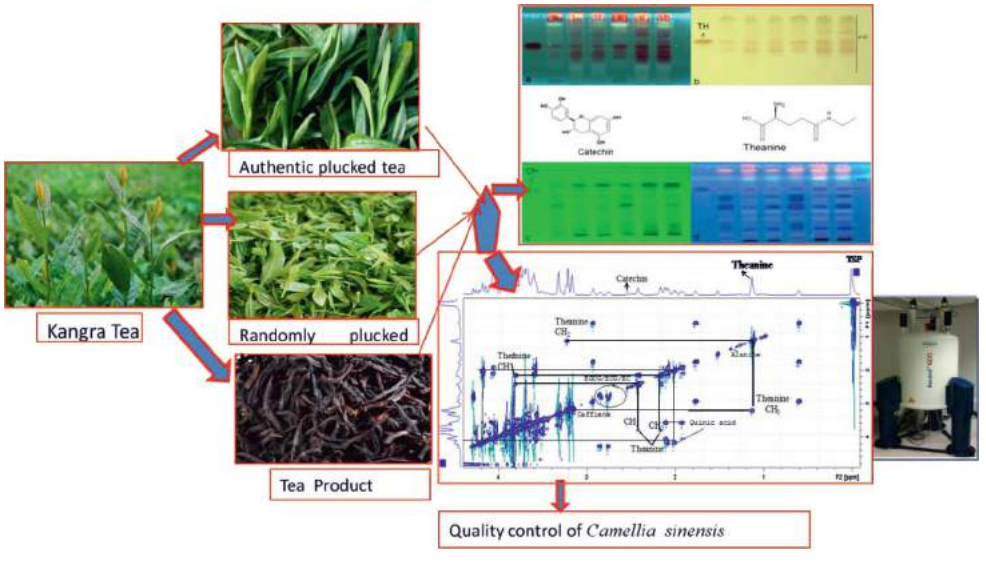


Fig. 1 HPTLC based quality control method and metabolomics of *C. sinensis* using NMR

Publications:

- Kumar D, Kumar R, Singh B and Ahuja PS (2016) Comprehensive chemical profiling of *Picrorhiza Kurroa* Royl Ex Benth. using NMR, HPTLC and LC-MS/MS techniques. *Combinatorial Chemistry & High Throughput Screening*, 19: 153-158.
- Kumar D, Gulati A and Sharma U (2016) Determination of theanine and catechin in *Camellia sinensis* (Kangra Tea) leaves by HPTLC and NMR techniques. *Food Analytical Methods,* 9: 1666-1674.
- Kumar D (2015) Application of Nuclear magnetic resonance (NMR) spectroscopy: Promising analytical technique. Critical review in analytical chemistry.
- Kumar D, Kumar R, Singh B and Ahuja PS (2015) Reproducible RP-HPTLC based quality control method for endangered medicinal plant *Picrorhiza kurrooa* Royle Ex Benth. *Journal of Planar Chromatography*, 28(3): 256–261.

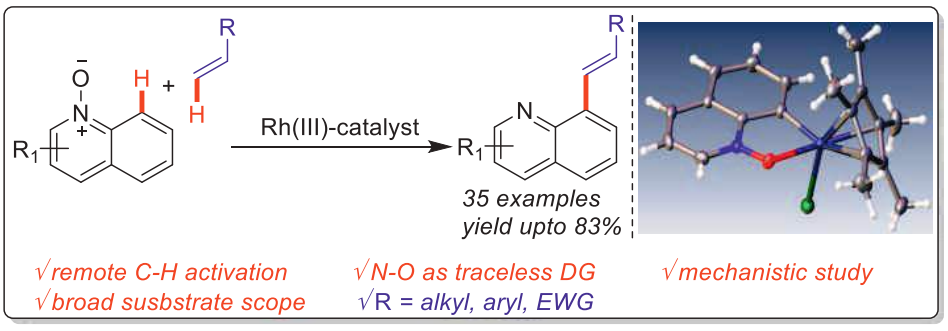
Upendra Sharma, Scientist

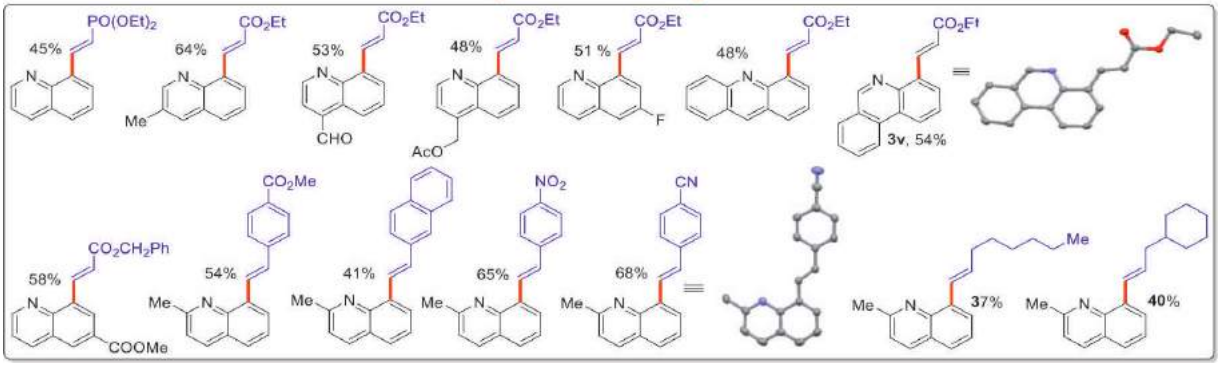
upendra@ihbt.res.in

Research Area: C-H Activation and phytochemistry

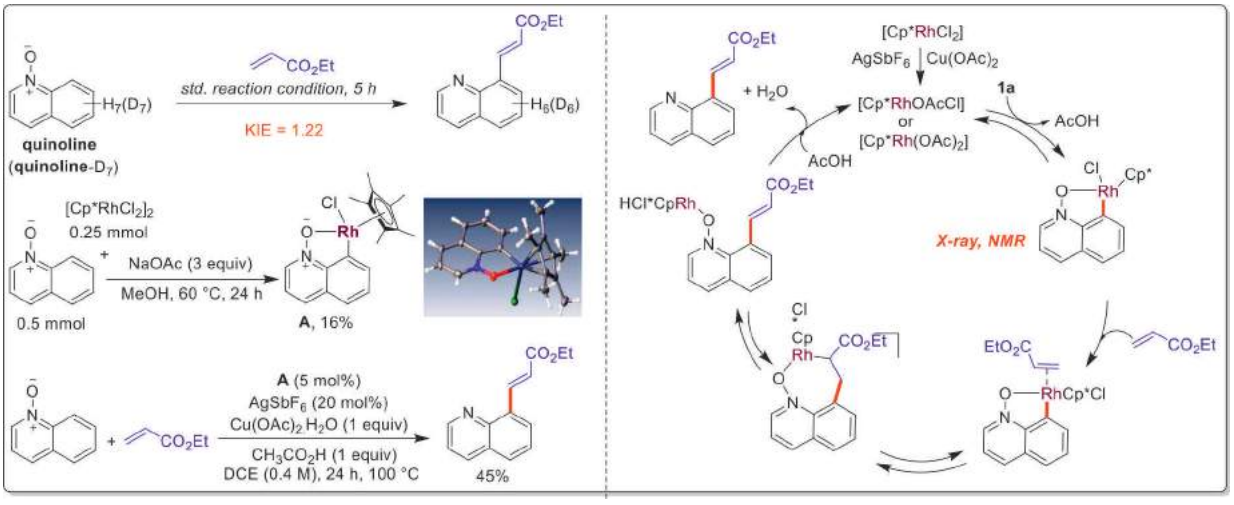
C-H Activation and functionalization: efficient bioactive molecule synthesis: The research work carried out by our group to give thrust on the basic science keeping close correlation with future applications. Natural product based novel and bioactive molecules will impute the therapeutic application in modern science. The scientific validation of Ayurveda plants provide scientific basis for their use leading towards high social impact.

Rh(III)-catalyzed dehydrogenative coupling of quinoline N-oxides: A Rh(III)-catalyzed oxidative dehydrogenative coupling of quinoline N-oxides with alkenes to provide 8-alkenylated quinoline derivatives through remote C-H activation is reported. Main features of the current catalytic method include N-oxide as traceless directing group, high selectivity for C-8 position and broad substrate scope. Mechanistic studies such as isolation and characterization of key five-membered rhodacycle intermediate has also been performed. Thirty five new quinoline derivatives were synthesized via distant C-H activation.Rhodacycle with quinoline *N*-oxide was synthesized that can help in establishing the mechanistic pathway of current reaction.



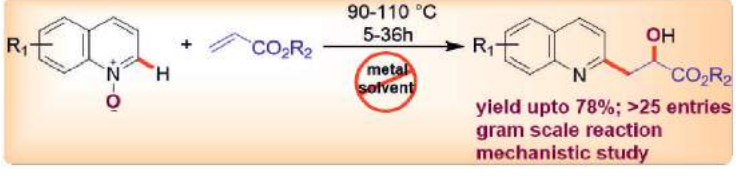


Selected examples of first time synthasized molecules



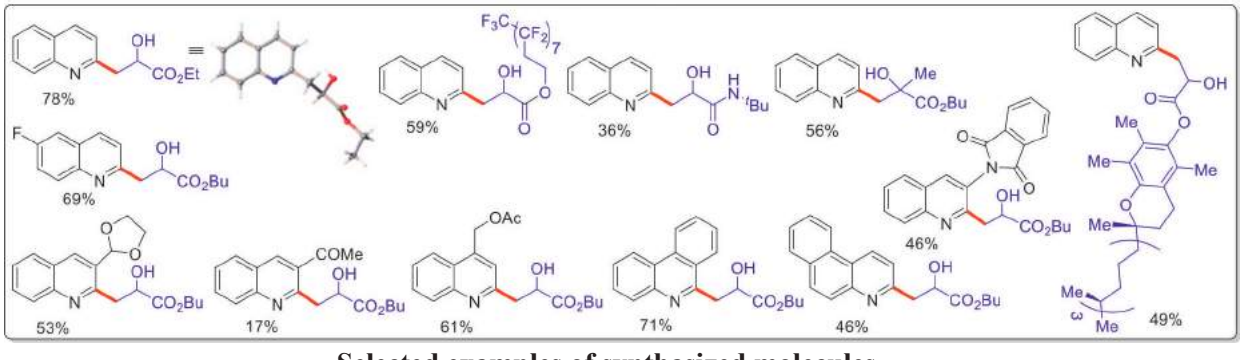
Mechanistic study and proposed reaction pathway

Catalyst and solvent-free alkylation of quinoline N-oxides with Olefins: A catalyst/solvent-free, one-pot and operationally simple method have been reported for the synthesis of quinoline substituted α-hydroxy carboxylic derivatives by hydroxyheteroarylation of olefins with quinoline *N*-oxides.



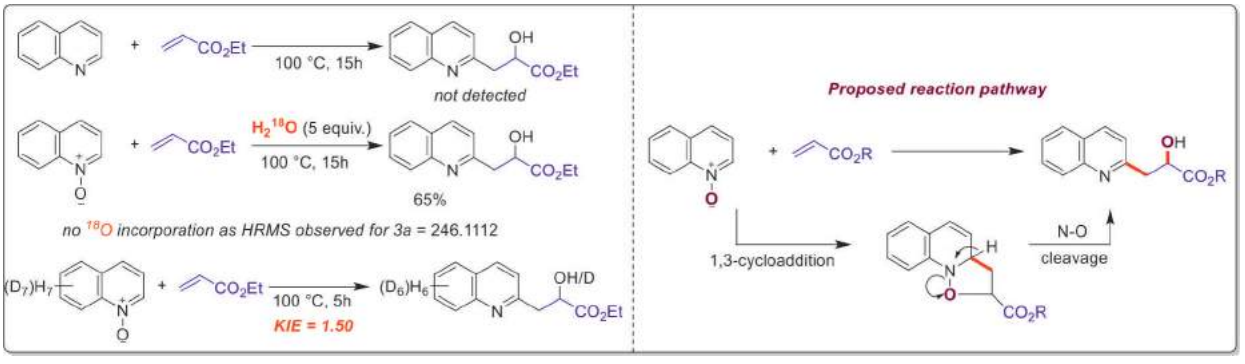
The reaction features high atom-economy, mild and reagent/solvent-free conditions, broad substrate scope and good selectivity with high yields. Preliminary mechanistic study to shed light into the reaction pathway was also carried out.

Use of quinoline instead of quinoline *N*-oxide failed to provide any product confirming the later requirement. To probe the O-atom transfer course, standard reaction was carried out in the presence of 99% $H_2{}^{18}O$. HRMS and GC-MS analysis of the isolated product revealed no ^{18}O incorporation, thus suggesting that O-atom transfer is probably intramolecular. Competition



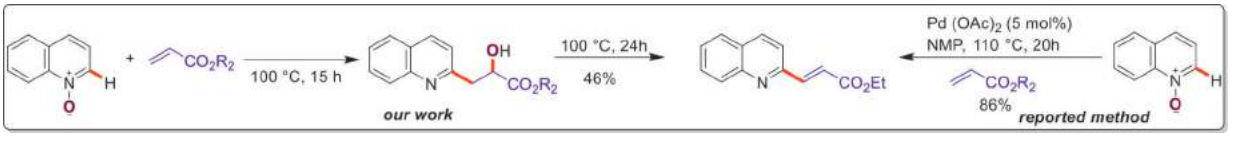
Selected examples of synthesized molecules

experiment between quinoline and the deuterated analogue *d7*- quinoline revealed a kinetic isotope effect of $k_H/k_D \approx 1.50$, indicating that the cleavage of C-H bond of quinoline *N*-oxide may or may not be involved in the rate-limiting step. On the basis of these preliminary mechanistic experiments and literature, a probable mechanistic pathway is depicted. Reaction might involve 1,3-dipolar cycloaddition followed by cleavage of N-O bond to provide the final product.



Mechanistic study and proposed reaction pathway

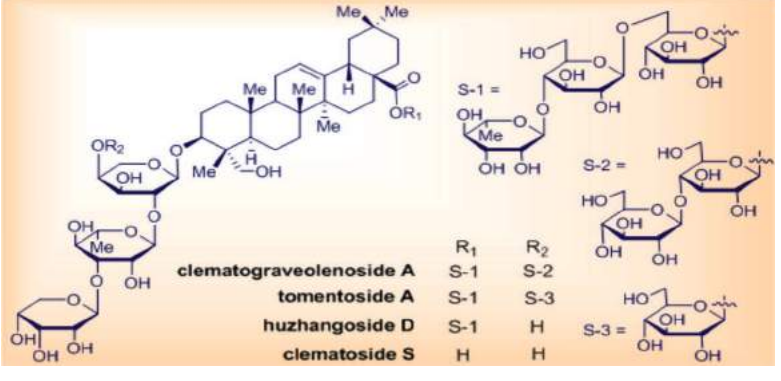
Quinoline substituted *α*–hydroxy carboxylic acid derivatives (**3a)** can be converted into corresponding C-2 olefinated quinoline by simply heating at 100 ^{0}C for 24h without using any additive or solvent albeit in low yield.



Metal free direct olefination

Phytochemistry:

Clematis graveolens: A new hederagenin based triterpenoid saponin, clematograveolenoside A (1), along with three known saponins, tomentoside A (2), huzhangoside D (3) and clematoside S (4), were isolated from the roots of *Clematis graveolens*. The structure of new compound was elucidated as 3-O-β-D-ribopyranosyl-(1→3)-α-L-rhamnopyranosyl-(1→2)-[β-D-glucopyranosyl-(1→4)-β-D-



Structure of compounds isolated from clematis graveolens

glucopyranosyl-(1→4)]-α-L-arabino pyranosyl hederagenin 28-O-α-L-rhamnopyranosyl-(1→4)-β-D-glucopyranosyl-(1→6)-β-D-glucopyranoside (1), on the basis of detailed analysis of chemical and spectroscopic data including 1D- and 2D NMR. This is the first report for the isolation of tomentoside A (2) from this genus and huzhangoside D (3) and clematoside S (4) from this species. Compound 2 was found more effective against aphid, *Aphis craccivora* with an LC_{50} of 1.21 and 0.46 mg/L at 72 and 96 h after treatment respectively and was followed by compound 4 (LC_{50} = 2.33 and 1.88 mg/L) and 1 (LC_{50} = 3.17 and 2.60 mg/L). In case of termite (*Coptotermis homii*), compound 1 was found more toxic with an LC_{50} of 0.12 mg/L after 24 h of treatment followed by compound 2, 3 and 4 (LC_{50} = 0.13, 0.15 and 0.19 mg/L respectively).

Publications:

- Kumar R, Kumar I, Sharma R and Sharma, U (2016). Catalyst and Solvent-Free alkylation of Quinoline *N*-oxides with Olefins: Direct Access to Quinoline Substituted α–Hydroxy Carboxylic Derivatives. *Organic & Biomolecular Chemistry*, 14: 2613-2617.
- Kumar D, Gulati A and Sharma U (2016) Determination of Theanine and Catechin in Camellia sinesis (Kangra Tea) Leaves by HPTLC and NMR Technique. *Food Analytical Methods,* 9(6): 1666-1674.
- Sharma R, Kumar R, Kumar I and Sharma U (2015) Rh(III)-Catalyzed Dehydrogenative Coupling of Quinoline *N*-Oxides with Alkenes: *N*-Oxide as Traceless Directing Group for Remote C-H Activation. *European Journal of Organic Chemistry,* 7519-7528.
- Sharma R, Thakur R, Kumar R, Kumar I and Sharma U (2015) Distant C-H Activation/Functionalization: A New Horizon of Selectivity beyond Proximity. *Catalysis Reviews: Science and Engineering,* 57(3): 345-405.
- Rattan R, Reddy SGE, Dolma SK, Fozdar BI, Gautam V, Sharma R and Sharma, U (2015) Triterpenoid Saponins from *Clematis graveolens* and Evaluation of their Insecticidal Activities. *Natural Products Communications,* 10(9): 1525-1528.

Aparna Maitra Pati
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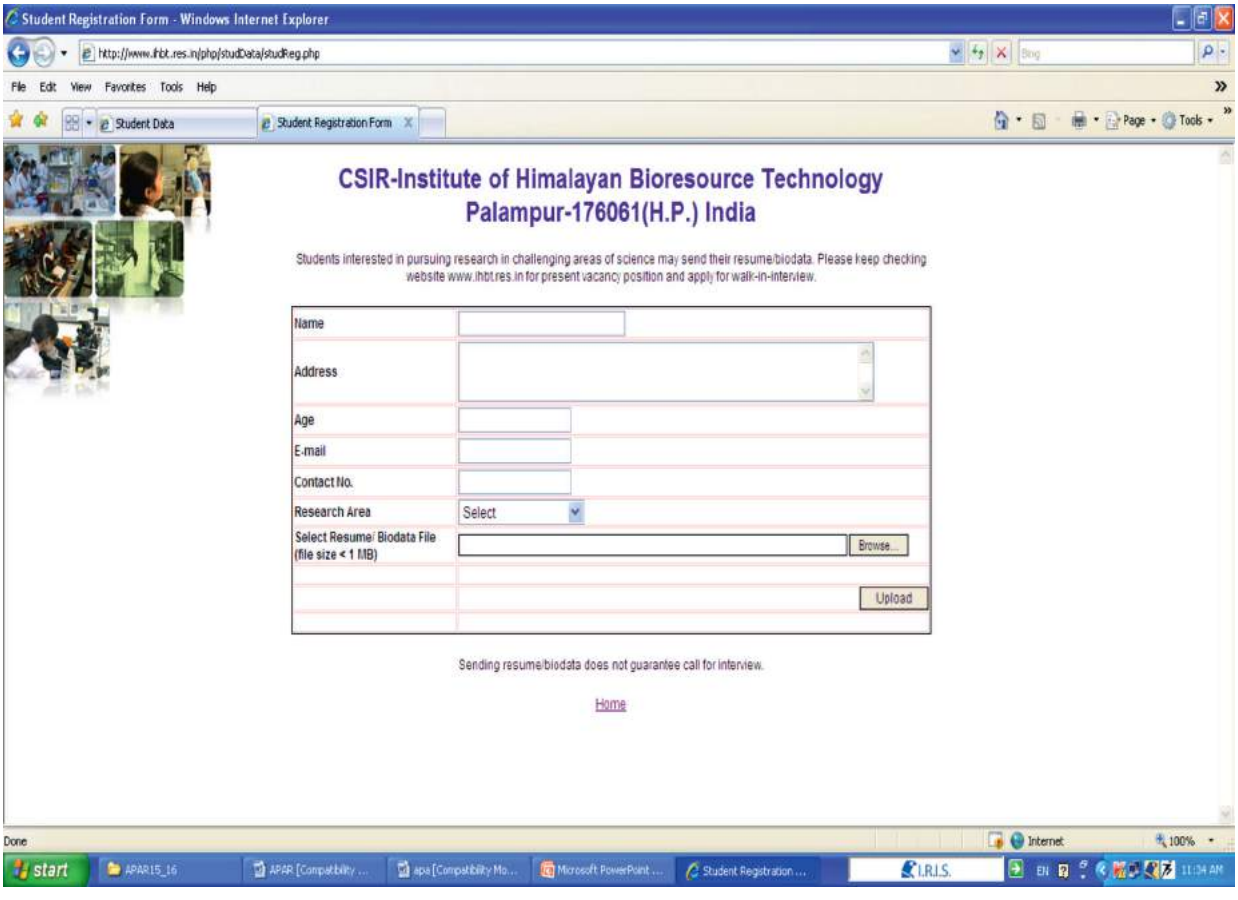
Research area: R & D Management

Planning Project Monitoring & Evaluation

- Coordinated meetings to align institutional activities in light of Dehradun declaration and compiled MANTHAN document.
- Compiled information for CSIR-IHBT and CSIR annual report. Report on significant achievements of the institute were sent to CSIR HQ on monthly basis.
- Developed a webpage through which students interested in pursuing research in challenging areas of science may send their resume/biodata



Scientists can check or download student's CV through link from scientist login

Student Data - Windows Internet Explorer

http://www.ihbt.res.in/php/studData/studView.php

सी.एस.आई.आर. - हिमालय जैवसंपदा प्रौद्योगिकी संस्थान

CSIR - Institute of Himalayan Bioresource Technology

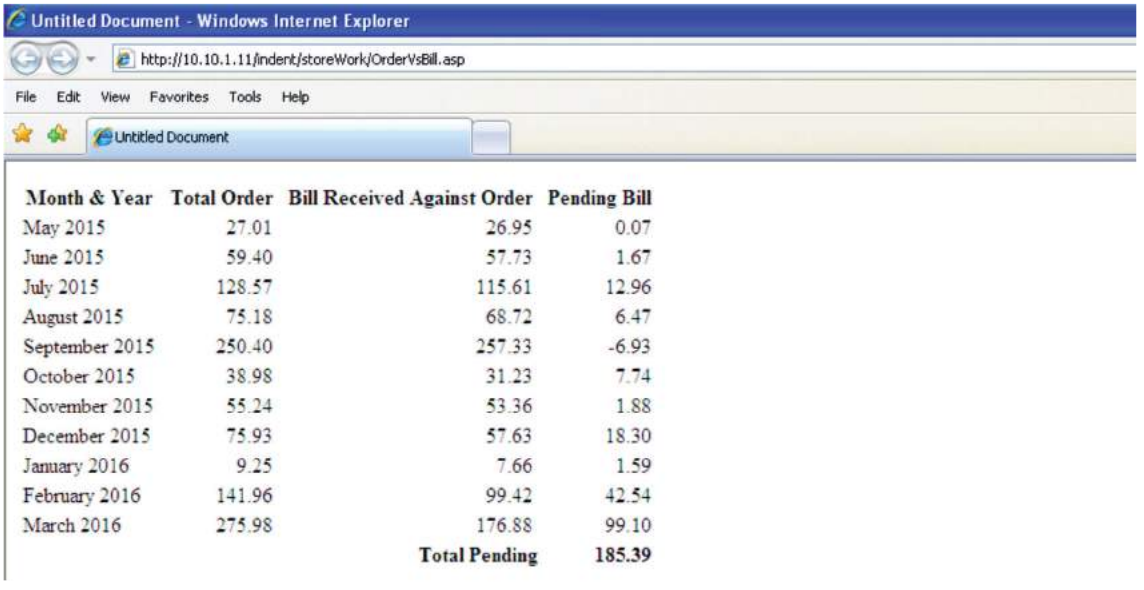
(Council of Scientific & Industrial Research)

Post Box No. 6 Palampur - 176061 (H.P.) INDIA

Student Data

SNo.	Name	Address	Age	Email	Contact	Area	Date of Submission
1	Nikita Yadav	Room no-A108, KMS Hall of Residence NIT Rourkela odisha	22	nikita.yadav1905@gmail.com	8826725846	PlantDisease	18/04/2016
2	kopppisetty viswa chaithanya	09-07-035, bezawada gardens, yanam-533464	24	viswachaithanya.k@gmail.com	9486558186	Biotechnology	17/04/2016
3	kopppisetty viswa chaithanya	09-07-035, bezawada gardens, yanam-533464	24	viswachaithanya.k@gmail.com	9486558186	Biotechnology	17/04/2016
4	kopppisetty viswa chaithanya	09-07-035, bezawada gardens, yanam-533464	24	viswachaithanya.k@gmail.com	9486558186	Biotechnology	17/04/2016
5	Muhamad Aadil Yatoo	khore sherabad pattan district baramulla, jammu & kashmir	22	may48081@gmail.com	7665139953	ChemSci	17/04/2016
6	Aakanksha Sharma	KH-244 New Kavi Nagar Ghaziabad,Uttar Pradesh 201002	22	ak2612@ rediffmail.com	01204122278	Agronomy	15/04/2016
7	YOGESH SHARMA	House no.-2771, jawahar colony, NIT Faridabad Haryana				0	14/04/2016
8	YOGESH SHARMA	H.no.-2771, jawahar colony , NIT faridabad HARYANA	23	yogesh21sharma92@gmail.com	7060333038	Biotechnology	14/04/2016
9	Muralikrishna Mallempati	Hyderabad	29	murali.mallempati@gmail.com	9848131620	Biotechnology	14/04/2016
10	GEETIKA SHARMA	HIG-88,House No.-207/5,Housing board colony,Nahan,distt.-sirmaur,H.P.	23 years old	geetikasharma008@gmail.com	9780045092	Biotechnology	12/04/2016
		sandeep kumar thakur s/o ranjit singh village baroh po					

- Developed a webpage for displaying month wise data w.r.t. Indent's order and bills received against orders (in lakhs)



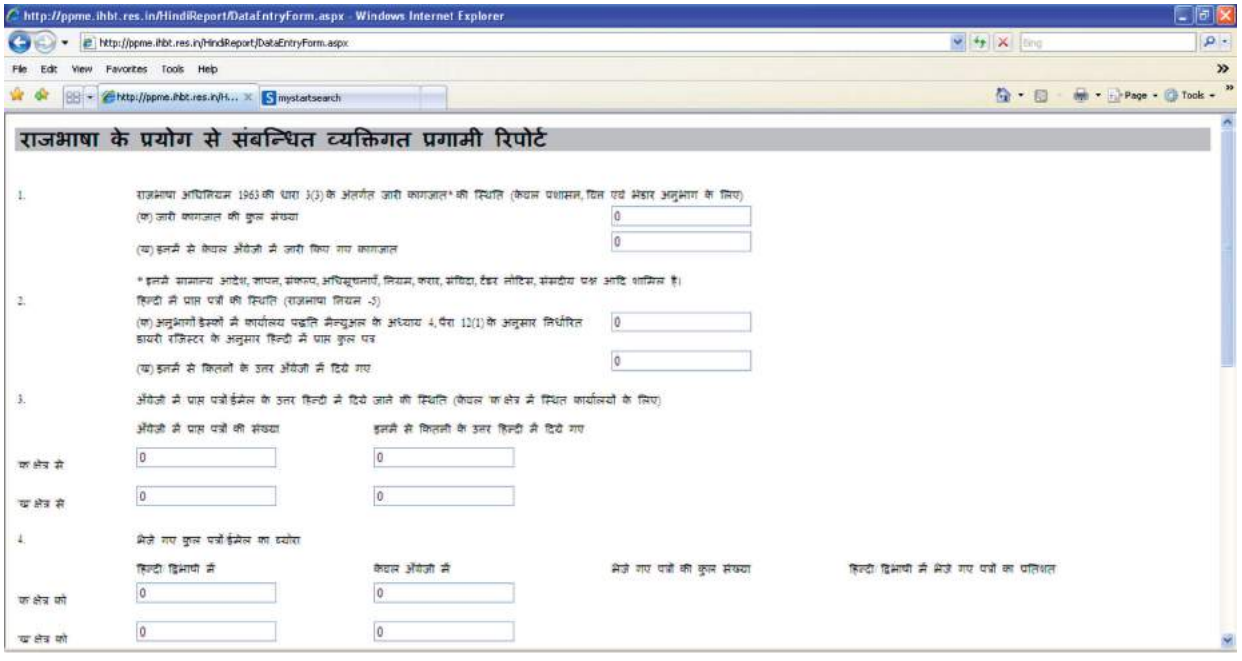
Untitled Document - Windows Internet Explorer

http://10.10.1.11/indent/storeWork/OrderVsBill.asp

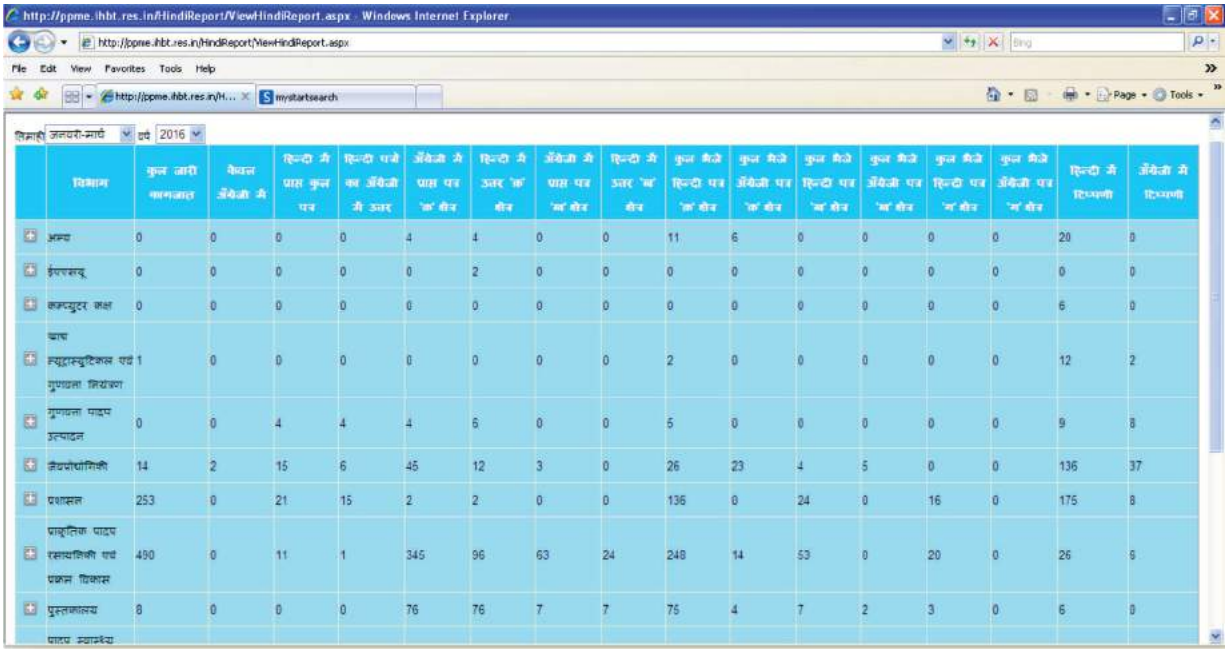
Untitled Document

Month & Year	Total Order	Bill Received Against Order	Pending Bill
May 2015	27.01	26.95	0.07
June 2015	59.40	57.73	1.67
July 2015	128.57	115.61	12.96
August 2015	75.18	68.72	6.47
September 2015	250.40	257.33	-6.93
October 2015	38.98	31.23	7.74
November 2015	55.24	53.36	1.88
December 2015	75.93	57.63	18.30
January 2016	9.25	7.66	1.59
February 2016	141.96	99.42	42.54
March 2016	275.98	176.88	99.10
		Total Pending	**185.39**

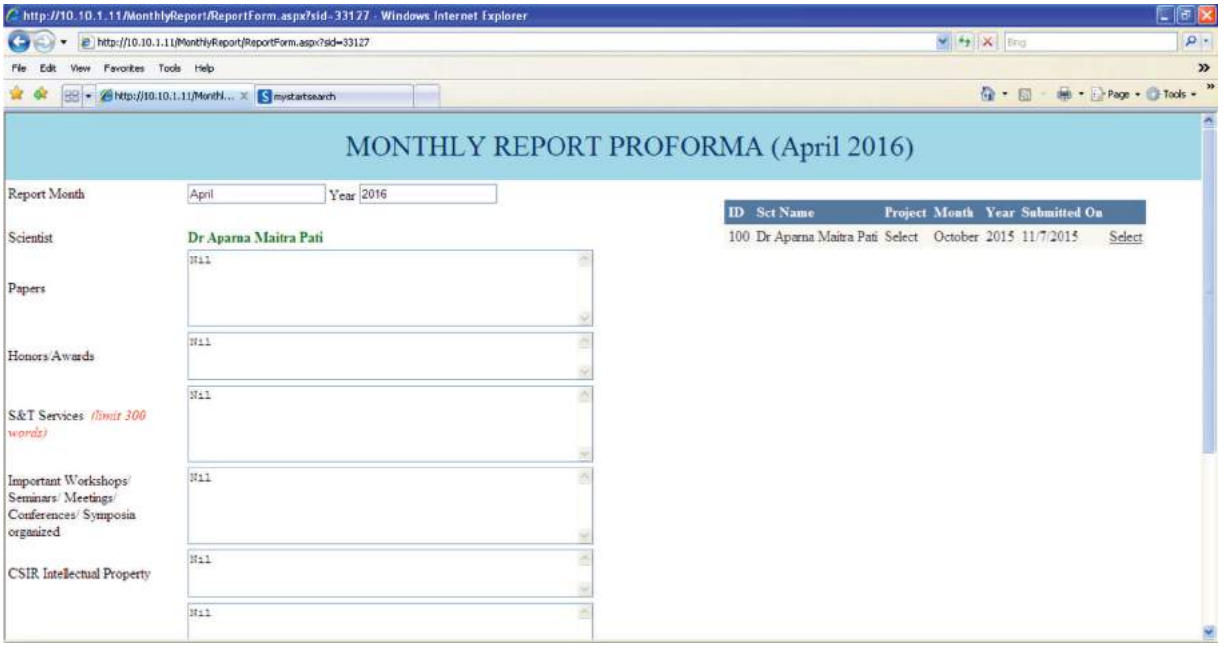
- राजभाषा हिन्दी के प्रयोग से संबंधित व्यक्तिगत प्रगामी डाटा के इनपुट हेतु ऑनलाइन फॉर्म तैयार किया।



- राजभाषा हिन्दी के प्रयोग से संबंधित इनपुट की गयी व्यक्तिगत प्रगामी डाटा की तिमाही संकलित रिपोर्ट ली जा सकती है।



- Developed online system using C# and SQL Server 2008 R2 for input and compilation of monthly report data



Output of Monthly Report Data submitted by Individual Scientist

- The cell recorded initiation of 18 new projects funded by various agencies.
- Carried out monitoring of institutional performance w.r.t publications (119), ECF (Rs. 352 lakhs), patents (13), and technology transfers (3).

