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वार्षिक प्रतिवेदन
Annual Report
2018-19

Monk Fruit: Adding Sweetness to Life

सीएसआईआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
CSIR-Institute of Himalayan Bioresource Technology
पालमपुर–176 061 (हि.प्र.) / Palampur-176 061 (H.P.)

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Annual Report
2018-19

With Best Compliments from
Dr. Sanjay Kumar
Director

CSIR- Institute of Himalayan Bioresource Technology
Palampur (H.P.)-176061

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OVERVIEW OF CSIR-IHBT

Vision

To be a global leader on technologies for boosting bioeconomy through sustainable utilization of Himalayan bioresources

Mission

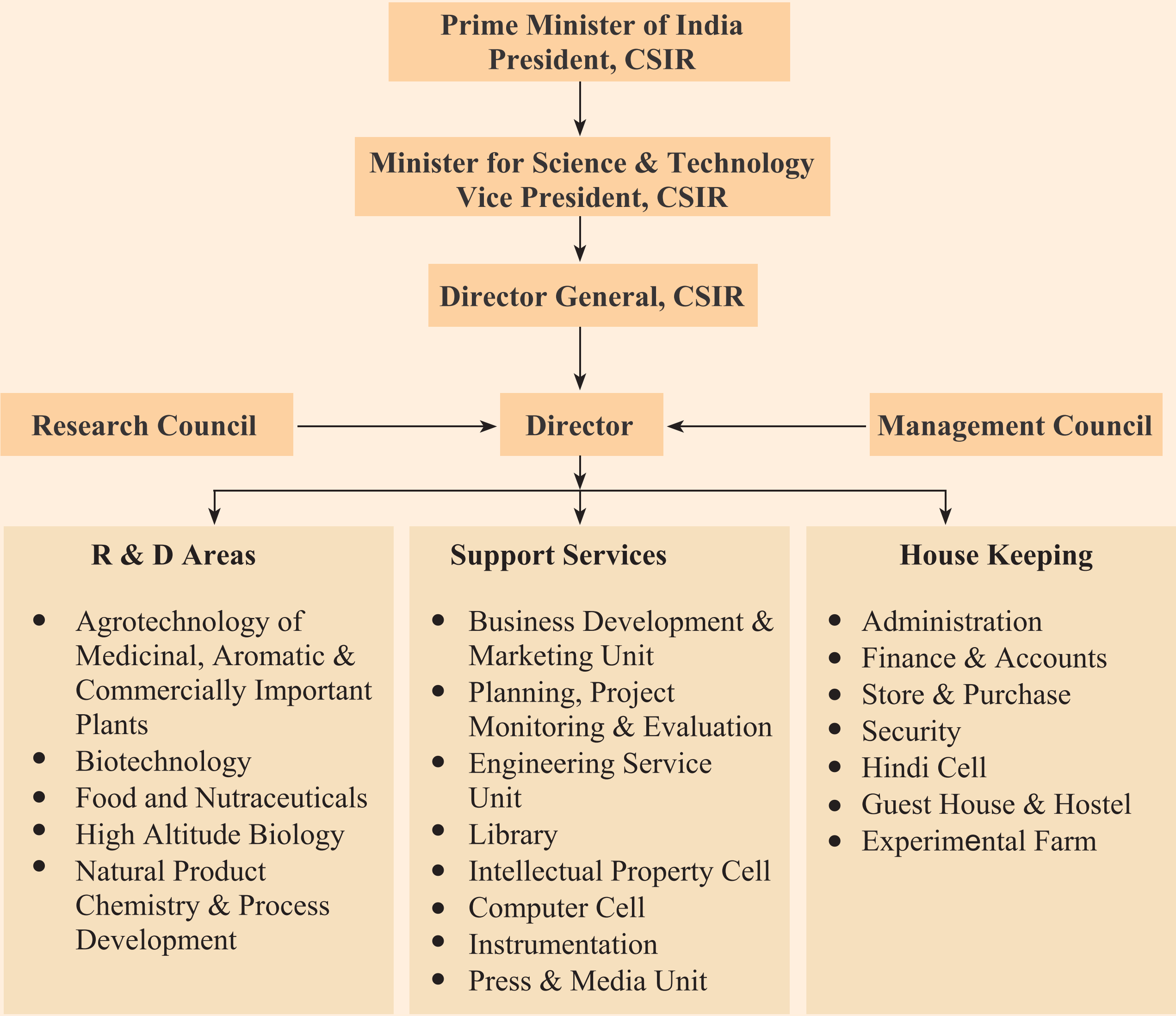
To discover, develop and commercialize processes and products from Himalayan bioresources using cutting-edge science and technology

CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT), perched in the lap of majestic snow clad mountains of Dhauladhar range in the western Himalaya, has a history that dates back to 1960s when CSIR proposed to set up a National Biological Research Institute at Palampur in H.P. The state government at that time made available 1225 acres of land for this establishment. This could not materialize and the matter remained undecided for 18 years. In the mean time, major portion of the allocated land paved way for the establishment of H.P. Agricultural University (now CSK HPKV) and other organisations. Subsequently, CSIR Regional Research Laboratory (RRL), Jammu also opened a Regional Research Centre at Palampur in a rented building to make a base for setting up of the proposed CSIR institute. The then Director of RRL, Jammu played a vital role in this matter and took possession of the remaining 226.1 acres of land in 1978. Subsequently, the then Chief Minister of H.P. formally requested Prof. Nurul Hasan, the Vice President of CSIR during that period to initiate the process and give a final shape to the proposal of setting up a CSIR institute. Finally, the foundation stone of CSIR Complex Palampur was laid on July 2, 1983 and the first Coordinating Director was appointed in February, 1984. Since then, the institute has been relentlessly working towards the development of technologies for sustainable utilization of Himalayan bioresources and societal upliftment. Based on the mandate of the institute and the milestones achieved, CSIR Complex, Palampur was rechristened as the institute of Himalayan Bioresource Technology in 1997. Further, to catalyze the economy of the high mountains through technological interventions, a Centre for High Altitude Biology (CeHAB) was established at Ribling (3450 m amsl, near Keylong), district Lahaul & Spiti, H.P. on October 1, 2012.

The institute is involved in harnessing and sustainable utilization of Himalayan bioresources through multifaceted state-of-the-art facilities for basic as well as translational research to develop end-to-end processes and products. The institute has a strong patent portfolio based on cutting edge science and vast experience of successful commercialization of technologies for propelling industrial growth. The institute has proven credentials in boosting economy through empowerment and enhancing livelihood of tribal and other communities of high altitude areas through floriculture, cultivation of medicinal & aromatic plants and processing of local resources for value addition.

ORGANIZATIONAL STRUCTURE

CSIR- Institute of Himalayan Bioresource Technology



Prime Minister of India
President, CSIR

Minister for 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 Nutraceuticals
- High Altitude Biology
- Natural Product Chemistry & Process Development

Support Services

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

House Keeping

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

RESEARCH COUNCIL

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Chief Executive Officer
Vittal Mallya Scientific Research Foundation,
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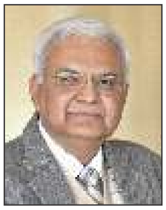

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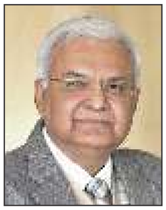
MANAGEMENT COUNCIL



Dr. Sanjay Kumar, Chairman
Director
CSIR-Institute of Himalayan Bioresource
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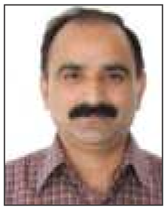
Dr. Anil Koul
Director
CSIR-Institute of Microbial
Technology,
Chandigarh



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Bioresource Technology,
Palampur (H.P.)

Sh. Alok Sharma
Member Secretary
Administrative Officer
CSIR-Institute of Himalayan
Bioresource Technology,
Palampur (H.P.)

IMPRESSIONS

01 May 2018

Shri Giriraj Singh, MoS (IC) MSME, Govt. of India: ‘आज मैं पहली बार IHBT आया मुझे लगा की मुझे यहाँ बहुत पहले आना चाहिए था। जिससे यहाँ पर हो रहे अति उपयोगी कार्यों से देश के किसानों, युवाओं और बेरोजगार युवाओं की लाभ देने का प्रयन्त करता। यहाँ के वैज्ञानिकों द्वारा किए गये कार्य बहुत ही सराहनीय हैं। संस्थान द्वारा किए गये कार्यों का वर्णन करना संभव नहीं हैं। IHBT द्वारा स्टीविया की खेती की तकनीक तथा उसके processing की विधि विकसित की गयी है जो देश युवाओं को तथा किसानों को रोजगार तथा आय बढ़ाने के लिए क्रांतिकारी कदम है। संस्थान द्वारा जंगली गेंदे की खेती, चाय की farming, चाय के विभिन्न उत्पाद, bio-plastic तथा microbes के प्रयोग से cellulose, एक बहुत की चमत्कारी कार्य है। संस्थान द्वारा युवा incubatees को दिये जाने वाला प्रशिक्षण बहुत लाभकारी है। आज आवश्यकता है कि देश के हर प्रदेश के युवाओं तथा किसानों तक IHBT द्वारा विकसित तकनीक को पहुँचाना है। जिससे रोजगार के अवसर प्रदान किए जा सकें। देश के Entrepreneurs उद्योगों को IHBT में निमंत्रण देकर एक workshop का आयोजन किया जाना चाहिए जिससे अनेक रोजगार के अवसर उत्पन्न किए जा सकते हैं। मैं IHBT के सभी वैज्ञानिकों का आभारी हूँ तथा उनके उज्ज्वल भविष्य की कामना करता हूँ।’’

06 May 2018

श्री जय राम ठाकुर, मुख्यमंत्री (हि.प्र.): ‘‘आज CSIR में आने का अवसर मिला। बहुत बेहतर प्रयास, नये आविष्कार और आविष्कारों को रोजगार के साथ जोड़ने के प्रयास किए गये हैं।’’

10 May 2018

डॉ. तेज़ प्रताप, पूर्व–कुलपति–कृषि विश्व विद्यालय, जैविक खेती विशेषज्ञः ‘‘आज 8 वर्ष बाद IHBT देखने का मौका मिला। Moving towards Incubators, startups, entrepreneurs. This is the way to harness fruits of science and technology for the welfare of society. I also appreciate interest of IHBT in organic agriculture.”

13 May 2018

श्री प्रसन्न कुमार पाटसाणी, लोकसभा सदस्यः ‘‘बहुत ही बेहतरीन और जन उपयोगी कार्य देख कर अभिभूत हुए। इनका प्रचार करना। आवश्यक है, जिससे लोगों को रोजगार और उपयोग की वस्तुएँ आसानी से मिल सकेंगी। ऐसे क्षेत्रों में जहाँ इनकी उपलब्धि नही है, वहाँ भी वस्तुएँ पहुँचाना आसान होगा। मेरा सभी शोधार्थियों को धन्यवाद।’’

13 May 2018

डॉ. सुनील बलिराम गायकवाड़, सांसद, ‘‘इस संस्थान में हमारे देश के किसानों की आय दोगुना बनाने के लिए जो करना चाहिए उस प्रकार का रिसर्च यहाँ हुआ है। मैं भारत सरकार के इस संस्थान को बहुत–बहुत शुभकामनाएँ देता हूँ।

14 June 2018

Shri Deepak Vohra, Ambassador Special Advisor:“You are the Best, the others are the rest! India is proud of its children like you!”.

03 July 2018

Dr. L.M.S. Palni, Vice Chancellor, Graphic Era University, Dehradun: “Being one of the founder IHBTian (March1989 to Nov1992) it was indeed a heart-warming visit and very rewarding in more ways than one. So nice to see the small seedling sown at that time grown into a 'vishal vat vriksha' thanks to the vision and timeless efforts of number of former and current director of IHBT. Lots of good memories got revived, and I want to wish this institute every success for times to come.”

27 July 2018

Prof. Sudhir K. Sopory, “Distinguished scientist, SERB and Former VC, JNU and Director, ICGEB, New Delhi “It has been a privilege to have been associated with IHBT for a number of years as a member of RC. Have seen the growth of this institute, which is unique in its research activities. Ranging from genomics to the field biology and application of the bioresources of this region. The leadership of IHBT has provided the vision and the scientists and all staff have converted that vision into reality. Every visit here has been a learning experience and it is a pleasure to see excitement on the part of the Director and staff to do better. My best wishes to Dr. Sanjay and everyone for even more exciting research to take IHBT to greater heights.”

01 October 2018

Prof. V.L. Chopra, Ex. Member Planning Commissioner & Director General ICAR: "My association with IHBT has been long and intimate taking back to transformational changes in the organization's development (including designing of the building of the institute) under the leadership of Dr. Akshay Gupta. It has been a rare privilege that the leadership that followed, Dr. P.S. Ahuja and now Dr. Sanjay have been of close personal friends and has added intimacy to my association with the institute. The institute has a reason for scientific contributions and on ground developmental activities that should make everyone proud. We all rejoice on this account and feel very grateful for the institute's many and varied contributions. During the last couple of years, the face of all round development and improvement has been palpable. This is visibly evident in work output, enthusiasm and commitment of its employees of all categories. Dr Sanjay Kumar has brought elegance to the campus besides giving new direction to its work philosophy and focused attention to meeting the institute's mandate. The institute's contributions have been many and varied and of the great significance. It is my faith that improvements will continue and that best is yet to be come. My hearty congratulations to you all and thanks for considering me a part of the family."

02 October 2018

Dr. Arun Tiwari, "Spent some finest time here. I consider the ultimate value of science as the change it brings in the quality of the life of people, particularly the poor and marginalized. IHBT has created a technology platform where Himalayan diversity is being harnessed, into products that would serve people and enrich livelihood. I can see that IHBT is becoming an international centre by 2020. What is being developed here is indeed beneficial to the billions of people living in marginalized areas across the world. God bless."

28 February 2019

Dr. Surinder Singh, CSIRO, Canberra Australia: "I have thoroughly enjoyed my visit to IHBT. I think is the best institute in India. They are doing great work in translational science with a view to benefit society. I especially like their emphasis on small holding local farmers."

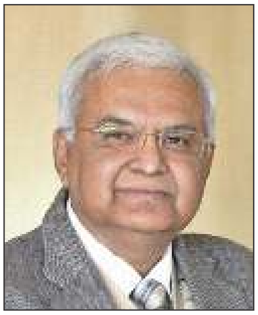
28 February 2019

Prof. Vinod Yadava, Director, NIT Hamirpur: "Very fruitful and informative visit related to application of bioscience for human health. I have found many scopes related to the application of engineering for the development of machines which are used for making valuable products being developed at CSIR-IHBT. This visit has created an opening for collaboration between NIT and CSIR-IHBT. The institute is working on cutting edge technologies which are capable of converting bio-resources into products and have negligible effect on human health."