- As a part of routine activity, maintenance of database and regular updating of information pertaining to project, staff, paper, patent, ECF, royalty, MoU, resource management etc were carried out.
- Conducted 52nd and 53rd Meeting of Research Council of IHBT, Palampur on 8th June 2015 at New Delhi and 3-4th December, 2015 at Palampur respectively.
- Handled queries for project training coordinated the training of 56 as winter and summer trainees in different divisions of the institute.
- To nurture scientific temper among young children, the cell organized visits of students from various schools and colleges.
- Furnished information on 14 cases under RTI Act and filed quarterly reports to RTI portal www.rti.gov.in
- Organized National Technology Day, IHBT Foundation Day, CSIR Foundation Day and National Science Day celebrations on behalf of the Institute.
- Regularly updated information in CSIR-IHBT website and intranet.
- As a part of social media activity, created official CSIR-IHBT account on Facebook (CSIRIHBT) and Twitter (CSIR_IHBT).
- Total no. of Facebook Posts (96) and Tweets (84) during 2015-16.

Ajay Rana, Scientist Fellow

ajayrana@ihbt.res.in

Research area: Development of value added products and process technologies for bioresource valorisation

Major achievements: Developed a green and efficient process for extraction of plant butter from the fruits of *Sapium sebiferum* (Fig. 1) which otherwise finds no utilization. The butter obtained from outer tallow layer of fruits is quite stable due to high content of palmitate esters. It is equivalent to cocoa and shea butter (table 1) and has huge potential for its utilization in cosmetic industry due to vegan origin. Detailed chemical characterization is in progress.

Fig. 1 Sapium butter obtained from *S. sebiferum* fruits

Table 1. Comparative data of major fatty acids in plant butters

Fatty acids	Sapium	Cacoa	Shea
Palmitic acid (C16:0)	50-60 %	26.0 %	2-9 %
Oleic acid (C18:1)	25-30 %	34.5 %	40-60 %
Stearic acid (C18:0)	2-5 %	34.5 %	20-50 %
Linoleic (C18:2)	1 %	3.2 %	3-11%

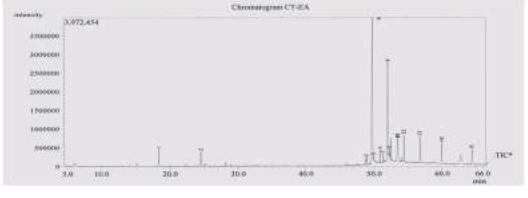


Fig. 2. GS-MS profile of major fatty acids in *S. Sebiferum* butter

A process has been developed for preparation of natural and refreshing instant tea soluble in hot as well as in cold water. This instant tea is free from synthetic preservatives and additives. Each powder serving of instant green tea contains health and quality attributes (Fig. 2) equivalent to cup of green tea infusion. The shelf life and stability studies of the product are underway.

Fig. 3. Instant tea prepared from green tea and HPLC profile of major active constituents in instant tea. Peaks are labelled Peak 1: GC, 2: EGC, 3: Cat, 4: Caff, 5: EC, 6: EGCG, 7: ECG, 8: CG

Table 2. Major constituents in infusions of different teas and instant tea

S. No	Sample	Catechins (mg/gm)	Caffeine (mg/gm)	Theanine (mg/gm)
1	Green Tea	48.2	15.9	3.9
2	Orthodox Black Tea	25.2	16.5	4.3
3	CTC Black Tea	9.4	20.8	4.1
4	Instant Tea	42.2	14.5	3.3

Work is under progress on process optimization for purification of catechins at 100 Kg fresh tea leaves per batch along with the industrial partner (M/s Baijnath Pharmaceutical Pvt. Ltd.) under BIRAC sponsored project. Seasonal batch extraction is underway at CSIR-IHBT premises up to the maximum available limit and the same has to be initiated with 100 kg leaves in the industrial partner site as soon as the installation of major instruments will be performed at their end.

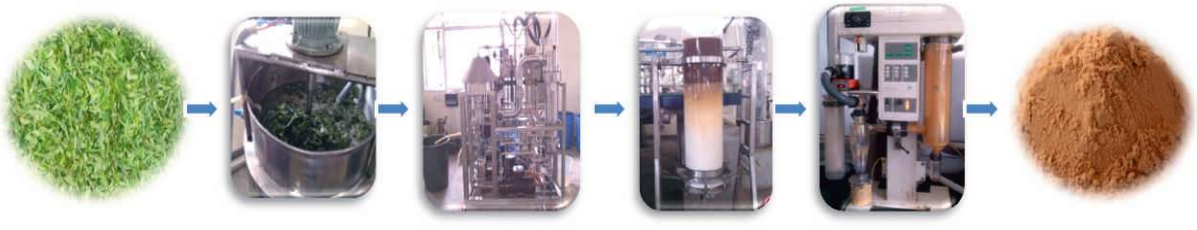


Fig. 4. Extraction and purification of catechins from tea leaves

The yield and purity levels obtained with 20 Kg fresh leaves per batch were maintained while using 40 Kg fresh tea leaves in the experimental trials.

Major activites:

- Working on quality augmentation of tea based diversified products (tea concentrates and wines) and their preparation from CTC black tea waste (MLP - 0070)
- Working on characterization of phytochemicals from underutilized parts of tea plant (mature leaves, flowers and fruits) for development of new products and formulations (DST SERB Project)
- Working on process optimization for extraction and purification of tea catechins at industrial scale (100 kg tea leaf) under BIRAC sponsored project in collaboration with M/s Baijnath Pharmaceutical Pvt. Ltd. (BIRAC Project)

Publications:

- Rana A, Singh HP, Gulati A (2015) Concurrent analysis of theanine, caffeine and catechins using hydrophobic selective C_{12} stationary phase. *Journal of Liquid Chromatography and Related Technologies*, 38: 709-715.

- Joshi R, Rana A, Gulati A (2015) Studies on quality of orthodox teas made from anthocyanins rich tea clones growing in Kangra Valley, India. *Food Chemistry*, 176: 357-366.
- Rana A, Singh HP, Gulati A (2015) Investigation of major phenolic antioxidants from Camellia sinensis Fruits. *Cogent Chemistry*, Vol. 1, Issue 1.
- Rana A, Kumar D, Joshi R, Gulati A, Singh HP (2015) *In vitro* cytotoxicity of black tea theaflavin digallates against Chinese hamster ovary cell lines (CHOK1) and glioma cell lines (C-6). *Chemistry of Natural Compounds*, 51: 835-839.
- Rana S, Gupta S, Rana A, Bhushan S (2015) Functional properties, phenolic constituents and antioxidant potential of industrial apple pomace for utilization as active food ingredient. *Food Science and Human Wellness, 4: 180-187.*

Patent:

- Ajay Rana, Harsh Pratap Singh and Ashu Gulati. A new energy efficient process for manufacturing of high quality green tea with enhanced flavors. PCT/IN2015/000078.

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Research area: Medicinal chemistry and nanotechnology

Often cytotoxic chemotherapeutics have low therapeutic index and harmful toxic effects. These efforts were focused towards development of drug delivery systems to enhance the therapeutic index of chemotherapeutic drugs. Conjugation of drugs and/ ligand to macromolecular carriers offers a mechanism to enhance the solubility of hydrophobic therapeutics, sustained drug release while minimizing nonspecific uptake, improving intracellular penetration and allowing for site-specific targeting via both passive and active targeting methods. As a result, drug-delivering devices confer a substantial reduction in toxicity but have accompanied improved efficacy thereby increase the importance of clinical utility.

Mission and goals

- Development of targeted drug delivery dendrimer conjugated nanodevices of naturally occurring therapeutic molecules as single or in combination with sustained release ability against different diseases including cancer.
- Synthesis of macromolecular drug carrier from natural sources with potential sensitivity to drug release upon external stimuli like pH, temperature, heat etc.

In our present work, we have developed dendrimer conjugated Estramustine (an anticancer drug) (DEM) with its antitumor effect on a mouse skin carcinogenesis model (DMBA-TPA-induced papilloma formation model). The obtained results were compared with the well known therapeutic drugs estramustine phosphate (EM). The obtained result indicated a more pronounced anti-tumor effect of the DEM as compared to EM. Proliferation and inflammation was inhibited and induction of apoptotic cell in tumor tissue played an important role in lowering > 50 % no of papilloma per mouse as compared to carcinogen control (CC) group (Fig. 1).

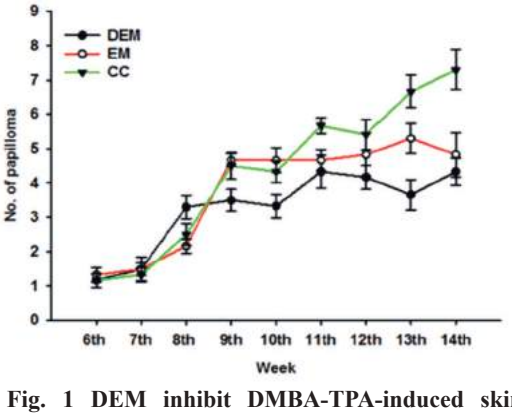

Fig. 1 DEM inhibit DMBA-TPA-induced skin tumor promotion in Swiss albino mouse skin. The tumor data were recorded in terms of number of number of tumor per mice, starting from 6th week onwards up to 12th week.

Publications:

- Kojima C, SK UH, Fukushima D, Irie K, Akazawa N, Umeda M, Niidome T (2015) Effect main chain conformation to thermosensitivity in elastin-like peptide-grafted polylysine. *RSC Advanced*, 5:104900-104906.
- Fukushima D, Sk UH, Sakamoto Y, Nakase I, Kojima C (2015) Dual stimuli-sensitive dendrimer: photothermogenic gold nanoparticle-loaded thermo-responsive elastin-mimetic dendrimers. *Colloids and surfaces B: Biointerfaces*, 132: 155–160.

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Research Area: High Altitude Microbiology

Study of bacterial community from alpine regions with reference to climate change and bioprospection: The organisms inhabiting cold and radiation rich alpine regions are economically viable. The poly-adaptational strategies endow the organisms with extremozymes which finds applications in various industries. The psycrotrophic bacteria surviving at 10C were isolated and identified from alpine regions. The 16S rRNA gene sequences have been submitted in NCBI GenBank under accession numbers KT766011 to KT766058 and KU342587 to KU342612. The bacteria were found to produce low temperature active enzymes with adaptive traits to withstand the extreme conditions of high altitude. Whole genome sequencing of few bacteria were also undertaken for genomic insights of cold active industrial enzymes and understanding its survival strategies in the cold environment.

Screening of rhizospheric bacteria of *Picrorhiza kurroa* from Lahaul valley to apply them for biological hardening in low altitude regions: *Picrorhiza kurroa* is an important medicinal herb endemic to Himalayan alpine areas. High mortality rate was observed during hardening of tissue culture raised plants in low altitude regions. In order to overcome this problem, soil microbial flora from the rhizosphere of this plant growing *in situ* in the Lahaul valley were identified. The bacteria surviving in temperatures corresponding to low altitude regions and possessing efficient plant growth promoting activities. These were used as formulations during the hardening process with positive results (>85% survival).

Publications:

- Himanshu, Swarnkar MK, Singh D and Kumar R (2016) First complete genome sequence of a species in the genus *Microterricola*, an extremophilic cold active enzyme producing bacterial strain ERGS5:02 isolated from Sikkim Himalaya. Journal of Biotechnology, 222: 17-18.
- Kumar R, Singh D, Swarnkar MK, Singh AK and Kumar S (2016) Complete genome sequence of *Arthrobacter alpinus* ERGS4:06, a yellow pigmented bacterium tolerant to cold and radiations isolated from Sikkim Himalaya. Journal of Biotechnology, 220: 86-87.
- Kumar R, Singh D, Swarnkar MK, Singh AK and Kumar S (2015) Genome assembly of *Chryseobacterium polytrichastri* ERMR1:04, a psychrotolerant bacterium with cold active proteases, isolated from East Rathong Glacier in India. Genome Announcement. 3(6):e01305-15. doi:10.1128/genomeA.01305-15.
- Kumar R, Singh D, Swarnkar MK, Singh AK and Kumar S (2015) Complete genome sequence of *Arthrobacter* sp. ERGS1: 01, a putative novel bacterium with prospective cold active industrial enzymes, isolated from East Rathong glacier in India. Journal of Biotechnology, 214: 139–140.

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Research Area - Population genetics, functional genetics and genomics

Himalayan region is one of the geographical areas on our planet known for its diverse flora including many wild edible, medicinal and aromatic plants from a wide range of altitudes and environmental conditions. Most of the plants are either consumed by local inhabitants or utilised in drug industries. Often, there is a large variations in the morphological and biochemical characters of wild edible fruits. Thus, identification of plants with higher quality/yield will be helpful.

In view of the above, my current efforts were focused on Next generation sequencing technology for genome wide marker development required for genotyping and elite selection.

Simultaneously, identification of male/female specific markers for dioecious plants in trees, where females are economically preferred over males is also underway. Generally such plants take a long time to express their sexual characters. Hence, the sex of such trees is not recognizable until they reach sexual maturity.

Efforts are also put forth to find out possible association of molecular markers that can be correlated with biochemical and morphological traits. These will help in identification of candidate genes responsible for higher nutritional potential and can further be utilized in breeding programme of the target species for promoting commercial plantations. Preliminary results showed a large variation (significant at $p>0.05$) in morphological and biochemical parameters of wild genotypes of *Myrica esculenta*. Thus, more than 200 individuals of *Myrica esculenta* were collected from 12 populations of Himachal Pradesh and Uttarakahand and genotyping based on microsatellite markers was initiated. Markers associated with quality related traits are expected to be helpful for selection of elites.

RURAL DEVELOPMENT ACTIVITIES

• **Rural development in the Western Himalayan region and adjoining plains through transfer of CSIR-IHBT technologies:** Institute has major goal of rural development in the north western Himalayan region and northern plains. The following activities were pursued during the year under CSIR rural development programme:

- Promotion and value addition to the traditional/underutilized crops of high altitude region
- Advisory and extension services for improving productivity and quality of China hybrid tea
- Transfer of agro-techniques and post-harvest management technology of commercially important cut flower crops
- Production of characterized planting material of industrial and commercial plants for facilitating crop diversification and processing of aromatics and herbals
- Demonstration of essential oil production technologies
- Improvement of apple production and quality through training growers, and dissemination of virus tested planting material of apple rootstocks through tissue culture industry

Promotion and value addition to the traditional/underutilized crops of high altitude region: Buckwheat, a traditional crop of the high altitude Himalayan region is a pseudo cereal having multifarious utility. The grains possess healthier starch, fiber and fat profile. It is the richest food source of rare carbohydrate compounds, called fagopyritols (especially D-chiro-inositol). In order to use these nutritional properties as an alternate ready-to-use value added food products such as puffed bar and noodles were developed from buckwheat.

Advisory and extension services for improving productivity and quality of China hybrid tea: Strengthening of the tea industry in this region by improving crop quality and cost reduction through mechanization of farm operations is prime need in the current scenario of scarcity of farm labour and rising costs. As tea is source of livelihood to about 2000 farmers, mostly small growers, development of this machine would benefit them directly.

During the year 5 training programmes were conducted and demonstrations on handling of different tea machines and their use held. Workshop for up-gradation of tea quality and productivity were also organised. A 6-page bilingual technical folder, in English and Hindi, "Tea Farm Mechanization" was released for the tea growers on National Science Day i.e. 28.02.2016.

Advisory services were extended for

improving productivity and quality of Kangra tea and promotion of tea farm mechanisation.

Advisory services and field demonstrations were held at Champhai district, Mizoram with DRDA staff.

Tips on tea plantation and nursery management

Training on agro-techniques and post-harvest management technology of commercially important cut flower crops: Organized two days training cum demonstration on "Cultivation and post harvest technologies of flower crops" for 13 participants from Kangra (HP) on March 3-4, 2016.

Trainees attending training programme on floriculture

Two demonstration plots of marigold were set up in the farmers' field in Amb tehsil, one at village Dhandari and another at village Bhadrkali. Total 1700 plants of cv. Pusa Narangi were planted in each location in an area of 200 sqm. In addition, a technical brochure on "Growing Agapanthus in Foot Hills of Himalayas", was released and distributed to flower growers.

Generation and distribution of quality planting material of floricultural crops to the farmers, as per their requirement, is one of the main activities of the Institute. Quantity of planting material supplied during the year at different places has been shown hereunder.

S. No.	Crop	Quantity supplied	Place
1	Lilium	2435 nos. bulbs	Kangra, Mandi
2	Marigold	5516 nos. seedlings	Kangra, Una
3	Bird of Paradise	567 nos. seedlings	Kullu, Palampur
4	Alstroemeria	94 nos. plants	Chamba, Kangra
5	Agapanthus	1558 nos. seedlings	Solan, Kullu
6	Gerbera	368 nos. rooted plants	Kangra
7	Carnations	100 nos. rooted cuttings	Kangra

Production of characterized planting material of industrial and commercial importance for facilitating crop diversification and processing of aromatics and herbals: Wild animal and stray cattle menace has recently emerged as a serious intimidation to the traditional farming, forcing many of the farmers to abandon their fields. A strong need is being felt to diversify agriculture and grow Himalayan friendly plants with assured returns to the community. Promotion of cultivation of aromatic crops, by providing quality planting material, agrotechnology, processing technology and value addition to the products, holds promise for entrepreneurship development and creating import substitute in the flavour and fragrance sector. Potential of *Tagetes minuta* as high value aromatic crop has already been tried and tested by the Institute. Keeping it in view, surveys for introduction of Tagetes cultivation in Sainj and Banjar regions of Kullu district, Tissa and Chauri area of Chamba, parts of Kangra, Mandi and Kinnaur districts were conducted. Subsequently, the farmers of these areas as well as from Kinnaur were imparted training on cultivation and distillation of the aromatic crops. In addition to this, the planting material medicinal, aromatic and industrial crops was generated and supplied to the farmers. The details have been shown below:

S.No.	Crop	Quantity of planting material raised	supplied to the farmers/grower
1	Damask rose var. Jwala and Himroz	1,00,000 rooted plants	4430 (rooted plants) 17350 (Stem cutting)
2	Stevia	Seed 6 kg	5 kg
3	Stevia rooted plant	2.0 lakh	7700
4	Rosemary	20,000 rooted plants	821
5	Scented geranium	10,000 rooted plants	197
7	Lavender	15,000 rooted plants	4426
8	Wild marigold	50.0 kg seed	50 kg
9	Misc. crops	20,000 rooted plants	350

For promotion of the cultivation of important medicinal and aromatic crops, seven demonstration plots, two each on stevia and damask rose, and one each on rosemary, scented geranium and lavender were set up at Chandpur farm of the Institute for the benefit of the farmers. Fifteen enthusiastic entrepreneurs and farmers from different parts of the state and country visited the experimental farm and demonstration units.

Damask nursery

Lavender nursery

Stevia nursery

Rosemery nursery

Farmers from Sainj and Banjar valley of Kullu getting training on aromatic crops

Farmers from Kinnaur attending a lecture on cultivation of aromatic crops

Training and demonstrations on processing of aromatics and herbals:

Training on valeriana oil distillation: A training program-cum-demonstration on essential oil distillation of valeriana roots was imparted to the farmers of village Saikothi, Tehasil Churah, Tissa Block, District Chamba, HP during December 28-31, 2015.

Two batches of 186 and 133 kg dry valeriana roots were processed for production of valeriana oil with an average recovery of 0.58% in essential oil distillation in unit.

Training on lemongrass oil distillation: On the request of the farmers, a series of training programs-cum-demonstrations were conducted in Kangra and Una (HP) on lemongrass oil distillation, employing the existing mobile essential oil distillation unit. The detail of training programs conducted is as below:

S. No.	Date	Place where demonstration imparted	Weight of material distilled	Yields of Essential oil
1	9 March	VPO Lagru, Teh. Jwalamukhi, Distt. Kangra	220 kg	0.44%
2	9 March	VPO Lagru, Teh. Jwalamukhi, Distt. Kangra	150 kg	0.53%
3	11 March	VPO Anjoli, Teh. & Distt. Una	225 kg	0.62%
4	11 March	VPO Pinjore, Teh. & Distt. Una	185 kg	0.37%
5	13 March	VPO Basoli, Teh. & Distt. Una	180 kg	0.39%
6	13 March	VPO Nagal Slangri, Teh. & Distt. Una	230 kg	0.53%
7	14 March	VPO Kalruhi, Teh. Amb, Distt. Una	219 kg	0.56%
8	15 March	VPO Kalruhi & Amlehar, Teh. & Distt. Una	215 kg	0.59%

Commissioning of essential oil distillation unit: Technical services were extended for commissioning of a 2 quintal capacity distillation unit at village Saikothi, Tehsil Churah, Tissa Block, Distt. Chamba. Distillation of Tagetes oil was done during the season by the farmer, which accounted for Rs. 18,00,000 by sale of the oil. In addition, 2 kg valeriana oil was also distilled by the farmer in the same distillation unit, which fetched Rs. 40,000 return.

Improvement of apple production and quality through distribution of virus tested planting material of apple rootstocks: Economic importance of the apple for the state of Himachal Pradesh due to suitable climate conditions has overcome by the fact that plant viruses infecting these trees sharply decrease their production. The major problem is at the level of selecting disease free planting material for raising healthy orchards. The problem is compounded by the fact that a thorough screening of these crops has not been done from the aspect of virus infections in Indian scenario. Therefore activity on developing virus free budwood was taken up to benefit the growers in getting true-to-type, good quality virus free planting material for obtaining

enhanced production of quality fruits. Focus was kept on commercially important rootstocks of

Root stock M9, M111 and M7 maintained and propagated under tissue culture

apple (MM111, MM106, M7, M9, EM9, M793). Like other plants, these rootstocks are susceptible to infection by a number of pathogens including viruses. Major viruses that infect apple are *Apple chlorotic leaf spot virus, Apple mosaic virus, Apple stem grooving virus* and *Apple stem pitting virus*. An important viroid that is found with a high incidence is *Apple scar skin viroid*. Therefore, there was a need to eliminate these viruses by meristem tip culture and thermotherapy procedures in conjunction with antivirals like ribavirin, virazole etc. As these were in regular demand by tissue culture industry, these rootstocks were regularly maintained in tissue culture bottles and tested for freedom from viruses.

A total of 40 bottles @ Rs 1000 and 30 bottles @ Rs 1500 of virus free tissue culture plants were provided to the industry for further multiplication and suppling planting material to the farmers.

Introduction of Apple in Mizoram: Apple growing was never tried in Mizoram state in North East India. Therefore, keeping in view the importance of apple cultivation for boosting rural economy, the Institute made first attempt to introduce this fruit plant in Champhai district as out of the 8 districts in Mizoram, this district is relatively cool and monthly mean minimum temperature here ranges to 8.4-9.3°C in the month of December and January months. The work was initiated jointly with Project Director of DRDA of Champhai district. Two sets of cultivars with low chilling requirement, between 300-500 hours, were selected for introduction. Set I comprising of cultivars Anna and Dorsett

Golden, with chilling requirement of below 300 hours, and another set of cultivars Fuji and Gala, having chilling requirement of nearly 500 hours, were carried from Himachal Pradesh. Demonstration plots were set up at 10 locations, accommodating a total of 210 apple sapling. On the spot training was organized for capacity building of staff of DRDA and farmers. The plants have been growing satisfactorily.

Promotion of bamboo propagation for skill development and livelihood benefits: Important bamboo species such as *Phyllostachys pubescens*, *Dendrocalamus hamiltonii, Bambusa bambos,*

Low chilling Apple cultivars

Demonstration on layout and pit making

Demonstration on planting sapling and growth of the plant after 40 days

B.multiplex, Sasa auricoma etc. were raised in nurseries under field condition. The cutting were raised and seedling plants of these species were transplanted in the poly house at the Institute's nursery and supplied to different agencies for greening of degraded land in Kangra district. A total of 178 people including villagers, entrepreneurs, growers of Himachal Pradesh and Punjab foresters and forest officials were trained about the methods of raising nurseries and establishment of plantations. They were also offered trainings on plant tissue culture for micropropagation of maggar bamboo. The standardized methods of preparing and raising of bamboo nurseries were also demonstrated. Over 18,000 bamboo plants of different species were supplied to different agencies/farmers in different parts of the country (Table 3)

Besides the above, two agencies were contacted for preparation of bamboo boards, tiles and floorings. These were CSIR-CBRI, Roorkee and a private company in Jalpaiguri. The activity is

expected to boost entrepreneurship development.

Bamboo Charcoal, Bio-char and Activated Charcoal: Conventionally, charcoal is made in dome shaped charcoal kiln which consists of bricks and clay mortar with molasses, making it

Establishment and demonstration of bamboo nurseries

Training programme for forest officials at CSIR-IHBT, Palampur

strong to withstand high temperature. But, three major problems are generally encountered in these types of kilns, (i) porous body (ii) production of higher proportion of semi cooked/uneven feed material (wood/bamboo) (iii) generation of high volume of smoke, causing environment pollution. Fire inside the dome is regulated by the air supply. After attaining a temperature of above 550°C the wood gets converted into charcoal in next 8-10 hours. As the body of conventional kiln is porous so fire inside the kiln even after complete sealing of whole unit brakes out during opening of inlet port for unloading of the prepared charcoal. Watering of charcoal to control fire results in soaking of water and deteriorate the quality of charcoal. If kiln is kept for natural cooling, total charcoal shall be converted into ash. Other concern is that in conventional kiln, a considerable volume of wood at the base and side of kiln remains as semi baked which reduces the efficiency of kiln. Thirdly, a large volume of smoke generated during baking of wood, causing environment pollution. In order to solve these problem, the design of conventional kiln was modified after trying various alternatives. A simple portable charcoal kiln has finally been designed to enhance temperature to convert the biomass into Biochar and Activated charcoal. It will be fabricated with locally available material by the local fabricator.

Table 3. Supply of quality planting material of bamboo

S.No.	Species	Total plant supplied	Name of Parties
1.	Moso bamboo	5,000	Add. DFO, Research Forest Division, Srinagar, J&K
2.	*D.hamiltonii*	1,000	The Manager, Woodland Overseas School, Daduya road, Hoshiarpur (Punjab)
3.	*D.hamiltonii*	833	Mr. Jitender Singh, Dasuya, Hoshiarpur (Punjab)
4.	Moso Bamboo	550	Mr. Majan Bader, J&K
5.	*D.hamiltonii*	500	Mr. Rajpal Singh, Hoshiarpur (Punjab)
6.	*D. hamiltonii*	1,000	Mr. Balwan Singh, Woodland Overseas, School, Dasuya Road, Hoshiarpur (Punjab)
7.	*P.pubesence (Moso bamboo)*	550	Mr. Tejpal, AEO, Agriculture Dept., Lalmandi, Srinagar, J&K
8.	Moso bamboo	1,250	DFO, Forest Division, Sundernagar (HP)
9.	Moso bamboo	2,500	Project Director, DWDA, Shimla (HP)
	Bambusa bambos	2,500	
10.	*P.pubesence*	400	CSIR-IHBT for plantation purpose under Rural Development Project, Rakh Nagri, Distt. Kangra (HP)
11.	Moso bamboo	500	IIRD, Shimla (HP)
12.	Moso bamboo	850	DFO, Suket Forest Division, Sundernagar (HP)
13.	Different species	95	Viveka Foundation, Mansimbal, Distt Kanrga (HP)
14.	Different species	053	DFO, Palampur (HP)
15.	Different species	125	National Director, CORD, Sidhbari, Dharamshala (HP)
16.		100	R.O., Nurpur (HP)
17.	*D.hamiltonii*	50	Mr. Pema Lama, Bir Colony, Baijnath, Distt Kangra (HP)
18.	*P.pubesence*	20	Karma Tasa Buddha Monastery, Baijnath, Distt Kangra (HP)
19.	*Moso bamboo*	20	Mr.Kapil Malik, Faridabad (UP)
20.	*D.hamiltonii*	20	315 Field Regiment, Alhilal, Distt Kangra (HP)
21.	Mixed species	281	Others parties
Total		18,197	

AcSIR students activities on Rural Development Programme

Under CSIR-800 course, the AcSIR students conducted survey and awareness compaign of important diseases, drinking water and soil health in 3 villages panchayats in Kandwari region.