31 March 2019

Dr. Shekhar C. Mande, Director General, CSIR & Secretary DSIR "This has been a lovely and memorable visit. Starting with the interactions with farmers who have benefitted by the aroma mission, till the interactions with all the members of the CSIR-IHBT family, each experience has been very good. It is great to see the social impact of the work of CSIR-IHBT with their ambition plans of future, including sequences of whole genomes of important plants, mechanization of tea harvest, implementation of horticulture at a large scale, food processing and aroma mission, we all look forward to the contribution of CSIR-IHBT in the coming year. Best Wishes to all CSIR-IHBT family."

FROM THE DIRECTOR'S DESK



It is with great pleasure that I present the annual report of our institute for the year 2018-19. Last year, CSIR-IHBT made an entry in the SCImago Institutional Rankings for the first time and attained 9th place within top 30 institutes of CSIR, which further improved to 7th position this year.

CSIR-IHBT has been recognized as a nodal lab for implementing various projects across 20 CSIR-labs under the theme, Agri-Nutri-Biotech. The objectives of the theme are to develop agro-technologies for boosting farmer's income through commercially important crops and to foster value added products of industrial and societal relevance through scientific interventions.

During the year, CSIR launched a new mission on "Nutraceuticals and Nutritionals" for health and wellness with 10 CSIR institutions participating and CSIR-IHBT as a nodal institute. Based on the major health issues confronted by the Indian population at present, the mission has seven thematic areas, *viz.*, enhancing nutrition, bone health, non-communicable diseases, cognition, immunity, sleep disorders and central nervous system. CSIR-IHBT is participant in five thematic areas to develop nutraceuticals using traditional wisdom from Himalayan region.

The institute continued to work on various mission mode, translational, focused basic research and niche creating projects in the areas of (i) Himalayan environment, (ii) pharmaceuticals and phytopharmaceuticals, (iii) aroma, (iv) agrochemicals, (v) food and nutraceuticals, (vi) fiber, (vii) colours and dyes, (viii) algae and fungi with an aim to boost bio-economy. We also continued our research activities on cutting edge science and technology for discovery, and development of technologies from Himalayan bioresources.

As a new initiative, research on "bioprospection of microbiome from Himalayan niches" was undertaken for exploration of microbial diversity of Himalayan region for biotechnological applications. The project envisages to sequence microbial isolates and decipher metagenomics diversity. Work on adaptation strategies and potential bioprospection of the bacterial community of eastern and western Himalayas lead to identification of important enzymes such as phospholipase, lipase, and proteases. Studies on *Pseudomonas frederiksbergensis* ERDD5:01 and *Janthinobacterium lividum* ERGS5:0 provided the genetic basis of freezing and frequent freeze-thaw cycle tolerance.

In yet another activity, consortia of efficient hydrolytic psychrotrophic bacteria was developed that was active at ≤15°C, and capable of assisting composting at low temperature. This bacterial formulation holds potential for degradation of organic waste in regions such as cold deserts of Lahaul and Spiti.

The institute has embarked to target the global market of industrial enzymes, wherein an efficient L-asparaginase with no glutaminase activity was discovered earlier from microbe of Himalayas for therapeutic applications in treating acute lymphocytic leukemia. The enzyme has potential applications in food processing industry as well. It can be used to reduce acrylamide (a carcinogen) formation in starch based food products, such as potato chips. In our effort to isolate indigenous enzymes for degumming of vegetable and rice bran oil, 15 efficient phospholipase producing bacteria were screened and characterized from high altitude region that yielded a strain with > 10 U/mg phospholipase activity on rice bran oil at 37°C. To meet the industrial demands, a dedicated protein production facility is being established for bioprocessing and upscaling of enzyme production.

In the area of enzyme prospection, we also reported a functional polyphenol oxidase (PPO) cloned and characterized from tea. Interestingly, PPO was found to have a role in PEG-induced programmed cell death (PCD).

The institute participated in key mission-projects of CSIR on phytopharmaceuticals, aromas and nutraceuticals. Under the Phytopharmaceutical Mission, about 1.5 crore quality planting material of *Stevia rebaudiana* was raised for nation-wide cultivation, starting from Himachal Pradesh, Punjab, Uttar Pradesh, Haryana, Uttrakhand, Chhattisgarh and Andhra Pradesh. Additionally, 1.40 lakh quality plants were also raised for captive cultivation of *Valeriana jatamansi, Picrorhiza kurroa, Saussurea lappa* and *Inula racemosa*. *In vitro* approaches for conservation were followed for commercially important rare, endangered & threatened (RETs) species such as *Sinopodophyllum hexandrum, Picrorrhiza kurroa, Fritillaria roylei* and *Trillium govanianum*. Consequently, several thousand plants of *P. kurroa* and *S. hexandrum*, raised under Palampur conditions, were rehabilitated in their natural habitats to rescue them from their RET status. A total of 40 acres of land was brought under captive cultivation of medicinal plants including for RET species.

Several medicinal plants, valued for its metabolites, are routinely uprooted from wild in large scale, and their status continues to dwindle. CSIR-IHBT developed an indigenized low cost bioreactor facility for the production of industrially important plant metabolites. Such alternative system will not only help in fulfilling the industrial demand, but also decrease the mounting pressure on natural habitat due to overexploitation. *In vitro* adventitious root culture system developed for *Valeriana jatamansi*, reduced the production cycle for valepotriates to 45 days compared to 2 years under natural habitat.

A total of 800 accessions representing 50 geographically distinct natural populations of RETs species including *P. kurroa, S. hexandrum, F. roylei* and *T. govanianum* were characterized at the molecular level for identification of core populations. Forty plant species identified under the mission were introduced in the gene bank at Centre for High Altitude Biology (CeHAB), Keylong, Lahaul & Spiti. Suitable locations to extend area for *in-situ* conservation of RET species were identified using ecological niche modelling.

To facilitate the basic understanding of pharmaceutically important biosynthesis pathways, species specific genome-wide genomic resources were created. Functional annotation with multiple public databases identified key genes involved in biosynthesis of picrosides, podophyllotoxin, and so on. About 6000 microsatellite markers are being utilized for genetic diversity assessments and development of conservation strategies for targeted plant species.

Under the CSIR Aroma mission, farmers of Chamba (the aspirational district of H.P.) and other districts of Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Arunachal Pradesh, Manipur, Odisha, Punjab, Haryana, Uttar Pradesh, Madhya Pradesh, Chhattisgarh and Tamil Nadu were empowered by CSIR-IHBT. The area under the crops *viz*., wild marigold, damask rose, Indian valerian and lemongrass was extended to over 256 ha in Himachal Pradesh. With 7.6 tonnes of high grade tagetes oil, the state became the highest producer of tagetes oil in the country for two consecutive years that generated revenue of Rs. 5.56 crores. The activity benefitted 728 farmer families.

To empower farmers, nine field distillation units for extraction of essential oils were set up in the farmers' fields in Himachal Pradesh and Manipur. Essential oil giant Ultra International Limited, recognized the work through 'Ultra International Team Award' for innovative and impactful efforts towards promotion of 'Cultivation and Processing of Aromatic Crops for Improving the Production of Essential oils in India'. Several training programs were organized under CSIR-Aroma Mission to train farmers on cultivation and processing of aromatic crops.

Multi-location trials of aromatic crops were laid down in regions of Himachal Pradesh, Punjab and Uttarakhand for evaluation of different accessions. Accessions CSIR-IHBT-VJ-05 (*Valeriana jatamansi*), CSIR-IHBT-RD-04 (*Rosa damascena*), CSIR-IHBT-TM-09 (*Tagetes minuta*), CSIR-IHBT-AM-02 (*Artemisia maritima*) and CSIR-IHBT-DH-04 (*Dracocephalum heterophyllum*) were identified with significantly enhanced productivity as compared to check varieties of respective aromatic crops.

Integration of bee keeping with cultivation of aromatic crops and development of a unique Bee Hive for efficient honey extraction is underway along with CSIR-CSIO, Chandigarh. This will lead to efficient and hygienic way to harvest honey.

Based on traditional knowledge on Himalayan plants, formulation is being developed from plants like *Cissus quadrangularis* and *Vitex negundo* to manage cartilage health in human population. The formulation inhibited reactive oxygen species production in interleukin-1-beta induced osteoarthritis in mice chondrocyte, suggesting its role for improving cartilage health.

Use of *Punica granatum* peel, rich in punicalagin, exhibited cardio-protection activity *via* activation of nitric oxide-mediated pathway and apoptosis inhibition. Similarly, nutraceutical products were developed using species of *Withania*, *Bacopa* and *Mucuna* for the management of neurological conditions. Formulation showed improvement in cognitive (alpha synuclein protein aggregation, dopamine and acetylcholine levels etc.) and anti-ageing activities in *C. elegans* multicellular model system.

Continuing work on tea based nutraceutical, the green tea epigallocatechin gallate (EGCG) was identified as a modulator of cellular age-associated immune dysfunctions. Standardized extract from *P. kurroa* showed promising results against non-alcoholic fatty liver disease (NAFLD) by lowering the level of fat deposition. Similarly, apigenin, a bioflavonoid present in vegetables and fruits was found to suppress epilepsy associated neurobehavioral conditions.

CSIR-IHBT developed convenient foods such as multigrain protein mix utilizing cereals, millets and pulses and instant soup mixes for protein and micronutrient malnutrition. The products are preservatives and additives free. Further micronutrient fortification was achieved by incorporating vitamin D enriched shiitake mushroom, and iron and zinc fortification through microalgae *Spirulina*. The technology was transferred to two firms. Similarly, the institute also developed the process for ready to eat *Khichadi*, which is a wholesome meal having the perfect balance of nutrients. The product has no added chemical or preservatives and has shelf life of six months for which also technology has been transferred.

One lakh units of protein and fiber enriched cereal bars, and ready to eat khichdi were distributed to the victims of Kerala Floods in September, 2018.

Promising cash crops are much desired for higher gross returns and diversification. CSIR-IHBT introduced seeds of the high value condiment, Heeng (*Ferula assa-foetida* L.) through ICAR-NBPGR, New Delhi for cultivation in India. Six accessions of Heeng (EC966538 with Import Permit-318/2018 and EC968466-70 with Import Permit-409/2018) were procured. Presently, these accessions are being grown CeHAB, Ribling under the vigil of ICAR-NBPGR.

Monk fruit (*Siraitia grosvenorii* (Swingle) C. Jeffrey ex A.M.Lu & Zhi Y. Zhang), a low calorie natural sweetener, was also introduced in India last year by the institute. The nursery raising technique and different propagation methods have been developed for generation of quality planting material at large scale. Studies on its processing technology, reproductive and molecular biology are being undertaken. The institute was instrumental in the introduction of chia and quinoa in North India as a new crop.

In continuation to our earlier activities on saffron, experimental plots were laid out in non-traditional areas of Chamba, Shimla, Kullu and Kinnaur districts of Himachal Pradesh, Munshiyari and Bhageshwar in Uttarakhand, Ooty in Tamil Nadu, Kalaktang in Arunachal Pradesh, Shipgear in Sikkim and Imphal in Manipur states. While the success has been obtained for the plants sown in Bharmour (Chamba) and Sangla (Kinnaur) regions, Flowering has been observed in other locations in the first year. Second year validation is still due.

As per an agreement with North Eastern Region Community Resource Management Project (NERCORMP), North East Council, GoI, Shillong, CSIR-IHBT imparted training to farmers of North East region under a programme entitled, "Capacity building of NERCORMP communities on cultivation of low chilling varieties of apple and its post - harvest management". In the state of Mizoram, the institute had introduced low chilling varieties of apple during 2016 which produced fruits of quality at par with fruits available in the market. Extending the activity, and apple will be planted in 15.6 acres in Mizoram, Manipur and Meghalaya states.

Our studies on Plant Growth Promoting Rhizobacteria (PGPR) showed the usefulness of *Pseudomonas azotoformans* and *Bacillus siamensis* on saffron and *Arthrobacter psychrochitiniphilus* on onion crops. Data showed results at par with applied dose of NPK in experimental field trials. These bacteria have potential to be developed into potential biofertilizer for the crops.

Cultivation of floriculture crops like tulips, lilium, gerbera, calla lily, marigold and carnation was further promoted in Himachal Pradesh, Jammu & Kashmir, Punjab and Uttarakhand for the benefit of farmers. The area under these crops was extended to 24 acres, benefiting 154 farmers, with Rs. 1.78 Cr monetary gain. In our previous study, hydroponic cultivation of lilium was shown to reduce the flowering time to 2 months as compared to 5 months in open field conditions. The quality in terms of plant height and number of quality buds was better under hydroponic condition as compared to the open field conditions. With a target to produce lilium flower round the year, a successful completion of seven cultivation-cycles under hydroponic condition has now been achieved.

Regarding our work on pollution abatement plants, study on Areca Palm showed 70% reduction in total volatile organic compounds, 84% reduction in carbon monoxide, and 38% reduction in carbon dioxide. The species was found suitable for indoor spaces of drawing room, living room and kitchen.

Earlier we reported transplantation of a novel mechanism to reduce photorespiratory losses of CO_2 and NH_3 in C_3 plants by heterologous co-expression of three enzymes phosphoenolpyruvate carboxylase, aspartate aminotrnasferase and glutamine synthetase. This work has been identified as an important contribution in the field by F1000 prime group. This led to enhancement of growth, biomass and yield in transgenic *Arabidopsis thaliana*, a C_3 plant. This mechanism is now successfully transplanted in *Brassica juncea*. Results showed improvement in phenotypic parameters.

In the area of computational biology, miRNA-876 was identified as a master regulator of insulin resistance in humans, thereby making it directly as a potential and highly promising therapeutic target for the treatment of diabetes. In another *in silico* study, anti-seizure activity of himachalenes against human epilepsy was demonstrated to be better than the commercially available, Wortmannin. Several phytomolecules were found to have therapeutic potential against drug sensitive and resistant strains of malarial parasite. Moreover, a novel domain (NACHT NTPase), known for its role as defense regulator in animal lineages, was identified in early green plants through advanced computer techniques.

To understand the molecular mechanism of self-incompoatibility in tea, genome-wide transcriptional analysis identified 182 differentially expressed genes involved in pollen tube germination & elongation, fertilization and abscission. The study on pollen-pistil interaction hypothesized that a late-acting gametophyte self-incompatibility initiated in style and sustained up-to ovary with the active involvement of *csRNS, SRKs & SKIPs*, whereas, *COBL10, RALF, FERONIA-rlk, LLG* and *MAPKs* were identified as key candidates facilitating cross-fertilization in tea.

In yet another study on resistant (R) gene(s) mining in potato, 44 *TIR-NBS-LRRs* (*TNL*) encoding for 60 proteins were identified utilizing publically available genome sequence data for *Solanum tuberosum* group Phureja. Further localization and *in-silico* physical mapping grouped these proteins in two clusters, thus enhancing our knowledge regarding the role of these genes in plant defense against fungal pathogen.

In the area of virology, studies on plant microbe involving cucumber mosaic virus revealed association of its suppressor protein with the host rubisco small subunit and glycine rich protein to facilitate short and long distance movement. Wildly growing *Ficus palmata* was identified as a natural host of apple stem grooving virus, a very important virus of apple.

In another study, *Rumex nepalensis* was identified as an off-season host of *Tomato leaf curl virus*. Interestingly, *P. kurroa*, an ethnopharmacologically important endangered medicinal herb, traditionally used in several preparations of Indian Ayurvedic medicine, was found to be naturally infected by a complex of alternanthera yellow vein virus and cotton leaf curl Multan betasatellite, when grown at mid hill altitude in Palampur. Alternate hosts are important for survival of the viral pathogens during unfavourable conditions.

In its vision to be a referral facility for the flora of Himalaya, the Institute digitized its complete holdings with future plans of making it online. Further, during the current year, 20 species new to the herbarium (PLP) were added. The Institute also contributed significantly towards the hyperspectral library wherein, spectral signatures of 42 plant species were prepared. These can be accessed through webpage, https://nisa.geos.iitb.ac.in of Department of Science and Technology, Government of India.

On the traditional knowledge documentation front, the institute identified importance of *Quercus semecarpifolia*, and *Cotoneaster bacillaris* in making indigenous tools of day-to-day importance by the *Bhangalis*. Further, on the basis of use value, *Pteridium aquilinum*, *Juglans regia*, *Corylus jacquemontii*, *Urtica dioica*, *Diplazium maximum* and *Angelica glauca* were identified to be the most important plant species for the Gujjars of Churah, Chamba.

Fire remains a prominent threat in the Himalaya. For fire management, using Sentinel satellite images of the year 2017, the institute mapped fire affected areas in Palampur and Dharamshala tehsils of district Kangra, H.P which were 1503.63 ha and 630.57 ha, respectively. On the modeling and simulation front, potential distribution of treeline species *Betula utilis*, niche in the Hindu-Kush Himalayan region was predicted for future scenario (year 2061–2080). The species was projected to become vulnerable to 21st century climate changes.

The patterns of functional diversity of high altitude vegetation was studied. The study showed that functional diversity is low at high elevations, such that diverse plant species tend to develop relatively similar traits to cope with the common conditions of 'harsh' environment.

Ecological amplitude of 418 species of high altitude vegetation (>3000 m) were elucidated to understand the ecological characterization of high altitude vegetation. Species niche width, elevational range and rarity status of all these species were estimated that suggested 26 species to have relatively higher extinction risks due to changing climate. Further, studies on leaf traits (area and mass) in a large number of high altitude plants suggested that high leaf water mass and leaf dry mass increase are related to light interception costs and metabolic mass components of leaves and efficient resource use. Morpho-physiological changes in leaves of *Rhododendron anthopogon* studied along season gradients suggested that traits are closely associated with plant adaptation in response to seasonal changes.

In a pioneering initiative, the Institute initiated eradication of *Ageratina adenophora* – a highly noxious invasive species and plantation of multipurpose native species through community involvement.

In the area of natural product chemistry, systematic phytochemical investigation of *Zanthoxylum armatum*, *Narcissus tazetta* and *Zephyranthes minuta* led to the characterization of fifteen cytotoxic alkaloids including two new molecules. Characterization of marker compounds will be helpful in the quality control parameters of these plant species.

An eco-friendly and cost effective process has been developed at 100 Kg scale for the extraction of natural colours from *Brassica oleracea*. The optimized process afforded non-toxic, non-hygroscopic, crystalline, stable and biodegradable natural colours/dyes which can be successfully used for developing food and cosmetic products.

Working on nano-composite materials, palladium and rhodium supported catalyst (Pd@PS and Rh@PS) have been synthesized and applied for different carbon monoxide fixation reactions for the synthesis of benzoimidazoles, quinolones, carbazolone, and isoindolinones as a drug candidate. More than 150 molecules were synthesized using these approaches.

Synthesis of quinoline-based antimalarial agents is also in progress. This year four novel catalytic methods have been developed for the synthesis of new quinolines derivatives. Use of earth abundant cobalt-metal based catalyst and molecular oxygen as the oxidant are the highlights of these new developed catalytic methods. About 250 molecules, including fused *N,N´*-heterocycles, have been synthesized *via* innovative C-H activation/functionalization strategy and are currently being evaluated for their anti-malarial potential. A new initiative on merging photo- and electro-catalysis with C-H activation are undertaken this year to replace metal-oxidant with green, economic and renewable sources.

With an aim to prospect Himalayan plant resources for cellulose based products, lab scale process has been developed for the preparation of cellulose pulp and nanocellulose. Currently work on conversion of cellulose pulp into textile fiber is underway. Additionally, institute has also initiated work on the utilization of animal waste particularly cow dung for the cellulose based value added products.

Growing resistance against current antibiotics and crop protection chemicals is of global concern. Therefore, in the current year, two mission mode projects on pharmaceuticals and agrochemical development were initiated. Avibactam - a β-lactamase inhibitor was demonstrated to restore the efficiency of antibiotics against resistant pathogens. Under pharma and agro mission project, a novel lab scale process for the synthesis of Avibactam is being developed to reduce the import.

Agrochemicals such as insecticides, fungicides and herbicides play a crucial role in ensuring food and nutrition security of the nation. Recognizing this problem, development of a new process for epoxiconazole, a fungicide molecule is being undertaken under crop protection chemical mission.

In our continuing effort to search for biocompatible molecular imaging probe, carbohydrate based bright blue and red emitting carbon dots (CDs) of ~3.3 - 5.8 nm were synthesized. Besides high fluorescence quantum yield and photostability at physiological conditions, the developed CDs showed anti-bacterial activity against *Escherichia coli* as well.

In another study, chemical and green surfactants were used for the nano-emulsification of citronellal oil. It showed an early killing of *Pseudomonas aeruginosa* as compared to non-emulsified citronellal oil.

CSIR-IHBT is committed towards its social scientific responsibility. Therefore, this year also, the institute organized various activities for school children and their teachers under the JIGYASA programme throughout the year. JIGYASA is a student-scientist connect programme between Council of Scientific and Industrial Research (CSIR) and Kendriya Vidyalaya Sangathan (KVS). This year, more than 3166 students and faculty members from various schools, institutes, universities and colleges visited the institute on various occasions. Scientists of the institute visited various schools and delivered popular science lectures to motivate and attract students towards science and technology.

In continuation to preceding year's 'student seminar series', the 2nd student seminar series was held on 5th September 2018. The seminar theme for this year was “Expanding Scientific Horizon: from Basic to Translation Research”. A total of 28 entries were received for the same. In addition, tagline, photography, and quiz contests were also held. Importantly, the seminar was fully sponsored by different agencies who came forward and nurtured the initiative.

In a national level competition organized by the Department of Science & Technology (DST), Govt. of India, two of our research scholars, Mr Sourabh Soni and Ms Bipasha Bhattacharjee, were awarded with cash prize of Rs 10,000/- along with Certificate of Appreciation under an initiative of DST “Augmenting Writing Skills for Articulating Research”.

A number of skill developmental programmes were conducted under CSIR Integrated Skill Initiative in the area of floriculture and analytical chemistry. Training was imparted to 165 Graduate/ Post Graduate/ Ph.D. students at the Institute for one to twelve month duration. A DBT sponsored skill development programme on advanced diploma in plant tissue culture was initiated this year for students of biology from all across the country. The aim of these skill development programs was to generate skilled manpower for industry, academia and self-employment.

The institute has been recognised as one of the incubation centers under the Himachal Pradesh, Chief Minister STARTUP scheme and DSIR-CRTDEH since September, 2017. Under the scheme, a total of fourteen incubatees registered their ideas in the area of food processing, floriculture, process development and biotechnology.

A noteworthy activity of CSIR-IHBT was its participation in the AnalytiCSIR portal of CSIR. The portal caters to online requests by users within and outside CSIR for the use of high end/major equipments of the institute.

The institute continued to strengthen its infra-structure and scientific analytical facilities. In this regard, a number of routine and high end equipment were added. The protein purification system, the mass/PDA directed auto purification system and multipurpose essential oil field distillation units are some of the worthy to mention. A biologically relevant heterotopic xenograft model for head and neck squamous cell carcinoma (HNSCC), arthritis, idiopathic pulmonary fibrosis (IPF) and colitis were other major developments in this regard. Farm activities were also strengthened by constructing additional state of the art green and poly houses and new growth chambers were added to the existing facilities.

Work on construction of Type-V, IV and III staff quarters which were started in the financial year 2017-18 are at the stage of near completion. Besides this, Natural Product Chemistry Lab, canteen building and Botanical Garden were up-graded and existing bamboo treatment plant was extended. A parking area for Regulatory Research Centre and a path up to the pentagon was constructed.

In order to make the institute more user friendly for the staff, residents and visitors, a bi-lingual institutional guide map was prepared and set up at two locations in the campus. Additionally, sign boards indicating different locations of the institute were set up. The old conference hall, Directors conference room and auditorium were named after the eminent scientists, Sir JC Bose, Sir CV Raman and Dr. SS Bhatnagar, respectively.

CSIR-IHBT showcased its technologies and products in various business meetings, trade fairs and exhibitions at regional as well as national levels. Moreover, the institute signed 68 agreements/MoUs including 5 technology transfer (ToTs), 31 material transfer agreements (MTAs), and 26 miscellaneous MoUs including those with different farmer societies. Institute also signed 6 MoUs for different innovation projects under “Chief Minister's Start up Scheme”.

It was strongly felt that the Institute should have its own logo. The Institutes logo was finalized based on the entries received through an open competition. Emulating nature's five elements Earth, Sky, Water, Air and Fire, the logo carries their essence in “Ribbon, Circle, Mountains, Trees and Path” that signifies the vision and mission of the Institute.

Notably during the year, the institute was graced with the presence of Shri Giriraj Singh, Hon'ble Minister of MSME, Shri Jai Ram Thakur, the Hon'ble Chief Minister of Himachal Pradesh, Dr. Shekhar C Mande, the Hon'ble Director General of CSIR, and other esteemed dignitaries.

The research council was instrumental in aligning CSIR-IHBT activities with the industry. It was due to their initiative, that ideas for START-UPs were invited from various research groups of the institute and a stake-holder's meet was organized during the 54th Research Council meeting. The research and management councils, the CSIR-headquarters and various funding agencies continued to support and motivate the institute towards achieving scientific excellence and social scientific responsibilities.

Jai Hind!

(Sanjay Kumar)

निदेशकीय प्रतिवेदन

मुझे सीएसआईआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान के वर्ष 2018–19 का वार्षिक प्रतिवेदन प्रस्तुत करते हुए अत्यन्त हर्ष हो रहा है। पिछले वर्ष सीएसआईआर–आईएचबीटी ने एसीइमेगो संस्थान रेंकिग में सीएसआईआर के 30 शीर्ष संस्थानों में 9वां स्थान पाया था, इस वर्ष और सुधार करते हुए हम 7वें स्थान पर हैं।

सीएसआईआर–आईएचबीटी को एग्री–न्यूट्री–बायोटेक विषय के अन्तर्गत 20 सीएसआईआर– प्रयोगशालाओं में विभिन्न परियोजनाओं को लागू करने के लिए नोडल लैब के रूप में मान्यता दी गई है। इसका मूल उद्देश्य व्यावसायिक दृष्टि से महत्वपूर्ण फसलों की कृषि प्रौद्योगिकी को विकसित करके किसानों की आय में वृद्धि और वैज्ञानिक पहल के माध्यम से औद्योगिक और सामाजिक रूप से उपयोगी मूल्यवर्द्धित उत्पादों को बढ़ावा देना है।

वर्ष के दौरान सीएसआईआर ने स्वास्थ्य और पोषण के लिए 'न्यूट्रास्यूटिकल्स और न्यूट्रिशनल' पर एक नये मिशन प्रारम्भ को किया है जिसमें देश भर के 10 सीएसआईआर संस्थानों के नेटवर्क के साथ सीएसआईआर–आईएचबीटी इस मिशन का नोडल संस्थान है। भारतीय जनमानस द्वारा सामना की जा रही प्रमुख स्वास्थ्य संबन्धी मुद्दों के आधार पर इस मिशन के सात प्रमुख विषय क्षेत्र हैं जो इस प्रकार हैं पोषण बढ़ाना, अस्ति स्वास्थ्य, गैर संक्रामक रोग, अनुभूति, इम्यूनिटी, निद्रा विकार, और केंद्रिक तंत्रिका तंत्र। संस्थान हिमालय क्षेत्र के पारंपरिक ज्ञान का उपयोग करके न्यूट्रास्यूटिकल विकसित करने के लिए पांच विषयगत क्षेत्रों में भागेदारी निभा रहा है।

जैवआर्थिकी को बढ़ावा देने के लिए (i) हिमालयी पर्यावरण, (ii) फाइटोफार्मास्युटिकल्स, (iii) अरोमा, (iv) फार्मास्यूटिकल्स, (v) कृषि रसायनिकी, (vi) खाद्य एवं न्यूट्रास्युटिकल्स, (vii) फाइबर, और (Viii) रंग एवं रंजक के क्षेत्रों में विभिन्न मिशन मोड, ट्रांसलेशनल, केन्द्रित मूलभूत शोध/फोकस बेसिक रिसर्च और उत्कृष्ट परियोजनाओं पर संस्थान का काम आगे बढ़ रहा है। हम हिमालयी जैवसंपदा से प्रौद्योगिकियों के विकास के लिए अत्याधुनिक विज्ञान और प्रौद्योगिकी पर अपनी अनुसंधान गतिविधियों को भी आगे बढ़ा रहे हैं।