Disease incidence survey and awareness about associated risk factors: imparting a better life to rural population in Kandbari (Arindam Ghosh Mazumder, Ganesh Panzade, Rubbel Singla, Shiv Kumar, Sourabh Soni)

A door-to-door survey on a population selected by stratified random sampling method was carried from June to August 2015 in three gram panchayats *viz.* Nain (5 wards), Nanahar (7 wards) and Saperu (5 wards) in Kandbari region of Baijnath Development Block. The primary objective was to estimate the prevalence of the major health disorders and to analyze the impact of different factors like lifestyle, food habits and socio-economic status on disease incidence. A total number of 472 families (2,566 people with average household size 6) were surveyed randomly in this area to collect demographic, socio-economic and disease specific data, and a questionnaire was applied.

Survey revealed that Blood Pressure, Anemia, Diabetes, Eye/Ear infections and Stones (Kidney and Gall Bladder) were the five major prevalent health problems affecting the natives. Of the total population, 53.8 % females and 29 % males were suffering from health problems. Age group 41-60 was the most prone for Diabetes as well as Blood Pressure, while the age group 19-40 was the major risk group for Stones and Anemia. Out of the people suffering from health problems, 13.6 % females and 11.6 % males were found to be co-morbid.

Lack of scientific knowledge regarding health hazards, ignorance and inadequate preventive measures and practices, improper garbage disposal and lack of hygiene practices could lead to future outbreak of diseases and epidemics in the region. Hence steps were undertaken to make the targeted population aware about the possible preventive measures that can be undertaken by them in order to evade the health related problems, thus imparting them a better standard of living.

AcSIR students conducting survey of disease incidence in Kandbari region

Surveillance and water quality monitoring in Kandbari region (Vandana Thakur, Tanvi Sharma, Maheshwar Singh Thakur)

Survey of Kandbari region showed that all three gram panchayats viz., Nain, Nanahar and Saperu had tap water as a primary source for drinking water and hand pump, bauri and kuhl were the secondary sources. Kuhl water source was mainly used for animal drinking and irrigation purposes. Very few households (< 15 %) used filtered water for drinking purpose. Water borne diseases like stone, stomach discomfort, acidity etc. were also found among people, which was an alarming condition.

The water samples from different sources were analyzed for physical, chemical and bacteriological quality parameters viz., Appearance, Turbidity, pH, Alkalinity, Total hardness, Calcium hardness, Chloride, Fluoride, Iron, Total residual Chlorine, Nitrite, Nitrate and Total dissolved solid content. These parameters are governed by Bureau of Indian Standards and required to be carefully monitored so as to determine water quality. Water analysis report showed that in summer season, there were no major problems associated with water quality. Majority of the water samples were found within the acceptable limits for physical and chemical parameters. Few samples were found approaching the upper limit of respective acceptable limits. In bacteriological analysis, water samples of bauri and kuhl showed the presence of coliforms, making them unsuitable for human as well as animal drinking purpose. In addition, the survey revealed that during rainy season, people usually face the problem of presence of particulate matter (dust, soil particles etc.) in drinking water supply thereby necessitating the use of filters during that period.

Absence of regular water testing and monitoring system in the villages and lack of proper expertise in operating water testing kits, absence of rain water harvesting systems in the village and contamination of household water supply with particulate matter during rainy season were the major findings in the study.

AcSIR students conducting survey of water sources and testing quality of water

Soil analysis for higher crop productivity in Kandbari region (Nisha Dhiman, Aditya Kulshreshtha and Himankshi Rana)

The soil in Kandbari region was found to be sandy loamy and clayey loamy, and was slightly acidic in nature. Soil pH was found to be ranging between 6-6.5 which is suitable for optimal crop growth of the crop plants. Soluble salts were also found to be within normal range in all soil samples of the region. It was found that Nanahar gram panchayat has relatively higher available phosphorous content. On an average, phosphorous concentration of soil of all wards ranged between 3-10 ppm which means it was in deficient range (>10 ppm) coinciding with Himachal Pradesh Soil Information System report. This deficiency can be overcome by supplementing soil with phosphorus-based fertilizers such as superphosphate etc. Available potassium content was observed to be in higher range (90-200 ppm) in most of the soil samples. Available nitrogen in the soil samples varied between 103-646 Kg/ha and was highest in Ward 3 of Nain panchayat. Values of calcium were found to be ranging from 164 ppm to 1360 ppm and highest amount of calcium was observed in the soil samples of Nanahar (ward 1 and ward 6) while relatively equal level of calcium in soil samples of Nain and Saperu. The level of Iron were less than normal (50-100 ppm) in soil samples of Nanahar (ward 2, 5), Nain (ward 1) and Saperu (Ward 1, 5). People of all 3 panchayats have been using NPK mixture of 12–32–16.

Based on the results crop specific recommendations for better agriculture productivity were made to farmers of the region. They were educated on modern techniques of fertilizer application. For getting better returns from agriculture, the interested farmers and gram panchayat pradhans were exposed to protected cultivation of high value crops at the Institute.

AcSIR students testing soil of Kandbari region and exposing the Panchayats Pradhans and farmers on protected cultivation of high value crops

Participation in Exhibitions:

Ashok Kumar. International Exhibition "Agri-Tech India 2015" at Bangalore International Exhibition Centre (BIEC), 21-23 August 2015 organized by Media Today Pvt. Ltd.

Kiran Saini, Sukhjinder Singh, Sanjay Kumar and J.P. Dwivdi. Exhibition of Institute's technology in a Kisan Mela at Kangra Himachal Pradesh, 25-27 October, 2015, organised by Divya Himachal.

CSIR-IHBT participated in 'India International Science Festival (IISF)' at IIT Delhi, organized by the Ministry of Science & Technology and Earth Science on December 04-08, 2015 and the CSIR has been awarded for IInd price for CSIR technologies and products. (Group Member- Arvind Kumar Verma and Vivesh Sood). (Picture 1, 2012207, 20151204 and IISF).

CSIR-IHBT participated in 'CSIR-Foundation day' at Science Center, organized by CSIR on September 26, 2015 and demonstrated CSIR –IHBT technologies and products. (Group Member- Arvind Kumar Verma and Ajay Parmar).

CSIR-IHBT participated in 'State Level Holi Festival-2016' at Pragati Madan, Palampur organized by Sub Divisional Officer(C)-cum-Chairmain, State Level Holi Committee on March 21-24, 2016 and demonstrated CSIR –IHBT technologies and products. CSIR-IHBT has been awarded Ist, IInd and three consolation price for CSIR technologies and products. (Group Member- Arvind Kumar Verma and Vivesh Sood, Sukhjinder Singh and Virat)

TRAINING PROGRAMMES

Sud RK and Dhadwal VS (2016) Demonstration and training on handling of plucking machines, skiffing machines, weeder and power sprayer planters from Ajhu area of Distt. Mandi along with Tea Board official, 14 planters, March 31.

Sud RK and Dhadwal VS (2016) Demonstration and training on handling of plucking machines, skiffing machines, weeder and power sprayer. Planters from Nagri area along with Tea Board official, 12 planters, March 31.

Sud RK and Dhadwal VS (2016) Training cum demenstration of plucking, skiffing, pruning and weeding machines and power spayer for mechanization of tea farms for tea growers from Chauntra and Gopalpur area, 9 planters, March 28.

Sud RK, Kumar Rakesh and Pal Probir Kumar (2016) Training of farmers from Sainj and Banjar region of Kullu district on cultivation of medicinal and aromatic crops, 16 farmers, March 16-17.

Sud RK, Gupta Mahesh and Verma Arvind (2016) Training of farmers from Kinnaur district on cultivation of medicinal and aromatic crops, 16 farmers, March 16-17.

Kumar R (2016) Cultivation practices of *Tagetes minuta*. Batote , Distt Ramban, Jammu and Kashmir, 10 Participant, March 15.

Sharma Mohit (2016) Demonstration on lemongrass oil distillation at VPO Kalruhi, Teh. Amb, Distt. Una (HP), March 15.

Kumar R (2016) Cultivation practices of damask rose. Farmers of Reasi, Jammu, 10 Participant, March 14.

Sharma Mohit (2016) Demonstration on lemongrass oil distillation at VPO Nagal Slangri, Teh. & Distt. Una (HP), March 13.

Sharma Mohit (2016) Demonstration on lemongrass oil distillation at VPO Ajnoli, Teh. & Distt. Una (HP), March 11.

Sharma Mohit (2016) Demonstration on lemongrass oil distillation at VPO Lagru, Teh. Jwalamukhi, Distt. Kangra (HP), March 9.

Bhargava B (2016) Two days training cum demonstration on cultivation and post harvest technologies of flower crops, Kangra (HP), March 3-4.

Sud RK and Dhadwal VS (2016) Structuring tea garden for using mechanical devices for tea plucking for Manager and farm workers of Dharmshala area, 9 traineees, February 26.

Sud RK and Dhadwal VS (2016) Training programme on mechnized skiffing and pesticide spraying, 10 growers, February 24.

Sud RK and Dhadwal VS (2016) Young tea pruning for bush frame formation and pesticide spray demonstration, Thandole Tea Estate , January 29.

Sud RK (2016) Training on tea plantation management for promoting tea productivity and quality (with Tea Board), Chauntra, 40 planters, January 22.

Sud RK (2016) Training on tea plantation management for promoting tea farm mechanization (with Tea Board), Baijnath, 40 planters, January 21.

Gupta M (2016) Training and awareness programme on "Bamboo and bamboo food products" in association with Pradhan, Gram Panchayat Bharmat, Tehsil Palampur, District Kangra (HP), 15 women participants , CSIR-IHBT, Palampur, January12.

Sharma Mohit (2015) Training on Valeriana oil distillation*:* A training program-cum-demonstration on essential oil distillation of Valeriana roots was imparted to the farmers of village Saikothi, Tehasil Churah, Tissa Block, District Chamba (HP). Two batches of 186 and 133 kg dry valeriana roots were processed on essential oil distillation unit and produced valeriana oil with an average recovery of 0.58%. Technical assistance was rendered in setting up of a distillation unit having 2 quintal/batch capacity at village Saikothi, Tehsil Churah, Tissa Block, Distt. Chamba (HP), December 28-31.

Gupta M (2015) Participated and demonstrated food product technologies in "National Level Vendor Development Programme" organized by MSME development Institute, Solan (H.P), December 2-3.

Sud RK (2015) Field management and processing technology of tea. Training programme with Tea Board of India, Tanda, Palampur, 40 growers, November 6.

Gupta M (2015) Organized one day awareness workshop on "Value added Food Processing", 32 Participants, Killar, Pangi (H.P.), October12.

Gupta M (2015) organized one day awareness workshop on "Value added Food Processing and Preservation", 65 Participants, CeHAB, Ribling, Keylong (Lahaul and Spiti), October10.

Kumar R (2015) Nursery raising practices, cultivation of important medicinal and aromatic plants in trans Himalayan region. CeHAB, Tandi, Keylong, Distt. Lahaul and Spiti (HP), 43 Participant, September 3.

Kumar R (2015) 3 trainings on "Cultivation of endangered MAPs at Lahaul", held in June, August, and September 2.

Kumar R (2015) Cultivation of important aromatic crop Clary sage in cold desert area. Village Jagla, Keylong, Distt. Lahaul and Spiti (HP), 4 Participant, September 1.

Sud RK and Dhadwal VS (2015) Improved methods of tea plantations and management of blister blight during monsoon season, Technical Officer (Tea) Office, 40 growers, August 21.

Sud RK and Dhadwal VS (2015) Workshop on National Programme for Organic Production (NPOP), a programme sponsored by APEDA, New Delhi, 75 participants, August 5.

Kumar R (2015) Production technology and multiplication techniques of important medicinal and aromatic plants. Sumnam Village, Keylong, district Lahaul and Spiti (HP), 6 Participant, July 30.

Kumar R (2015) Cultivation technology of important medicinal and aromatic plant. Sansha village Keylong, district Lahaul and Spiti (HP), 6 Participants, July 29.

Singh V, Sud RK and Verma A (2015) Workshop on cultivation, value addition and marketing of lemon grass & medicinal plants, Block Development, Amb, Una, H.P., 26 farmers, July 6-10.

Sud RK and Dhadwal VS (2015) Demonstration on young tea planting for new plantation development. Mansimbal tea estate, 5 trainees, July 1.

Kumar R (2015) Nursery raising practices, cultivation and essential oil extraction of important medicinal and aromatic plants. CeHAB, Ribling (Tandi), Keylong, district Lahaul and Spiti (HP), 12 Participant, June 24.

Sud RK and Dhadwal VS (2015) Training on cultivation of large cardamom, 25 trainees, June 12.

Sud RK and Dhadwal VS (2015) Management of tea flush during lull period of first flush, Gopalpur, 12 participants May 18.

Sud RK and Nadda Gireesh (2015) Management of scale insect in tea plantations in Kangra valley, the Kangra Valley Small Tea Growers Association Meeting, Chai Bhawan, Palampur, 25 growers May 2.

Singh V, Sud RK and Verma A (2015) Workshop on cultivation, value addition and marketing of aromatic and medicinal plants, Swan River Project, PIU Gagret, Una, H.P. 32 farmers, April 22-24.

Dhadwa VS and Sud RK (2015) Training of small tea growers of Thandole area on quality tea plucking. Banuri Tea Expt. Farm, 15 trainees, April 12.

Dhadwa VS and Sud RK (2015) Training of small tea growers of Massairna area on quality tea plucking. Banuri Tea Expt. Farm, 15 trainees, April 11.

Dhadwal VS and Sud RK (2015) Training of small tea growers of Bhawarna area on quality tea plucking. Banuri Tea Expt. Farm, 15 trainees, April 10.

Sud RK (2015) Training on tea plantation management for promoting tea farm mechanization (with Tea Board), Palampur, 40 planters, January 1.

LECTURE DELIVERED AT WORKSHOPS/TRAININGS

Bhavya Bhargav (2015) Cut flower production of Marigolds and Chrysanthemum crops, Workshop on "Cultivation, value addition and marketing of lemongrass and medicinal plants of subtropical Himachal Pradesh", CSIR-IHBT, Palampur, July 9.

Bhavya Bhargav (2016) Protected cultivation of flowers, Department of Agriculture, Mata Gujri College, Fatehgarh Sahib, Punjab, February 4.

Bhavya Bhargav (2016) Production technology of lilium, Demonstration-cum-Training Programme on "Production and post harvest technology of commercially important flower crops", March 3-4.

Rakesh Kumar (2016) Cultivation of medicinal and aromatic plants of high altitude. Kisan Mela cum entrepreneurs workshop at CSIR-IIIM Jammu, March 13.

Rakesh Kumar (2016) Conservation and cultivation of high altitude medicinal plants in cold

desert region of the western Himalayas. Workshop on High altitude Medicinal Plants held at ICFRE, Dehradun, March 21-22.

R.K. Sud and Kiran Saini (2016) *Tagetus minuta*, a suitable alternate crop to maize monkey in menace area, Saikothi, Chamba, March, 29.

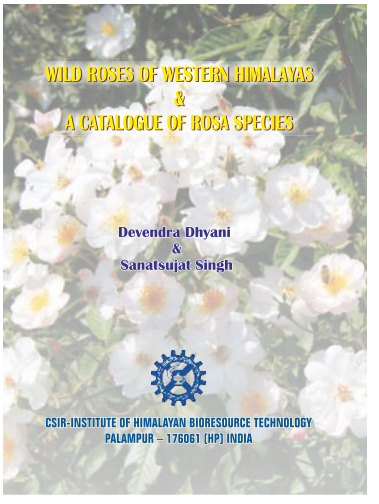
R.K. Sud and Kiran Saini (2016) *Tagetus minuta*, a suitable alternate crop to maize in monkey menace area, Chowari, Chamba, March, 30.

R.K. Sud and Kiran Saini (2016) Importance of aromatic crops in monkey menace agriculture field, lecture organized by an NGO Samarpan, Bhatiyat, Chamba, March 30.

TV TALKS (DOORDARSHAN KENDRA SHIMALA)

- Probir Kumar Pal and R.K. Sud. Stevia cultivation in Himachal Pradesh, 11.06.2015,
- Bhavya Bhargava and R.K. Sud. Gladiolus cultivation in Himachal Pradesh, 12.06.2015
- Gopichand and R.K. Sud. Economic importance, propagation and cultivation of *Crataegus oxycantha*, 16.06.2015
- Bhavya Bhargava and R.K. Sud. Commercial cultivation of gerbera under protected condition. 16.07.2015.
- R.K. Sud. Tea catechins, a potential source of antioxidant Zee TV and ETV channels, 30.06.2015.
- R.K. Sud. Tea plantation management for harvesting quality crop during monsoon period in Kangra Valley. 24.07.2015
- Amit Chawla and R.K. Sud. Current status and conservation needs of medicinal plants in Himachal Pradesh. 04.08.2015
- Rakesh Kumar and R.K. Sud. Economic importance, cultivation and post-harvest management of the medicinal plant Vacha (Sweet Flag or *Acorus calamus*). 28.08.2015.
- Rakesh Kumar. Activities of medicinal and aromatic plants: nursery raising, cultivation and post harvesting TV pogramme Kisanon ke teerth sthal, 19.10.2015.
- Bikram Singh and R.K. Sud. Quality estimation of medicinal and aromatic plants. 06.11.2015
- Om Prakash and R.K. Sud. Importance of bamboo and its propagation. 04.12.2015
- Alka Kumari. Importance of Ferns, 15.12.2016
- Amit Kumar. Bioresource Mapping and Database Development, 15.12.2016
- S.K. Vats. Plant adaptation under climate change scenario, Programme under Swatchh Bharat, 23.12.2015
- R.K. Sud. Adhunik Tirthsthal-CSIR-IHBT, Palampur, 08.01.2016
- Rakesh Kumar. Vacha (*Acorus calamus*) ki unnat kheti, DD Shimla, 23.12.2015 and 15.02.2016.

TECHNICAL FOLDERS/BROCHURE



PATENTS, PUBLICATIONS, TRAININGS, MANPOWER DEVELOPMENT AND SUPPORT ACTIVITIES

PATENT(S) FILED

Ajay Rana, Harsh Pratap Singh and Ashu Gulati. A new energy efficient process for manufacturing of high quality green tea with enhanced flavors. PCT/IN2015/000078.

Reddy SGE and Sahotra S (2015) A novel medium composition for culturing the entomopathogenic fungus, *Lecanicillium lecanii.* Filed for Indian patent, Reference number 0285NF2015 dated 11/1/2016.

PATENT(S) GRANTED

Agnihotri Vijai Kant, Bikram Singh, Garikapati Dyva Kiran Babu, Gopi Chand, Rakesh Deosharan Singh and Paramvir Singh Ahuja. Process for the modification of *Curcuma aromatica* essential oil. date of Patent 30.06.2015. US Patent No. 9,068,141 B2.

Anish Kaachra, Surender Kumar Vats, Paramvir Singh Ahuja, Sanjay Kumar. An expression construct and process for enhancing the carbon, nitrogen, biomass and yield of plants. peoples republic of china (Application No. 201280027891.9; granted 05/11/2015);European patent (No: 269968; granted on 19/08/2015).

Shashi Bhushan, Sakshi Gupta, Garikapati Dyva Kiran Babu, Mohit Sharma,Paramvir Singh Ahuja. Method and apparatus for the separation of seeds from fruit pulp/slurry/pomace, date of Patent 21.04.2015. US Patent No. 9,011,942 B2.

Vijai Kant Agnihotri, Bikram Singh, GD Kiran Babu, Gopichand, Singh, Rakesh Deosharan, PS Ahuja. Process for the modification of Curcuma aromatica Essential Oil. PCT application number PCT/IB2012/050962, dated 01-03-12, US application No. US14/000539, Publication Date: Dec. 12, 2013, Filling date August 20, 2013, Publication No. US2013/0331467 A1, Priority date: 29-03-2013, date of Patent 30.06.2015, US Patent No. 9068141 B2.

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Abiodun OO, Sood S, Osiyemi OA, Agnihotri VK, Gulati A, Ajaiyeoba EO and Singh B (2015) *In vitro* antimicrobial activity of crude ethanol extracts and fractions of *Terminalia catappa* and *Vitex doniana*. *African Journal of Medicine and Medical Sciences*, 44(1): 21-26.

Acharya A, Rawat K, Bhat K A, Patial V and Padwad YS (2015) A Multifunctional magneto-fluorescent nanocomposite for visual recognition of targeted cancer cells. *Materials Research Express*, 2(11).

Agnihotri VK (2015) *Crocus sativus* Linn. : An informative review. *Aperito Journal of Advanced Plant Biology*, 1(1): doi:10.14437/AJAPB-1-103.

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augment reproduction. *Scientifica*, Article ID 4741086, 4 pages dx.doi.org/10.1155/2016/4741086.

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Ahmad N and Anis M (2015) *In Vitro* approaches for conservation and sustainable utilization of *Podophyllum hexandrum* and *Picrorhiza kurroa* - an overview on these endangered medicinal herbs of Western Himalaya. *In: Plant Tissue Culture: Propagation, Conservation and Crop Improvement*, Springer, Singapore.

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Kant K, Agnihotri VK and Ghosh M (2015) Antioxidant guided chemical investigations of picrorhiza kurroa. 13: 978-3-659-70625-7; ISBN-10: 3659706256, pp 68, LAP LAMBERT Academic Publishing , Saarbrücken, Germany.

Reddy SGE, Dolma SK and Bhardwaj A (2016) Plants of Himalayan region as potential source of biopesticides for lepidopteron insect pests. IN: Herbal insecticides, repellents and biomedicines: effectiveness and commercialization (Eds. Vijay Veer and Reji Gopalakrishnan), Springer India.

RK Asrani, Vikram Patial and Meenakshi Thakur (2015) Ochratoxin A: Possible mechanisms of toxicity. IN: Ochratoxins: Biosynthesis, Detection and Toxicity. (Eds. Daniel Porter), 1st Edn, pp. 57-89, Nova Science Publishers, NY.

Sood A, Alpy and Uniyal SK (2016) Biodiversity characteristics of the Western Himalaya. *In* Das and Bera (Eds). *Plant Diversity in the Himalaya Hotspot Region*.

Yadav AK, Kaundal S, Sharma Aand Singh S (2015) Chilling stress tolerance in plants: Physiology and mechanisms. IN: Recent advances in plant stress physiology (Eds. Praduman Yadav and Sunil umar). ISBN 978-93-5124-730-2, pp.-185-199, Astral International (P.) Ltd. India.

Book(s) published

Kumar Sanjay (2015) Technologies for livelihood enhancement. (Eds V.L. Chopra and Sanjay Kumar), ISBN: 978-93-83305-81-0, New India Publishing Agency, New Delhi, India.

SEQUENCE DATA SUBMITTED

Guleria S, Thakur R, Gulati A and Reddy SGE (2016) Entomopathogenic fungus, *Paecilomyces* sp (IHBF-1) isolated from *Spodoptera litura* (Palampur) (Accession No: Ln886694).

Guleria S, Thakur R, Gulati A and Reddy SGE (2016) Entomopathogenic fungus, *Beauveria brongniartii* (IHBF-2) isolated from soil (Mango, Kangra) (Accession No: Ln886695).

Guleria S, Thakur R, Gulati A and Reddy SGE (2016) Entomopathogenic fungus, *Cordyceps brongniartii* (IHBF-3) isolated from grasshopper (Stevia) (Accession No: Ln886696).

Guleria S, Thakur R, Gulati A and Reddy SGE (2016) Entomopathogenic fungus, *Paecilomyces* sp (IHBF-4) isolated from soil (Tea, Palampur) (Accession No: Ln886697).

Guleria S, Thakur R, Gulati A and Reddy SGE (2016) Entomopathogenic fungus, *Beauveria brongniartii* (IHBF-5) isolated from soil (Mango, Kangra) (Accession No: Ln886698).

Guleia S, Thakur R, Gulati A and Reddy SGE (2016) Entomopathogenic fungus, *Beauveria brongniartii* (IHBF-6) *Beauveria brongniartii* isolated from soil (Berseem, Kangra) (Accession No: Ln886699).

ENTREPRENEURIAL PROGRAMMES

Gupta M (2016) Organized one day awareness programme on "Entrepreneurial support in functional food and nutraceuticals through Incubator" in association with Ministry of MSME, Govt. of India, February 27.

Gupta M (2015) One day Industry meet organized on "Food and Nutraceuticals" in association with DSIR, New Delhi for industry linkage development and assessment of their needs, Where 29 industry representative and progressive entrepreneurs participated, CSIR-IHBT, Palampur, August10.

TRAININGS IMPARTED

Vishal Kondal. GNDU, Amritsar (Punjab), 26 May 2015 to 26 June 2015.

Samita Kumari Gene Transformation (Transgenics). Department of Vegetable Sciences and Floriculture, CSK HPKV, Palampur, 14-28 March 2015, Supervised by Dr. Amita Bhattacharya.

Madhu from I.S.F. College Moga, Punjab, 4 January to 5 February 2016.

Rajat Bhardwaj. I.S.F. College Moga, Punjab, 4 January to 29 January 2016.

Pierre Nobosse. TWAS-CSIR fellow under project entitled "Application of Nanotechnology in development of Nutraceuticals intended to the management of oxidative stress, 8 September 2015.

Umar Ahmad Sheikh. School of Biosciences and Biotechnology Baba Ghulam Shah Badshah University, Rajouri, six months M.Sc. Biotechnology dissertation entitled "Exploring the involvement of PI3K/AKT/mTOR pathway in pentylenetetrazol kindled mice model December 2014 to May 2015.

Abu Bakar. 'Basic techniques in Plant Tissue Culture' of Department of Biological Sciences, Usmanu Danfodiyo University, Nigeria, 18-21 May, 2015 under supervision of Dr. Amita Bhattacharya.

Paramjit Singh. Project officer, Potato Centre of Excellence, Jalandhar and Dr. Damandeep Singh, Horticulture Development Officer, Jalandhar on 'Basic techniques in Plant Tissue Culture' to during 13- 17 July 2015, supervised by Dr. Amita Bhattacharya.

25 students of Department of Genetics, CSK HP KV, Palampur on genetic transformation methods 18 December, 2015, supervisced by Dr. Amita Bhattacharya.

CONFERENCE/TRAINING/WORKSHOP/SYMPOSIUM PRESENTATIONS

Thakur M, Asrani RK, Sahrma PK, Patil RD**,** Brij Lal and Omparkash (2016) Traditional usage of ethno-medicinal plants of Kangra and Chamba districts of Himachal Pradesh, India. 3rd International Congress of the Society for Ethnopharmacology: Ethnopharmacology & Evaluation of Medicinal Plants– Global Perspectives, Ravishankar University Raipur, Chhattisgarh, February 19-21.

Mahesh G (2015) Traditional and nutraceutical rich fermented foods of western Himalayan region in 3rd ANNAM National Food and Agro Biodiversity Conference at Kochi, Kerala, December 10-14.

Singh S, Kumar R, Sharma RK, Kumar N and Ahuja PS (2015) Comprehensive agro-biotechnological efforts for genetic improvement and conservation of seabuckthorn (Hippophae L.). Abstract published in the 7th Conference of the International Seabuckthorn Association (ISA 2015) Seabuckthorn Emerging Technologies for Health Protection and Environmental Conservation, NASC Complex New Delhi, India, pp26, November 24-26.

Lal B (2015) Herbal based value added tea for health attributes. seminar on 'Scope and Development of Tea Based Value Added Products and Essential oil / Aromatic and Medicinal Plants' at Ooty, Nilgiris, organized by MSME Department, Government of Tamil Nadu, November 20-21.

CONFERENCES/TRAINING/WORKSHOP/MEETING ATTENDED

Kumar R (2016) "Workshop on High altitude medicinal plants" ICFRE, Dehradun, Uttrakhand, March 21-22.

Singh D (2016) 8th NIPER (RBL)-CSIR-CDRI Symposium on "Current trends in medicinal chemistry and pharmaceutical sciences in drug discovery" NIPER, Raebareli March 18-19.

Patial V (2016) 6th International Symposium on "Current Trends in Drug Discovery Research (CTDDR)", CSIR-CDRI, Lucknow, February 25 -28.

Singh D (2016) 6th International Symposium on "Current trends in drug discovery research" CSIR-CDRI, Lucknow, February 25-28.

Kumar R, Uniyal S and Sreenivasulu Y (2016) "Leadership development programme 4th module" CSIR, HRDC, Ghaziabad, February 22-25.

Kumar A (2016) Attended "31st Induction Training Programme for Scientists" CSIR-HRDC, Ghaziabad, February 1-10.

Singh D (2016) Served as an external examiner for thesis evaluation and conducted dissertation viva-voce of one M. Tech. [Food Technology (Nutragenomics)] student at department of life sciences and technology, Punjab Institute of Technology (PTU main campus), Kapurthala, January 18.

Kumar R, Uniyal S, Sreenivasulu Y and Chawla A (2015) "Leadership development programme 2nd module" CSIR, HRDC, Ghaziabad, December 7-17.

Kumar A (2015) Attended workshop on "The art of public speaking and technical writing". CSIR-HRDC, Ghaziabad, November 18-20.

Lal B (2015) Botanical garden of CSIR-IHBT Palampur – An Introduction national conference Indian Botanic Garden, CSIR-NBRI, Lucknow, November 18–20.

Singh D (2015) 3rd Biennial national conference of indian academy of veterinary nutrition and animal welfare on "Livestock Production-cum-Health and Crop Mixed Farming for Nutritional Security" organized by CSK HPKV, ICAR-IVRI and ICAR-IGFRI stations at Palampur, November 4-5.

Brij L (2015) attended Workshop-cum-Brain storming Session on Current status and future prospects of animal production system in North-West Himalayan region. ICAR-IVRI, Regional Station Palampur during October13-14.

Kumari A (2015) attended National conference on "Cryptogam research in India: Progress and

prospects". CSIR-NBRI, Lucknow, delivered Special Lecture during Pteridophyta session, September 28–29.

Sigh D (2015) Attended board of studies meeting at Chandigarh University and formulate/modify syllabus M.Sc. Toxicology, April 28.

Shivling VD, Sharma SK, Goap A, Ghanshyam C, Arora D, Kumar S and Kumar R (2015) A real time computational and statistical model (with high availability) of early warning for plant protection and pest control for crops (exp.Kutki). IEEE International Conference on Computer Graphics, Vision and Information Security (CGVIS). KIIT University, Bhubaneswar, Orissa, India, November 2-3.

Gireesh Nadda (2015) attended workshop on "Multi-institutional synergy spproach for pesticide related issues in India" at AIIMS, New Delhi, jointly organized by IPFT, Gurgaon and AIIMS, New Delhi, 23 November.

INVITED LECTURES FROM CSIR-IHBT

Dr. Sanjay Kumar (2015) Integrating transcriptomic and metabolomic approaches to understand plant performance under stressful environment: case studies of plants in western Himalayas in DST sponsored "South Africa-India Bilateral Agricultural Biotechnology Workshop" be held during February 23-27, 2015 at NIPGR, New Delhi, February 24.

Dr. Sanjay Kumar (2015) Biotechnological approaches to bioprospecting genes, proteins and plant processes in western Himalaya special lecture on the eve of superannuation of Dr.T. C. Bora, Chief Scientist and Head, Biotechnology Division at CSIR-NEIST, Jorhat, Assam, March 30.

Dr. Sanjay Kumar (2015) Molecular approaches to modulate biosynthesis of natural products of medicinal importance during National Conference on Therapeutic Potential of Natural Products: Current Innovations and Future Trends organized by Department of Genetics, Maharshi Dayanand University, Rohtak-124001, Haryana, March 19.

Dr. Sanjay Kumar (2015) Plant adaptations at high altitude in International Conference on 'Low temperature ccience and biotechnological advances' during 27-30 April, 2015 being organised by Indian Council of Agricultural Research (ICAR), NBPGR in collaboration with Society for Low Temperature Biology (SLTB), UK, Royal Botanic Gardens (RBG), Kew, UK and National Academy of Agricultural Sciences (NAAS), India, April 30.

Dr. Sanjay Kumar (2015) invited in DST Sponsored INSPIRE- 2015 Science Camp to be held at I.S.F. College of Pharmacy, Moga from 26 -30 September, September 28.

Dr. Sanjay Kumar (2015) invited to deliver lecture in "Dr. G.V. Joshi memorial Lecture Award of the Society for the year 2015 during 3rd International plant physiology congress on "Challenges and strategies in plant biology research" to be organized at Jawahar Lal Nehru University, New Delhi, December 11-14.

Dr. Sanjay Kumar (2015) Invited to deliver lecture in INSPIRE INTERNSHIP CAMP organized by CSK HPKV, Palampur, September 15-19

Damanpreet Singh (2015) Alternative to experimental animals: Zebrafish as an ideal model in a Faculty Development Program at Chandigarh University, Mohali, July 13.

Damanpreet Singh (2016) "Natural products as potential therapeutic agents for comprehensive management of epilepsy" in 8th NIPER (RBL)-CSIR-CDRI Symposium on Current Trends in Medicinal Chemistry and Pharmaceutical Sciences in Drug Discovery at NIPER, Raebareli, March 19.

VISITS ABROAD

Dr. Sanjay Kumar: Attended First Egyptian – Indian Workshop on Biotechnology. Academy of Scientific Research and Technology, National Research, Tahrir Str., Dokki, 12311 Cairo, Egypt, October 25-26, 2015.

Dr. Sanjay Kumar: Attended to explore S&T cooperation between CSIR and Taiwan's research institutions and industry. Ministry of Science Technology, Taipei, Taiwan, January 25-29, 2016.

Dr. Sanjay Kumar: Attended CSIR delegation to visit the National Institute of Medicinal Materials (NIMM), Hanoi, Vietnam. April 11-14, 2016.

POSTER PRESENTED

Sharma Supriya, Kulurkar Pankaj, Singh Bikram, Patial Vikram (2016) Nephroprotective effect of Picrorhiza kurroa on cyclophosphamide-induced renal damage in mice. 6th International Symposium on Current Trends in Drug Discovery Research (CTDDR), CSIR-CDRI, Lucknow, February 25-28, p. 347.

PARTICIPATION IN EXHIBITION

Dr. Ashok Kumar: "Agri-Tech India 2015" Bangalore International Exhibition Centre (BIEC), Media Today Pvt. Ltd, August 21-23.

Dr. Sukhjinder Singh and Sh. Vikrant Awasthi. Indian Science Congress- 2016.University of Mysore, Mysore, Karnataka.

PRIZES/ AWARDS/ RECOGNITIONS

Bhavya Bhargava received Best Flower Show, 1st and 2nd prize for CSIR-IHBT in State level Holi Mahotsav Palampur 2016 organized by Department of Horticulture, Himachal Pradesh, 16th March 2016.

Brij Lal has been recognized as a Member of the Editorial Board of the quarterly journal, Indian Journal of Natural Products and Resources (formerly known as *Natural Products Radiance)* for the period of two years i.e. from 1st January 2015 to 31st December 2017.

Brij Lal, Sr. Principal Scientist has been elected as a member of the Executive Council (EC) by the

Society of Ethnobotanists (SEB), Lucknow for the year 2014-2017.

Brij Lal, has been elected as one of the members of the Executive Council of Indian Fern Society (IFS), Chandigarh for the year 2015-16.

Kamal Kant, Mayanka Walia, Vijai K Agnihotri, Vijaylata Pathania, Bikram Singh received the Indian Pharmaceutical Association (IPA) awarded Prof. M. L. Khorana Memorial best paper award (Rs. 10000/- cash and memento) in the field of "Pharmacognosy, Phytochemistry & Alternative Medicine and Pharmaceutical Biotechnology" for the year 2013 to the paper entitled "Evaluation of antioxidant activity of *Picrorhiza kurroa* (leaves) extracts. Paper published in Indian J Pharm Sci, 2013, 75(3):324-9 and the award was given on June 6th, 2015.

Meetu Verma, Aarti Wali, Sumit Dhadwal, Brij Lal, Alka Kumari, Arun K Sinha, Vijai K Agnihotri. "Comparative Estimation of Natural Colors and Dyes from some Selected Pteridophytes Growing in the Western Himalayas." Best Poster award 3rd prize in National Conference on "Modern Approaches to Pteridophytes: Biology, Biodiversity and Bioresource", 2014, 72-73, 20-21 December 2015 at CSIR-IHBT, Palampur, HP, India.

Sanjay Kumar. Professor G.V. Joshi Memorial Lecture Award-2015 awarded by the Indian Society for Plant Physiology for outstanding contributions in the field of Plant Physiology and Cognate Sciences on 12th December, 2015 during 3rd International Plant Physiology Congress, New Delhi

RK Sud. Guest of Honour award by Sri Sai University, Palampur, 18.06.2015.

Shashi Bhushan. Raman Research Fellowship-2015-16.

MEMBERSHIP OF PROFESSIONAL BODIES/ORGANIZATIONS

Damanpreet Sigh nominated as a Life member of Indian Science Congress Association (ISCA, Membership No.: L27062).

THESIS/DISSERTATION/REPORT/SUPERVISED

Ph. D.

Ashwani Jha (2015) Computational analysis of sRNAs and their regulatory system. AcSIR, Supervised by Dr. Ravi Shankar.

Mrigaya Mehra (2016) Computational analysis of complex repeats, miRNAs and their associations. AcSIR, Supervised by Dr. Ravi Shankar.

Sukhjinder Singh (2015) Economics of Herbal Processing Industrial Units of Punjab and Himachal Pradesh. Supervised by Dr. Sharanjit Singh Dhillon, Guru Nanak Dev University, Amritsar.

M. Sc./M. Tech.

Aakriti Verma. Studies on genome wide markers identification in *Stevia rebaudiana* Bert.

University Institute of Engineering and Technology, Kurukshetra University, Kurukshetra, Supervised by Dr. RK Sharma,.

Akash Chaturvedi. Amplification validation studies of Intron length polymorphism (ILP) markers in tea. Jiwaji University, Gwalior, Supervised by Dr. RK Sharma.

Anjali Mishra. Studies on development of polymorphic transcriptome derived microsatellite markers in tea. Jiwaji University, Gwalior, Supervised by Dr. RK Sharma.

Manish Kumar. Validation of SSR markers in *Stevia rebaudiana* Bert. Beant College of Engg and Technoology, Gurdaspur, Supervised by Dr. RK Sharma.

Shikha Kalotra. Studies on basic DNA fingerprinting techniques for plant diversity characterization. Guru Nanak Dev University, Amritsar, Supervised by Dr. RK Sharma.

Suman (2015) Phytoremedian potential of Phragmites karka for chromium contaminated soil. Central University of Himachal Pradesh, Shahpur, Kangra, Supervised by Dr. Brij Lal.

Teenu Bhadiar (2015) Arsenic tolerance and accumulation by gametophytes of the fern Pteris cretica L. Central University of Himachal Pradesh, Shahpur, Kangra, Supervised by Dr. Alka Kumari.

B. Sc./B. Tech.

Anupam Khanoria (2015) In vitro production of corms and cormlets of saffron. School of Bioengineering and Food Technology, Shoolini University, 15th June – 28th August, Supervised by Dr. Amita Bhattacharya.

Tania (2015) Studies on three important ferns for their promotion as potential bioresource(s) of commercial value. SUS College of Engineering Technology, Tangori, Mohali, 2nd February – 28th May, Supervised by Dr. Amita Bhattacharya.

EVENTS

Member of Parliament visits CSIR-IHBT

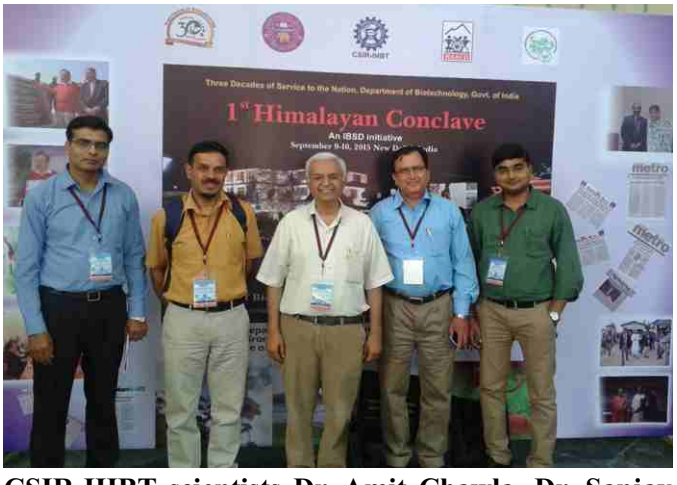
Shri Ronald Sapa Tlau, Hon'ble Member of Parliament of Rajya Sabha from Mizoram and member of Committee on Science & Technology and Environment & Forest, GOI visited CSIR-Institute of Himalayan Bioresource Technology, Palampur on 14 August 2015. The Hon'ble MP was apprised about the various technologies developed by the Institute. He visited different fields and laboratories of the Institutes and interacted with the scientists. He expressed hope that technologies developed by the Institute would also benefit the north-eastern states of the country.

Shri Ronald Sapa Tlau hoisted the national flag at the Institute along with the Dr. Sanjay Kumar, Director of the institute.

First Himalayan Conclave - 2015

The institute co-organized the "First Himalayan Conclave - 2015" on September 9 at University of Delhi in association with Institute of Bioresources and Sustainable Development (IBSD), Department of Botany, University of Delhi and HESCO, Dehradun. More than 300 people from

different parts of the country participated in the conclave. Deliberations were held on saving the Himalayan ecosystem and safeguarding the interests of the local people. A group of scientists along with Dr. Sanjay Kumar, Director, CSIR-IHBT participated in the Conclave.



CSIR-IHBT scientists Dr. Amit Chawla, Dr. Sanjay Uniyal, Dr. Sanjay Kumar, Director, Dr. SK Vats and Er. Amit Kumar in Conclave

National Technology Day

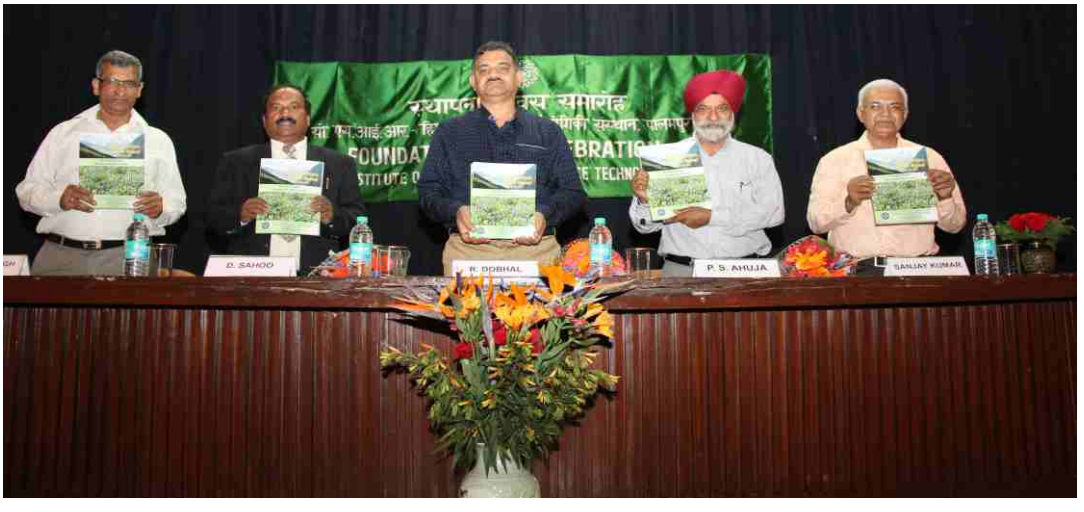
The Institute celebrated the National Technology Day on May 11, 2015. Dr. Javed N. Agrewala, PhD, FNASc, FASc, FNA, Bhatnagar Awardee CSIR-Institute of Microbial Technology, Chandigarh delivered the National Technology Day lecture on "Challenges and Solutions for a Rational Vaccine Design for TB-endemic Regions".

Dr. Bikram Singh, Dr. Javed N. Agrewala and Dr. Arvind Gulati (from left to right)

CSIR Foundation Day

CSIR Foundation Day celebrated on 26th September, 2015. Prof. Dinabandhu Sahoo, Director, Institute of Bioresources and Sustainable Development (IBSD), Imphal delivered Foundation Day lecture on the topic entitled "Role of algae in the changing world". Dr. P.S. Ahuja, Former Director General, CSIR and Former Director, CSIR-IHBT, Palampur was the Guest of Honour and Dr. Rajendra Dobhal, Director General, Uttarakhand State Council for Science & Technology, Dehradun was the Chief Guest of the function.

Dr. Bikram Singh, Dr. Rajendra Dobhal, Dr. Deenbandu Sahoo, Dr. PS Ahuja and Dr. Sanjay Kumar(from left to right)



Releasing of Annual Report- 2014-15 and technical folders

National Science Day

National Science Day celebrated on 28th February 2016. Dr. Satish Kumar Sr. Scientist, JNTBGRI delivered Science Day lecture on "Orchid cultivation, trade and income generation".

Dr. Bikram Singh, Dr. Satish Kumar and Dr. Sanjay Kumar (from left to right)

Students from Navoday Vidyalaya, Paprola, Baijnath visited the labs of the Institute

Students from Navoday Vidyalaya, Paprola, Baijnath with Director of the institute

RESEARCH COUNCIL

Prof. Samir Bhattacharya Former Director, CSIR-IICB, Kolkata Emeritus Professor NASI and Sr. Scientist School of Life Sciences, Visva Bharati (A Central University), Santiniketan- 731 235	**Chairman**
Members	
Prof. Bharat B. Chattoo Professor & Coordinator Biotechnology Programme, Genome Research Centre Dept. of Microbiology and Biotechnology Centre MS University of Baroda, Baroda- 390002	**Prof. Alok Bhattacharya** Professor School of Life Sciences & Computational and Integrative Sciences Jawaharlal Nehru University, New Delhi- 110067
Dr. N. Sathyamurthy Director Indian Institute of Science Education & Research Mohali, Knowledge City, Sector 81, SAS Nagar Manauli PC- 140306	**Prof. S. K. Sharma** Former Vice Chancellor CSK -H.P. Krishi Vishwavidyalaya Shanti Kunj, Ghuggar Tanda, Palampur-176061
Prof. Narpinder Singh Professor Department of Food Science & Technology Guru Nanak Dev University, Amritsar- 143005	**Prof. Sandeep Verma** Department of Chemistry Centre for Environmental Sciences and Engineering Indian Institute of Technology, Kanpur-208016
Dr. Renu Swarup Adviser, Ministry of Science & Technology, Department of Biotechnology, Government of India Block-2, 7th Floor, CGO Complex, Lodhi Road, New Delhi-110003	**Dr. Imran Siddiqi** Chief Scientist CSIR-Centre for Cellular and Molecular Biology Uppal Road, Hyderabad– 500007
Dr. Ram A. Vishwakarma Director CSIR-Indian Institute of Integrative Medicine, Canal Road, Jammu – 180001	**Prof. Siddhartha Roy** Director CSIR-lndian Institute of Chemical Biology 4, Raja SC Mullick Road, Jadavpur Kolkata - 700032
Dr. Jai Rup Singh Founder Vice Chancellor, Central University of Punjab, Bathinda Former Vice Chancellor, GNDU, Amritsar Former President, Indian Society of Human Genetics # 52, Sector 63, Mohali 160 062, India	**Head or his Nominee (Permanent Invitee)** Planning & Performance Division (PPD) Council of Scientific & Industrial Research Anusandhan Bhawan, 2, Rafi Marg New Delhi-110 001
Dr. Sanjay Kumar Director CSIR-Institute of Himalayan Bioresource Technology Post Bag No.6 Palampur-176 061 (H.P.)	**Dr. Aparna Maitra Pati (Member Secretary)** Scientist & Head Planning Project Monitoring & Evaluation CSIR-Institute of Himalayan Bioresource Technology Post Bag No.6, Palampur-176 061 (H.P.)

MANAGEMENT COUNCIL

Chairman	
Dr. Sanjay Kumar Director CSIR- Institute of Himalayan Bioresource Technology Palampur- 176061, Himachal Pradesh.	
Members	
Dr. Ram A. Vishvakarma Director CSIR-Indian Institute of Integrative Medicine Jammu, Jammu & Kashmir.	Dr. Aparna Maitra Pati Senior Principal Scientist CSIR- Institute of Himalayan Bioresource Technology Palampur- 176061, Himachal Pradesh.
Er. GD Kiranbabu Principal Scientist CSIR- Institute of Himalayan Bioresource Technology Palampur- 176061, Himachal Pradesh.	Dr. Yogendra S. Padwad Scientist CSIR- Institute of Himalayan Bioresource Technology Palampur- 176061, Himachal Pradesh.
Dr. Sudesh Kumar Principal Scientist CSIR- Institute of Himalayan Bioresource Technology Palampur- 176061, Himachal Pradesh.	Sh. Mukhtiar Singh Principal Technical Officer CSIR- Institute of Himalayan Bioresource Technology Palampur- 176061, Himachal Pradesh.
Sh. Parag Patar Finance & Accounts Officer CSIR- Institute of Himalayan Bioresource Technology Palampur- 176061, Himachal Pradesh.	**Member Secretary** Sh. Alok Sharma Administrative Officer CSIR- Institute of Himalayan Bioresource Technology Palampur- 176061, Himachal Pradesh.

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राजभाषा विभाग, भारत सरकार एवं परिषद् मुख्यालय द्वारा समय–समय पर जारी निर्देशों के अनुरूप हिन्दी में कार्य करने के लिए उचित वातावरण बनाने और राजभाषा हिन्दी में मूल रूप से कार्य करने को प्रोत्साहित करने के लिए संस्थान में किए गए कार्यों का संक्षिप्त विवरण इस प्रकार है:

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संस्थान में 03 अगस्त 2015 को 02.30 बजे अपरान्ह एक हिन्दी कार्यशाला का आयोजन किया गया। इस कार्यशाला का मुख्य उद्देश्य हिन्दी भाषा का दैनिक कार्यालयी काम–काज में उपयोग करना था। इस कार्यशाला में मुख्य वक्ता डॉ. पूरन पाल, वरिष्ठ हिन्दी अधिकारी, सीएसआईआर मुख्यालय, नई दिल्ली ने 'राजभाषा नीति और हमारा दायित्व' पर संभाषण दिया। डॉ. पाल ने अपने संबोधन में राजभाषा नीति बड़ी सहज एंव सरल भाषा में प्रकाश डाला। उन्होने राजभाषा नीति में विभिन्न प्रावधानों के विषय में बताया और उदाहरण सहित यह भी बताया कि कैसे हम अपने कार्य करते हुये सहज ही राजभाषा का अनुपालन कर सकते है। कार्यशाला में प्रतिभागियों द्वारा हिन्दी भाषा के उपयोग में आ रही कुछ समस्याओं का भी निवारण किया।

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संस्थान में हिन्दी सप्ताह 2015 का मुख्य समारोह 21.09.2015 को संस्थान के सभागार में आयोजित किया गया। समारोह का संचालन करते हुए वरिष्ठ प्रधान वैज्ञानिक डा अपर्णा मैत्रा पति ने हिन्दी दिवस के आयोजन के उद्देश्य तथा संस्थान की राजभाषा संबन्धी गतिविधियों पर विस्तार से प्रकाश डाला।

इस अवसर पर ''पश्चिमी हिमालय का वास्तुशिल्प और खान–पान'' विषय पर प्रतिष्ठित पुरातत्व विशेषज्ञ डा. ओ. सी. हांडा का एक व्याख्यान आयोजित किया गया।

संस्थान के निदेशक डा. संजय कुमार ने संस्थान की गतिविधियों एवं उपलब्धियों के विषय में जानकारी दी। उन्होंने सभी कर्मचारियों से निवेदन भी किया कि संस्थान की यह नीति है कि प्रेरणा, प्रोत्साहन से ही कार्य किया जा सकता है। परन्तु इसका मतलब यह नहीं कि राजभाषा नीति के अनुपालन की अवहेलना की जाए। उन्होंने आशा व्यक्त करते हुए कहा कि भविष्य में संस्थान में राजभाषा नीति के अनुपालन में प्रगति दिखाई देगी।

संस्थान के प्रशासन अधिकारी श्री जगदीश पराशर ने कर्मचारियों को राजभाषा संबन्धी आवश्यक निर्देशों की जानकारी दी तथा सभी से निवेदन किया कि वे अपना अधिक से अधिक कार्य हिंदी में करें। उन्होंने सभी को यह भी जानकारी दी कि संस्थान के सभी कम्प्यूटरों में यूनिकोड डाल दिया गया है तथा अब हिंदी में टंकण संबन्धी समस्या का हल हो गया है, इससे सभी अपना कार्य आसानी से हिंदी में कर सकते हैं।

vkbZ-,p-ch-Vh- lqokn frekgh vkuykbu if=dk

संस्थान ने रजत जयंती वर्ष के उपलक्ष्य में एक ऑनलाइन तिमाही न्यूजलेटर शुरु करने का निर्णय लिया था। इसी क्रम में अब तक इसके 28 अंक संस्थान की वेबसाइट में उपलब्ध हैं। इसके लिए सामग्री जुटाना, टंकण, संपादन एवं वेबसाइट में उपलब्ध कराने का कार्य किया।

oSclkbV v|ruhdj.k

संस्थान की हिन्दी वेबसाइट का अद्यतनीकरण किया गया तथा सामग्री को अनुवाद, टंकण एवं यूनिकोड में करके संस्थान वेबसाइट पर उपलब्ध है।

iLrd] if=dk,a ,oa lanHkZ lkefxz;ksa dk miyC/k djkuk

राजभाषा विभाग, भारत सरकार एवं परिषद् मुख्यालय द्वारा समय–समय पर जारी निर्देशों के अनुरूप हिन्दी में कार्य करने के लिए उचित वातावरण बनाने और राजभाषा हिन्दी में मूल रूप से कार्य करने को प्रोत्साहित करने के लिए हिन्दी में प्रकाशित सहायक सामग्रियों जैसे पुस्तकें, कोश, पत्रिकाएं और अन्य संदर्भ साहित्य संस्थान में उपलब्ध करवाय इसके अतिरिक्त विभिन्न प्रयोगशालाओं/संस्थानों द्वारा प्रकाशित पत्रिकाओं को भी संस्थान में उपलब्ध करवाया गया। इस वर्ष 54000 रुपये की हिंदी पुस्तकों की खरीद की गई। इसके अतिरिक्त प्रशासन में सदर्भ सामग्री भी हिंदी में उपलब्ध कराई गई।

jkt Hkk"kk lacU/kh dk;kZUo;

नए कार्यभार करने वाले कर्मचारियों को राजभाषा नीति एवं संस्थान में राजभाषा अनुभाग के कार्यों के बारे में व्यक्तिगत रूप से अवगत कराना।

हिंदी की तिमाही रिपोर्ट के लिए विभिन्न अनुभागों/प्रभागों से आंकड़े प्राप्त कर रिपोर्ट सीएसआईआर मुख्यालय भिजवाई गई।

राजभाषा कार्यान्वयन की दिशा में वार्षिक कार्यक्रम एवं सीएसआईआर मुख्यालय से प्राप्त निर्देशों के अनुपालन हेतु आवश्यक आदेश जारी किए गए।

संस्थान की राजभाषा कार्यान्वयन समिति की सितम्बर व दिसम्बर 2015 की तिमाही बैठकों को का एजेंडा तैयारी, बैठक का आयोजन, कार्यवृत तैयार एवं परिपत्र एवं कायार्लय ज्ञापन जारी करना।

विभिन्न प्रभागों राजभाषा संबंधी निरीक्षण किया गया तथा उन्हें गाइड किया।

विभिन्न अनुभागों से प्राप्त कागजातों का हिंदी अनुवाद उपलब्ध करवाया गया।

संस्थान में राजभाषा कार्यान्वयन को बढ़ाने के लिए कर्मियों को प्रेरित एवं प्रोत्साहित करने के निमित्त आवश्यकतानुसार समस्त सहायताएं यथा अनुवाद, कम्प्यूटर में यूनिकोड सक्रिय करना आदि कार्य किए गए।

हिंदी के ज्ञान से संबंधित रोस्टर में प्रविष्टियां एवं अद्यतन किया गया।

उच्चाधिकारियों द्वारा समय–समय पर सौंपे गए अन्य कार्य निष्पादित किए गए।

lkfgfR;d dk;ZØe

dfo xks"Bh

संस्थान में 4 अगस्त 2015 को सभागार में कवि गोष्ठी का आयोजन किया गया। इस काव्य गोष्ठी में हिमाचल प्रदेश के साहित्यकारों के अतिरिक्त प्रख्यात कवि रामकुमार आत्रेय (कुरुक्षेत्र) तथा कवि एवं समीक्षक डा. सुभाष

रस्तोगी जीरकपुर (मोहाली) ने भी कविता पाठ किया। नरेश कुमार 'उदास' ने सभी कवियों एवं कवित्रियों का विशेषज्ञता आधारित परिचय दिया। उन्होंने हिन्दी के उत्थान के लिए कवियों, साहित्यकारों के योगदान की प्रशंसा करते हुए कहा कि साहित्यकार भाषा को सरल–सहज तथा लोकप्रिय बनाने में सेतु का काम करते है। इस गोष्ठी में ज्वलंत मुद्दों को आधार बनाकर कवियों ने अपनी रचनाओं के माध्यम से श्रोताओं का मनोरंजन किया।

कवि रामकुमार आत्रेय ने दोहों के माध्यम से नई पीढ़ी को सन्देश दिया। वहीं डॉ. रस्तोगी ने माँ को लेकर सृजित अपनी कविता में माँ की महानता तथा उसकी वास्तविक स्थिति का मार्मिक वर्णन किया। नरेश कुमार 'उदास' ने अपनी कविताओं में मादा भ्रूण हत्या को लेकर प्रश्न उठाए, तथा कविता की गहराई को समझाते हुए कहा, कविताएं सब का भला चाहती हैं वह सब के लिए न्याय माँगती हैं। हंसराज भारती ने अंचल की समस्याओं को उठाते हुए पहाड़ से जुड़ी यादें सांझा की। डा. गौतम व्यथित ने हिंदी भाषा का गुणगान करते हुए अपनी कविता में यह दर्शाया कि हिंदी आज विदेशों में भी लोकप्रिय हो रही है। राजीव कुमार त्रिगर्ती ने मानवीय संवेदनाओं को वर्तमान परिपेक्ष में सुन्दर ढंग से प्रस्तुत किया। प्रकाश चन्द धीमान ने महात्मा बुद्ध की महानता पर कविता पाठ किया।

वहीं कवित्रियों में डॉ. नलिन विभा नाज़ली ने मानव मन की निष्ठुरता की बात की। सुमन शेखर ने 'अनापेक्षित प्रश्न' तथा 'बेटी का जाना' नामक कविताओं में मानवीय सरोकारों, संवेदनाओं को प्रभावशाली ढंग से उठाया । कमलेश सूद ने अपनी कविताओं में मानव को भाईचारा रखने तथा मिल–जुल कर रहने की नसीयत दे डाली।

सुशील गौतम ईलाक्षी ने इंसान के मुखौटेबाजी वाले रूप को लेकर व्यंगयात्मक रचना प्रस्तुत की। कवियत्री अपर्णा धीमान ने ''पिंजरे में कैद पंछी' की कथा–व्यथा को अपनी काव्यात्मक शैली में पढ़ा।

मंच की अध्यक्षता कर रहे मुख्य वैज्ञानिक डॉ. बिक्रम सिंह ने प्रस्तुत की गई सभी कविताओं को सराहा तथा धन्यवाद प्रस्तुत करते हुए प्रशासन अधिकारी श्री जगदीश पराशर ने भी कवियों/कवियत्रियों द्वारा अपने बहुमूल्य समय में से थोड़ा समय निकाल संस्थान में आयोजित कवि गोष्ठी में भाग लेने के लिए आभार व्यक्त किया।

vU; dk;Z

संस्थान द्वारा किये जा रहे शोध कार्यो को आम जनता तक पहुंचाने के उद्देश्य से समाचार पत्रों में विभिन्न लेख प्रकाशित करने हेतु सामग्री उपलब्ध करवाई गई।

संस्थान द्वारा आयोजित किए जाने वाले विभिन्न समारोहों जैसे सतर्कता जागरुकता सप्ताह, कौमी एकता सप्ताह, सद्भावना दिवस, सीएसआईआर स्थापना दिवस, आईएचबीटी स्थापना दिवस, विभिन्न कार्यशालाओं के आयोजनों, निमंत्रण पत्र, विज्ञापन, प्रेस नोट आदि को तैयार करने करके इसे प्रैस–मीडिया को उपलब्ध कराना।

संस्थान के प्रशासन के स्थापना, रिसर्स स्कॉलर संबन्धी कार्य, सामान्य अनुभागों के कार्यों,स्टॉफ क्लब, संस्थान की समितियों से संबन्धित कार्य तथा संस्थान की ओर से लोकप्रिय विज्ञान लेख ''विज्ञान प्रगति' एवं समाचार पत्र में प्रकाशित करने में वैज्ञानिकों का सहयोग किया।

ADMINISTRATION

Administration unit provides support services to R&D activities. Administrative staff has to keep pace with the timely implementation of the R&D activities with an overall goal to realize mandate of CSIR.

Main administrative functions are:

- Recruitments of staff in the institute
- Service matters related to staff
- Security activities
- Housing to employees
- Maintain safe & healthy working environment at the institute
- Liaising with the local and state administration and/or authorities
- Implementation of CSIR directives
- Frame policies as per institutional requirement

Administration has been strongly working towards (i) a cohesive work culture, (ii) timely completion of task time lines so that staff feels motivated in a positive work environment.