एक नई पहल के रूप में, जैवप्रौद्योगिकी के अनुप्रयोगों के लिए हिमालयी क्षेत्र की सूक्ष्मजैव विविधता की खोज के लिए हिमालयी क्षेत्र से माइक्रोबायोम के बायोप्रोस्पेक्शन पर शोध किया जा रहा है। परियोजना में माइक्रोबियल आइसोलेट्स को अनुक्रमित करने और मेटाजिनोमिक्स विविधता को समझने पर कार्य किया जा रहा है। पूर्वी और पश्चिमी हिमालय के जीवाणु समूहों की अनुकूलन पद्धति और संभावित बायोप्रोस्पेक्शन पर कार्य करते हुए फॉस्फोलाइपेज़, लाइपेज़ और प्रोटीएज़ जैसे महत्वपूर्ण एंजाइमों को खोजा गया। *स्यूडोमोनास फ्रेडरिक्सबर्गेंसिस* ERDD5:01 *जेन्थिनोबेक्टेरियम लिविडम* ERGS5:0 पर अध्ययन से फ्रिजिंग और फ्रीज–था साइकल टॉलरेंस के आनुवंशिक आधार कोसमझने में सहायता मिली है।

एक अन्य गतिविधि के अन्तर्गत कुशल हाइड्रोलाइटिक साइकोट्रॉफ़िक बैक्टीरिया का कंसोर्टिया विकसित किया गया यह ≤15°C पर सक्रिय पाया गया, और कम तापमान पर खाद बनाने में सहायता करने में सक्षम था। इस जीवाणु की फॉर्मुलेशन द्वारा लाहौल और स्पीति के ठंडे मरुस्थलीय क्षेत्रों में जैविक कचरे के क्षरण की अपार संभावना है।

संस्थान ने औद्योगिक एंजाइमों के वैश्विक बाजार को लक्षित करने के हमारे उद्देश्य में, हिमालयी सूक्ष्मजैव स्रोतों से एक प्रभावी एन–एस्परजिनेस एंजाइम की खोज की जिसमें कोई ग्लूटामिनेज़ गतिविधि नहीं थी तथा यह हिमोसाइटिक ल्यूकेमिया के उपचार में चिकित्सीय अनुप्रयोगों के लिए उपयोगी है। इस एंजाइम काखाद्य प्रसंस्करण उद्योगों में व्यापक अनुप्रयोग है। इसका उपयोग स्टार्च आधारित खाद्य उत्पादों जैसे आलू के चिप्स में एक्रिलामाइड (एक कार्सिजोजेन) के निर्माण को कम करने के लिए किया जा सकता है। वनस्पति और राइस ब्रान तेल के अपघटन के लिए स्वदेशी एंजाइमों को अलग करने के हमारे प्रयास में उच्च तुंगता वाले क्षेत्रों से 15

कुशल फॉस्फोलाइपेज़ जीवाणुओं की जांच और लक्षणचित्रित किया गया। जो 37°C सेंटीग्रेट पर राइस ब्रान तेल में >10 U/mg फॉस्फोलिप गतिविधि पाइ गई। औद्योगिक मानकों और आवश्यकताओं को पूरा करने के महत्व को समझते हुए, इन एंजाइमों के बायोप्रोसेसिंग और अपस्केलिंग के लिए एक विशेष सुविधा स्थापित की गई है।

एंजाइम प्रोस्पेक्शन के क्षेत्र में हमने चाय से एक कार्यात्मक पॉलीफेनोल ऑक्सीडेज को (PPO) क्लोन एवं लक्षणचित्रित किया। इस PPO ने PEG–प्रेरित प्रोग्राम्ड सेल डेथ (PCD) में महत्वपूर्ण भूमिका निभाई।

संस्थान ने सीएसआईआर के फाइटोफार्मास्यूटिकल, अरोमा और न्यूट्रास्यूटिकल जैसे प्रमुख मिशन मोड परियोजनाओं में भी भागीदारी की। फाइटोफार्मास्यूटिकल मिशन के अन्तर्गत *स्टीविया रेबोडियाना* के लगभग 1.5 करोड़ गुणवत्ता युक्त पौध सामग्री को हिमाचल प्रदेश, पंजाब, उत्तर प्रदेश, हरियाणा, उत्तराखंड, छत्तीसगढ़ और आंध्र प्रदेश जैसे देश भर के विभिन्न राज्यो में तैयार किया गया। इसके अतिरिक्त, *वेलेरियाना जटामांसी, सौसुरिया लापा* और *इनुला रेसीमोसा* के 1.40 लाख गुणवत्ता युक्त पौधों को कैप्टिव खेती के लिए तैयार किया गया। *इन विट्रो दृष्टिकोण* के माध्यम से *पिक्रोराइज़ा कुरोआ, फ्रिटिलारिया रॉयली* और *ट्रिलियम गोवैनियम* के संरक्षण के लिए भी प्रयास किए जा रहे हैं। परिणामस्वरुप पालमपुर की जलवायु परिस्थितियों में तैयार किए गए *सिनोपोडोफिलम हेक्सैंड्रम* और *पिक्रोराइज़ा कुरोआ* के कई हजार पौधों को उनके प्राकृतिक स्थलों में लगाया गया जिससे ये दुर्लभ, लुप्तप्राय और संकटापन्न पौधों (आरईटी) की श्रेणी से बाहर आ सके। अब तक 40 एकड़ भूमि को दुर्लभ, लुप्तप्राय और संकटापन्न पौधों (आरईटी) प्रजातियों सहित औषधीय पौधों की खेती के अन्तर्गत लाना भी एक महत्वपूर्ण योगदान रहा।

कई औषधीय पौधे जो कि अपने मेटाबोलाइट के लिए मूल्यवान हैं, उन्हे नियमित रूप से बड़े पैमाने पर वनो से उखाड़ दिया जाता है और वो हमेशा घटते बढ़ते रहते संस्थान ने औद्योगिक दृष्टि से महत्वपूर्ण पौधों के मेटाबोलाइटस के उत्पादन के लिए कम लागतयुक्त एक स्वदेशी बायोरिएक्टर सुविधा विकसित की है। इस प्रकार की वैकल्पिक प्रणाली से न केवल औद्योगिक मांग को पूरा करने में सहायता मिलेगी, अपितु अत्याधिक दोहन के कारण प्राकृतिक संसाधनों पर बढ़ते दबाव में भी कमी आएगी। *वेलेरियाना जटामांसी* के लिए विकसित *इन विट्रो* अपस्थानिक प्ररोह संवर्धन से मेटाबोलाइटस के उत्पादन चक्र प्रयोगशाला में 45 दिन का है जो कि प्राकतिक स्थलों में लगभग 2 वर्ष का होता है।

पिक्रोराइज़ा कुरोआ, सिनोपोडोफिलम हेक्सैंड्रम, फ्रिटिलारिया रॉयली और *ट्रिलियम गोवैनियम* की 50 भौगोलिक रूप से अलग प्राकृतिक स्थलों के 800 से अधिक परिग्रहणों को आणविक स्तर पर एकत्र किया गया। मिशन के अन्तर्गत पहचाने गए 40 पौधों की प्रजातियों को उच्च तुंगता जीवविज्ञान केन्द्र केलांग, लाहौल स्पीति में प्रतिपादित किया गया है। पारिस्थितिक निश मॉडलिंग का उपयोग करते हुए *इन सिटु* संरक्षण के लिए उपयुक्त स्थलों की पहचान की गई।

औषधीय रूप से महत्वपूर्ण जैवसंश्लेषण प्रक्रिया की मूल समझ को सुविधाजनक बनाने के लिए विभिन्न प्रजातियों के विशिष्ट जीनोम स्तरीय जिनोमिक्स संसाधन बनाए गए। कई सार्वजनिक डेटाबेस के साथ कार्यात्मक विश्लेषण के पश्चात पिक्रोसाइड्ड, पोडोफाइलोटॉक्सिन, सैपोनिन बैसिनोस्टेरॉइड, कैरोटीनॉइड, डाइपेनॉइड, फ्लेवोलोइड, फिनाइलप्रोपेनाइड, स्टेरॉयड और टर्पिनाइड बैकबोन के जैवसंश्लेषण में शामिल प्रमुख जीनों की पहचान की गयी। इसके प्रश्चात 6000 से अधिक माइक्रोसैटेलाइट मार्करों की खोज की गयी तथा उनका उपयोग चयनित प्रजातियों के संरक्षण पद्धति के विकास के लिए किया जा रहा है।

सीएसआईआर अरोमा मिशन के अन्तर्गत हिमाचल प्रदेश के आकांक्षात्मक चम्बा जिला एवं अन्य जिलों में तथा जम्मू और कश्मीर, उत्तराखंड, अरुणाचल प्रदेश, मणिपुर, ओडिशा, पंजाब, हरियाणा, उत्तर प्रदेश, मध्य प्रदेश, छत्तीसगढ़ और तमिलनाडु के राज्यों के किसानों का सशक्तिकरण किया गया। जंगली गेंदा, दमस्क गुलाब, वेलेरियाना और लेमनग्रास जैसी फसलों को हिमाचल प्रदेश में 256 हेक्टेयर क्षेत्र से अधिक क्षेत्र में लगाया गया। हिमाचल प्रदेश पिछले दो साल में जंगली गेंदे के 7.6 टन

उच्च ग्रेड के सगंध तेल का उत्पादन करके जंगली गेंदा की खेती में देश का नंबर एक राज्य बन गया। इससे 5.56 करोड़ रुपये की आय हुई तथा 728 किसान परिवारों को लाभ हुआ।

किसानों को सशक्त बनाने के लिए सुगंधित फसलों से सगंध तेल के उत्पादन के लिए हिमाचल प्रदेश और मणिपुर के विभिन्न स्थानों पर नौ आसवन इकाइयां भी स्थापित की गईं। किसानों को सगंध फसलों के प्रसंस्करण की दिशा में अभिनव और प्रभावशाली प्रयासों के लिए संस्थान को अल्ट्रा इंटरनेशनल टीम अवार्ड से सम्मानित किया गया। सीएसआईआर अरोमा मिशन के अन्तर्गत किसानों को सगंध फसलों की खेती और प्रसंस्करण पर कई प्रशिक्षण कार्यक्रम आयोजित किए गए।

विभिन्न परिग्रहणों के मूल्यांकन के लिए हिमाचल प्रदेश, पंजाब और उत्तराखंड के विभिन्न क्षेत्रों में सगंध फसलों के बहु स्थलीय परीक्षण लगाए गए। सीएसआईआर – आईएचबीटी–वीजे–05 (*वेलेरियाना जटामांसी*) सीएसआईआर–आईएचबीटी–आरडी–04 (*रोजा डेमेसिना*) सीएसआईआर – आईएचबीटी–टीएम–09 (*टेजेटिस माइन्यूटा*), सीएसआईआर– आईएचबीटी – एएम–02 (*आर्टिमीज़िया मैरिटिमा*) और सीएसआईआर – आईएचबीटी – डीएच – 05 (*ड्रैकोसिफैलम*) में अन्य परिग्रहणों की अपेक्षा अधिक उत्पादकता पाई गई।

सगंध फसलों की खेती के साथ मधुमक्खी पालन से कुशल शहद निष्कर्षण के लिए सीएसआईआर–सीएसआईओ, चण्डीगढ़ के साथ फ्लो हाइव के विकास का कार्य चल रहा है। इससे कुशल और स्वस्थ शहद प्राप्त करने का मार्ग प्रशस्त होगा।

वर्ष के दौरान सीएसआईआर ने स्वास्थ्य और पोषण के लिए 'न्यूट्रास्यूटिकल्स और न्यूट्रिशनल' पर एक नये मिशन प्रारम्भ को किया है जिसमेंदेश भर के 10 सीएसआईआर संस्थानों के नेटवर्क के साथ सीएसआईआर – आईएचबीटी इस मिशन का नोडल संस्थान है। भारतीय जनमानस द्वारा सामना की जा रही प्रमुख स्वास्थ्य संबन्धी मुद्दों के आधार पर इस मिशन के सात प्रमुख विषय क्षेत्र हैं जो इस प्रकार हैं पोषण बढ़ाना, अस्ति स्वास्थ्य, गैर संक्रामक रोग, अनुभूति, इम्यूनिटी, निद्रा विकार, और केंद्रिक तंत्रिका तंत्र। संस्थान हिमालय क्षेत्र के पारंपरिक ज्ञान का उपयोग करके न्यूट्रास्यूटिकल विकसित करने के लिए पांच विषयगत क्षेत्रों में भागेदारी निभा रहा है।

जनसमुदाय में अस्थि रोग स्वास्थ्य का प्रबन्धन करने के लिए हिमालयी पौधों (*Cissus quadrangularis* और *Vitex negundo*) से पारंपरिक ज्ञान के आधार पर फार्मूलेशन तैयार किया जा रहा है। निर्गुन्डी और हड़जोड के सूत्रीकरण ने चूहों के उपास्थिकोशिका में इंटरल्यूकिन–1 बीटा द्वारा प्रेरित गठिया जैसी स्थिति में प्रतिक्रियाशील ऑक्सीजन प्रजातियों के उत्पादन को बाधित किया, इससे उपस्थिति स्वास्य में सुधार के लिए इस सूत्रीकरण की भूमिका मानी जा सकती हैं।

प्यूनिकालेजिन से भरपूरअनार के छिलकों का उपयोग, नाइट्रिक ऑक्साइड की मध्यस्थता वाले एंटीऑक्सिडेंट उत्तरदायी मार्ग और एपोप्टोसिस अवरोधक के सक्रियण के माध्यम से कार्डियो–संरक्षण गतिविधि के लिए प्रभावी पाया गया।इसी प्रकार न्यूरोलॉजिक समस्याओं के प्रबन्धन के लिए विथानिया, बेकोपा और मुकुना की प्रजातियों का उपयोग करके पोषक तत्वों के उत्पाद विकसित किए गए। इस फार्मूलेशन ने *सी. ऐलिगेंट* बहुकोशिकीय मॉडल प्रणाली में संज्ञानात्मक (अल्फा सिन्यूक्लिन प्रोटीन एकत्रण, डोपामाइन और एसिटाइलकोलाइन स्तर) और एंटी–एजिंग गतिविधयों में सुधार दर्शाया।

चाय आधारित ग्रीन टी एपिगैलोकैटेचिन गैलेट (ईजीसीजी) और पारंपरिक रूप से प्रयोग किए जाने वाले पौधों को क्रमशः बुढ़ापे और रोग प्रतिरोधक स्वास्थ्य को बढ़ाने की क्षमता के लिए मान्य किया गया। मानकीकृत *पिक्रोराइज़ा कुरोआ* अर्क से गैर–मादक फैटी लीवर रोग (एन.ए.एफ.एल.डी.) के खिलाफ आशाजनक परिणाम दिखे हैं। यह वसा के जमाव को कम करता है और यकृत में विभिन्न जनुको की अभिव्यक्ति को प्रेरित करता है। इसी प्रकार एपिजिनिन सब्जियों और फलों में मौजूद एक बायोफ्लेवोनॉइड मिर्गी से जुड़े न्यूरो संबन्धी रोगों को मिटाने तथा कम करने के लिए कारगर पाया गया है।