FINANCE & ACCOUNTS

Finance & Account section is playing a vital role in the management of finances and providing support to scientific, technical as well as other administrative officials. The division manages the activities of budgetary control and adopts remedial measures for optimum utilization of allocation according to the guidelines of CSIR. In addition to this, it maintains accounts of the institute as per CSIR guidelines and also provides services for effective planning, utilization and post utilization of grants received for, grant-in-aid, sponsored consultancy, collaborative projects and technical services aid.

Broad activities of Finance and Account section are:

- Assist and advise Director on financial, auditing and accounting related matters
- Preparation and compilation of revised estimate and budget estimate of the institute
- Management of financial resources received from CSIR, GAP, Sponsored, CNP & CLP projects
- Ensuring scrupulously implementation of financial directives of the Government of India
- Offering financial concurrence to the proposals developed in the institute
- Keeping liaison with CSIR HQ on financial, accounting and audit related matters
- Co-ordinating the duties related to CAG and CSIR internal audit and providing their

replies

- Authorization of the payment to all suppliers, contractors and service providers
- Authorization of the payment to all employees for their official and personal claims
- Maintenance of various accounting records as per CSIR guideline
- Maintenance of various records of bank debits, credits, DD, NEFT, RTGS, etc
- Finalization of pension, family pension, timely issuance of PPOs and timely payment of pensionary benefits.
- Investment of resources from laboratory reserve funds.

STORES & PURCHASE

The Stores & Purchase section is mainly responsible for procurement of capital equipments from India and abroad, purchase of spares and consumable items, AMCs of equipments, ARC for chemicals, etc. Stores maintain a minimum inventory of routine consumable items. Different teams like Technical & Purchase Committee, Equipment Prioritization Committee and Standing Disposal Committee helps the division in arriving at suitable decisions as per the CSIR Purchase Rules of Goods & Services 2008. The division also co-ordinates activities between indenting, planning, accounts, administration, vendors & various agencies like bank, customs, insurance, transportation, clearing & forwarding agents etc.

The major procurements made during 2015-16

- UFLC/UPLC/UHPLC-MSMS IMS System.
- Hyperspectral Imaging System
- Automated Liquid Handling System
- UPLC/UHPLC/Ultrafast HPLC System
- Pulse Field Gel Electrophoresis
- AKTA Flux 6, Cross Flow system.
- Capillary Electrophoresis
- Cluster for High performance computing and Hadoop.
- Portable Photosynthesis System.
- Hydroponics & Aeroponics system in existing green house.
- Portable Thermal Imaging Camera.
- Apart from above, orders for many other equipments, accessories and spares, office equipments, Chemicals, ARC for supply of specials gases etc. were placed.

BUSINESS DEVELOPMENT AND MARKETING UNIT (BDMU)

Activities of BDMU: Evaluated techno-economic feasibilities of technologies developed by the Institute. Drafted agreements for transfer of technologies. Responded to the queries of farmers/ entrepreneurs regarding different technologies (floriculture, tissue culture, stevia, damask rose, catechins etc.). Evaluated the price for services. Raised expression of interest (EOI) for different technologies (e.g. food products; 1,3 cyclohexane). Facilitated for timely payment of service tax and VAT related to the Institute. Participated in exhibitions for promotion of Institute's technologies. Facilitated more than 500 students for their visit at CSIR-IHBT. Impact assessment studies were undertaken.

Services provided:

A. Agreements: Drafting of Agreements with different Entrepreneurs and evaluation of cost of technology transfer. Agreement signed with the entrepreneurs/ institutions are:

- M/s Agri Natural India, Ludhiana on 18 February 2016
- M/s Root and Flowers, Palampur on 4 February 2016.
- M/s Minocha Industries, Shimla on 4 February 2016.
- M/s Pushp Biotech and Farms, Thana- Bharol, Solan on 10 December 2015.
- M/s Model Floriculture Centre/PCDO, Palampur at Holta, Kangra on 9 October 2015.
- The Institute of Bioresources and Sustainable Development (IBSD), Imphal (Manipur) on 26 September 2015.
- M/s FEEDS, Manipur on 21 August 2015.
- Signed agreement with IAVI on 7th August, 2015

B. Responded the queries of more than 50 farmers/ entrepreneurs for CSIR-IHBT technologies.

C. Participation in Exhibitions for the Promotion of CSIR-IHBT's Technologies

- International Agritech-2015, Bangalore International Exhibition Centre, Bangalore, 21-23 August 2015.
- Divya Himachal- Kisan Mela- 2015, MC Ground, Kangra (HP), 25-27 October 2015.
- Indian Science Congress-2016, University of Mysore, 3-7 January 2016**.**
- Holi Festival-2016, Palampur (HP), 22-25 March 2016.

COMPUTER CELL

IHBT has campus wide network facilities over the fiber backbone with a fleet of servers from HP, IBM and Supermicra. Under National Knowledge Network dedicated 1 Gbps leased line has been provided for internet facility throughout the campus including hostel and faculty residences.

Implemented centralized wireless solution in the Institute enabling users an easy access to internet

irrespective of location within the campus.

Network security hardware like Unified Threat Management Solutions, IDS, IPS, centralized wireless controller, anti-virus on client server based model and SMTP spam/virus protection software etc, and its policies have been deployed to protect IHBT resources centrally.

Constant support was lent for in-house management of IHBT DNS (Domain Name Server), WEB, Email and Proxy servers on Linux. Also facilitated Virtual Classroom and Video-Conferencing facilities for the Institute.

As a routine job this cell constantly extended services related to network, computers and peripherals over Local Area Network in the campus.

LIBRARY: IHBT-KNOWLEDGE RESOURCE CENTRE (IHBT-KRC)

A range of knowledge resources in library of the institute includes research journals in online & print mode, books, subject encyclopedias, research reports, online & CDs databases, theses in the field of science and technology. Library is support research and academic activities of the institute with a range of services including reference and consultation, circulation, document delivery, resource sharing, information alert, user awareness using ICTs for web based library management and its services, which resulted in new knowledge generation by researchers in this institute. Information was on impact factor of journals, publishers' guidelines to authors, publishing policy of journals for selecting quality journals to publish their research articles. Assistance was also provided to S&T staff for online submission of research articles.

Library also has a good collection of books in Hindi language containing books on general reading such as social science, science, biographies, literature, etc. Records of the whole collection of the library have bibliographic information in KOHA software of library management with hyper links if that record is available on internet and can be accessed over internet through- http://library.ihbt.res.in.

Library OPAC: The Online Public Access Catalogue (OPAC) is accessible on IHBT Website to search all the bibliographic records available in the Library database through Koha software. It allows on-line reservation, renewal and recommendation for new resources, besides indicating status of a particular document. It is searchable by keywords, author, title, accession number, subject etc. at http://10.10.1.31/ in addition to link in library website.

National Knowledge Resource Centre (NKRC): NKRC is a national consortium of CSIR and DST libraries with the aim to provide a wide range of quality knowledge resources. The library has been the founder member of this consortium. Scientists and scholars of the institute are being facilitated access to 2500+ e-journals of all major publishers, patents, standards, citation and bibliographic databases through this consortium. Apart from licensed resources, NKRC is also a single point entity that provides its users with access to a multitude of open access resources. The

consortium envisions emerging as a leader to serve the R&D sector with much needed information to strengthen the research and development system in the country (http://nkrc.niscair.res.in/indexpage.php).

Citations: Citations reports were prepared for research articles and made available to scientists of the institute aiming to assess the impact of research done and published by them. This work was done by using the international resource like Web of Science, SciFinder and google scholar.

User orientation: Orientation to new users on access of online journals and databases was provided enabling them to use resources more widely and effectively.

Reference Service: Queries related to journal articles, specific topics are being attended to with print and online resources. Bibliographic as well as full text of reference are also provided from the library.

Photocopy and printing service: Printing requirements for relevant documents such as official documents, project proposals, project reports by scientists, scholars and staff of the institute. Binding documents is also being facilitating from the KRC.

Newspapers clipping service: Library is subscribing 16 daily newspapers in Hindi and English. All the newspapers subscribed are scanned and marked important news items for further dissemination to scientists for information. Library is managing Newspaper Clippings Blog at-http://ihbtinnews.blogspot.in/

During the year, Library was visited by 4865 visitors including scientists, students, research scholars, faculty members from several academic and R&D institutions to consult library resources in addition to about 1 lakh accesses from online resources. Photocopying/ laser printing service were one of important services offered by the library and provided more than 5.25 lakhs of pages of photocopies/ printing to the scientists, research scholars and staff of the institute.

PHOTOGRAPHY UNIT

This unit provides a comprehensive photographic and videography services in the Institute, which includes recording research activities both in the labs as well as in the demonstration plots for all the scientists and scholars. It strives to achieve the highest standards using traditional skills and modern technologies with high production values and commitment to quality to ensure best reproduction in theses and publications.

The collection and preservation of photographic images includes photographs of field trials at different intervals as well as special videography of the field experiments. In addition to providing direct support to research and development activities, the

unit covers activities of all the official functions, trainings, workshops, conferences and symposia organized in the Institute.

It also caters to the requirement for television programmes by scientists depicting their field & lab activities, demonstration/experimental plots and field surveys along with interviews with farmers and entrepreneurs those are provided with the technologies from the Institute. Regular assistance rendered to design cover page of annual reports, brochures of prosessing technologies, in-house manthan magazine, book tissue culture, banners & certificates to the participants in trainings, workshops, conferences, symposia, invitation & greeting cards, posters of research activities and labels for lab products. Technical support provided in making short film related to CSIR-IHBT technologies, activities and products such as:

i. चाय से केटेकिन (Catechin) बनाने की तकनीक
(https://www.youtube.com/watch?v=mpD7TzBWC70)
ii. Herbal sweetener from stevia(https://www.youtube.com/watch?v=_Wm13_xst9s)
iii. Virus free apple rootstocks (https://www.youtube.com/watch?v=mc282jhXFCg)
iv. Bamboo the green gold (https://www.youtube.com/watch?v=Qruu7nr0HVQ)
v. A unique novel enzyme super oxide dismutase(https://www.youtube.com/watch?v=M93ucaTtHZw)

STAFF

SCIENTIFIC

Director

Dr. Sanjay Kumar

Dr. Gireesh Sahni

(18.05.2015 to 10.06.2015)

Dr. Anil Sood, Acting Director

(01.01.2015 to 30.04.2015)

Chief Scientist

Dr. Bikram Singh

Dr. Virendra Singh

Dr. Anil Sood

Dr. Arvind Gulati

Sr. Principal Scientist

Dr. Devendra Dhayani

Dr. Ashu Gulati

Dr. Brijlal

Dr. RK Sud

Er. KK Singh

Dr. (Ms.) Aparna M. Pati

Dr. (Ms.) Amita Bhattacharya

Principal Scientist

Er. GD Kiran Babu

Dr. Gopi Chand

Dr. S.K. Vats

Dr.Vipin Hallan

Dr. Sanjay K. Uniyal

Dr. R.K. Sharma

Er. Amit Kumar

Dr. Y Sreenivasulu

Dr. Sudesh Kumar

Senior Scientist

Dr. Sanat Sujat Singh

Dr. Rakesh Kumar

Dr. Shashi Bhushan

Dr. Pralay Das

Dr. Rituraj Purohit

Dr. Sushil Kr. Maurya

Dr. Dharam Singh

Scientist

Dr. Gireesh Nadda

Dr. Vijai Kant Agnihotri

Dr. Ravi Shankar

Dr. Probir Kumar Pal

Er. Mohit Sharma

Dr. Amit Chawla

Dr. Ashok Kumar

Dr. SGE Reddy

Dr. Mahesh Gupta

Dr. Yogendra S Padwad

Dr. Amitabha Acharya

Dr. Dinesh Kumar

Dr. Vikram Patial

Dr. Manoj Kumar

Dr. Damanpreet Singh

Dr. Vishal Acharya

Dr. Ashok Singh

Dr. Upendra Sharma

Dr. Bhavya Bhargava

Dr. Kunal Singh

Dr. Ashish Rambhau Warghat (10.12.2015)

Dr. Rajiv Kumar (16.12.2015)

Dr. Narendra Vijay Tirpude (02.02.2016)

Junior Scientist

Dr. Partha Ghosh

TECHNICAL

Principal Tech. Officer

Dr. Raja Ram

Sh. Mukhtiar Singh

Sr. Technical Officer (3)

Sh. Om Prakash

Sh. RS Shekhawat

Dr. Sukhjinder Singh

Sr. Technical Officer (2)

Dr. Robin Joshi

Dr. (Ms.) Kiran Devi (12.06.2015)

Sr. Technical Officer (1)

Dr. Avnesh Kumari

Sh. Vikrant Gautam

Sh. Jai Prakash Dwivedi

Dr. Kiran Singh Saini

Sh. Ramdeen Prasad

Sh. JS Bisht

Dr. Rajneesh

Dr. Pankaj K Markand

Sh. Shiv Kumar

Sh. Bijan Bihari Garnaik

Technical Officer

Sh. Vivesh Sood

Sh. Mahesh S

Sh. Ramjeelal Meena

Sh. Mohit K Swarnkar

Sh. Jasbeer Singh

Sh. Om Parkash

Ms. Vijay Lata Pathania

Sh. Pabitra Gain

Technical Assistant

Ms. Meenakshi

Sh. Arvind Kumar Verma

Sh. Anil K Choudhary

Sh. Dharmesh Kumar

Sh. Pawan Kumar

Sh. Virat Abhishek

Mrs. Rimpy Diman

Sh. Saurabh Sharma

Sr. Technician(2)

Sh. Khushal Chand

Sh. Dhruv Kumar

Sh. Om Prakash

Sh. Bhushan Kumar

Sh.VS Dhadwal

Sh. Dhruv Kumar

Sh. Ajay Parmar

Sh. Karandeep

Sh. Ramesh Kumar

Sh. Parveen Kumar

Sh. Kuldip Singh

Technician(2)

Sh. Harmesh Chand

Sh. Sanjay Kumar

Sh. Avinash C. Rana

Sh. Sandeep Sood

Sh. Ranjeet Singh

Sh. Ajay Kumar

Technician (1)

Sh. Surjeet Singh

Sh. Arvind Kant

Sh. Vikas Kumar

Ms. Jasveer Kaur

Lab Assistant

Sh. Naresh Kumar

Sh. Amar Singh

Lab Attendant Gr. I(2)

Sh. Baldev Singh

Ms. Rajni Devi Chettri

Sh. Rakesh Chand

Ms. Anupama Saini

Sh. Shamsher Singh

Sh. Uttam Chand

Sh. Balak Ram

Lab Attendant Gr. I(1)

Sh. Girja Nand

Sh. Deepak Sood

Sh. Kuldip Singh

Sh. Balwant Raj

Engineering service

Assistant Executive Engineer

Sh. Sandeep Tripathi

Sh. Rakesh Kumar

Sh. Anil Kumar

Assistant Engineer

Sh. Mukesh Gautam

ADMINISTRATION

Administrative Officer

Sh. JK Prashar (upto 15-10-2015)

Sh. Alok Sharma (from 23-11-2015)

Section Officer (G)

Sh. SD Rishi

Sh. Amarjeet

Assistant (GEN) Gr. I

Sh. Raj Kumar

Sh. Parveen Singh

Sh. Devraj Nagina

Sh. Ved Prakash

Sh. Keerti Raj

Ms. Santosh Kumari

Assistant (GEN) Gr. II

Sh. Baldev

Sh Kiran Kumar

Ms. Pooja Awasthi

Private Secretary

(Vacant)

Senior Stenographer

Sh. Didar Singh Patial

Senior Hindi Translator

Sh. Sanjay Kumar

Security Assistant

Sh. Trilok Nath

Coupon Clerk

Sh. Anand Sharma

Staff Car Driver

Sh. Pratap Chand

Sh. Braham Dass

Sh. Lakhvinder Singh

Sh. Nitesh Kumar

Cook

Sh. Oman Singh

Sh. Karan Singh

Chowkidar

Sh. Ramesh Kumar

Sh. Baleshwar Prasad

Sh. Kuldip Singh

Sh. Bhawani Ram

Sh. Devinder Singh

Tea/Coffee Maker

Sh. Bipan Gurang

Others

Sh.Thaman Bahadur

Ms. Rujala Devi

Sh. Shankar

Sh. Bipan Kumar

FINANCE & ACCOUNTS

Finance & Accounts Officer

Sh. Ishwar Das (upto 30-10-2015)

Sh. Parag Patar (from 15-11-2015)

Section Officer (F&A)

Sh. Darshan Singh

Assistant (F&A) Gr. I

Sh. Manoj Kumar

Sh. Vipan Kumar

Sh. Vikash Patiaya

Assistant (F&A) Gr. II

Ms. Aruna Kumari

STORE & PURCHASE

Store & Purchase Officer

Sh. SD Rishi, Incharge (S&P) on 11.11.2015-31.03.2016

Sh. SP Prabhakar (upto 10.11.2015)

Section Officer (S&P)

(Vacant)

Assistant (S&P) Gr. I

Smt. Vimla Devi

Sh. Rajeev Sood

Assistant (S&P) Gr. II

Vacant

Assistant (S&P) Gr. III

Sh. Bhadur Ram

Transferred to CSIR Laboratories and Other Establishment :

Dr. Yogesh Balkrishen Pakade transferred to CSIR-NEERI, Nagpur on 30.06.2015

Sh. Vikas Patiaya, Assistant Gr.I (F&A) transferred to CSIR-IIIM, Jammu on 05.01.2016

Sh. J.K. Prashar, A.O. transferred to CSIR-CSIO, Chandigarh on 16.11.2015

Sh. S.P. Prabhakar, S.P.O. transferred to CSIR-CDRI, Lucknow on 10.11.2015

Sh. Ishwar Dass, F&AO transferred to CSIR-IMTECH, Chandigarh on 30.10.2015

Sh. Nand Lal, Group 'C' Non Tech. transferred to CSIR-IMTECH, Chandigarh on 04.03.2016

Superannuation

Dr. Anil Sood, Chief Scientist on 30.04.2015

Sh. Ramesh Kumar, Group 'C' Non Tech. on 30.04.2015

Smt. Vimla Devi, Asstt. Gr.I (S&P) on 1.05.2015

Dr. Virendra Singh, Chief Scientist on 1.08.2015

Sh. Om Prakash, Sr. Tech. (2) on 31.08.2015

Sh. D. Dhyani, Sr. Pr. Sct. on 30.09.2015

Dr. Raja Ram, P.T.O. on 30.09.2015

Sh. Harmesh Chand, Tech. (2) on 30.09.2015

Sh. Bhushan Kumar, Sr. Tech. (2) on 30.09.2015

Sh. Bahadur Ram, Asstt. Gr.III (S&P) on 30.09.2015

Sh. Naresh Kumar, Lab. Assistant on 30.09.2015

Dr. Arvind Gulati, Chief Scientist on 31.01.2016

Sh. Khushal Chand, Sr. Tech. (2) on 31.01.2016

Sh. Dharub Kumar, Sr. Tech. (2) on 31.01.2016

Resigned

Dr. Anil Kumar Singh, Scientist

Sad demise

Dr. Neeraj Kumar, Senior Scientist expired on 28.03.2016

Scientist Emeritus

Dr. S.K. Sharma

Dr. O.P. Sharma

Scientist Fellow

Dr. Alka Kumari

Dr Ajay Rana

Dr. Ugir Hossain SK

Dr. Tanuja Rana

DST INSPIRE Faculty

Dr. Rakshak Kumar

DST Young Scientist

Dr. Sandeep Rawat

Dr. Rohit Sharma

Dr. Rakesh Kumar

Research Fellow

Mr. Himanshu Sharma

Ms. Ruchi Sharma

Mr. Sunny Dhir

Mr. Rahul Mohan Singh

Mr. Saurabh Sharma

Mr. Gulshan Kumar

Ms. Amita Kumari

Mr. Surinder Kumar

Mr. Nitul Ranjan Guha

Ms. Prithu Pratibha

Ms. Shashi Kiran

Ms. Mrigaya Mehra

Ms. Sushila Sharma

Mr. Aditya Kulshresta

Ms. Vandna Chawala

Mr. Jai Parkash

Mr. Sandeep Kumar

Ms. Shikha

Ms. Parul Goel

Mr. C.Bal Reddy

Mr. Manoranjan Kumar

Mr. Vishal Sharma

Ms. Preeti

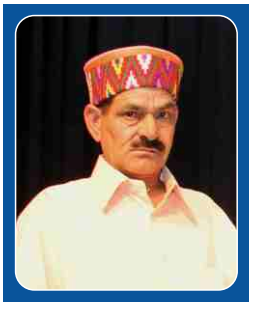
Ms. Monika Bhuria

Mr. Ajay Kumar

Ms. Poonam Roshan
Ms. Indu Gangwar
Ms. Shivalika Pathania
Ms. Kiranman Singh Rawat
Ms. Madhu Kumari
Ms. Vandna Thakur
Ms. Bharti Lalhal
Mr. Vinod Bhatt
Mr. Saurabh Sharma
Mr. Ashish Kumar
Ms. Shruti Bhardwaj
Mr. Bhuvnesh Sareen
Mr. Ashish Kumar
Mr. Gagandeep Singh
Mr. Maheshwar Singh Thakur
Ms. Nisha Dhiman
Mr. Ganesh P Panzade
Mr. Dinesh Thakur
Mr. Sourabh Soni
Ms. Rubbel Singla
Mr. Roushan Kumar
Mr. Maheshwar Singh Thakur
Ms. Tanvi Sharma
Mr. Aridam Ghosh Majumdar
Mr. Manpreet Sharma
Mr. Inder Singh
Mr. Pradeep Singh
Ms. Poonam Bharti
Mr. Dhanjay Bhattacharjee
Ms. Shobha Mehra
Ms. Shivali Rana
Mr. Maneet Rana
Ms. Shivani Sharma
Mr. Rakesh K Singh
Ms. Meenakshi Thakur
Mr. Rakesh Kumar

Staff Superannuated

Dr. Anil Sood
Chief Scientist
on 30.04.2015

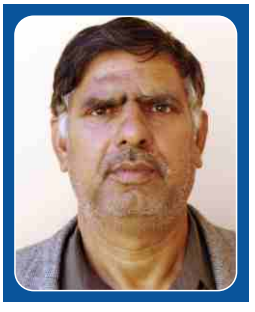


Sh. Ramesh Kumar
Gr'C'Non-Tech.
30.04.2015

Smt. Vimla Devi
Assistt Gr.I (S&P),
31.05.2015

Dr. Virendra Singh
Chief Scientist
on 31.08.2015

Sh. Om Prakash
Senior Technician (2)
on 31.08.2015



Sh. Bhushan Kumar
Sr. Technician (2),
30.09.2015

Sh. D. Dhyani
Sr. Principal Scientist,
30.09.2015

Sh. Harmesh Chand
Technician (2),
30.09.2015

Sh. Naresh Kumar
Lab. Assistant,
30.09.2015

Staff Superannuated

Sh. Bahadur Ram
Assitt Gr.III (S&P),
30.09.2015

Dr. Raja Ram
Pr. Technical Officer,
30.09.2015

Dr. Arvind Gulati
Chief Scientist,
31.01.2016

Sh. Dharub Kumar
Sr. Tech. (2),
31.01.2016

Sh. Khushal Chand
Sr. Technician (2),
31.01.2016

वार्षिक प्रतिवेदन का सार

औषधीय, सगंध और व्यावसायिक महत्वपूर्ण पादप कृषि प्रौद्योगिकी

संस्थान पश्चिमी हिमालय क्षेत्र एवं साथ लगते मैदानी क्षेत्रों में ग्रामीण विकास के लिए विभिन्न कार्यक्रमों द्वारा योगदान दे रहा है जिसमें उच्च तुंगता क्षेत्र में परम्परागत एवं फसलों के लिए मूल्यवर्धन का कार्य कर रहा है। चाइना हाइब्रिड चाय की उत्पादकता एवं गुणवत्ता के सुधार हेतु परामर्श सेवाएं भी प्रदान कर रहा है।

व्यावसायिक महत्व के कर्तित पुष्प फसलों के प्रबन्धन के लिए कृषि तकनीक और फसलोपरान्त प्रबन्धन

- सगंध तेल उत्पादन की तकनीक का प्रदर्शन
- चाय मशीनीकरण का प्रदर्शन
- मिजोरम में सेब के पौधों को लगाया गया।
- जिला ग्रामीण विकास अभिकरण के साथ सहयोग
- सगंध फसलों की खेती के विकास की संभावना

संबहन भट्ठा द्वारा बांस की लकड़ी के कोयला का उत्पादनः इस वर्ष भी बांस की लकडी के कोयले के रूपांतरण का कार्य जारी रहा। विभिन्न बांस की प्रजातियों को संबहन भट्ठा द्वारा लकड़ी के कोयले के रूप में रूपांतररित एवं उसकी उपयोगिता का परीक्षण किया गया। पांच क्विंटल बांस की लकड़ी का कोयला तैयार किया गया। जिसमें 76–85% कार्बन पाया गया। इसके अलावा 1000 किलो ग्राम पीसे हुए बांस के कोयले के चूर्ण को मै. यूनीफेक्ट लिमिटेड, (M/s Unifect Limited, UK) ब्रिटेन के द्वारा प्रसाधन सामग्री निर्माण कंपनी M/s Body Shop UK को पांच डालर प्रति किलो के दर से निर्यात किया गया। इस वर्ष भी 500 किलो ग्राम कोयले के चूर्ण की मांग कंपनी द्वारा प्राप्त हुई है। इसके लिए भी बांस के कोयले का निर्माण किया है एवं 200 माइक्रोन पाउडर में चूर्णित किया गया है। इस चूर्णित कोयले को 50–70 माइक्रोन पाउडर में चूर्णित करने का प्रयास जारी है जिससे अन्य कार्यों में इसकी उपयोगिता का पता किया जा सके। बांस के विभिन्न भागों को जैविक कोयला एवं सक्रियित कोयला निर्माण के लिए एक संयंत्र का प्रारूप का निर्माण किया जा रहा है जिसमें कोयला निर्माण का तापमान 800 डिग्री सेल्सियस से ज्यादा होगा और दूषित भाप और धूआं की मात्रा मे कमी होगी एवं वातावरण शुद्ध रहेगा।

स्टीविया प्रजनन

स्टीविया में नई किस्मों के विकास के लिए प्रजनन द्वारा नई पौध तैयार की गई जिसमें रेबौडिओसाइड–ए के लिए चयन किया जाएगा। चयनित पौधो को खेत में दो वर्षो तक मूल्यांकन के बाद उपयुक्त पाए जाने पर नई किस्म के रूप में विकसित किया जाएगा।

कैला लिली प्रजनन

प्रजनन कार्यक्रम द्वारा तैयार हाइब्रिड कैला लिली पौधों में पुष्प विशेषताओं जैसे कि फूलों के आकार, उपज तथा गुणवत्ता में बदलाव पाया गया। विकसित हाइब्रिड पौधों का पॉलीहाउस तथा खेत में मूल्यांकन किया जा रहा हैं।

जरबेरा प्रजनन

नियन्त्रित प्रजनन कार्यक्रम द्वारा तैयार हाइब्रिड जरबेरा पौधों में विभिन्न पुष्प विशेषताओं में बदलाव पाया गया। विकसित हाइब्रिड पौधों का मूल्यांकन खेत में दो वर्षों तक किया गया एवं चयनित हाइब्रिड पौधों को व्यवसायिक खेती के लिए उपयुक्त पाया गया। जरबेरा की नई किस्मों को ऊतक संवर्धन द्वारा परवर्धन किया जा रहा है ।

स्टीविया

जब स्टीविया में पौध से पौध दूरी (45 सें.मी.X 45 सें.मी. और 60 सें.मी. X 45 से.मी.) व खरपतवार नियंत्रण (कंट्रोल, खरपतवार

मुक्त, हाथ द्वारा निराई, पेंडीमिथलीन + 1 हाथ द्वारा निराई और ऑक्सीफ्लोरफेन +1 हाथ द्वारा निराई) की जाँच की गयी, तब पाया गया कि स्टीविया की पौध को 45 से.मी. x 45 से.मी. पर लगाने व पेंडीमिथलीन स्प्रे के एक महीने के बाद हाथ द्वारा निराई से स्टीविया के जैव-भार (बायो-मास) में अन्य स्थितियों की अपेक्षा एक महत्वपूर्ण ढंग से बढ़ोतरी हुई। हाईपेरिकम परफ़ोरेट्म के विकास व उपज के ऊपर वातावरण स्थितियों का अध्ययन करने के लिए नवम्बर 2015 में फ्री-एयर कार्बन-डाईऑक्साइड वृद्धि (फ़ेस) व फ्री-एयर तापमान वृद्धि (फेटी) व दोनों (फ़ेस + फेटी) में परीक्षण किया गया। पौधों की लम्बाई में फेटी में 30 व 60 दिन के बाद वृद्धि पायी गयी। साथ ही में 30 दिन के अनावरण पर फेटी में पत्तों की संख्या में भी अन्य स्थितियों की तुलना में बढ़ोतरी देखी गया। देश के विभिन्न भागों से हिपोफिया सेलिसीफोलिया को एकत्रित कर हिफोपी जर्मप्लास्म केन्द्र रिबलिंग, केलांग, लाहौल-स्पीति को समृद्ध बनाया गया। लगभग 43 प्रजातियाँ उतराखंड व 17 प्रजातियाँ सिक्किम से एकत्रित की गयी। जिन्सेंग के प्रदर्शनी प्रक्षेत्र जो कि शांशा गाँव, तहसील केलांग, लाहौल-स्पीति में है, पौधों के वृद्धि व विकास का विवरण लिया गया।

कीटविज्ञान प्रयोगशाला

कीटविज्ञान प्रयोगशाला में कीड़ों के सूक्ष्मजीवियों के विलगन व लक्षणचित्रण की दिशा में कार्य शुरू किया है, ताकि औद्योगिक रूप से महत्वपूर्ण एंज़ाइम्स बनाए जा सकें। साथ ही में हम सूक्ष्मजीवियों (वाइरस व फंजाई) पर आधारित जैवकीटनाशक बनाने की दिशा में कार्य कर रहे हैं। हमारे समूह ने औषधीय, सगंध एवं व्यावसायिक महत्वपूर्ण पौधों को हानि पहुँचाने वाले कीड़ों व माईट्स के नियंत्रण के लिए परामर्श सेवाएं प्रदान की है।

दमस्क गुलाब दुनिया में सबसे उच्च मूल्य आवश्यक तेल उत्पादन पौधों में से एक है। हालांकि, फूल की उपज और तेल की मात्रा पर छंटाई प्रणाली और मैग्निशियम सल्फेट MgSO4 के प्रभाव के बारे में जानकारी अभी भी अनसुलझी है। इस प्रकार, एक प्रयोग के दो छंटाई प्रणाली (पूर्ण और आंशिक) और पाँच स्तरों के मैग्निशियम सल्फेट MgSO4 (नियंत्रण के रूप में पानी स्प्रे, MgSO4 @ 5-0, 10-0, 15-0, और 20-0 ग्राम/ली शामिल) संचालित किया गया था। आंशिक छंटाई प्रणाली से पूर्ण छंटाई प्रणाली की तुलना में अधिक फूल उत्पादन किया। MgSO4 @ 15-0 ग्राम/ली. स्प्रे से नियंत्रण के साथ तुलना में 26-38% अधिक फूल उपज दर्ज की गई। स्टीविया फसल उत्पादन प्रणाली में संरक्षण कृषि अभ्यास के प्रभाव का मूल्यांकन पश्चिमी हिमालय क्षेत्र में किया गया है। आकड़ों के विश्लेषण से पता चला है कि पारंपरिक प्रथाओं की जुताई से शून्य जुताई प्रथाओं की तुलना में लगभग 22–50% सूखी पत्ती उपज (टन/हेक्टेयर) में वृद्धि हुई।

स्टीविया प्रजनन

पोलीप्लोइड स्टीविया सी.एस.आई.आर–आई.एच.बी.टी.–एस.टी.–03 (सी.–7–3–4) का मूल्यांकनः टेट्राप्लोइड स्टीविया जीनोटाइप बीज को 24 घंटे के लिये 0.6% बक्सबीपबपदम कोलचिशिन के द्वारा उपचार से विकसित किया गया। पोलीप्लोइड स्टीविया जीनोटाइप सी.एस.आई.आर–आई.एच.बी.टी.–एस.टी.–03 (सी.–7–3–4) स्टीविया से फ्लो साइटोमेट्री के माध्यम से प्रतिष्ठित किया गया और जड़ टिप कोशिकाओं में गुण सूत्र गिनती द्वारा टेट्रोप्लोइड स्थिति की पुनः पुष्टि की। जीनोटाइप सी.एस.आई. आर–आई.एच.बी.टी.–एस.टी.–03 (सी.–7–3–4) का रुपात्मक गुणों के साथ ही जैव रासायनिक लक्षणों के लिए भी मूल्यांकन किया गया।

गुलदाउदी प्रजनन

गुलदाउदी के अनुवांशिक सुधार द्वारा नवीन फूल रंग, आकार और प्रकार के लिए विविध जननद्रव्य के बीच 78 संकरण किए गए। संकरण विधि द्वारा तैयार किया गया संकरण एफ–1 के बीजों को गमलों में उगाया गया। इन उगाए गए एफ 1 संकर पौधों में से फूल के रंग, आकार और प्रकार के आधार पर 16 एफ–1 संकर पौधों का चयन किया गया। इन चयनित पौधों का आगे गुणन और मूल्यांकन भी किया जाएगा।

गेंदा प्रजनन

गेंदे के अनुवांशिक सुधार के लिए संकरण और चयन विधि द्वारा 99 प्रजनन लाइनों का विकास किया गया। इन चयनित प्रजनन लाइनों का 2014–15 और 2015–16 के दौरान दो सत्रों के लिए रूपात्मक कृषि लक्षणों के लिए मूल्यांकन किया गया।

कीट प्रबंधन के लिए जैव कीटनाशकों का विकास

हमारा शोध समूह मुख्य रूप से कीटों प्रबंधन के खिलाफ माइक्रोबियल कीटनाशकों के विकास के लिए पश्चिमी हिमालय क्षेत्र में कृषि, बागवानी और वन पारिस्थितिकी तंत्र से कीट शवों और मिट्टी के नमूनों से देशी नस्लों के एंटमोपथोजेनिक कवक (ईपीएफ) कीट के अलगाव और लक्षण वर्णन पर काम कर रहा है। हम हिमालय वनस्पति को लक्ष्य बना कर उनके कीटनाशी गुणों का क्रमश: डियमोंईक्क मोथ, प्लुटेलला क्ष्यलोस्टेल्ला; तंबाकू कमला, स्पोडोप्टेरा लिटुरा; एफिड, आफिस क्राशिवोरा कीटों के खिलाफ उनका अध्ययन कर रहे हैं। हमारा शोध समूह औषधीय पौधों को लक्ष्य बनाने वाले कीटों के जीव विज्ञान और जीवन चक्र पर ऊंचे तापमान और कार्बन डाइऑक्साइड के प्रभाव पर भी काम कर रहा है।

हाल के वर्षों से पहाड़ी राज्यों में कृषि के विविधिकरण के लिए बहुत बल दिया गया है। पहाड़ी क्षेत्रों में विभिन्न प्राकृतिक जलवायु परिस्थितियां फूलों की खेती के लिए लिए बेहतर अवसर प्रदान करते हैं जो कि बाज़ार में बेमौसमी (ऑफ सीजन) फूलों के रूप में बिकता है।

ऑर्किडस की कृषि प्रौद्योगिकी का विकास दुनिया के फूलों के बाजार में ऑर्किड पुष्प एक महत्वपूर्ण हिस्सा बन गया है। ऑर्किडस को कर्तित पुष्प व पॉट प्लांट्स के रूप में, जैव अणुओं का हर्बल दवाओं के लिए भी उगाया जाता है। कर्तित और पॉट प्लांट्स ऑर्किडस, विभिन्न आकार, रंग, रूपों, दिखने में विविधता और लंबे समय तक ताज़ा रहने के कारण बाजारों में उच्चतम मूल्य प्राप्त होता हैं। इस संदर्भ में पश्चिमी हिमालय में उच्च मूल्य शीतोष्ण ऑर्किडस की खेती की संभावना को देखते हुए, हम ऑर्किडस की कृषि प्रौद्योगिकी, उत्पादकता, गुणवत्ता में सुधार और व्यावसायीकरण को विकसित करने में कार्य कर रहे हैं। 2015 के दौरान, सिम्बीडीयम के आठ संकर यानी 'पिंक क्लाइश मून वीनस', 'विंटर बीच सी ग्रीन ', 'Eushi Kam', 'Sleeping Nymph', ''Soul Hunt 6' , CM12 , CM03 , CM02 , और CM06 दूसरे के साथ ऑर्किड प्रजातियों Arundina graminfolia , Zygopatalum lutermilium , Cattleya और Dendrobium aphyllum अध्ययन करने के लिए एकत्र किया।

लिलियम

फूलों की मांग में वृद्धि होने के कारण, वर्ष भर पुष्प उत्पादन, उत्पादकों के लिए महत्वपूर्ण गतिविधि हो गया है। कंदीय फूलों में विकास व पुष्पन के नियंत्रण के लिए विशेष तापमान और रसायनों के साथ उपचार करते हैं । इस संबंध में, हमने लिलियम की दो किस्में पाविया और एरकोलानो की वृद्धि और फूल उत्पादन का मूल्याकंन पॉलीहाउस परिस्थिति में किया।

जैवप्रौद्योगिकी

हिमालय क्षेत्र की सूक्ष्म जीव और पौध विविधता से बायोप्रोस्पेक्शन द्वारा प्रासंगिक घटकों की पहचान तथा इनके औद्योगिक उपयोग के लिए अच्छे अवसर मिलते हैं। हमारे समूह ने बायोप्रोस्पेक्शन द्वारा जीन, एंजाइमों और मेटाबोलिक पाथवे पर शोध किया और हिमालय में विभिन्न ऊँचाई क्षेत्र में पौधों के अनुकूलन को समझने में प्रयास किया। इसी दिशा में शोध में एक अनूठे एंजाईम superoxide dismutase (SOD) को Potentilla atrosangunia पौधे से पहचान कर निकाला गया। यह 0 से 50°C में कार्य करता है। एक दूसरे शोध में हिमालय के औषधीय पौधों जैसे पिक्रोराइजा कुरूआ में सेकंडरी मेटाबोलाइट्स के नियमन में picroside के जैवसंश्लेषण से तापमान के महत्व का पता चला। तापमान नियामक तंत्र पर शोध से miRNA की लाइब्रेरी तैयार की और पिक्रोराइजा कुरूआ की पत्ती और कंद ऊत्तकों से विश्लेषण किया तथा इसकी विभिन्न तापमान में प्रतिक्रिया के विनियमन में phenylpropanoid, stibelinoid, cysteine और methionine metabolism की भूमिका के महत्व को समझा। इस तरह के अध्ययन से पौध सेकंडरी मेटाबोलिज़्म और सिंथेटिक जीव विज्ञान के मेटाबोलिक इंजीनियरिंग में प्रभावकारी उपयोग हैं।

जैवप्रौद्योगिकीय माध्यम से हिमालय जैवसंपदा का संरक्षण एवं संभावित सतत जैवआर्थिकी के लिए उपयोग

पश्चिमी हिमालय क्षेत्र में लुप्तप्रायः औषधीय पौधों के संरक्षण के लिए सतत कार्य चल रहा है। हिमाचल प्रदेश के विभिन्न भागों से एकत्रित करके उतक संवर्धन प्रक्रिया के विभिन्न तरीकों से सालमपंजा के 15 विभिन्न परिग्रहणों का इन–विट्रो इन–विट्रो रिपोजेटरी स्थापित की। पिक्रोराइजा कुरुआ (कुटकी) के उतक संवर्धन तकनीक से तैयार पौधों को पॉलीहाउस परिस्थितियों में दृढ़ीकरण किया गया तथा 85 प्रतिशत से अधिक सुरक्षित पाए गए। बारडोस्टैकिस जटामांसी की पत्तियों को एक्सप्लांट के तौर पर उपयोग करके अत्याधिक मात्रा में कैलस बनाया गया तथा् उसमें केश वयक 'नारडिन' पाया।

आनुवांशिक रूप से संशोधित चाय के पौधों का विकास तथा प्रजनन प्रदर्शन संबन्धित मूल्यांकन किया गया। इसमें आनुवांशिक रूप से व असंशोधित पौधों में प्ररुपी समानता पाई गई। यद्यपि पौधों के विकास के मापदंड लगभग समान पाए गए, परन्तु आनुवांशिक रूप से संशोधित पौधों की लम्बाई कम व फल–फूलों के झड़ने की दर व खाली बीज गठन की दर सामान्य से अधिक पाई गई। संशोधित पौधों के प्रजनन व्यवहार में अवसाद दर्शनीय रहा।

ऊतक संवर्धन से बने हुए बांस के तनों का ट्रांसक्रिप्टोम किया गया। पुष्प संक्रमण के विभिन्न जीनों के उच्च व निम्न विनियमन तथा अन्य द्विपत्री व एकपत्री मॉडल पौधों के होमोतोगस ट्रांसक्रिप्टोम कारक दर्ज किए गए तथा पुष्प संक्रमण के कुछ मार्कर की पहचान की गई।

कोशिकाओं में केटेकिन का स्थानीयकरण का अध्ययन करने के लिए पहली बार केटेकिन स्पेसेफिक रिएजेंट (CSR) का प्रयोग किया गया। इस अध्ययन में CSR से रंगे हुए पत्तों तथा तने के माइक्रोटोम वर्गों में सुनहरे पीले रंग के केटेकिन ग्लोबयुल का कोशिकीय स्थनीयकरण का पता चला। बायोलिस्टिक गन उपाय से ट्रांसजेनिक पौधो की वृद्धि, पुनर्जनन का चार वर्ष तक मूल्यांकन किया गया।

मुक्त वायु में कार्बनडाईआक्साईड संवर्धन तथा तापमान में वृद्धि : जलवायु परिवर्तन के बदलते परिवेश में वनस्पतियां बदलती परिस्थितियों पर किस प्रकार प्रतिक्रिया करती है, इस हेतु ''मुक्त वायु कार्बनडाईआक्साइड संवर्धन तथा तापमान में वृद्धि के तहत अध्ययन'' की सुविधा को सबसे उन्नत माना जाता है। इस प्रकार की सूचनाओं को उत्पन्न करने हेतु विविध क्षेत्रों तथा विश्व की पारिस्थितिकीय प्रणालीयों में निहित परिवर्तनशीलता तथा वनस्पतियों के विभिन्न समूहों का अध्ययन आवश्यक है।

- गैसों के विभिन्न समूहों का अध्ययनः वर्तमान वर्ष में कार्बनडाइआक्साइड के बढ़ते हुए जैसे– हायपेरिकम परफोरेटम, पिक्रोराईजा कुरूआ, रयूमेक्स नेपालेसिस, हैरेक्सेकम आफिसिनेल (उच्च तथा निम्न उच्च तुंगता के पादप समुदाय) तथा वेलेरियाना जटामांसी पर अध्ययन किया गया। इन पर बसंत तथा पतझड़ की अवधि में शरीर क्रिया विज्ञान, वास्य आकारिकी, माध्यमिक चपापचची संघटकों तथा जैव ईधन के विभाजन का अध्ययन किया गया।
- उच्च कार्बनडाईआक्साईड के अन्तर्गत (FACE) संतृप्त प्रकाश संश्लेषण (Asat) बसन्त तथा शरद ऋतु के महीनों के दौरान सभी प्रजातियों मे अधिक पाया गया।
- टैरेक्सेकम ऑफिसिनालिस के Asat में प्रतिशत बदलाव पतझड़ ऋतु की अपेक्षा बसन्त ऋतु में अधिक पाया गया।

टैरेक्सेकम ऑफिसिनालिस के कम ऊंचाई के समुदायों का उच्च तुंगता के समुदायों की प्रजातियों से तुलना करने पर पतझड़ की अपेक्षा बसंत मे Asat में 3 गुना अधिक परिवर्तन पाया गया।

निचले खण्ड के Asat वेलेरियाना जटमांसी तथा रयूमेक्स नेपालेन्सिस के पौधों तथा उच्च तुगंता के पिक्रोराईजा कुरूआ के पतझड़ के पौधों मे बसन्त की अपेक्षा अधिक वृद्धि पाई गयी।

दोनों ऋतुओं के अध्ययन के दौरान यह पाया गया कि दोनो ऋतुओं में FACE की सभी पौधप्रजातियों की रन्ध्र चालकता सदैव कम हो जाती है।

निम्न ऊंचाई की प्रजातियों में बसंत की अपेक्षा पतझड़ की ऋतु में अधिक परिवर्तन देखा गया। पतझड़ मे दैरेक्सेकम ऑफिसिनेल तथा पिक्रोराइजा कुरूआ की उच्च तुगंता कर प्रजातियों मे अपेक्षाकृत अधिक कमी प्रदशित हुई।

उत्थित तापमान की परिस्थितियों में उगायी गयी हैरेक्सेकम आफिसिनेल की प्रजाति में उष्मा के प्रत्युत्तर हेतु विभिन्नता देखी गयी।

Asat में बसंत ऋतु में बढ़त जबकि पतझड़ में ह्रास देखा गया।

बसन्त ऋतु में उष्मा का प्रकार बढ़ाने पर Asat की खुले मे वास करने वाली प्रजातियों टैरेक्सेकम ऑफिसिनालिस तथा हैरेक्सेकम आफिसिनेल में बढ़त जबकि निचले खंण्ड की बेलेरियाना जटामांसी तथा रयूमेक्स नेपालेन्सिस की प्रजातियों मे दोनों ऋतुओं के दौरान ह्रास देखा गया।

FATI .की परिस्थितियों मे खुले में वास करने वाली पिक्रोराईजा कुरुआ की उच्च तुंगीय विस्तार वाली प्रजाति के Asat में बसन्त ऋतु में ह्रास देखा गया। सभी प्रजातियों के gs में बसन्त ऋतु की अपेक्षा पतझड़ की ऋतु में उष्मा के प्रत्युत्तर हेतु अधिकता पायी गयी।

- मुक्त वायु में कार्बनडाईआक्साईड संवर्धन (FACE) तथा मुक्त वायु के तापमान में वृद्धि (FATI) के तहत मुल पॉलीफिनोल कंटेट में विभिन्नता_:पॉलीफिनोल कांटेट में ($P<0.05$)की बढ़त देखी गयी। उत्थित तापमान में रयूमेक्स नेपालेन्सिस की पत्तियों में पॉलीफिनोल कंटेट उल्लेखनीय ($P>0.05$) कम हो जाता है। यद्यपि नियंत्रित परिस्थितियों में उगायी गयी पत्तियों की अपेक्षा जड़ों में कुल पॉलीफिनोल उल्लेखनीय ($P<0.05$) बढ़ जाता है।

ऊंचाई के साथ–साथ पॉलीफिनॉल कंटेट में विभिन्नताः

खुले में उगने वाली रयूमेक्स नेपालेन्सिस के अध्ययन हेतु इस पौधे के बीजों को चार विभिन्न ऊंचाईयों 800मी.,1300मी., 2200मी. तथा 4000मी. से संग्रहण कर पॉलीहाऊस के अन्दर उगाया गया। अवस्थिति मे अध्ययन हेतु इस प्रजाति के नमूनों को उक्त चारों ऊंचाईयों से लेकर इनके पैतृक स्थान तक संग्रहित किया गया।

उक्त प्रजाति की पत्तियों में बाह्य तथा अन्तः परिस्थितयों में वक्र रेखीय प्रतिक्रिया देखी पायी गई। 800 मी. की बाह्य तथा 2200 मी. की ऊंचाई की अन्तः परिस्थितकीय ऊंचाईयों की तुलना करने पर कुल पॉलीफिनोल कांटेट में उल्लेखनीय ($P<0.05$) की वृद्धि पाई गयी।

Whitefly द्वारा Apple scar skin viroid का सक्रिय संचरण

प्रकृति में पौधों के बीच न्यूक्लिक एसिड ट्रांसफर कई मायनों में होने की संभावना है। Whitefly *Trialeurodes vaporariorum* द्वारा *Apple scar skin viroid* (ASSVd) के ssRNA genome का सक्रिय संचरण पहली बार प्रस्तुत किया गया। इतना ही नहीं विषाणुभ का डीएनए फार्म भी कीट से पहचाना गया। फ्लोएम प्रोटीन 2 (CsPP2) के माध्यम से विषाणुभ की स्थानांतरण क्षमता में सुधार देखा गया। PP2/ASSVd का कॉम्प्लेक्स संक्रमित पौधों में stably उपस्थित था। विषाणुभ की तरह के कुछ RNAs फ्लोएम में पाए जाते हैं , जिनकी whitefly द्वारा पौधें के बीच हस्तांतरण आसानी से होना संभव है।

वेलेरियाना जटामांसी और सोयाबीन, बिगोमोवायरस और कुकुम्बर मोजेक वायरस Cucumber Mosalc virus (सीएमवी) के प्राकृतिक परपोषी के रूप में पहचाने गए।

वेलेरियाना जटामांसी और सोयबीन के प्राकृतिक virome की पहचान करने के लिए अध्ययन के दौरान यह देखा गया कि वेलेरियाना जटामांसी में सीएमवी और सोयाबीन में विगोमोवायरस उपस्थित है। इससे यह लगता है कि जटामांसी सब्जियों के महत्वपूर्ण वायरस के लिए एक जलाशय के रूप में कार्य कर सकता है।

ग्लाइसिन मैक्स के संक्रमित पौधे से एजरेटम ईनेशन वायरस और एक अल्फासेटेलाइट का पूरा न्यूकलोटाइड अनुक्रम।

सोयाबीन (ग्लाइसिन मैक्स) के पौधों में सिलवटें, पीलापन और वृद्धि में रुकावट हिमाचल प्रदेश के कुछ क्षेत्रों में देखा गया। पीसीआर पर आधारित प्रयोगों द्वारा एक begomovirus की उपस्थिति का पता लगाया गया। वायरल जीनोम को अनुक्रमित किया गया, जिससे यह पता चला कि यह Enation वायरस, जो कि एजरेटम कॉनिजायडस को संक्रमित करता है। एप्पल स्टेम ग्रुविंग विषाणु कचनार और बांस के पौधों को प्राकृतिक रूप से संक्रमित करता है।

आहारीय रेशों और पॉलीफिनॉल जैसे उत्पादों के लिए सेब खली (भुक्तशेष) का मूल्यवर्धन करके सतत औद्योगिक वृद्धि के साथ–साथ यह महत्वपूर्ण स्वास्थ्यवर्धक संपूरक भी प्रदान करेगा। आहारीय रेशों का सूरक्षा मूल्यांकन करके विभिन्न प्रकार के उत्पाद

तैयार करने की दिशा में कार्य प्रगति पर है। सेब खली मुख्य रुप से सेल कोशिका पॉलीसैक्राइडस से युक्त होता है तथा इसमें फैलाव, जल अवरोधन और वसा अवशोषण क्षमता जैसी विशेषताएं पाई गई हैं। शोध से यह भी सामने आया है कि इसमें बेहतर जलयोजन गुण होते हैं जो कम केलरी के आहारीय रेशों वाले उत्पादों को बनाने की संभावनाएं प्रदान करते हैं।

प्रोटीन के असाधारण गुण प्राप्त करने के लिए प्रोटीन इंजीनियरिंग के कई पहलुओं पर काम किया जा रहा है (जैसे तापमान और पीएच की निर्भरता पर व्यवहार और अन्य स्थिरता के मुद्दों सहित) औद्योगिक महत्व के प्रोटीन /एंजाइमों की रचना विश्लेषण इसकी तर्कसंगता और नए आयाम प्रदान करें। एक और अधिक मजबूत प्रोटीन, जो थर्मोस्टेबिलिटी और वर्तमान सीमा से अधिक गतिविधि कर सके, को विकसित करने के लिए प्रयास जारी हैं।

हिमालय क्षेत्र के सूक्ष्म जीवों के औद्योगिक विकास के लिए दोहन एवं अनुकूलन पर कार्य चल रहा है। सूक्ष्म जीवों की विविधता एवं नवीनता का मानव उपयोगगिता के लिए अध्ययन भी किया जा रहा है।

स्टूडियो ऑफ़ कम्प्यूटेशनल बायोलॉजी एंड बायोइन्फरमेटिक्स यूनिट ने इस वर्ष तीन महत्वपूर्ण दिशाओं में कार्य किया है। इस लैब ने miRNA सम्बन्धी कुछ महत्वपूर्ण कार्य किये हैं, जिसमें इन्होने ये बताया है कि अब तक जिस तरीके से miRNAs क पता लगाया जाता था, वह काफी पुराना और संकीर्ण तरीका प्रतीत होता है। इस कारण से miRNAs और उनके रेगुलेटरी गतिविधियों का सटीक पता नहीं लगाया जा पा रहा था। फलस्वरूप, हम आज भी जैविक सिस्टम के कार्यप्रणाली को ढंग से नहीं समझ पा रहे हैं जहाँ miRNAs कई तरीकों से जैविक सिस्टम का नियंत्रण करते हुए कोशिका, अंग, रोगों के होने न होने एवं अन्य निर्माण के बेहद ही संवेदनशील क्रियाओं में मौजूद है। इस ग्रुप ने पहली बार एक नयी और काफी ही भरोसेमंद विधि के द्वारा कुल 11,234 नियंत्रक sRNAs बिग डेटा पता लगाया है जो की कई महत्वपूर्ण विधियों में मौजूद हैं और कई जैविक क्रियाओं को कर सकते हैं। ये सारे RNAs पहले और परंपरागत अन्वेशण के प्रक्रिया में नहीं पाये जा सके थे। 25 विभिन्न कैंसरों के उपर 25TB डेटा का इस्तेमाल करते यह अध्यन किया गया है। इनमे से sRNAs कैंसरों का पता लगने में भी सक्षम दिखे। यह कार्य अत्यन्त ही सम्मानित जर्नल न्यूक्लिक एसिड्स रिसर्च में प्रकाशित हुआ है। इसके अतिरिक्त इस लैब ने Solanum के जीनोम पर काम करते हुए उसमें मौजूद रेपिटेटिव एलिमेंट्स की भी खोज की है और ये भी दिखाया है कि धारणा के विपरीत कई काम्प्लेक्स रेपोतस जीनोमिक सिस्टम में सक्रिय हैं और ट्रांसक्रिप्शन कर रहे हैं। इसके साथ ही इस समूह ने arabidopsis के ट्रांसजेनिक पर लिगिनिंग और सुपरॉक्सिडेस फार्मेशन प्रक्रिया सम्बन्ध को उजागर करने हेतु ट्रांस्क्रिप्टोमिक्स का कार्य किया।

लक्षित दवा खोज के क्षेत्र में कम्प्यूटर के उपयोग से क्रांतिकारी परिवर्तन आया है। इस व्यवस्था के प्रभावी उपयोग से पहले तो नियंत्रित स्थिति में ट्यूमर के नमूनों का विश्लेषण किया गया। इसके अलावा, CXCR4-केन्द्रित वर्णनकर्ता आधारित वर्गीकरण मॉडल पहली बार हमने विकसित किया और यह भी पादप व्युत्पन्न छोटे अणुओं का भंडार स्क्रीन करने के लिए हिमालय पौधों की प्रजातियों से संभावित अवरोधकों को प्राप्त करने के लिए उपयोग किया गया है।

आधुनिक युग में रोग साइट के सरचनात्मक विवरण के नैदानिक इमेजिंग और चिकित्सा निदान का अत्यंत महत्व है। यह प्रारंभिक चरणों में रोगसाइट का पता लगाने के लिए सहायता करता है और इस प्रकार चिकित्सा निदान में एक विलक्षण भूमिका निभाता है। इस संबंध में, नैनोकणों को इन–विट्रो में और इन–विवो में विशिष्ट कोंट्रस्टिंग एजेंट के रुप में अपनी क्षमता के लिए मेडिकल इमेजिंग के क्षेत्र में जाना जाता है। संस्थान में नैनोकणों, जो विशिष्ट कैंसर कोशिकाओं को लक्ष्य बनाने के लिए उपयोग किया जा सके, डिजाइन करने का कार्य चल रहा है। फॉलिक एसिड की संकर नेनोमेटिरियल्स पर रसायनिक विकारता यह दर्शाती है कि रिसेप्टर मध्यस्थता एंडोसाइटोसिस प्रक्रिया नैनोकणों के इंट्रासेलुलर स्थानीयकरण के लिए जिम्मेदार है। इसके अलावा चूहों पर किए गए शोध से पाया गया कि यह नैनोकण पूरी तरह से दोहरी मोड इमेजिंग सामग्री के रुप में उपयोग करने के लिए सुरक्षित है।

पादप जीवाणु इंटरेक्शन, मॉलिक्यूलर पादप रोगविज्ञान

सेब में स्कैब रोग सम्बंधित शोध: विश्व में भारत सेब का पांचवां सबसे बड़ा उत्पादक है (एफएओ, 2013) और यह पश्चिमी हिमालय क्षेत्र की एक प्रमुख फसल है। हर साल कवक रोगों के कारण किसानों को भारी नुकसान होता हैं। उनमें से एप्पल स्केब जो

बेंचुरिया इनएक्वालिस की वजह से होता है सबसे घातक बिमारियों में से एक है। संस्थान एप्पल स्केब के दौरान बेंचुरिया और सेब के बीच हो रहे बदलावों को समझने के लिए कार्य कर रहा है। ट्रांस्क्रिप्टोमिक दृष्टिकोण का प्रयोग उन जीन की पहचान करने के लिए किया गया, जो कि सेब–बेंचुरिया इनएक्वालिस संगत के दौरान अंतर सम्बंधित रूप से अभिव्यक्त हो रहे थे, इस से सेब के 9407 जीन खोजे गए। इन–सिलिको विधि का प्रयोग ट्रांसक्रिप्ट्स के संभावित सीक्रेटोम होने के लिए किया गया। इस विधि से 517 संभावित सेक्रेटरी प्रोटीन्स की पहचान की गयी है। इन ट्रांसक्रिप्ट के निस्रपण से महत्वपूर्ण विषैलापन कारकों के लक्षण वर्णन और प्रभावोत्पादक की पहचान करने में मदद मिलेगी।

टमाटर के रूट विल्ट रोग सम्बंधित शोध: इससे पहले टमाटर प्रोटीओम के कुछ चयनित प्रोटीन की द्विज्यामितीय विश्लेषण के माध्यम से पहचान की गई, जो फ्यूरेरियम कवक से संक्रमित थे। कुछ चयनित जीन टमाटर– कवक परस्पर क्रिया में उनके मूल्यांकन के लिए आगे विशेषीकरण कर रहे हैं।

केसर के साथ जुड़े लाभकारी जीवाणु की भागीदारी विकसित करने हेतु शोध किया जा रहा है। जिसका उद्देश्य सूक्ष्म जीवी संरोपणो को राइजोबैक्टीरिया के भिन्न भिन्न जीन प्ररूप के चयन द्वारा विकसित करना है। इसमें राइजोबैक्टीरिया के उन प्ररूप का चुनाव किया जिन के पास अपने भागीदारी सहयोगी के साथ मिलकर पादप वृद्धि और उत्पादकता को विस्तार करने वाली क्षमता थी । इस कार्य की प्रगति के दौरान विल्ट और कॉर्मरॉट रोग जनक के प्रति विरोध और इस के साथ अजैव तनाव सहिष्णुता के सन्दर्भ में भी विचार किया जा रहा है। दस कुशल राइजोबैक्टीरिया का चयन पौधों की वृद्धि और अजैविक तनाव सहिष्णुता के कारकों के आधार पर किया जा रहा है। केसर के पौधों में वृद्धि को बढ़ावा देने वाले पी.जी.पी.आर. के मूल्यांकन के दौरान यह पाया गया कि नियंत्रित परिस्थितियों में सामान्य की तुलना में पौधों में अधिक वृद्धि हुई। केसर के विकास को बढ़ावा देने में राइजोबैक्टीरिया की भूमिका और प्रभाव के आकलन करने के लिए वर्तमान में पॉट और फील्ड परीक्षण पंपोर, कश्मीर में किये जा रहे हैं।

तनाव ग्रसित कृषि प्रणालियों में फसलों की उत्पादकता में सुधार के लिए पीजीपीआर: तनाव परिस्थितियां फसलों की वृद्धि और उपज को सीमित करती है। पादप हार्मोन एथिलीन तनाव परिस्थितियां जैसे लवणता, बाढ़, सूखा, तापमान, भारी धातुओं, कीटनाशकों और पादप रोगजनक की उपस्थिति में पौधों की शारीरिक प्रतिक्रियाओं को उत्तेजित करता है। पीजीपीआर एसीसी-दीअमिनेस को उत्पादित करता है जो कि एसीसी को विभेदित करता है। इस परियोजना का उद्देश्य, एसीसी-दीअमिनेस पीजीपीआर के निर्माण के विकास के लिए हैं, जो पर्यावरण के अनुकूल, मिट्टी और तनाव सहिष्णु पौधों के विकास की संयंत्र प्रणाली के लिए फायदेमंद और अधिक किफायती हो सकता है। विभिन्न फसलें जैसे आलू, लहसुन, गेहूं और मटर के विकास को बढ़ावा देने के लिए चयनित राइजोबैक्टीरिया के प्रभाव का मूल्यांकन करने के लिए वर्तमान में बजौरा, कुल्लू (एच.पी.) में क्षेत्र परीक्षण का कार्य प्रगति पर है।

भारतीय हिमालय के कुछ औषधीय पौधों से अंतः पादपी सूक्ष्मजीव और उनके प्राकृतिक उत्पादों का जैव निरीक्षण: परीक्षक जीवों की सूची के सापेक्ष 1184 राइजोबैक्टीरिया अगार ओवरले विधि के द्वारा परीक्षित किये गए, उनमें से कुल 85 जीवाणुओं में एक या अधिक परीक्षण जीवों के खिलाफ कूप विसरण विधि से रोगाणुरोधी गतिविधि को दिखाया। रोगाणुरोधी गतिविधि के लिए चुने गए 25 अंतः पादपी और 4 मृदा सूक्ष्मजीवों सहित पच्चीस सूक्ष्म परजीवी, सीएसआईआर–सूक्ष्मजीवी प्रोद्योगिकी संस्थान के रोगाणुरोधी यौगिकों की संरचना व्याख्या के लिए निवेदित किया गया है ।