संस्थान ने भोजन और पोषक तत्वों को विकसित करने के उद्देश्य से, अनाज, बाजरा और दालों का उपयोग करके

एक मल्टीग्रेन प्रोटीन मिश्रण बनाया गया। यह उत्पाद प्रिजरवेटिव और एडेटिव मुक्त है।विटामिन डी समृद्ध शिटाके मशरूम और आयरन और जिंक फोर्टिफाइड स्पिरुलिना जैसे पोषक तत्वों को शामिल करके सूप मिक्स भी विकसित किया गया।उत्पादों को दो फर्मों को हस्तांतरित किया गया। इसी प्रकार संस्थान ने खाने के लिए एकदम तैयार (रेडी टू ईट) खिचड़ी को तैयार करने की प्रक्रिया को भी विकसित कर लिया है, जिसमें कि पोषक तत्वों का सही संतुलित है। यह उत्पाद प्रिजरवेटिव और एडेटिव मुक्त है तथा 6 माह तक उपयोग में लाया जा सकता है।

एक लाख यूनिट प्रोटीन और फाइबर से समृद्ध बार तथा खिचड़ी को सितंबर, 2018 में केरल बाढ़ के पीड़ितों को वितरित किया गया।

संस्थान ने एनबीपीजीआर, नई दिल्ली के माध्यम से भारत में उच्च मूल्य के मसाला, शुद्ध हींग (फेरूला हींग, एसाफोटिका) के बीज लगाने की पहल की है। हींग की 6 किस्मों को आयातित (EC966538 आयात परमिट सं. तथां-318/2018 तथा EC968466-70 आयात परमिट सं. -409/2018) किया गया। वर्तमान में, यह एनबीपीजीआर की निगरानी में उच्च तुंगता जीवविज्ञान केन्द्र, रिबलिंग में इसकी खेती की जा रही है।

संस्थान ने एक वर्ष पूर्व मोंक फ्रूट (कम कैलोरीयुक्त प्राकृतिक स्वीटनर) को भारत में एक नई फसल के रूप में लगाया है। मोंक फ्रूट की पौध तैयार करने तथा प्रवर्धन की विभिन्न तकनीकों को भी विकसित किया गया। मौजूदा वर्ष में इसके प्रक्रमण, प्रजनन और आण्विक जीव विज्ञान पर अध्ययन भी किया गया।संस्थान ने उत्तर भारत में चिया, किनवा को लगाने में भी महत्वपूर्ण भूमिका निभाई।

हमारे पहले के कार्यों को जारी रखते हुए, हिमाचल प्रदेश के चम्बा, शिमला, कुल्लू और किन्नौर जिलों उत्तराखंड के मुंशियारी और भागेश्वर, तमिलनाडु के ऊटी, अरुणाचल प्रदेश के कलक्टांग, सिक्किम के शिपगियर और मणिपुर के इंफाल जैसे गैर–पारंपरिक क्षेत्रों में केसर की खेती का कार्य प्रारंभ किया गया। चम्बा के भरमौर तथा किन्नौर के सांगला क्षेत्रों में उगाए गए पौधों में सफलता मिली है। प्रथम वर्ष में विभिन्न स्थलों पर इसकी फसल में पुष्पण देखा गया दूसरे वर्ष का वेलिडेशन अभी बाकी है।

एनईआरओआरएमपी, उत्तर पूर्व संघ, भारत सरकार, जीओआई, शिलांग के साथ एक समझौते के अन्तर्गत, सीएसआईआर–आईएचबीटी, उत्तर पूर्व नॉर्थ ईस्ट क्षेत्र के किसानों को लो चिलिंग सेब प्रजाति और इसकी फसलोपरान्त प्रबन्धन की खेती पर उक्त समुदायों की क्षमता निर्माण पर प्रशिक्षित कर रहा है। संस्थान ने 2016 में मिजोरम राज्य में लो चिलिंग सेब की किस्मों को लगाया था और वहां से प्राप्त फसल बाजार में उपलब्ध फलों की गुणवत्ता के समान ही पायी गई। अब इस गतिविधि का विस्तार करते हुए मिजोरम, मणिपुर और मेघालय में 15.6 एकड़ में सेब लगाया जाएगा।

एक अन्य अध्ययन में केसर पर दो *राइजोबैक्टीरिया, स्यूडोमोनास एज़ोटोफोर्मंस* और *बेसिलस सियामेन्सिस* तथा प्याज की फसलों पर *आर्थ्रोबैक्टर साइकोट्रिक्टिनफिलस* का मूल्यांकन किया गया और प्रायोगिक क्षेत्र परीक्षणों में एनपीके की प्रयुक्त मात्रा के साथ अच्छे परिणाम प्राप्त हुए। इन जीवाणुओं ने पीजीपीआर गतिविधि प्रदर्शित की और इसे फसल के लिए संभावित जैव उर्वरक में विकसित किया जा सकता है।

किसानों के लाभ हेतु हिमाचल प्रदेश, जम्मू और कश्मीर, पंजाब और उत्तराखंड में ट्यूलिप, लिलियम, जरबेरा, कैला लिली, गेंदा और कार्नेशन जैसे पुष्प फसलों की खेती को प्रोत्साहित किया गया। फूलों की खेती के क्षेत्र को 24 एकड़ तक बढ़ाया गया, जिसमें 154 किसानों को लाभान्वित किया गया जिससे 1.78 करोड़ रुपये का लाभ हुआ। लिलियम की हाइड्रोपोनिक खेती ने खुले प्रक्षेत्र परिस्थिति में 5 महीने की तुलना में फूलों के समय को 2 महीने तक कर दिया। हाइड्रोपोनिक परिस्थितियों में पौधों की ऊंचाई और गुणवत्ता युक्त कलियों की संख्या खुले प्रक्षेत्र की अपेक्षा अच्छी पायी गई।वर्ष भर लिलियम के फूल प्राप्त करने के लक्ष्य के लिए हाइड्रोपोनिक स्थिति के अन्तर्गत 7 चक्रों में फसल प्राप्त करने का सफल प्रयोग किया जा चुका है।

प्रदूषण नियंत्रण करने वाले पौधों पर कार्य जारी है। इसके अर्न्गत आंतरिक (इनडोर) वायु प्रदूषण उन्मूलन के लिए एरेका पाम पर हमारे अध्ययन ने कुल वाष्पशील कार्बनिक

यौगिकों में 70%, कार्बन मोनोऑक्साइड में 84% और कार्बन डाइऑक्साइड में 38% की कमी पायी गई। यह पौधा घरों की बैठक (ड्राइंग रूम), शयनकक्ष (लिविंग रूम) और रसोई (किचन) जैसे स्थलों के लिए उपयुक्त पाया गया है।

पूर्व में हमने तीन एंजाइम, phosphoenolpyruvate carboxylase, aspartate aminotransferase और glutamine synthetase के सह–अभिव्यक्ति द्वारा सी 3 पौधों में प्रकाशीय श्वसन (photorespiration) की प्रक्रिया में CO_2 और NH_3 के नुकसान को कम करने के लिए प्रत्यारोपण एक नयी क्रियाविधि के बारे में बताया था। इससे ट्रांसजेनिक एरॉबिडोप्सिस (C_3 पौधा) में बायोमास और फसल में वृद्धि हुई। इस काम की F1000 प्राइम ग्रुप (जीव विज्ञान और चिकित्सा में 8,000 से अधिक अंतरराष्ट्रीय अग्रणी विशेषज्ञों का एक संकाय) द्वारा सराहना की गयी है। इस क्रियाविधि को अब ब्रासिका जांसिया में सफलतापूर्वक प्रत्यारोपित किया गया है। परिणामों ने फिनोटाइपिक मापदंडों में सुधार दिखाया।

कम्प्यूटेशनल जीव विज्ञान के क्षेत्र में, miRNA-876 को मनुष्यों में इंसुलिन प्रतिरोध के एक प्रमुख नियामक के रूप में पहचाना गया, जिससे इसे सीधे मधुमेह के उपचार के लिए संभावित और अत्यधिक आशाजनक चिकित्सीय लक्ष्य के रूप में बनाया जा सके। एक अन्य अध्ययन में, मानव मिर्गी के खिलाफ हिमाचलिसं के दौरा रोधी गतिविधि को व्यावसायिक रूप से उपलब्ध वॉर्टमैनिन से बेहतर होने के लिए प्रदर्शित किया गया। कई पादप–अणुओं में दवा संवेदनशीलता और मलेरिया परजीवी के प्रतिरोधी उपभेदों के खिलाफ चिकित्सीय उपचार क्षमता पाई गई। इसके अतिरिक्त एक नवीन डोमेन (NACHT NTPase), जो जानवरों की वंशावली में रक्षा नियामक के रूप में अपनी भूमिका के लिए जाना जाता है, को उन्नत कंप्यूटर तकनीकों के माध्यम से प्रारम्भिक हरे पौधों में पहचाना गया।

चाय में आत्म अक्षमता के आणविक तंत्र को समझने के लिएजिनोम वाइड ट्रांसक्रिप्शनल विश्लेषण के आधार पर 182 जीन्स की खोज की गयी जो कि पोलन टयूब जर्मिनेशन एवं इलॉगेशन, निषेचल तथा विलग्न में शामिल होती है। वर्तमान पोलन–पिस्टिल इंटरेक्शन के शोधकार्यों में हमने ये पाया कि चाय में स्वप्रमाणन की प्रक्रिया के दौरान csRNS, SRKs तथा SKIPs की सहायता से एक अंत समय वालर रेल्फ इनकेपेटिवेलिटी पायी जाती है जो कि स्टाइल से प्रारम्भ होगर ओवाी तक कायम रहती है। इसके अतिरिक्त COBL10, RALF, FERONIA-rlk, LLG तथा MAPKs की खोज की गयी जो कि चाय में फर्टिलाइजेशन को समझने के लिए महत्वपूर्ण पक्ष हो सकते हैं।

वायरोलॉजी के क्षेत्र में, जंगली रूप से बढ़ने वाले *फाइकस पॉमेटा* को सेब के एक बहुत महत्वपूर्ण वायरस, के प्राकृतिक होस्ट/परजीवी के रूप में पहचाना गया। एक अन्य अध्ययन में, *रुमेक्स नेप्लेन्सिस* की पहचान टोमैटो लीफ कर्ल वायरस के एक ऑफ सीजन होस्ट के रुप में की गई। उल्लेखनीय यह है कि, *पिक्रोराइज़ा कुरोआ* एक जातीय रूप से महत्वपूर्ण औषधीय जड़ी बूटी जो कि पारंपरिक रूप से भारतीय आयुर्वेदिक चिकित्सा की कई दवाइयों में प्रयुक्त किया जाता है। अलटरनेंथेरा यलो वेन वायरस और काफटन पत्ती कर्ल मुल्तान बीटासेटेलाइट के कॉम्प्लैक्स द्वारा संक्रमित पाया गया, जब इसे पालमपुर की मध्य पहाड़ी ऊंचाई पर उगाया गया। प्रतिकूल परिस्थितियों में वायरल रोगजनकों के अस्तित्व के लिए वैकल्पिक परजीवी महत्वपूर्ण हैं।

हिमालय की वनस्पतियों के लिए एक रेफरल सुविधा हेतु अपनी अभिकल्पना में, संस्थान ने अपनी पूर्ण संग्रह (होल्डिंग्स का डिजिटलीकरण किया। इसके अलावा, इस वर्ष के दौरान, पादपालय (पीएलपी) में 20 और प्रजातियों को सम्मिलित किया गया। संस्थान ने हाइपरस्पेक्ट्रल लाइब्रेरी के लिए भी महत्वपूर्ण योगदान दिया, जिसमें 42 पौधों की प्रजातियों के वर्णक्रमीय संकेत (स्पैक्ट्रल सिग्नेचर) तैयार किए गए। इन्हें भारत सरकार के विज्ञान और प्रौद्योगिकी विभाग के वेबपेज, https://nisa.geos.iitb.ac.in के माध्यम से देखा (एक्सेस) किया जा सकता है।

पारंपरिक ज्ञान दस्तावेज़ीकरण के क्षेत्र में संस्थान ने भंगालियों द्वारा दिन–प्रतिदिन महत्व के स्वदेशी उपकरण बनाने में *क्वेरकस सेमेकार्पिफ़ोलिया,* और *कॉटनएस्टर*

बेसिलारिस के महत्व के बारे में जाना। इसके अतिरिक्त उपयोगिता के आधार पर, *टेरिडियम एक्वलिनम, जग्लांस रिगिया, कोरिलस जक्वेमोंटीअर्टिका डोइका, डिप्लेजियमम मेक्सिमम* और *ऐंजेलिका ग्लोका* को चुराह, चंबा के गुर्जरों के लिए सबसे महत्वपूर्ण प्रजाति के रूप में पहचाना गया।

हिमालय क्षेत्र में आग एक प्रमुख खतरा बनी हुई है। वर्ष 2017 के प्रहरी उपग्रह चित्रों का उपयोग करते हुए, अग्नि प्रबंधन के लिए, संस्थान ने हिमाचल प्रदेश के जिला कांगड़ा के पालमपुर और धर्मशाला तहसीलों में आग से प्रभावित क्षेत्रों की क्रमशः 1503.63 हेक्टेयर और 630.57 हेक्टेयर भूमि की मैपिंग की। मॉडलिंग और सिमुलेशन क्षेत्र पर, हिंद–कुश हिमालयी क्षेत्र में *बेटुला यूटिलिस* ट्रीलाइल प्रजातियों, के भविष्य के परिदृश्य (वर्ष 2061–2080) में संभावित डिस्ट्रिब्यूशन की संभावना प्रकट की गई। इसका 21वीं सदी के जलवायु परिवर्तनों के प्रति संवेदनशील होने का अनुमान है।

हिमालय में पहली बार उच्च तुंगता वाले क्षेत्रों की वनस्पतियों की कार्यात्मक विविधता के प्रतिमान (पैटर्न) को बताया गया। कठोर पर्यावरणीय परिस्थितियों के कारण उच्च तुंगता वाले क्षेत्रों के पौध समूहों में कम कार्यात्मक विविधता होती है, इससे उच्च तुंगता वाले क्षेत्रों के पौधों की प्रजातियां कठोर वातावरण का सामना करने के लिए अपेक्षाकृत समान लक्षणों का प्रदर्शन करती हैं।