स्टीविया रिवॉडियाना और रोडिओला इम्ब्रिकाटा से सेकेन्डरी मेटाबोलाइट की इन–विट्रो उत्पादन के लिए पादप कोशिका संवर्धन और अंग संवर्ध प्रणाली के विकास का कार्य किया जा रहा है। स्टीविया में मौजूद स्टीवियोसाइड और रिवौडियोसाइड प्राकृति मिठास के रूप में अपने उपयोग के लिए जाना जाता है, rhodiola में salidrosides होते हैं जिसे एडाप्टोजेनिक और नर्व–टॉनिक के रूप में प्रयोग किया जाता है। इन यौगिकों की देश एवं विदेश के बाजार में भारी मांग है। इस संबन्ध में लक्षित मेटाबोलाइट का बड़े पैमाने पर उत्पादन के लिए कैलस प्रचूरोद्भव प्रोटोकॉल और कोशिका संवर्ध को मानकित किया गया है।

वैश्विक जलवायु परिवर्तन के प्रकाश में उच्च तुंगता जीवविज्ञान हमेशा से ही शोधकर्ता के लिए विशेष रुप से आकर्षक रहा है। चरम पर्यावरण की स्थिति जैसे कम वायुमंडलीय दबाव [उच्च यू.वी. विकिरण और अस्थिर कम तापमान] अत्यंत जटिल और डाइनैमिक पादप प्रोटेओम को प्रभावित करते है। पादप प्रोटेओम ने जीवविज्ञान के कई विभिन्न महत्वपूर्ण पहलुओं और जटिल प्रक्रियाओं को समझने में तेजी से योगदान दिया है। इसके अलावाए मास स्पेक्ट्रोमेट्री आधारित प्रोटेओमिक अप्रोच प्रोटीन की गुणात्मक और मात्रात्मक जानकारी के साथ ही और तनाव सहिष्णुता से जुड़े प्रोटीन मोडिफिकेशन प्रस्तुत करता है।

खाद्य एवं न्यूट्रास्यूटिक्ल

भारतीय चाय की सुगंध घटकों के लक्षण वर्णन पर हमारे काम को आगे बढाते हुए, हमने नीचे दार्जिलिंग क्षेत्र वाली चाय पर ध्यान केंद्रित किया। चाय की खुशबू घटक एक साथ आवसन निष्कर्षण और पेय विधि द्वारा निकाले गए, जिससे हम चाय की पूरी सुगंध प्रोफाइल पा सके। चाय के अर्क की सुगंध प्रोफाइल में प्रमुख घटक–जिरेनिओल, लीनालूल, नेरो, हेक्सानोइक एसिड थे, जबकि माइनर यौगिकों में 3,6–डाइमिथाइल –2H – पायरन –2–ऑन, α–और β –आयोनोन, सिट्रल और फरफुराल शामिल थे। दिलचस्प है, इस चाय में मिथाइल सैलिसिलेट और पायराजीन्स जो कांगड़ा ऑर्थेडॉक्स चाय में प्रमुख यौगिकों के रुप में वर्तमान और नट्टी स्वाद के लिए जिम्मेदार हैं रिकॉर्ड नहीं किए गए।

संस्थान में इससे पहले एक डाइअजोंटाईज्द सलफानीलामिएड अभिकर्म विशेष रुप से चाय की पत्तियों में कैटेकिन के स्पेक्टरोंमेट्रिक मूल्यांकन के लिए विकसित किया गया था। डाइअजोंटाईज्द एक्लिामाईड समूह के साथ अभिकर्मक एक सुनहरा पीला जटिल उपज के लिए इलेक्ट्रॉन अमीर एज़ो युग्मन द्वारा फलेवन –3– ऑल की एक अंगूठी के साथ प्रतिक्रिया करते हैं। अब हमने कैटेकिन के हिसटोकेमिकल मूल्यांकन के लिए इस अभिकर्मक के उपयोग को देखा। चाय के माइक्रोटॉम कटौती वर्गों में अभिकर्मक दागे अनट्रान्स्फोर्म्ड और ओस्मोटिन व्यक्त ट्रांसजेनिक चाय पत्तियों और स्टेम में कैअेकिन सुनहरे पीले ग्लोबुलेस के रुप दिखाई दिए। ये सुनहरे पीले ग्लोबुलेस को ट्रांसजेनिक चाय के पौधों में गैर ट्रांसजेनिक पौधों की कोशिकाओं से अधिक पाया गया। इन ग्लोबुलेस का माप संचित की तुलना में व्यक्त ओस्मोटिन में अधिक था और 20% PM ट्रीटेड में अत्यधिक तनाव में बरकरार कोशिकाओं में सुनहरे पीले ग्लोबुलेस की वृद्धि हुई। कैटेकिन उत्पादन की मात्रा का स्पेक्टरोंमेट्रिक मूल्यांकन द्वारा पुष्टि की गई। चाय में थेयनिन और कैटेकिन की पहचान और मात्रा को नापने के लिए HPTLC मानकीकृत और सटीकता और विश्वसनीयता के लिए मान्य किया गया। थेयनिन और कैटेकिन HPTLC द्वारा विभिन्न चाय के अर्क में मात्रा और एचपीएलसी के साथ मान्य किया गया। एक अन्य प्रयोग में, एनएमआर आधारित मेटाबोलोमिक अध्ययनों से यह भी व्यापक मेटाबोलाइट रुपरेखा और चाय के नमूनों में कैफीन के साथ थेयनिन और कैटेकिन के मात्रात्मक आकलन के लिए इस्तेमाल किया गया।

चाय की पत्तियों से कैटेकिन की शुद्धि पर हमारे काम के साथ सतत, कैटेकिन के उत्पादन हमारे प्रायोगिक संयंत्र में ताजा चाय की पत्तियों (40 किलो) पर शुद्धता का स्तर बनाए रखने में अनुकूलित किया गया था। BIRAC की उद्ययोग एवं शिक्षा इंटरफेस परियोजना के तहत हमें ओद्यौगिक सहयोगी बैजनाथ फार्मास्यूटिकल्स प्राइवेट लिमिटेड के साथ कम से 100 किलो ताजा चाय प्रति बैच में कैटेकिन शुद्धि के लिए मंजूरी मिली है। थ्यिाफलेविन निर्माण ग्लुटामीन के बायोट्रान्सफॉर्मेशन पर अध्ययनः चाय के रिजकेस्फेयर से एकत्रित 220 से अधिक माइक्रोबियल आइसोलेटस को ग्लुटामीन बायोट्रांसफॉर्मेशन अध्ययन से एल थेयनिन के एंज्यमतिक संश्लेशण के लिए जांच की गई। सात माइक्रोबियल आइसोलेटस में 40–55% थियाफ्लेविन के निर्माण करने के लिए उच्च रूपांतरण दिखा। इन सातों आइसोलेटस को विभिन्न मापदण्डों (तापमान,पीएच,सब्सट्रेट एकाग्रता) का उपयोग कर आगे अनुकूलन के अध्ययन के लिए ले जाया जा रहा है।

हमारा मुख्य उद्देश्य समाज के स्वास्थ्य एवं कल्याण के लिए पश्चिमी हिमालय क्षेत्र के पारंपरिक, अपशिष्ट उत्पाद एवं कम उपयोग में लाए गए खाद्य पदार्थों को विकसित करना है। हमारा उपक्रम पश्चिमी हिमालय क्षेत्र के स्थानीय भोजन को संरक्षित करना है। अतः हमने स्वदेशी एवं पेटेंट "Technology for Commercial Production of ready-to- eat food based on ethnic recipes of H.P. especially Kangri Dham" दायर किया है, जो कि क्षेत्रीय खाना पकाने की शैली एवं सामग्री के अद्वितीय स्वाद एवं रुचि का प्रदर्शन करती है। हम कुपोषण को रोकने के लिए पोषण युक्त खाद्य पदार्थ,गेहूँ से एलर्जी रोग के लिए ग्लूटन रहित भोजन का सूत्रीकरण एवं

स्वस्थ जीवन के लिए संजातीय भोजन के उत्पादन पर भी कार्यरत हैं। हम नए उत्पादों को विकसित करने के लिए, जरूरत पर आधारित अनुसंधान, मौजूदा उत्पादन से शोधन और हिमाचल प्रदेश के खाद्य प्रसंस्करण उद्योग की समस्या निवारण क्रियाओं में सम्मिलित हैं। फसल उत्पाद की बहुलता के दौरान, उपज उपरांत हानि को कम करने के लिए हमने पोषण युक्त शुष्क ताजा फल जैसे की, सेब, चीकू और मक्का इत्यादि को विकसित एवं अनुकूलित किया है, जो कि सामाजिक पोषण और स्वास्थ्य के सुधार के लिए पौष्टिक स्नैक्स के तौर पर भी उपयोग किया जा सकता है। यह उत्पाद देश में नए उद्योग और व्यापार को उत्पन्न करने में कारगर साबित हो सकता है।

गिलोय, आयुर्वेद सहित विभिन्न पारंपरिक औषधीय प्रणालियों में सबसे व्यापक रूप से इस्तेमाल पौधों में से एक है। इस पादप को पीलिया, गठिया, मूत्रविकार, त्वचारोग, मधुमेह और एनीमिया के इलाज के लिए पारंपरिक रूप से इस्तेमाल किया जा रहा है। इस पौधे में विविध वर्ग के रसायन जैसे एल्कलॉइड, डिटेर्पेनोइड्स, लकटोनेस, ग्लाइकोसाइड, स्टेरॉयड, फिनोल, स्निग्ध विभिन्न यौगिक इत्यादि मौजूद है। इस पृष्ठभूमि के साथ वर्तमान अध्ययन में गिलोय के अलगाव, संरचना, व्याख्या, मात्रा का ठहराव और कैंसर रोधित इम्यूनोमॉड्यूलेटरी क्षमता का मूल्यांकन किया गया है।

भिन्न और पृथक रसायनों की कैंसररोधी गतिविधियों के लिए, चार कैंसर कोशिका लाइनों, KB, CHOK1, HT-29 और SiHa पर मूल्यांकन किया गया। संभावित इम्यूनोमॉड्यूलेटरी क्षमता का अध्ययन चूहों के प्राथमिक स्प्लेनोसैट्स पर किया गया था। सामान्य चरण HPTLC विधि के बाद तीन बायोएक्टिव यौगिकों अर्थात N-formylannonain (1), 11-hydroxymustakone (5) और yangambin में मात्रा निर्धारित की गई थी जो की गिलोय के पंद्रह विभिन्न पौधों से ली गयी थी।

विभिन्न अंशों की क्रोमेटोग्राफी शुद्धि से आठ शुद्ध अणुओं को अलग किया गया। N-formylannonain (1), magnoflorine (2), jatrorrhizine (3) palmatine (4), 11-hydroxymustakone (6), tinocordiside (5), cordifolioside (7) और yangambin (8) । सभी अंश KB और HT-29 कोशिकाओं के खिलाफ सक्रिय थे जब कि शुद्ध अणुओं में palmatine (4) KB और HT–29 कोशिकाओं के विरुद्ध सक्रिय पाया गया था ; tinocordiside (7) KB और CHOK1 के विरुद्ध तथा yangambin (8) KB कोशिकाओं के विरुद्ध ही सक्रिय था। हालांकि N-formylannonain(1), 11-hydroxymustakone (5), और yangambin इम्यूनोमॉड्यूलेटरी गतिविधि के लिए ही सक्रिय मिले थे। गिलोय के इन शुद्ध अणुओं के औषधीय मूल्यांकन से कैंसर विरोधी और इम्यूनोमॉड्यूलेटरी गतिविधियों के साथ–साथ पारंपरिक औषधीय मूल्यों का भी पता चलता है।

हमारा उद्देश्य प्राकृतिक अणुओं, न्यूट्रास्यूटिक्लस एवं नैनो सामग्री आदि की सुरक्षा और विषाक्तता का मूल्यांकन करना है। यह अध्ययन अंतरराष्ट्रीय स्तर के दिशा निर्देशों का उपयोग करके किये जाते हैं। इस वर्ष हमनें स्टीविया तथा सुपरऑक्साइड डिसम्यूटेज़ पर सुरक्षा और विषाक्तता मूल्यांकन किया। इसके अलावा हम इन पदार्थों की प्रभावोत्पादकता का भी पता चला, जिसमें कर्कुमिन तथा पीपेरिन को जिगर कर्क रोग में एक साथ उपयोग करने के लाभ का पता लगाया। इसके अतिरिक्त हमनें व्यर्थ होने वाली सेब की खली में पॉलीफिनोल की उपस्थिति तथा उनका जिगर के रोग में होने वाले लाभ का भी पता लगाया।

प्रयोगशाला में चल रहे शोध कार्य का उद्देश्य प्रयोगात्मक पशुओं के इस्तेमाल से पश्चिमी हिमालयी वनस्पति के सक्रिय तत्वों की पहचान करना तथा उनका चिकित्सीय अन्वेषण एवं पुष्टि करना है। खाद्य पदार्थों का चिकित्सिक उपयोग एवं उनकी अहानिकारिकता का परिक्षण भी हमारे शोध कार्य का भाग है। इसी सम्बन्ध में अनार (प्यूनिका ग्रानाटम Punica granatum)की छाल की हृदयरक्षक भूमिका पर कार्य किया गया है। अनार की छाल को प्राय: व्यर्थ ही माना जाता है परन्तु उसमे उच्च मात्रा में फिनोलिक्स phenolics, पयूनिगालासिन punigalacin, गैलिक ऐसिड gallic acid इत्यादि पाए जाते हैं। अनार की छाल का अध्ययन चूहों के आइसोप्रोटेरिनॉल प्रेरित हद्रय रोधगलन isoproterenol induced myocardial infarction मॉडल पर किया गया तो उनमें हृदयरक्षक क्षमता की पुष्टि की गयी।

औषधीय पौधों में फिनोलिक्स Phenolics जैसे सक्रिय तत्वों की मात्र अधिक होती है। किन्तु इन सक्रिय तत्वों के उचित फार्माकोकाइटिक्स pharmacokinetics का ज्ञान न होने के कारण इनका उपयोग सीमित हो जाता है। करक्यूमिन Curcumin ऐसा ही एक फिनोलिक्स phenolic तत्व है जो जरणकारी तनाव oxidative stress को कम करने में कारगर है, लेकिन इसकी अवशोषण

क्षमता कम होने के कारण इसके उपयोग पर प्रभाव पड़ता है। इसके अवशोषण को बढ़ाने के लिए करक्यूमिन curcumin को पाइपेरिन piperine के साथ DENA induced hepatocellular carcinoma के लिए इस्तेमाल किया गया। curcumin और piperine के संयुक्त इस्तेमाल से जिगर के कैंसर से hepatocellular carcinoma ग्रसित चूहों में समुन्नति देखी गयी। पश्चिमी हिमालय में पाए जाने वाले अन्य औषधीय पौधों जैसे कि जिन्को बाइलोवा Gingko biloba, क्रोकस स्टाइवस Crocus sativus इत्यादि का अध्ययन भी स्नायविक विकारों पर किया जा रहा है।

हाल ही में हमने संस्थान में सीपीसीएसईए (CPCSEA) से प्रयोगशाला पशु प्रजनन के लिए अनुमति प्राप्त की है। जो हमें प्रयोगशाला पशुओं के विभिन्न ख़ालिस उपभेदों को उपलब्ध कराने में सक्षम बनाएगा। प्रायोगिक पशुओं के अध्ययन तथा प्रयोगशाला पशुओं की बढ़ती मांग को ध्यान में रखते हुये, एसपीएफ (विशिष्ट पैथोजन फ्री) पशु प्रजनन और आवास की सुविधा की स्थापना का विशिष्ट महत्व है। एसपीएफ कालोनियों की स्थापना की इस उपलब्धि को हासिल करने के लिए हमें राष्ट्रीय और अंतरराष्ट्रीय दिशा निर्देशों के अनुसार विभिन्न प्रकारों के लिए पशुओं की त्रैमासिक स्वास्थ्य निगरानी कार्यक्रम की स्थापना करना हमारा ध्येय है। भविष्य में हमारा ट्रांसजेनिक जानवरों की कायोनिया स्थापित करने और उनका प्रयोग के लिए उपयोग करने का भी लक्ष्य है। इस प्रकार इन जानवरों के लिए जीनोटाइपिंग प्रक्रियाओं की स्थापना भी हमारा ध्येय होगा। मनुष्यों और पशुओं की सैकड़ों रोग समान हैं, और इस तरह प्रयोगशाला पशुओं का मानव बीमारी के अध्ययन के लिए पशु मॉडल के रूप में कार्य कर सकते हैं। इससे रोग जनन सीखने तथा संभावित इलाज खोजने के लिए पशु मॉडल का विकास, मानव स्वास्थ्य की बेहतरी के लिए महत्वपूर्ण हम NMU या DMBA द्वारा स्तन ट्यूमर के रासायनिक प्रेरण अध्ययन करने तथा फेफड़ों के कैंसर के अध्ययन NTCU का उपयोग करने वाले हैं। नई दवाइओं/अणुओ के फायदेमंद तथा हानिकारक प्रभावों का आकलन करने में प्रयोगशाला पशुओं पर परीक्षण करना आवश्यक हैं।

उच्च तुंगता जीवविज्ञान

नृवानस्पतिक ज्ञान का प्रलेखन

हिमाचल प्रदेश के चम्बा जिले के भरमौर और तीसा के दूरस्थ वन क्षेत्रों में रहने वाले समुदायों जैसे गद्दियों और गुज्जरों से लोकवानस्पतिक ज्ञान का अध्ययन किया गया। इस क्षेत्र के कई जानकार लोगों से संपर्क करके एवं साक्षात्कार के माध्यम से 50 पादप प्रजातियों के दैनिक उपयोग के बारे में जानकारी एकत्रित की गई। जिनमें से मुख्य जानकारी निम्नलिखित वनस्पति प्रजातियों के बारे में एकत्रित की।

एकोनिटम हैट्रोफिलम, एंजेलिका ग्लाउका, एरनेबिया बेंथिमी, डैक्टाईलोराइज़ा हेटेजिरिया, पिक्रोराइजा कुरुआ, पोडोफिलियम हैक्सेंड्रम, रेबडोसिया रिगोसस, स्वर्शिया पेनिकुलाटा आदि ऐसे पौधे हैं जो कि विभिन्न प्रकार के रोगों के निदान के लिए उपयोग में लाए जाते हैं। स्वर्शिया पेनिकुलाटा, रयूम इमोडी और एकोनिटम हैटरोफिलम को पेट के दर्द से निजात पाने के लिए उपयोग में लाया जाता है। एंजेलिका ग्लोका की जड़ों को जोड़ो की दर्द के लिए तथा डेक्टोराइजा हेटेजिरिया के कंद को सॉप के काटने पर उपयोग में लाया जाता है। बेटुला युटिलिस, वेलेरियाना जटामांसी, जुनिपेरस कम्यूनिस और जुरिनिया डोलोमिया जैसे पौधों का उपयोग विभिन्न प्रकार के अनुष्ठान में किया जाता है। कडु की जड़ों को बहुत ही रोचक ढंग से धुएं में सुखाकर संग्रहण किया जाता है।

पादपालय संग्रहण

संस्थान के पादपालय को और अधिक समृद्ध बनाने के लिए इस वर्ष 500 पादप नमूनों को विभिन्न स्थानों से एकत्रित करके पादपालय में संग्रहित किया। इस में से लगभग 100 का चयन करके के पश्चात सत्यापन किया तथा भविष्य में एक संदर्भ के तौर पर सुरक्षित रखा गया है। जिनमें से एरोबिडोप्सिस, जिमनेमा सिल्वेस्ट्री, ट्रोलियस एकोलिस, एक्वाजिया, निवालिस, एलियम सेमनोवी, प्रिमुला मेक्रोफिला, पेराक्यूलिजिया मैक्रोफिला , पेडिक्यूलेरिस ओडेरी आदि प्रमुख हैं।

टेरिडोफाइट पर अध्ययन

वाह टी इस्टेट, पालमपुर के निवेदन पर उन्हें एडेन्टम प्रजाति को लगाने के लिए संस्तुति की गईं। स्थानीय अनुसंधान संस्थानों से प्राप्त 155 पौध नमूनों का जिसमें से 32 टेरिडोफाइट हैं को प्रमाणित किया गया।

पश्चिमी हिमालय क्षेत्र की जैवसंपदा का सर्वेक्षण, खेती, गृहीकरण, लक्षणचित्रण और मानकीकरण के उद्देश्य से वेलेरियाना जटामांसी के उत्कृट पौधों की रासायनिक लक्षणचित्रण द्वारा अनुवीक्षण तथा अंतः फसल के लिए उपयुक्त वृक्ष प्रजातियों की पहचान करने के लिए पश्चिमी हिमालय क्षेत्र का सर्वेक्षण किया गया। वेलेरियाना जटामांसी के लिए मिट्टी के नमूनों और जीपीएस बिन्दुओं के लिए हिमाचल प्रदेश, सिक्किम और पश्चिमी बंगाल के 20 विभिन्न स्थलों का सर्वेक्षण किया गया। इनके मृदा परीक्षण किए गए तथा इसे बहुगुणित किया जा रहा है। क्रेटेगस ऑक्सीकेंथा एंव जिन्को बाइलोवा की कृषि–तकनीक को मानकीकृत करने के लिए प्रक्षेत्र परीक्षण किए गए।

हिमाचल प्रदेश के कुल्लू जिले के सैंज, मनीकर्ण और गड़सा घाटियों में एनएचपीसी की 10 मलवाग्रस्त स्थलों में पुनः हरियाली लाने का कार्य वर्ष 2010 से 2012 तक किया गया था। तीखी ढलान युक्त यह स्थल 1403 से 2221 मीटर की ऊंचाई पर स्थित हैं। इसमें 11 प्रजातियों के पौधे लगाए गए थे। इसके साथ ही 7 झाड़ियों और शाकीय प्रजातियों को लगाया गया और प्रति वर्ष इन पौधों की वृद्धि के मानको को रिकार्ड किया जाता है। विभिन्न स्थलों में विभिन प्रजातियों जैसे वनखोड़, देवदार और रुबिनिया के पौधों ने अच्छी वृद्धि दर्ज की है। अधिकांश स्थलों में झाड़ियों में भी अच्छी वृद्धि पायी गई है।

इस वर्ष के दौरान पादप अतिक्रमण पर अपने कार्य को और आगे बढ़ाया तथा पाया कि सेपियम सेबीफेरम के प्रसार में उसके फलों का पकने का समय और पक्षियों की महत्वपूर्ण भूमिका है। साथ ही हमने ट्राइफोलिअम रेपेन्स में फूलों की ''रिकरविंग''को एक महत्वपूर्ण प्रजनन रणनीति के रुप में पाया। हिमालय क्षेत्र में ''होस्ट–इपीफाइट'' संबंधों पर अध्ययन में इसे अल्प मात्रा में पाया गया है। इसलिए टीम ने यूकेलिपटस ग्लोबुलस और पयरोसिया फ्लोकुलोसा (इपीफाइट फर्न) पर अध्ययन किया तथा पाया कि पेड़ की मोटाई, छाल एवं झुकाव फर्न को बढ़ने में महत्वपूर्ण योगदान करते हैं। इसके अतिरिक्त, लंबी अवधि के पारिस्थितिक अनुसंधान भूखंडों और पादप डेटाबेस पर काम जारी रखा है।

पश्चिमी हिमालय के जैवसंसाधनों का भू–स्थानीय मानचित्रण एवं डेटाबेस का विकासः

हिमाचल प्रदेश के जिला कांगड़ा में वनों में लगने वाली आग के लिए जिम्मेदार कारकों और आग के लिए संवेदनशील क्षेत्रो का पता लगाने का कार्य किया। हिमालय के वनों को विश्व में फैले हुए वनों में से आग के प्रति अधिक संवेदनशील माना जाता है। यह वन–संपदा और जैवविविधता के नुकसान, पारिस्थितिकी और पर्यावरण के लिए खतरा बन गया है। पाईनस रोक्सबर्गाई प्रकार के वन, निम्न ऊँचाई, उच्च तापमान, उच्च ढाल, दक्षिण–पश्चिम की तरफ सामना करने वाला स्वरूप, मई माह और मानवजनित विधनता क्षेत्र के वनों में लगने वाली आग के लिए जिम्मेवार प्रमुख कारको के रूप में की गई। कांगड़ा जिले के 10.7 प्रतिशत वन आवरण वनों में आग लगने की आशंका वाले क्षेत्र में 'बहुत अधिक' एवं 'उच्च' श्रेणी में वर्गीकृत किया गया। इस क्षेत्र के 14.2 प्रतिशत गांवो को वनों में आग लगने के खतरे में 'अधिक' श्रेणी में वर्गीकृत किया गया। एक डिजिटल भू–संदर्भित जंगल में आग का मानचित्र हिमाचल प्रदेश के देहरा वन प्रभाग के लिए भी तैयार किया गया है। पश्चिमी हिमालय में टेरिडोफाइट के स्थानीय वितरण को दर्शाने वाले मानचित्र भी तैयार किए हैं। हिमाचल प्रदेश के ग्रेट हिमालयन राष्ट्रीय उद्यान (GHNP), रूपी–भाभा वन्यजीव अभ्यारण (RBW) एवं पिन घाटी राष्ट्रीय उद्यान (PVNP) की शुद्ध प्राथमिक उत्पादकता (NPP) के सामयिक प्रतिमान वर्ष 2000–2014 के दौरान उपग्रह के आंकड़ों के उपयोग से तैयार किए हैं। हिमाचल प्रदेश के चम्बा जिले के भू–आवरण/भू–उपयोग के मानचित्र लैंडसैट उपग्रह के प्रतिबिम्ब से तैयार किए हैं जो इस क्षेत्र के विभिन्न भू–आवरण/भू–उपयोग वर्गों की नवीनतम परिस्थितियों को दर्शाता है। भारतीय हिमालय क्षेत्र के 45 चिकित्सीय पौधों की प्रकाशित स्रोतों से संकलित आंकड़ों से एक ई–इन्वेन्टरी भी बनायी गई है।

- उच्च तुंगता क्षेत्र में पादप विविधता और पादप प्रकार्यत्मक लक्षण (Functional Traits) का अध्ययन
- हिमालय के उच्च तुंगता क्षेत्र (3000 से 5000 मीटर) में 05 transects लगाए गए। इसमे sub alpine, treeline alpine और nival क्षेत्र में विविध प्रकार की वनस्पतियाँ मिलीं यहाँ प्रजातियों के क्षेत्र species range तथा पादप प्रकार्यत्मक लक्षण का अध्ययन किया गया। यहाँ Juniperus polycarpos बहुल जंगल दक्षिण क्षेत्र में पाये जाते हैं।
- लुप्त होने वाले आर्किड, डेक्टोराइजा हेटाजीरिया orchid, *Dactylorhiza hatagirea* के प्राकृतिक आवासों की परिस्थितियों का मूल्यांकन

हथ पंजा या सलेम पंजा या अंगमों लकपा के नाम से जाने वाले इस पादप प्रजाति का बहुत से रोगों जैसे घाव भरने तथा कामोद्दीपक के लिए औषधि के रूप में इस्तेमाल किया जाता है। घटते प्राकृतिक आवासों और अधिक माँग के कारण यह प्रजाति हिमालय में लुप्त होने की कगार पर है और इसे अभी भी जंगली क्षेत्र से ही निकाला जा रहा है क्योंकि इसकी खेती अभी शुरू नहीं की जा सकी है। इस अध्ययन में इसके रचमौचा विशेषता, समुदाय संरचना, और इसके संरक्षण के लिए अनेक चुनैतियों को समझा गया है। प्रदेश में 2900 मी से 4250 मी की ऊंचाई वाले कुल 25 क्षेत्रों में इसकी संख्या को जांचा गया और इसके पादप Functional Traits व इसकी आकार–विविधता का अध्ययन में यह पाया गया कि यह प्रजाति पृथक और छोटे भागों में कीचड़–दार तथा नम घास के मैदानों में ही विकसित होती है। इस प्रजाति को लुप्त होने से बचाने हेतु, इसकी खेती प्रणाली विकसित करने की आवश्यकता है और प्रकृति में इसके संरक्षण को प्राथमिकता देनी चाहिए।

मृदा कार्बन की मात्रा/घनत्व ग्लोबल कार्बन चक्र को संतुलित रखने में महत्वपूर्ण भूमिका निभाते हैं। इसलिए हमने इस अध्ययन में धौलाधार वन्यजीव अभयारण हिमाचल प्रदेश के शीतोष्ण वन में पाये जाने वाले विभिन्न वृक्ष प्रजातियों के कैनोपी के अंतर्गत आने वाले मृदा के कार्बन–घनत्व का आकलन कियाके अध्ययन से यह पता चला कि विभिन्न वृक्ष प्रजातियों के कैनोपी के नीचे पाये जाने वाले मृदा का कार्बन घनत्व अलग-अलग है, जिसमें क्वेर्कश सेमीकारफोलिया प्रजाति के कैनोपी के नीचे पाये जाने वाले मृदा का कार्बन घनत्व सबसे अधिक है। इसी अध्ययन के दौरान यह भी पाया गया कि विभिन्न वृक्ष प्रजातियों के कैनोपी के नीचे पाये जाने वाले विविध घास प्रजातियों में भिन्नता है तथा उनके बायोमास में अर्थपूर्ण अंतर है। इसके अलावा एक महत्वपूर्ण औषधीय पौधा पिक्रोराइजा से संबन्धित मॉडल विकसित करने के लिए अलग-अलग वातावरण में इसके पौधे रखकर इसके मार्फोलॉजी और फिजियोलॉजी के डाटा रिकार्ड किए गए।

लुप्तप्रायः और व्यावसायिक दृष्टि से महत्वपूर्ण औषधीय एवं सगंध पौध प्रजातियों के अत्याधिक दोहन से और प्राकृतिक आवासों के क्षरण होने के कारण हिमालय क्षेत्र में इसके संरक्षण के लिए कार्य की आवश्यकता है। अभी तक लाहौल के शुष्क मरुस्थल क्षेत्र में बहुत काम नहीं हुआ है। संस्थान के उच्च तुंगता जीवविज्ञान केन्द्र में पौधशाला में इस लुप्तप्राय प्रजातियों के संरक्षण का कार्य शुरु किया गया है। फार्मास्यूटिक्ल कम्पनियों द्वारा विभिन्न दवाईयों को बनाने के लिए लगातार बढ़ती मांग और जंगलों से अवैज्ञानिक तरीके से अत्याधिक दोहन के कारण इस बात का अनुभव किया गया कि इनके संरक्षण और प्रबन्धन की आवश्यकता है। इसी को ध्यान में रखते हुए संस्थान ने निम्न लक्ष्य निर्धारित किए हैं:

- उपयोगी पादप जैवसंपदा का गृहीकरण और उसे लगाना तथा उनकी कृषि तकनीक को विकसित करना
- आर्थिक दृष्टि से महत्वपूर्ण उच्च तुंगता जलवायु वाले पौधों के जर्मप्लाज़म एकत्रित करना
- हिमाचल प्रदेश के शुष्क मरुस्थल क्षेत्रों में खतरे में और आर्थिक दृष्टि से महत्वपूर्ण औषधीय एवं सगंध पौध प्रजातियों के वितरण का अध्ययन करना
- महत्वपूर्ण प्रजातियां
- हिफोपी जर्मप्लाज़म संसाधन केन्द्र
- रूस, लेह –लदाख, हिमाचल प्रदेश एवं रुस से लाए गए 300 से अधिक पौधों के जीनप्रारुपों को लगाया गया है।
- विकसित प्रौद्योगिकी
- स्नो वाटर हारवेटिंग प्रौद्योगिकी
- भूमिगत ग्रीनहाउस प्रौद्योगिकी
- प्राकृतिक पादप रसायनिकी एवं प्रक्रम विका
- समानव जीवन के सुधार के लिए प्रकृति आधारित नवोन्मेष

प्राकृतिक पादप उत्पाद एवं प्रक्रम विकास

व्यावसायिक रूप से महत्वपूर्ण पौधों जैसे की पिक्रोराइज़ा और केमेलिया और उनके उत्पादों जैसे चाय के लिए एनएमआर, UPLC-MS/MS और HPTLC तकनीक का उपयोग करते हुए व्यापक मेटाबोलाइट रूपरेखा, और किफायती गुणवत्ता नियंत्रण विधियों को विकसित किया गया है। इस साल हमने उच्च गुणवत्ता वाले स्टेवियोल ग्लाइकोसाइड (95% से अधिक शुद्धता) के उत्पादन के लिए सुधार प्रक्रिया विकसित की। साथ ही हरी चाय के पत्तों से चाय उत्पादन के लिए उच्च क्षमता (40 किलो ग्राम/बैच) की प्रक्रिया का विकास और बांस से कपड़ो के धागों को बनाने के लिए प्रयोगशाला पैमाने पर प्रक्रिया का विकास भी कर रहे हैं।

लघु दवा या दवा जैसे अणुओं की प्लाज्मा स्थिरता कम होती है और यह शरीर से बहुत जल्दी बाहर निकल आते हैं। एक रणनीति के तहत हम औषधि–पॉलिमर संयुक्त बना रहे हैं ताकि वो औषधि अणुओं के प्रवाह को निरंतर जारी रखने मे सक्षम हों। इस चुनौती को आगे ले जाने के लिए, हम बहुक्रिया नैनोयुक्ति का संश्लेषण, लक्षण वर्णन तथा उनका जीव में और जीव के बाहर कैंसररोधी गतिविधि के लिए औषधि अणुओं के प्रवाह को निरंतर जारी रखने की क्षमता का मूल्यांकन कर रहे हैं। वैकल्पिक दवा वितरण वाहक अणुओं की खोज हेतु, हम प्राकृतिक ग्लाइकोसाइड आधारित दवा /जीन वितरण बृहद् आणविक वाहक विकसित कर रहे हैं। हमारा विभाग पश्चिमी हिमालय क्षेत्र में पाये जाने वाले पौधों से अलग किए गए कैंसर कीमोथेरेपी और सूजन के लिए प्रासंगिक प्राकृतिक उत्पादों और उनके अनुरूपकों के संश्लेषण के नए तरीको के विकास के लिए काम कर रहे हैं।

वर्तमान में हम सूक्ष्म अणुओं और बायोएक्टिव एनालॉग्स के संश्लेषण में विद्यमान समस्याओं को हल करने के लिए उनके उत्प्रेराकीय व्यवहार एवं उपयोगों के परीक्षण करने के लिए विषम नैनो उत्प्रेरक के विकास में काम कर रहे हैं। विस्तारपूर्वक उत्प्रेरक का परीक्षण करने पर यह निर्दिष्ट होता है कि नैनो उत्प्रेरक का उपयोग किसी भी लिगेंड, अक्रिय वातावरण एवं परिष्कृत उपकरण का उपयोग किये बिना कई प्रकार की रासायनिक अभिक्रियाओं में प्रयोग किया जा सकता है। उत्प्रेरक का परीक्षण करने पर यह पार–युग्मन, ऑक्सीकरण एवं अपचयन अभिक्रियाओं में अति प्रतिक्रियाशील पाया गया। नैनो उत्प्रेरक का ओक्सिड़ेटीव एस्टरीफिकेशन प्रतिक्रियाओं में असामान्य व्यवहार होने के कारण, यह अपनी तरफ भविष्य में होने वाले परीक्षण के लिए ध्यान आकर्षित करते हैं।

बेहतर दवाओं के लिए ऐसे अणुओं की ख़ोज की जा रही हैं, जो कि प्रभावी हों और मानव शरीर द्वारा बर्दाश्त किए जा सकें। इस तरह के अणुओं को खोजने के लिए जैविक रूप से प्रासंगिक रासायनिक क्षेत्र के व्यवस्थित अन्वेषण की आवश्यकता है। प्राकृतिक उत्पादों का औषधि के रूप मे सफलता पूर्वक उपयोग किया जाता रहा है लेकिन प्राकृतिक उत्पादों की उपलब्धता और अन्य कारक उनके औषधि के रूप मे विकसित करने में मुख्य समस्या हैं। प्राकृतिक उत्पादों की उच्च सफलता दर को ध्यान में रखते हुए तथा वर्तमान मे दवा की कमी की समस्या के निराकरण हेतु प्राकृतिक उत्पादों और उनके समरूपों का चिकित्सा विज्ञान मे योजनाबद्ध तरीके से उपयोग किया जा सकता है। इसके अलावा, प्राकृतिक संसाधन लंबी अवधि के लिए उपलब्ध नहीं हो सकते; इसलिए महत्वपूर्ण अणुओं का उत्पादन करने के लिए 'जिनका हिट दर ज्यादा हो' कुशल संश्लेषण तरीकों के विकास और महत्वपूर्ण अणुओं के संश्लेषण में उनके उपयोग की दिशा में हम प्रयासरत हैं।

इस साल हमने यूकेलिप्टस सिट्रीडोरा (Eucalyptus citriodora) के फल, सेब (Malus domestica) के पत्ते, कम ऊंचाई पर उगाये जाने वाले जुनिपेरस कम्यूनिस (Juniperus communis) के उपरी हिस्से तथा कपूर कचरी (Hedychium spicatum) के राईज़ोम \(Rhizome) पर अक्षांशीय और मौसमी बदलाव का असर के सगंध तेल की उपज पर देखा गया। इस साल हमें जंगली हल्दी (Curcuma aromatica) के सगंध तेल में संशोधन पर एक अमेरिकी पेटेंट प्राप्त हुआ। इसके अलावा हमने पाया है कि सेब के पत्ते एक महत्वपूर्ण सहायक मेटाबोलाइट फ्लोरिडिजन (Phloridzin) का मुख्य स्रोत है।

हिमालय जैव सम्पदा और उससे निर्मित उत्पादों के मेटाबोलोमिक्स, लिपिडोमिक्स एवं गुणवत्ता नियंत्रण की दिशा मे शोध कार्यः आदिम युग से ही पौधों और मरीन स्त्रोतों को स्वास्थ्य की गंभीर जटिलताओं का इलाज करने के लिए प्रयोग किया जाता रहा है और अभी भी ये सब बहुत महत्वपूर्ण हैं। उनके व्युत्पन्न उत्पादों को नई दवाओं की खोज करने के लिए टेम्पलेट के रूप में भी इस्तेमाल किया जाता है। पौधों, मरीन स्त्रोतों व उत्पादों के रसायन विज्ञान, मेटाबोलाइट रचना और परिवर्तन को समझना एवं गुणवत्ता और गुणवत्ता नियंत्रण कि दिशा मे कार्य आजकल के समय की माँग है।

इसलिए हम वर्तमान में NMR, UPLC-MS/MS और HPTLC तकनीकों का उपयोग उतर-पश्चिम हिमालय के कुछ महत्वपूर्ण औषधीय पौधों की मेटाबोलाइट रूपरेखा एवं रचना और उनके गुणवत्ता नियंत्रण पर काम कर रहे हैं। इसके अलावा, हम lipidomics और **metabolomic** अध्ययन के माध्यम से Cratageous oxycantha की भूमिका का हृदय पर सुरक्षात्मक एवं विपरीत प्रभाव का पता लगाने की दिशा में काम कर रहे है। 600 MHz NMR तकनीक के फलस्वरुप हमने Picrorhiza kurroa Royle ex Benth का मेटाबोलाइट रचना की जांच की है। हमने पत्तियों और प्रकंदो में उपस्थित प्राथमिक और माध्यमिक मेटाबोलाइटस की पहचान की और इनके माध्यमिक मेटाबोलाइट में महत्वपूर्ण गुणात्मक अंतर को देखा।

हमने औषधीय एवं खाद्य पौधे P. kurroa और C. sinensis की गुणवत्ता नियंत्रण करने के लिए कम समय लगने वाली अत्यधिक महत्वपूर्ण, विश्वसनीय एवं प्रतिलिपि प्रस्तुत करने वाली विधि विकसित की है। हम प्राकृतिक पादप रसायन, गुणवत्ता नियंत्रण, पादप उत्पाद एवं उनकी मानकीकरण की दिशा में शोध कार्य हेतु प्रयासरत है।

हमारे समूह द्वारा संचालित काम मूल रूप से भविष्य के अनुप्रयोगों के करीबी संबन्धों को ध्यान में रखते हुए आधारभूत विज्ञान पर जोर देना है। प्राकृतिक उत्पाद आधारित नवीन और जैवसक्रिय अणु आधुनिक विज्ञान के क्षेत्र में चिकित्सकीय उपयोग में अपना स्थान बनाएगें। आयुर्वेद पौधों की वैज्ञानिक मान्यता से उनके उपयोग के वैज्ञानिक आधार प्रदान होगा तथा जिससे उच्च सामाजिक प्रभाव में भी गति आएगी। इन कार्यों से रासायनिक विज्ञान के विकास के लिए नए अवसर खुल जाएगें। वर्तमान में उद्योगों में हरित प्रौद्योगिकियों और सी– एच सक्रियण के लिए कटैलिसीस के क्षेत्र में हमारे काम को अपनाने के लिए इस क्षेत्र में बड़ा प्रभाव पड़ेगा, इसके लिए प्रयास जारी है।हमारे समूह के नए क्विनोलिन आधारित अणुओं सी एच सक्रियण /कार्यात्मकता के संश्लेषण की दिशा में काम कर रहा है ।

हमारा समूह प्रक्रम विकास और प्रयोगशाला प्रक्रियाओं को पायलट संयंत्र में व्यापक स्तर पर बढ़ाने के साथ–साथ प्रक्रम ज्ञान को विकसित करने एवं औद्योगिक रुप से महत्वपूर्ण जैवसक्रिय प्राकृतिक उत्पादों की प्रौद्योगिकी हस्तांतरण में लगा हुआ है। आम तौर पर यहां पर विभिन्न औषधीय एवं सगंध पौधों जैसे कि स्टीविया से स्टीवियॉल, चाय की हरी पत्तियों से केटेकिन और दमस्क गुलाब से गुलाब तेल एवं अन्य सगंध फसलों का प्रक्रमण किया जाता है। इसे अब व्यापक पैमाने में बढ़ाया जा रहा है। इसके बाद विभिन्न प्रक्रम प्रक्रिया मापदंडों को इष्टतम बनाया जा रहा है ताकि इन निष्कषणों से अधिकतम फसल प्राप्त की जा सके। इस समूह का प्रमुख कार्यक्षेत्र हैः प्रक्रम विकास, उपकरण एवं संयंत्र डिजाइन, प्रक्रम निगरानी, इष्टमीकरण, मेम्बरेन तकनीक, प्रक्रम की तकनीकी आर्थिक व्यवहार्यता।

चाय एक बहुपयोगी औषधीय पौधा है। भारत विश्व में चीन के पश्चात चाय उगाने बाला दूसरा प्रमुख देश है। चाय मे विविध प्रकार के अति उपयोगी रसायन पाए जाते हैं, जो कि कई प्रकार के रोगों से मानव शरीर की रक्षा करते हैं। यह रसायन शरीर में एंटिओकसिडेंट्स का कार्य करते हैं, एवं विभिन प्रकार के हानिकारक प्रतिक्रियाशील ऑक्सीजन प्रजातिओं (रेक्टिव ओक्सीजीन स्पीसिस) से शरीर की रक्षा करते हैं। हमने शोध के दौरान यह पाया कि चाय के अनुपयोगी भागों (बडी पत्तियाँ, फूल और फलों) में पर्याप्त मात्रा में उपयोगी रसायन पाए जाते हैं। अतः नवीन एवं किफ़ायती विधिओं के माध्यम से लाभदायक रसायनों का उत्सृजन कर नए मूल्य वर्धित उत्पादों जैसे कि एंटीऑक्सीडेंट युक्त कैप्सूल्स तथा पेय पदार्थ इत्यादि के निर्माण हेतु शोध कार्य किया जा रहा है।

ग्रामीण विकास कार्यक्रम

वैज्ञानिक एवं नवीकृत अनुसंधान अकादमी के छात्रों द्वारा ग्रामीण विकास कार्यक्रम की गतिविधियां

बैजनाथ विकास खंड के कंडवाडी क्षेत्र की तीन पंचायतों का सर्वेक्षण किया गया। इसका मुख्य उदेश्य स्वास्थ्य संबन्धी प्रमुख समस्याओं तथा स्थानीय लोगों की जीवनशैली, खान–पान और सामाजिक–आर्थिक स्तर का अध्ययन करना था। 472 परिवारों के सर्वेक्षण से यह पाया गया कि रक्तचाप, एनीमिया, मधुमेह, पथरी आंख–कान में खराबी जैसी पांच प्रमुख रोग हैं। स्वास्थ्य संबन्धी अनभिज्ञता अपर्याप्त कूड़ा कर्कट निपटान आदि से महामारी के फैलने की आशंका तथा रोकथाम के प्रति लोगों को जागरुक किया गया। एक अन्य सर्वेक्षण में इस क्षेत्र के जल की गुणवत्ता का अध्ययन किया गया। विभिन्न स्रोतों से जल की जांच की गई।

एक अन्य सर्वेक्षण में इस क्षेत्र की मिट्टी की जांच की गई तथा इसके आधार पर फसलों को लगाने की संस्तुति की गई। उर्वरक का प्रयोग किस प्रकार किया जाए ताकि अच्छी पैदावार हो इस बारे में भी जागरुक किया गया। जिसमें 2235 के लगभग लोगों को प्रशिक्षित किया गया। संस्थान द्वारा विभिन्न स्थानों पर चाय की खेती एवं मशीनीकरण, सगंध एवं औषधीय पौधों, सगंध तेल निष्कर्षण, पुष्प फसलों, खाद्य प्रसंस्करण एवं मूल्यवर्धन आदि लगभग 42 प्रशिक्षण कार्यक्रमों का आयोजन किया गया। वर्ष के दौरान 4 तकनीकी ब्रोशर प्रकाशित हुए। उद्योगों की आवश्यकताओं को पूरा करने के लिए 83270 कठोर और रोगमुक्त आलू की सोलह किस्मों के सूक्ष्म प्रवर्धित पौधों को मै. महिन्द्रा इंवेस्टमैंट प्राईवेट लिमिटेड, मोहाली पंजाब को उपलब्ध कराया और 632890 रूपये अर्जित किए गए। इसी तरह बॉस के 600 पौधों को जम्मू और कश्मीर, पंजाब और हिमाचल के विभिन्न अभिकरणों को प्रदान करके करीब एक लाख रूपए अर्जित किया गया।

योजना, परियोजना, अन्वेक्षण और मूल्यांकन इकाई

सी.एस.आई.आर. तथा आई.एच.बी.टी. के वार्षिक प्रतिवेदन के लिए सूचना को एकत्रित किया। इन्टरनेट तथा इन्ट्रानेट पर सामग्री को अद्यतन किया। एक वेबपेज को तैयार किया गया जिसमें इच्छुक छात्र अपने शोध संबन्धी जिज्ञासाओं के लिए आवेदन कर सकते हैं तथा संबन्धित वैज्ञानिक उनके विवरण के आधार पर उन्हें आगे कार्य के लिए आमंत्रित कर सकते हैं। चल रही 18 परियोजनाओं की सूचना का संकलित किया। प्रकाशन, पेटेंट आदि से संबन्धित जानकारियों को संग्रहित किया जिसमें 119 प्रकाशन , 352 लाख बाह्य प्राप्त धनराशि 13 पेटेंट और 3 प्रौद्योगिकी हस्तांतरण हैं। 52 एवं 53वीं अनुसंधान परिषद बैठक का आयोजन। संस्थान परिसर में विभिनन संस्थानों के 47 छात्रों को प्रशिक्षण दिलाया गया। संस्थान की गतिविधियों को बताने के लिए तथा स्कूली छात्रों में विज्ञान के लोकप्रियकरण के लिए समय–समय पर संस्थान में शैक्षणिक भ्रमण कराया गया। सूचना के अधिकार के अन्तर्गत 14 मामलों की जानकारी उपलब्ध कराई। सोसल मीडिया में संस्थान की गतिविधियों को प्रसारित करने के लिए फेसबुक एवं ट्वीटर अकांउट बनाए गए। विभिन्न सी.एस.आई.आर. स्थापना दिवस, आई.एच.बी.टी. स्थापना दिवस, राष्ट्रीय विज्ञान दिवस, राष्ट्रीय प्रौद्योगिकी दिवस सहित कई प्रकार के समारोहों का आयोजन भी किया।

बीडीएमयू

संस्थान द्वारा विकसित प्रौद्योगिकी का तकनीकी एवं आर्थिक मूल्यांकन कियाा गया। प्रौद्योगिकी हस्तातंरण के ड्राफ्ट करार बनाए गए। किसानों द्वारा विभिन्न पुष्प, औषधीय एवं सगंध फसलों के बारे में वांछित जानकारी को भी उपलब्ध कराया।

कम्प्यूटर इकाई

संस्थान परिसर में इंटररनेट सुविधा राष्ट्रीय ज्ञान नेटवर्क के अन्तर्गत 1Gbps लीज्ड लाइन द्वारा फाइबर नेटवर्क बैकबोन और एच. पी., आई.बी.एम. एवं सनमाइक्रा सरवर के माध्यम से प्रदान की जाती है। नेटवर्क सिक्योरिटी के लिए यूनिफाइड थ्रेट मैनेजमेंट सिस्टम, आईडीएस, आइपीएस, सेंट्रलाइज नेटवर्क सिक्योरिटी सिस्टम, एन्टीवायरस आन क्लाइंट सरवर मोडल तथा एसएमटीपी स्पेम/वायरस प्रोटेक्शन सॉफ्टवेयर को संस्थान के इ रिसोर्सस को संरक्षित करने के लिए लगाया गया है। इस इकाई द्वारा डोमेन नेम सरवर, डीएनएस, वेब, इमेल प्रोक्सी सरवर को प्रबन्धित किया गया और संस्थान में वीडियोकान्फ्रेंसिंग, वाई–फाई सुविधा तथा इससे संबन्धित सेवाएं भी उपलब्ध कराई गई।

फोटोग्राफी युनिट

फोटोग्राफी युनिट ने विभिन्न समारोहों, कार्यशालाओं, प्रशिक्षण आदि की कवरेज के अतिरिक्त शोध एवं विकास से संबन्धित विषयों पर भी फोटोग्राफी की।

पेटेंट

वर्ष के दौरान संस्थान ने 2 पेटेंट फाइल किए तथा 4 पेटेंट विदेश में प्राप्त/पंजीकृत हुए।

प्रकाशन

वर्ष के दौरान संस्थान ने स्तरीय जर्नल में 174 शोध पत्र प्रकाशित कराए। 2 हिंदी शोध पत्र भी प्रकाशित हुए। 3 लोकप्रिय विज्ञान लेख में प्रकाशित हुए। पुस्तकों में 8 लेख/पाठ प्रकाशित हुए। एक पुस्तकें प्रकाशित हुईं। पांच तकनीकी ब्रोशर प्रकाशित हुए।

संस्थान ने ग्रामीण विकास के अर्न्गत 41 प्रशिक्षण कार्यक्रमों का आयोजन किया। उद्यमिता विकास पर 2 कार्यक्रम का आयोजन किया गया।

संगोष्ठी/सेमिनार में प्रतिभागिता

संस्थान के वैज्ञानिकों ने 16 संगोष्ठियों बैठकों में प्रतिभागिता की तथा प्रस्तुतिकरण किया।

संस्थान ने 2 प्रदर्शनियों में अपने उत्पादों तथा प्रौद्योगिकी को प्रदर्शित किया।

व्याख्यान

संस्थान के निदेशक एवं वैज्ञानिकों ने 9 स्थानों में व्याख्यान दिए।

संस्थान में 5 आंमत्रित व्याख्यान आयोजित किए गए।

दूरदर्शन कार्यक्रम

संस्थान के वैज्ञानिकों ने वर्ष के दौरान 14 दूरदर्शन वार्ताएं प्रसारित

विदेश यात्रा

वर्ष के दौरान संस्थान के निदेशक ने मिस्र, ताइवान और विएतनाम का दौरा किया

छात्रों को प्रशिक्षण

संस्थान ने विभिन्न विश्वविद्यालयों/ संस्थानों के 8 छात्रों को प्रशिक्षण प्रदान किया।

संस्थान के वैज्ञानिकों को इस वर्ष कई महत्वपूर्ण पुरस्कार/सम्मान प्राप्त हुए।

इस वर्ष संस्थान के 3 शोध छात्रों ने पी. एचडी प्राप्त की, 7 छात्रों ने स्नातकोत्तर तथा 2 ने बी.टेक. डिग्री के लिए शोध–प्रबन्ध विभिन्न विश्वविद्यालयों में जमा किए।

OBITUARY

(18.09.1978 – 28.03.2016)

Dr. Neeraj Kumar, Senior Scientists in the institute lost his life in car accident near Nangal, Punjab while traveling from Chandigarh to Palampur (HP) on March 28, 2016. He joined the institute on 11 April 2008. He was a specialist scientist in the area of natural product chemistry and organic synthesis. He published more than 90 research papers in quality journals and have secured his research with patents. He is survived by his wife Dr. Pamita and daughter Varanya. He will always be remembered for his devotion, dedication and diligence.

CSIR-IHBT family prays for eternal peace to the departed soul and extends heartfelt condolences to the bereaved family.

शोध में सतत् व पर्यावरण अनुकूलता होना आवश्यक

कृषि व पशुपालन का देश की आर्थिकी व पोषण सुरक्षा में महत्वपूर्ण योगदान

पालमपुर : सम्मेलन के उद्घाटन सत्र में उपस्थित मुख्यातिथि व अन्य।

संजय कुमार जीवी जोशी स्मारक व्याख्यान पुरस्कार से सम्मानित

पालमपुर, 19 दिसम्बर (नि.स.): संजय कुमार निदेशक सी.एस.आई.आर. हिमालय जैव सम्पदा प्रौद्योगिकी संस्थान पालमपुर को प्रो. जीवी जोशी स्मारक व्याख्यान पुरस्कार-2015 से सम्मानित किया गया। यह पुरस्कार जवाहरलाल नेहरू विश्वविद्यालय नई दिल्ली में आयोजित तीसरे अंतर्राष्ट्रीय प्लांट फिजियोलॉजी कांग्रेस के दौरान प्लांट फिजियोलॉजी और आत्मीय विज्ञान के क्षेत्र में उनके उत्कृष्ट योगदान के लिए दिया गया। इससे पहले भी उन्हें कृषि

सीएसआईआर संस्थान पालमपुर ने तैयार किया फार्मूला

कैंसर से लड़ेगी चाय की पत्तियों से बनी दवा

विनोद राणा

- पत्तियों में मौजूद कैटेकिन से कमजोर याददाश्त है ठीक
- चीन, जापान हैं कैटेकिन के सबसे बड़े सप्लायर
- निजी कंपनी को दिया फार्मूला जल्द बाजार उतरेगी दवा

इनसे बनता है कैटेकिन

Northeast Today

undefined

by Northeast Today

Institute of Bioresources and Sustainable Development (IBSD), a National Institute under Department of Biotechnology, Government of India in association with Department of Botany, University of Delhi, HESCO, Dehradun and Institute of Himalayan Bioresource Technology IHBT(CSIR), Palampur organized the "First Himalayan Conclave – 2015" on September 9, 2015 at University of Delhi on wednesday.

More than 300 people from different parts of the country participated in the Conclave. You are aware that Himalayas have been the soul of the world by virtue of it's cultural, ecological and economical values, but unfortunately the importance of Himalayas and ecosystem services was underestimated. Deterioration of Himalayas due to inadequate attention has threatened our Life Supporting Resources. Status of forest, water, air and soil has become alarmingly grim. Himalayan resources have been shrinking fast and ultimate burnt has to be born by each one of us. Recent Natural Calamities in Uttarakhand, Kashmir and Nepal are some of the most recent examples, which is still fresh in our memory said Professor Dinabandhu Sahoo, Director of Imphal based Institute of Bioresources and Sustainable Development (IBSD), and Chairman of the Conclave.

He said, it is high time to have a debate and in depth deliberations on status and health of Himalaya. How we can join hands to serve the Himalayas and it's communities and the world at large he said. Professor K. Vijayaraghavan, Secretary, Government of India, Department of Biotechnology, New Delhi while inaugurating the function emphasized the role of scientists and Technologists to do more research for the benefit of the society. Dr.Anil Joshi, Director ,HESCO said that this conclave is the first initive to bring all stakeholders social workers,NGOs,Civil societies,Scientists and academicians under one platform to save Himalyas and safe gured the interests of local people.

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अमिताभ, मंडेला फूलों के भी हैं नाम

पालमपुर में राष्ट्रीय विज्ञान दिवस पर केरल के वैज्ञानिक डॉ. सतीश ने गिनाए किस्मों के नाम

THE TIMES OF INDIA | Global Warming

Himalayas under threat, say experts

NEW DELHI: The fragile Himalayan ecosystem is in poor health. Hundreds of scientists and students raised concern about the impact of climate change, urbanization, deforestation and other threats to the mountains at the first Himalayan Conclave on Wednesday at Delhi University.

On Thursday, the participating experts will formulate a charter of solutions as well as demands for the conservation of Himalayas.

Talat Ahmad, V-C, Jamia Millia University highlighted how the frequency of cloudbursts had increased dramatically over the years, so much so that this year there were three cloudbursts in a day in Kashmir Valley.

The two-day conclave, organized by the Institute of Bioresources and Sustainable Development, Himalayan Environmental Studies and Conservation Organization (Hesco) Dehradun, Institute of Himalayan Bioresource Technology and others, had over 300 participants.

Hesco director Anil Joshi said both BJP at the Centre and AAP in Delhi should contribute to saving the Himalayas. "That's because Yamuna, the lifeline of Delhi, is after all a Himalayan river. The people living in plains have been dependent on the Himalayas for water, food and even fresh air but have given nothing in return. It's a Himalayan debt," he said.

Dinabandhu Sahoo of IBSD focused on the amazing biodiversity of the eastern Himalayas, describing how Manipur is the only state to grow black rice that has anti-diabetic properties. "Arunachal Pradesh now has a great harvest of kiwi and Meghalaya hosted the first cherry blossom festival this year. India doesn't need to import... Himalayas have it all."

अगरबत्ती में महकेंगे श्रद्धा के फूल

सुनील दीक्षित, पालमपुर

खुशखबरी

- सीएसआईआर का आइएचबीटी देगा कार्य को अंतिम रूप
- मंदिरों में चढ़ाने के बाद पानी में बहा दिए जाते हैं फूल

बैजनाथ में शिवरात्रि के दौरान मंदिर की साज सज्जा के लिए लाए गए फूल।

सुगंधित लेमन घास से किसान होंगे मालामाल

घास से निकलेगा तेल, 1100 रुपये प्रतिलीटर है कीमत

विनोद राणा

क्या है यह सुगंधित घास

बीज के लिए पालमपुर करें संपर्क

मशीनीकरण से बढ़ेगा कांगड़ा चाय का उत्पादन : बृज बुटेल

अमर उजाला ब्यूरो

चाय उत्पादक विकसित तकनीक का करें इस्तेमाल

दैनिक जागरण

पूरी दुनिया पर होगा हिमालय पर प्रभाव का असर : प्रो. दीनबंधु

पहले हिमालय सम्मेलन में जुटे विद्वान ● ग्लोबल वार्मिंग के कारण कई तरह के असंतुलन

नवीन दृष्टिकोण से शोध की आवश्यकता

आई.एच.बी.टी. ने सी.एस.आई.आर. स्थापना दिवस समारोह मनाया

युवाओं और छात्रों को बताया विज्ञान का महत्व

हिमालय जैवसंपदा प्रौद्योगिकी संस्थान ने मनाया स्थापना दिवस

चारा व औषध क्षेत्र में शोध की आवश्यकता : संजय

संवाद सहयोगी, पालमपुर : वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद

सीएसआईआर ने मनाया स्थापना दिवस

पालमपुर (कांगड़ा)। वैज्ञानिक और औद्योगिक अनुसंधान परिषद (सीएसआईआर) संस्थान ने शनिवार को अपना स्थापना दिवस समारोह मनाया। संस्थान के निदेशक डा. संजय कुमार ने अतिथियों का स्वागत किया और सीएसआईआर की प्रमुख प्रयोगशालाओं एवं संस्थान के वार्षिक प्रतिवेदन को प्रस्तुत किया। उन्होंने कहा कि भारतीय हिमालय क्षेत्र की समृद्ध जैव विविधता जैव आर्थिकी (बायो इकोनॉमी) के क्षेत्र में अपार अवसर प्रदान करती है, जिसके लिए खाद्य, चारा, औषधि, सुगंध एवं ऊर्जा के क्षेत्र में नवीन दृष्टिकोण से शोध की आवश्यकता है।

वैटरिनरी कालेज में पशु उत्पादन बढ़ाने पर चर्चा

कार्यालय संवाददाता, पालमपुर

पालमपुर में राष्ट्रीय कान्फ्रेंस में जुटे देश भर से वैज्ञानिक

वैटरिनरी कालेज में शुरू हुई दो दिवसीय राष्ट्रीय कान्फ्रेंस में देश भर से जुटे वैज्ञानिक उत्कृष्ट शोध से पशु उत्पादन बढ़ाने पर मंथन करेंगे। भारतीय पशु पोषण व पशु कल्याण अकादमी द्वारा आयोजित सम्मेलन में विभिन्न प्रदेशों से आए वैज्ञानिक 'पोषण सुरक्षा के लिए पशु उत्पादन, स्वास्थ्य एवं मिश्रित खेती' विषय पर चर्चा करेंगे। बुधवार को सम्मेलन में मुख्यातिथि शिरकत करने पहुंचे हिमालय जैव संपदा प्रौद्योगिकी संस्थान के निदेशक डा. संजय कुमार ने कहा कि कृषि व पशुपालन का देश की आर्थिकी व पोषण सुरक्षा में महत्वपूर्ण योगदान है। प्रदेश में जलवायु और भौगोलिक विविधता के कारण फसलों और पौधों के साथ पशुओं के मामले में भी विविधता देखने को मिलती है। भारतीय पशु पोषण एवं पशु कल्याण अकादमी के अध्यक्ष डा. एनएन पाठक ने कृषि व पशुपालन से जुड़े सेवानिवृत्त विशेषज्ञों व वैज्ञानिकों से कुछ गांवों को गोद लेकर किसानों की सेवा करने का आह्वान किया। इस मौके पर वैटरिनरी कालेज के डीन डा. आरके अग्निहोत्री, डा. वीके शर्मा, डा. आदर्श कुमार और डा. सुदेश ने भी अपने विचार रखे। इस दौरान संबंधित प्रकाशनों का भी विमोचन किया।

पालमपुर : वैटरिनरी कालेज में दो दिवसीय कान्फ्रेंस में पुस्तक का विमोचन करते हिमालय जैव संपदा प्रौद्योगिकी संस्थान के निदेशक डा. संजय कुमार व वैज्ञानिक