उच्च तुंगता वाले क्षेत्रों की वनस्पतियों (3000 मीटर) की 418 प्रजातियों की विपुलता/ घनत्व का पता लगाया गया। इन सभी प्रजातियों की प्रजाति निश चौड़ाई, ऊँचाई सीमा और दुर्लभता की स्थिति का अनुमान लगाया गया और 26 प्रजातियों को जलवायु परिवर्तन के कारण अपेक्षाकृत अधिक विलुप्त होने वाला पाया गया।इसके अलावा, उच्च तुंगता वाले क्षेत्रों के पौधों की एक बड़ी संख्या में पत्ती के लक्षणों (क्षेत्र और द्रव्यमान) पर माप से अनुमान लगाया कि उच्च पत्ती के पानी के द्रव्यमान और पत्ती के शुष्क द्रव्यमान में वृद्धि प्रकाश अवरोधन लागत और पत्तियों के चयापचय द्रव्यमान घटकों और कुशल संसाधन उपयोग से संबंधित है। ऋतु अनुपात के साथ *रोडोडेंड्रोन एंथोपोगोन* की पत्तियों में मॉर्फो–फिजियोलॉजिकल परिवर्तनों ने सुझाव दिया कि ट्रेट मौसमी परिवर्तनों के लिए पौधे के अनुकूलन के साथ निकटता से जुड़े हैं।

एक अग्रणी पहल में, संस्थान ने एक अत्यधिक विषाक्त आक्रामक प्रजाति *अग्रीटिना एडेनोफोरा* के उन्मूलन की शुरुआत की और जनसमुदाय की भागीदारी के माध्यम से बहुउद्देशीय देशी प्रजातियों के पौधों का रोपण किया।

प्राकृतिक उत्पाद रसायन विज्ञान संस्थान की ताकत में से एक है। *जैन्थोंजाइलम आरमेटम, नारकिसस टजेटा* और *जिपेंथन्थस माइन्यूटा* की व्यवस्थित पादप रसायनिकी जांच से दो अणुओं सहित 15 साइटोटॉक्सिक अल्कलॉइड के लक्षणचित्रण में सहायता मिली। मार्कर यौगिकों की विशेषता इन पौधों की प्रजातियों के गुणवत्ता नियंत्रण मापदंडों में सहायक होगी।

प्राकृतिक रंगों और रंजकों के क्षेत्र में *ब्रैसिका ओलेरासिया* से प्राकृतिक रंगों के निष्कर्षण के लिए 100 किलोग्राम पैमाने पर पर्यावरण के अनुमूल और सस्ती प्रक्रिया विकसित की गई है। अनुकूलित प्रक्रिया द्वारा गैर विषैले, गैर–हाइग्रोस्कोनिक, क्रिस्टलीय, स्थिर और बायोडिग्रेडेबल प्राकृतिक रंगों और रंजकों कोनिकाला गया जो खाद्य और सौंदर्य प्रसाधन (कॉस्मेटिक) उत्पादों के लिए सफतलापूर्वक उपयोग में लाए जा सकते हैं।

नैनो–मिश्रित सामग्री पैलेडियम और रोडियाम समर्थित उत्प्रेरकों (Pd@PS व Rh@PS) को कार्बन मोनोऑक्साइड फिक्शेसन अभिक्रिया में उपयोग करके विभिन्न बेंजोइमिडाज़ोल, क्विनोलोन, कार्बाज़ोलोन और आइसोइंडोलिनोन जैसे 150 से अधिक ड्रग केडिंडेट को बनाया गया।

क्विनोलिन आधारित एंटीमेलेरियल एजेंटों का संश्लेषण भी प्रगति पर है। इस वर्ष 4 नवीन उत्प्रेरक विधियों को नए क्विनोनिंस डेरिवेटिव के संश्लेषण के लिए विकसित किया गया है। पृथ्वी के प्रचुर मात्रा में कोबाल्ट–मेटल आधारित उत्प्रेरण और आणविक ऑक्सीजन का उपयोग नए विकसित उत्प्रेरक उपायों का मुख्य आकर्षण हैं। फ्यूजड एन,ए'–हेटेरोसायकल सहित लगभग 250 अणुओं को अभिनव सी–एच सक्रियण / क्रियात्मक पद्धति के माध्यम से संश्लेषित किया गया है और वर्तमान में उनकी मलेरिया रोधी क्षमता के लिए मूल्यांकन किया जा रहा है। मेटल

ऑक्सीडेंड को हरित, आर्थिक और नवीकरणीय स्रोतों से बदलने के लिए सी–एच सक्रियण के साथ फोटो और इलेक्ट्रो कैटेलिसिस को विलय करने की एक नई पहल की गई है।

सेलुलोज आधारित उत्पादों के लिए हिमालयी पादप संसाधनों की संभावना के उद्देश्य से सेल्यूलोज पल्प और नैनासैल्यूलोज को तैयार करने के लिए प्रयोगशाला स्तर पर एक प्रक्रिया विकसित की गई है। वर्तमान में सेल्युलोज पल्प को टेक्सटाइल फाइबर में बदलने का कार्य चल रहा है। इसके अतिरिक्त संस्थान ने सेलूलोज आधारित मूल्यवर्धित उत्पादों के लिए विशेष रूप से गाय के गोबर से अपशिष्ट के उपयोग पर भी कार्य प्रारंभ किया गया है।

वर्तमान में एंटीबायोटिक्स और फसल सुरक्षा रसायनों के विरुद्ध बढ़ता प्रतिरोध वैश्विक चिंता का विषय है। इसलिए इस वर्ष फार्मास्यूटिकल्स और कृषि रसायन विकसित करने के लिए दो मिशन मोड परियोजनाएं प्रारंभ की गई हैं। एविबैक्टम–प्रतिरोधी रोगजनकों के विरुद्ध एंटीबायोटिक दवाओं की दक्षता को बहाल करने के लिए एक बीटी लैक्टमेज अवरोधक को प्रदर्शित किया गया। इनप्रोटिक्सः फार्मा और एग्रो मिशन परियोजनो के अन्तर्गत एविबैक्टम के आयात को कम करने के लिए एक नवीन प्रयोगशाला स्तरीय प्रक्रिया विकसित की जा रही है।

कीटनाशक, फफूंदनाशक और शाकनाशी जैसे कृषि रसायन राष्ट्र की खाद्य और पोषण सुरक्षा सुनिश्चित करने में महत्वपूर्ण भूमिका निभाते हैं। इस समस्या को देखते हुए, फसल सुरक्षा मिशन के अन्तर्गत एक कवकनाशी अणु, एपॉक्सीकोनाजोल के लिए एक नई प्रक्रिया का विकास किया जा रहा है।

जैव–आणविक इमेजिंग जांच के लिए हमारे निरंतर प्रयास में, 3.3–5.8 एन.एम. के कार्बोहाइड्रेट आधारित उज्ज्वल नीले और लाल उत्सर्जक कार्बन डॉट्स (सीडी) को संश्लेषित किया गया। शारीरिक परिस्थितियों में उच्च फ्लोरोसेंस क्वेंटम और फोटोस्टेबिलिटी के अलावा, विकसित सीडी ने *एस्चेरिचिया कोलाई* के विरुद्ध तरजीही बैक्टीरियलरोधी गतिविधि दिखाई। एक अन्य अध्ययन में, सिट्रोनेलल तेल के नैनो–इमसिफिकेशन के लिए एक रासायनिक और हरे रंग के सर्फेक्टेंट का उपयोग किया गया। इसने *स्यूडोमोनस एरुगिनोसा* के विरुद्ध प्रारंभिक और चयनात्मक किलिंग गतिविधि दिखाई।

एक अन्य अध्ययन में, सिट्रोनेलल तेल के नैनो – इमसिफिकेशन के लिए एक रासायनिक और हरे रंग के सर्फेक्टेंट का उपयोग किया गया। इसने *स्यूडोमोनस एरुगिनोसा* के विरुद्ध प्रारंभिक और चयनात्मक किलिंग गतिविधि दिखाई।

संस्थान अपनी सामाजिक वैज्ञानिक जिम्मेदारी के प्रति प्रतिबद्ध है। इसलिए, इस वर्ष भी, संस्थान ने जिज्ञासा कार्यक्रम के अन्तर्गत स्कूली बच्चों और उनके शिक्षकों के लिए विभिन्न गतिविधियों का आयोजन किया। जिज्ञासा वैज्ञानिक और औद्योगिक अनुसंधान परिषद (सीएसआईआर) और केंद्रीय विद्यालय संगठन के बीच एक छात्र–वैज्ञानिक संपर्क कार्यक्रम है। इस वर्ष विभिन्न अवसरों पर विभिन्न स्कूलों, संस्थानों, विश्वविद्यालयों और कॉलेजों के 3166 से अधिक छात्रों और संकाय सदस्यों ने संस्थान का दौरा किया। संस्थान के वैज्ञानिकों ने भी विभिन्न स्कूलों का दौरा किया तथा विज्ञान और प्रौद्योगिकी के प्रति छात्रों को प्रेरित करने और आकर्षित करने के लिए लोकप्रिय विज्ञान व्याख्यान दिए।

पूर्ववर्ती वर्ष की भांति इस वर्ष भी छात्र संगोष्ठी श्रृंखला को जारी रखने हुए दूसरे छात्र संगोष्ठी श्रृंखला को 5 सितंबर 2018 को आयोजित किया गया। इस वर्ष के लिए संगोष्ठी का विषय था 'विस्तार से वैज्ञानिक क्षितिज का विस्तार मूलभूत से ट्रांसलेशनल अनुसंधान'। इसके लिए कुल 28 प्रविष्टियाँ प्राप्त हुईं। इसके अतिरिक्त टैगलाइन, फ़ोटोग्राफ़ी और क्विज़ प्रतियोगिता भी आयोजित की गईं। संगोष्ठी पूरी तरह से विभिन्न एजेंसियों द्वारा प्रायोजित की गई थी।

भारत सरकार के विज्ञान एवं प्रौद्योगिकी विभाग (डीएसटी) द्वारा 'शोध सुस्पष्टता के लिए लेखन कला' विषय पर आयोजित राष्ट्रीय स्तर की प्रतियोगिता में हमारे संस्थान के श्री सौरभ सोनी तथा विपाशा भट्टाचार्जी को प्रशस्ति पत्र के साथ 10000/– रुपये के नगद पुरस्कार से सम्मानित किया गया।

पुष्प खेती और विश्लेषणात्मक रसायन विज्ञान के क्षेत्र में सीएसआईआर एकीकृत कौशल पहल के तहत कई

कौशल विकास कार्यक्रम आयोजित किए गए। एक से बारह महीने की अवधि के लिए 165 स्नातक / स्नातकोत्तर / पीएचडी छात्रों को प्रशिक्षण प्रदान किया गया। इस वर्ष पूरे देश के जीव विज्ञान के छात्रों के लिए डीबीटी प्रायोजित कौशल विकास कार्यक्रम के अन्तर्गत पादप सूक्ष्म प्रवर्धन के क्षेत्र में एडवांस्ड डिप्लोमा शुरू किया गया। इन कौशल विकास कार्यक्रमों का उद्देश्य उद्योग, शिक्षा और स्व–रोजगार के क्षेत्र में कुशल जनसंपदा तैयार करना है।

संस्थान को सितंबर, 2017 से हिमाचल प्रदेश, मुख्यमंत्री स्टार्टअप योजना और डीएसआईआर–सीआरटीडीइएफ के अन्तर्गत इनक्यूबेशन सेंटर के रूप में मान्यता दी गई है। इस योजना के अन्तर्गत कुल चौदह इनक्यूबेटीज़ ने खाद्य प्रसंस्करण, पुष्पखेती, प्रक्रम विकास और जैव प्रौद्योगिकीके क्षेत्र में अपने को पंजीकृत किया।

सीएसआईआर के एनालिटिसीएसआईआर पोर्टल में अपनी भागीदारी सीएसआइआर–आईएचबीटी की एक उल्लेखनीय गतिविधि रही। पोर्टल संस्थान के उच्च स्तरीय/ प्रमुख उपकरणों के उपयोग के लिए सीएसआईआर के भीतर और बाहर के उपयोगकर्ताओं द्वारा ऑनलाइन निवेदनों/मांग को पूरा करता है।

संस्थान ने अपनी आधारभूत ढांचे और वैज्ञानिक विश्लेषणात्मक सुविधाओं को सुदृढ़ करने के कार्य को जारी रखा। इस संबंध में, अपनी उपलब्ध सुविधाओं में कई नियमित और उच्च स्तरीय उपकरणों को जोड़ा गया। प्रोटीन शोधन प्रणाली, द्रव्यमान / पीडीए निर्देशित ऑटो शोधन प्रणाली और बहुउद्देशीय सगंध तेल क्षेत्र आसवन इकाइयां इसमें से कुछ प्रमुख हैं। औद्योगिक रूप से महत्वपूर्ण पादप चयापचयों के उत्पादन के लिए स्वदेशी कम लागत वाली बायोरिएक्टर सुविधा और सिर और गर्दन के स्क्वैमस सेल कार्सिनोमा (एचएनएससीसी) के लिए जैविक रूप से प्रासंगिक हेटरोटोपिक एक्सनोग्राफ़्ट मॉडल, गठिया, (आईपीएफ) और कोलाइटिस इस संबंध में प्रमुख है। अतिरिक्त ग्रीन हाउस और पॉली हाउस का निर्माण करके कृषि गतिविधियों को भी अधिक सुदृढ़ किया गया और मौजूदा सुविधाओं में नए कक्षों को जोड़ा गया।

वित्तीय वर्ष 2017–18 में शुरू किए गए टाइप– V, IV और III स्टाफ क्वार्टरों के निर्माण पर काम लगभग पूरा होने वाला है। इसके अतिरिक्त नेचुरल प्रोडक्ट केमिस्ट्री लैब, कैंटीन बिल्डिंग और वनस्पति उद्यान और मौजूदा बांस ट्रीटमेंट प्लांट का विस्तार गया। विनियामक अनुसंधान केंद्र के लिए एक पार्किंग क्षेत्र और पेंटागन तक एक मार्ग का निर्माण किया गया।

कर्मचारियों, निवासियों और आगंतुकों के लिए संस्थान को अधिक उपयोगी एवं अनुकूल बनाने के लिए, परिसर में दो स्थानों पर एक द्वि–भाषिक संस्थागत गाइड मैप तैयार किए गए। इसके अतिरिक्त, संस्थान के विभिन्न स्थानों को दर्शाने वाले साइन बोर्ड लगाए गए। पुराने सम्मेलन हॉल, निदेशक बैठक कक्ष और सभागार का नाम क्रमशः प्रसिद्ध वैज्ञानिकों, आचार्य जेसी बोस, सर सीवी रमन और डॉ एसएस भटनागर के नाम पर रखा गया।

सीएसआईआर–आईएचबीटी ने विभिन्न व्यावसायिक बैठकों, व्यापार मेलों और क्षेत्रीय एवं राष्ट्रीय स्तर पर प्रदर्शनियों में अपनी प्रौद्योगिकी और उत्पादों को प्रदर्शित किया। साथ ही संस्थान ने 68 समझौतों / एमओयू किए जिनमें 5 प्रौद्योगिकी हस्तांतरण, 31 सामग्री हस्तांतरण करार (एमटीए), 26 विविध एमओयू शामिल हैं, जिनमें विभिन्न किसान समूह शामिल हैं। संस्थान ने मुख्यमंत्री स्टार्ट अप योजना के अन्तर्गत विभिन्न नवाचार परियोजनाओं के लिए 6 समझौता ज्ञापन किए।

इस बात की आवश्यकता का अनुभव किया जा रहा था कि सीएसआईआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान, पालमपुर का अपना एक लोगो/ प्रतीक चिन्ह होना चाहिए इस वर्ष एक प्रतियोगिता के माध्यम से संस्थान को अपना 'लोगो' मिला। प्रकृति के पांच तत्वों प्थ्वी, आकाश, जल, वायु और अग्नि का अनुकरण करते हुए लोगो अपने सार को 'रिबन, वृत्त, पर्वत, वृक्ष एवं पथ में प्रकट करता है जो कि संस्थान की अभिकल्पना एवं उद्देश्य को दर्शाता है। लोगो को 31 मार्च 2019 को सीएसआईआर के माननीय महानिदेशक डॉ. शेखर सी मांडे द्वारा विमोचित किया गया।

इस वर्ष के दौरान, संस्थान श्री जयराम ठाकुर, हिमाचल प्रदेश के माननीय मुख्यमंत्री, श्री गिरिराज सिंह, लघु सूक्ष्म एवं मध्यम उद्यम मंत्री, डॉ. शेखर सी मांडे, सीएसआईआर महानिदेशक एवं विशेष सम्मानित गणमान्य लोगों की गरिमापूर्ण उपस्थिति से शोभायमान हुआ।

उद्योग के साथ संस्थान की गतिविधियों को संरेखित करने में अनुसंधान परिषद का महत्वपूर्ण योगदान था। यह उनकी पहल के कारण था, कि संस्थान के विभिन्न अनुसंधान समूहों से स्टार्ट–अप के लिए प्रस्ताव/विचार आमंत्रित किए गए और 54वें अनुसंधान परिषद के दौरान एक हितधारकों (स्टेकहोल्डर) की बैठक आयोजित की गई। अनुसंधान और प्रबंधन परिषद, सीएसआईआर – मुख्यालय और विभिन्न वित्त पोषित एजेंसियों के निरंतर सहयोग और प्रोत्साहनके फलस्वरुप संस्थान वैज्ञानिक उत्कृष्टता और सामाजिक वैज्ञानिक दायित्वों को पूरा करने में सक्षम हुआ।

जय हिंद!

(संजय कुमार)

Release of CSIR-IHBT LOGO
31st March 2019

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

CSIR-IHBT
1983

CSIR-IHBT LOGO

The logo signifies the vision and mission of the institute

Emulating nature's five elements ***Earth, Sky, Water, Air*** and ***Fire***, the logo carries their essence in "***Ribbon, Circle, Mountains, Trees*** and ***Path"***

Ribbon- bearing name of the institute, unifies the five elements. Brown colour represents mother Earth, symbolizes support, structure and stability.

Circle- denotes progressive movement, harmony, and infiniteness. Its blue colour signifies knowledge, power, integrity, serenity and unlimited opportunities.

Mountains- the four mountain peaks represent expanse of Himalayan ranges, *viz.*, 'The outer Himalayas (Shivaliks)', 'The lesser Himalayas', 'The Great Himalayas' and 'The Trans-Himalayas'. White colour of the peak, symbolizing purity and peace, represents snow that feeds river systems emanating from mountains.

Trees- represent diverse bioresources, that we work upon for generating bio-economy sustainably. Three trees represent the 'Trigarth' area, the ancient name of Kangra. Green symbolizes nature, growth, harmony and prosperity.

Path- signifies the eternal track for moving, achieving higher attainments. The twelve steps in the path represent the twelve Himalayan states, while the arrow indicates boosting bio economy using bioresources sustainably. Orange colour denotes strength, courage, sacrifice, and dedication.

(DR. SANJAY KUMAR)
Director
CSIR-IHBT, Palampur

(DR. SHEKHAR C. MANDE)
Director General
CSIR & Secretary DSIR
(Govt. of India)

CSIR-IHBT Logo design by: Pabitra Gain and Himani Agrawal

CSIR-IHBT LOGO

Background

It was strongly being realized that CSIR-Institute of Himalayan Bioresource Technology, Palampur should have its own logo that conveys the vision and mission of the Institute. For this, an open competition was held.

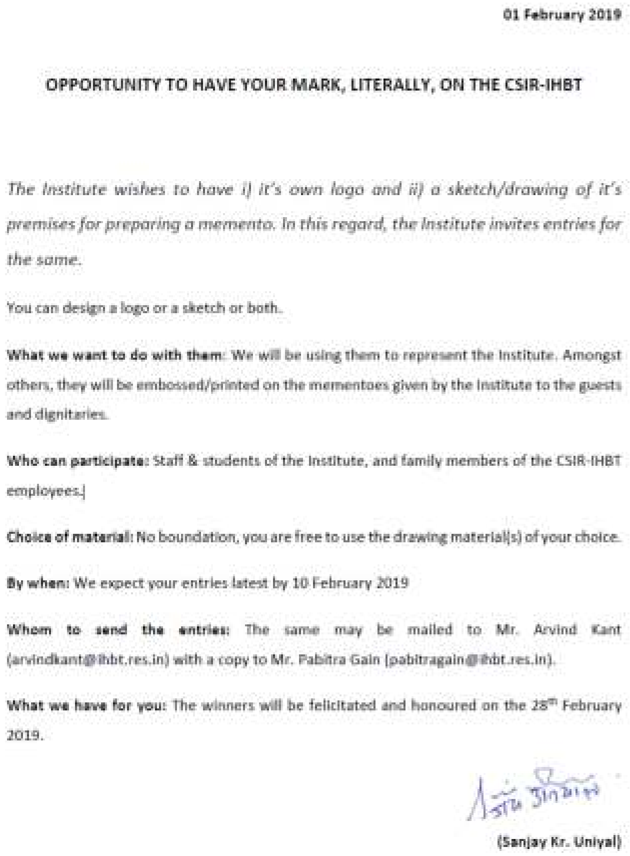
Call for entries

A call for entries was advertised. The competition was open to the staff & students of the Institute, and family members of the CSIR-IHBT employees (Figure 1).

Entries received

A total of 24 entries were received for the same.

The evaluators Figure 1 Call for entries The entries received by due date were then evaluated by a panel of judges based on their relevance to the Institute's vision and mission, work area, uniqueness, appeal, readability, and the message it conveys.



01 February 2019

OPPORTUNITY TO HAVE YOUR MARK, LITERALLY, ON THE CSIR-IHBT

The Institute wishes to have i) it's own logo and ii) a sketch/drawing of it's premises for preparing a memento. In this regard, the Institute invites entries for the same.

You can design a logo or a sketch or both.

What we want to do with them: We will be using them to represent the Institute. Amongst others, they will be embossed/printed on the mementoes given by the Institute to the guests and dignitaries.

Who can participate: Staff & students of the Institute, and family members of the CSIR-IHBT employees.|

Choice of material: No boundation, you are free to use the drawing material(s) of your choice.

By when: We expect your entries latest by 10 February 2019

Whom to send the entries: The same may be mailed to Mr. Arvind Kant (arvindkant@ihbt.res.in) with a copy to Mr. Pabitra Gain (pabitragain@ihbt.res.in).

What we have for you: The winners will be felicitated and honoured on the 28th February 2019.

(Sanjay Kr. Uniyal)

The chosen one Figure 2 The winner The logo that was finally selected unanimously is presented in Figure 2. The same was officially released on the 31st of March 2019 by Dr. S Mande, Hon'ble Director General Council of Scientific and Industrial Research and Dr. Sanjay Kumar, Director CSIR-IHBT in presence of the staff and students of the Institute.

लोगो/प्रतीक चिन्ह की चयन प्रक्रिया

पृष्ठभूमि/आधार

इस बात की आवश्यकता का अनुभव किया जा रहा था कि सीएसआईआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान, पालमपुर का अपना एक लोगो/ प्रतीक चिन्ह होना चाहिए जो कि संस्थान की परिकल्पना तथा उदेश्य को परिलक्षित करता हो। इसके लिए एक प्रतियोगिता का आयोजन किया गया।

प्रविष्टियों का आमंत्रण

प्रविष्टियों को आमंत्रित करने के लिए एक विज्ञापन निकाला गया। संस्थान के कर्मचारियों एवं उनके परिवार के सदस्यों एवं शोध–छात्रों (चित्र 1) इस प्रतियोगिता में अपनी प्रविष्टि प्रस्तुत कर सकते थे।

प्राप्त प्रविष्टियाँ

इसके लिए कुल 24 प्रविष्टियाँ प्राप्त हुईं।

मूल्यांकन समिति

संस्थान की परिकल्पना तथा उदेश्य, कार्य क्षेत्र, विशिष्टता, आकर्षक, पठनीयता, और संदेश युक्त नियत तिथि तक प्राप्त प्रविष्टियों का उसकी प्रासंगिकता के आधार पर निर्णायक मंडल के एक पैनल द्वारा मूल्यांकन किया गया।

चयन

लोगो/ प्रतीक चिन्ह, जिसे अंततः सर्वसम्मति से चयनित किया गया, चित्र 2 में प्रस्तुत किया गया है। आधिकारिक तौर पर इसे 31 मार्च 2019 को डॉ. शेखर मांडे, माननीय महानिदेशक वैज्ञानिक और औद्योगिक अनुसंधान परिषद और डॉ. संजय कुमार निदेशक सीएसआईआर–आईएचबीटी द्वारा संस्थान के कर्मचारियों और छात्रों की उपस्थिति में विमोचित किया गया।

'लोगो'/प्रतीक चिन्ह संस्थान की परिकल्पना और उद्देश्य को दर्शाता है

इस संरचना में युक्त रिबन, वृत्त, पर्वत, वृक्ष और पथ प्रकृति के पांच तत्वों पृथ्वी, आकाश, जल, वायु और अग्नि के द्योतक हैं।

रिबन– संस्थान का नाम लिए यह रिबन पांच तत्वों को एकसूत्र में बांधता है। इसका भूरा रंग इस पृथ्वी का प्रतिनिधित्व करता है, जो समर्थता, संरचना और स्थिरता का प्रतीक है।

वृत्त– प्रगतिशील, सामंजस्य/समरसता और अनंतता का प्रतीक है। इसका नीला रंग ज्ञान पराक्रम, सत्यनिष्ठा, धैर्य और असीमित अवसरों को दर्शाता है।

पर्वत– चार पर्वत चोटियाँ हिमालय पर्वतमाला व इसके चार घटकों अर्थात, 'आउटर हिमालय' (शिवालिक)', 'लैसर हिमालय,' 'द ग्रेट हिमालय' और 'ट्रांस–हिमालय' को प्रतिबिंबित करता है। शिखर का सफेद रंग, पवित्रता और शांति का प्रतीक है। यह बर्फ को दर्शाता है जो कि पर्वतों से निकलने वाली नदियों को पोषित करता है।

वृक्ष– विविध जैव–स्रोतों को दर्शाते हैं, जिन पर संस्थान जैव–आर्थिकी के उन्नयन हेतु प्रौद्योगिकीय उद्भवता एवं विकास पर शोध करता है। तीन पेड़ 'त्रिगर्त' क्षेत्र का निरुपण करते हैं, जो कांगड़ा का प्राचीन नाम है। हरा रंग प्रकृति, विकास, सद्भाव और समृद्धि का प्रतीक है।

पथ– सदैव गतिमान और निरंतर आगे बढ़ने का सूचक है। पथ के बारह चरण बारह हिमालयी राज्यों का प्रतिनिधित्व करते हैं, जबकि तीर जैवआर्थिकी के उन्नयन हेतु उद्भवता एवं विकास में हिमालयी जैवसंपदा के संपोषणीय उपयोग का संकेत देता है। नारंगी रंग शक्ति, साहस, त्याग और समर्पण को इंगित करता है।

डॉ. संजय कुमार
निदेशक
सीएसआईआर–आईएचबीटी, पालमपुर

डॉ. शेखर चि. मांडे
महानिदेशक, सीएसआईआर
वैज्ञानिक और औद्योगिक अनुसंधान विभाग

Technologies Available with CSIR-IHBT

Technologies available with CSIR-IHBT

S. No.	Title of Product/ Process/ Design / Equipment Developed	Market Size
1	Superoxide Dismutase (SOD)	World Enzyme Demand (Industrial and Speciality) USD 6,950 million in 2017 expected to reach USD 9,500 million
2	Variant of Super Oxide Dismutase (SOD)	World Enzyme Demand (Industrial and Speciality) USD 6,950 million in 2017 expected to reach USD 9,500 million
3	Phospholipase	World Enzyme Demand (Industrial and Speciality) USD 6,950 million in 2017 expected to reach USD 9,500 million
4	DNA barcode technology for plant authentication	India being among the 17 mega biodiversity countries of the world is a custodian of more 18,000 angiosperms with approximately 7000 medicinal plant of pharmaceutical importance. In India, annual medicinal plant based raw material trade is 1,28,000 tons with a value of Rs. 4200 crores annually and contributes 8% in total global market export. Indian pharmaceutical market is expected to grow up to USD 55 billion by 2020
5	*In vitro* production system for naphthoquinones (red colour) from *Arnebia euchroma*	
6	Ready to Eat crispy fruits and vegetables	Global freeze-dried product market is expected to grow at a CAGR of 7.23% and during the forecast period of 2016-2021, and reach USD 66.53 billion by 2021
7	Canning technology for Ready to Eat (RTE) foods	It is expected that the ready meals market in India would continue to grow at a CAGR of approximately 12.36% during the period 2016-21 and reach INR 2,901.53 million by 2020
8	Protein & fibre enriched cereal bars	India energy bars market is projected to grow at a CAGR of over 28%, in value terms, during 2017-2022
9	Vitamin D_2 enriched *Shitake* mushroom	The global demand for Shiitake mushroom is expected to reach approximately 4500 tonnes by 2025 with an estimated market of USD 35.4 billion and the international demand for vitamin D is estimated to reach USD 140 million by 2025 growing annually at 1.2%

S. No.	Title of Product/ Process/ Design / Equipment Developed	Market Size
10	Iron enriched fruit bars and candies	India energy bars market is projected to grow at a CAGR of over 28%, in value terms, during 2017-2022
11	Gluten-Free foods from Buckwheat	The global market for gluten-free products market was valued at USD 4.63 billion in 2015 and is projected to reach USD 7.59 billion by 2020, at a CAGR of 10.4% from 2015 to 2020
12	Bamboo candy and food products	It is estimated that by 2015 the world market of bamboo will increase to 20 billion dollars but India's bamboo market will be limited to 26, 000 crores only
13	Multigrain high protein mix	The global protein fortified foods and beverage market is estimated to reach USD 59.3 billion with a compound annual growth rate of 5.9% by 2022 of which one fifth to be contributed by Indian market at USD 12 billion
14	Iron and zinc enriched Spirulina based bars	Global spirulina market is expected to register a CAGR of 10% during the forecast period, and is estimated to be valued at nearly USD 2,000 million by 2026, from more than USD 700 million in 2016
15	Technology for the production of Aescin from Horse-chestnut	Up to 500 000 tonnes of *Aesculus* seeds are produced each year around the world, with the biggest proportion coming from the northern hemisphere. China 40% (100,000-240,000 tons/year), Korea 15% (up to 80,000 tons/year), Italy, Turkey, Japan around 10% each (up to 30,000 tons/year) and other countries 1-4% are the world's largest producers of *Aesculus*
16.	Mini Distillation Unit Herbostill™	
17.	Mini Laminar Flow Unit - Steriflow™	
18.	Gel Processing and Transfer Device (GEPROTED)™	
19	iRIS™ ……an easy solution to RNA isolation	
20	Culture vessel for rooting of micro shoots	
21	Tea Withering Machine	

S. No.	Title of Product/ Process/ Design / Equipment Developed	Market Size
22	Tea Catechins	Global market demand for the tea polyphenols was approximated at 4870 tons in year 2012 and it is predicted to grow at a CAGR rate of 8.5% during the forecasted period from year 2013 to year 2022
23	Tea Wine	Global wine market was valued at approximately USD 302.02 billion in 2017 and is expected to generate revenue of around USD, 423.59 billion by the end of 2023, growing at a CAGR of around 5.8% between 2017 and 2023
24	Herbal Tea	
25	Ready to serve Tea concentrates	Estimated global market of tea concentrates and ready to drink teas is USD 76 billion in 2017 with annual growth of 7 %
26	Technology for dietary fibre extraction from Apple pomace	The dietary fibre market is expected to reach USD 5.9 billion by 2022 and is growing continuously with a compound annual growth rate (CAGR) of 13.7%
27	Natural Colours from plants/vegetable sources	Food colors market is projected to reach USD 3.75 billion by 2022, at a CAGR of 8.40% from 2016
28	Diagnostic kits for *Prunus necrotic ringspot virus* (PNRSV)	
29	Formulation of herbal incense Cones from herbs and flowers	Growing at a CAGR of 15%, it is expected to grow exponentially reaching Rs 12,000 crore in the upcoming five years transforming this particular segment even more
30	L-Asparaginase (HimAsnase™) with no glutaminase activity for therapeutic and food processing applications	Global therapeutic enzymes market is estimated at USD 6 billion
31	Process for Scalable Production of 4-substituted cyclohexane-1,3-diones	
32	Process Development for 4-alkyl resorcinols production from 4-alkyl cyclohexane-1,3-diones	

S. No.	Title of Product/ Process/ Design / Equipment Developed	Market Size
33	5-Hydroxymethylfurfural (HMF) production from Carbohydrates	The global market for 5-HMF is expected to reach about 123.279 billion USD by 2022 from 116.750 billion USD in 2016
34	Processing of Stevia Leaves and conversion into Stevia Liquid Drops	Stevia market is expected to reach USD 565.2 million by 2020, reflecting a CAGR of 8.5% during the forecast period
35	Production of Steviol glycosides from dry stevia leaves	Stevia market is expected to reach USD 565.2 million by 2020, reflecting a CAGR of 8.5% during the forecast period
36	Production of Efficient Bio-fertilizer using Strains of *Pseudomonas trivalis* 745	Global Bio Fertilizers market stood at USD1.22 billion during 2017 and is projected to witness robust growth at a CAGR of 14.08% during 2018-23, thereby reaching USD2.76 billion by the end of 2023
37	Bamboo Charcoal	Global activated carbon market was valued at USD 4.74 billion in 2015 and is projected to reach USD 8.12 billion by 2021, at a CAGR of 9.4% from 2016 to 2021
38	Green process for nanocurcumin synthesis with increased solubility	Global curcumin market is expected to reach USD 94.3 million by 2022. India is the largest manufacturer of curcumin with production exceeding 80% of global market.
39	Conversion of Camphor into Borneol	d-Borneol one of the reduction product of d-camphor have very high value in the market (Rs. 40000 – 80000 per kg) and huge market (1-10 metric tonnesper year)
40	Process for Extraction of Sapium Wax	Global wax market is expected to reach USD 12.9 billion by 2025, and is expected to grow at a CAGR of 3.7% from 2017 to 2025
41	Development of Bio-lubricants from Sapium Oil	The bio-lubricants market is expected to grow from an estimated USD 2.47 billion in 2017 to reach USD 3.36 billion by 2022, at a CAGR of 6.4% between 2017 and 2022
42	Development of feed/ protein concentrate from Sapium seed meal.	Global Animal Feed Protein Ingredients Market is poised to cross USD 200 billion by 2024
43	Process for the Avibactam	
44	Development of process for Converting Raw Cellulosic Biomass into Textile Fiber and Nano- cellulose	The global cellulose fibers market is expected to reach at USD 36.96 Billion in 2020 at a CAGR of 9.49% over the period between 2015 and 2020

S. No.	**Title of Product/ Process/ Design / Equipment Developed**	**Market Size**
45	Agro-technology of stevia	Stevia market is expected to reach USD 565.2 million by 2020, reflecting a CAGR of 8.5% during the forecast period
46	Biofertilizers	Global Bio Fertilizers market stood at USD1.22 billion during 2017 and is projected to witness robust growth at a CAGR of 14.08% during 2018-23, thereby reaching USD2.76 billion by the end of 2023
47	Low calorie natural sweetner: Monk fruit *(Siraitiagrosvenorii)*	Transparency Market Research offers an eight-year forecast for the global monk fruit sugar market between 2018 and 2026. In a recently released report by the company, the global monk fruit sugar market is expected to register a CAGR of 4.5% during the forecast period
48	Micropropagation protocols for *Picrorhiza Kurroa,* an important medicinal plant of Himalaya	Global annual demand 5000 tonnes
49	Agro technology of Heeng *(ferula assa-foetida)*	Analysts forecast the Global Asafoetida Market to grow at a CAGR of 5.82% during the period 2019-2023
50	Agro-technology package for China hybrid tea (*Camellia sinensis*)	Global tea market was valued at USD 4.6 billion in 2016, and is projected to reach at USD 6.7 billion by 2023, growing at a CAGR of 5.5%
51	Agro-technology and process-technology of Damask rose (*Rosa damascene*)	The global demand of damask rose oil, concrete and absolute is 45 tonnes per year. Bulgaria and Turkey being the major producers of rose oil
52	Development of New Plant Varieties of Rose (Thorn- less Rose and Himalayan Wonder)	
53	Agro-technology and process-technology of wild marigold (*TagetusMinuta*)	The global demand of Tagetes oil is 20 tonnes, while the production is limited to 12 tonnes of essential oil
54	Agro-technology of Lilium	Annual demand of bulbs 1328 metric tonne

S. No.	Title of Product/ Process/ Design / Equipment Developed	Market Size
55	Agro-technology for CallaLily	Trade of Calla lilies in the Indian market is currently estimated at Rs.150 crores with an annual growth of 20%. Major producers of Calla lily are New Zealand, United States, Kenya and Taiwan
56	Agro-technology of Gerbera (*Gerbera Jamesonii*)	Gerbera is cultivated in India in over 900 acres. Trade in domestic market is estimated at Rs. 985 crores with an annual growth rate of 15%
57	Micropropagation protocols for industrially important crop plants	
58	Technology for production of quality Apple rootstock	Certified planting material of apple rootstocks has a huge demand. There is a need of 5-6 lakh plants/ year by the farmers, whereas under the national scenario, production is less than 50% of the demand. Virus tested planting material guarantees 20% more branches and 40% more spurs for better fruit production

CSIR-IHBT Technologies Rolled Out

TRANSFER OF TECHNOLOGIES
FIVE YEARS DETAILS

Incubatees: Various projects have been approved by the technical committee of the Industries Department of the State. The aim is to support and promote entrepreneurship by converting innovative technologies into business.

Sixteen incubates are being facilitated to undertake micro-propagated potato, fruit juices and other products, blended teas, tea-based diversified products, honey, vinegar and nutritional fruit burfi, e-trading platform for MAPs and commercially important crops, aloe vera juice and detox drinks.

Agreements/ MoUs signed: A total of 109 agreements/MoUs were signed during last five years (2014-15 to 2018-19). These include technology transfers, agreements for consultancy services, material transfers and other miscellaneous items/agreements with incubatees (Table 1).

Table 1 Details of agreements/ MoUs signed during last five years

Year	Transfer of Technology	Consultancy	Material transfers	Misc.	Incubatees	Total
2014-15	3	-	-	-	-	**3**
2015-16	-	1	2	-	-	**3**
2016-17	2	2	2	1	-	**7**
2017-18	4	4	6	4	10	**28**
2018-19	5	-	31	26	6	**68**
Total	**14**	**7**	**41**	**31**	**16**	**109**
Average	2.8	1.4	8.2	6.2	3.2	21.80

Technology transfers between 2014-19

A total of 14 agreements/ MoUs for transfer of technology were signed during the last five years.

- 2014-2015: Signed agreements for transfer of 3 technologies namely, SOD enzyme-US Patent 6485950, 26th November 2002; US patent 7888088, 15th February 2011, Tea RTD, tea wine, and tea catechins.
- 2016-2017: Signed agreements for transfer of 2 technologies (Ready to eat Kangridham and Crispy fruits). In addition, MoU was signed with The Lisavenko Research Institute of Horticulture for Siberia Technical cooperation in Hippophae research is envisaged.
- 2017-2018: Signed agreements for transfer of 4 technologies i.e., Tea catechins, Nutri bar, Ready-to-eat preservative free khichdi and Extraction of steviol glycosides.
- 2018-2019: Signed five agreements for transfer of technology i.e., manufacturing / processing of multigrain high protein

beverage mixes and soup mixes products, Large Scale Production of Biofertilizers (NFB, PSB, KMB); Vertical gardening and indoor air pollution abatement, Making herbal cones from temple waste flowers; and cultivation of *Lentinula edodes* (Shiitake mushroom) in synthetic logs for vitamin D2 enrichment (2 nos.).

Agreements for consultancy signed: A total of 7 agreements were signed, 6 on stevia cultivation and one on mass multiplication of bamboo species for consultancy during the last five years.

Material transfers: A total of 41 material transfer agreements were signed during the last five years as per following detail:

- 2015-2016: Virus free apple rootstock (2 nos.)
- 2016-2017: Him Stevia (1 no.) and Tissue culture raised gerbera varieties (1 no.)
- 2017-2018: Aseptic cultures of gerbera, apple and stevia (1 no.), Tissue culture raised potatoes (1 no.), Damask rose plants (4 nos.)
- 2018-2019: Wild Marigold (3 nos.), Rosemary (3 nos.), Stevia (4 nos.), Palmarosa crop (1 nos.), Gerbera culture (2 nos.) Bamboo culture (1 no.), Damask rose Varieties "Jwala" and "HimRoz" (16 nos.), RET MAPs (01 no.)

Miscellaneous Agreements/MoUs: 31 nos. (Miscellaneous agreements/ MoUs) were signed during the last five years. Year wise detail is as below:

- 2016-2017: State Medicinal Plant Board for consultancy on construction of drying shed and storage godown)
- 2017-2018: 4 nos. (Bioefficacy of new acaricides against tea mites with Crystal Crop Protection Pvt. Ltd., New Delhi and High altitude medicinal plant nursery at CeHAB with State Medicinal Plant Board, Department of Ayurveda, HP, and collaborative projects proposals RS-GIS domain, M/s. Excel Geomatics Pvt., Ghaziabad).
- 2018-2019: (26 nos.) (MoUs with farmers societies for installation of distillation Unit (9 nos.), MoU's with Industries for utilizing facility of CSIR IHBT for essential oil (3 nos.), MoU's with societies for cultivation and rural development in Uttarakhand, Northeast States, Lahaul & Spiti and upper area of district Shimla (4 nos.), agreements for production of floriculture plants using CSIR-IHBT facility (2 nos.), agreement for utilizing Retort facility (1 no.) and agreements for processing of stevia leaves and conversion into stevia liquid using CSIR IHBT facility (4 nos.), agreements for processing of green coffee beans (1 no.), MoU with The Palampur Rotary Eye Foundation (1 no.), MoU with M/s Nano Tech Chemical Brothers Pvt Ltd (1 no.).

Agreements/ MoUs signed with Incubatees: 16 nos. (agreements/ MoUs) were signed during the last five years. Year wise detail is as below:

- 2017-2018: A total number of 10 agreements were signed.
- 2018-2019: A total number of 6 agreements were signed.

CSIR-IHBT TECHNOLOGIES ROLLED OUT, MoU AND AGREEMENTS SIGNED DURING 2018-19

Sr.	Title of Agreements/ MoUs	Name of company with whom agreement/MoU were signed and technology transferred	Date of Signing
1	Grinding/Crushing and roasting of green coffee beans and blending coffee beans in 2-3 different flavours	M/s Himalaya Natural and Herbal Products, V.P.O Bundla, Palampur (H.P.)	03/04/2018
2	Wild marigold seeds for cultivation in Rourkela Odisha	M/s. Social Action for People (SAP), Sanyasipali P.O Kolabira, Distt Jharsuguda, Odisha	24/04/2018
3	Incubation facility in production of new potential crops (floriculture)	Mr. Shivanshu Mehta S/o Parveen Mehta, Ward No 9, Kasba Paprola 822, Distt Kangra (H.P.)	24/04/2018
4	Installation of distillation unit for processing technology of aromatic plants under CSIR Aroma Mission in Manipur	Namponliu Associates, Village Makhan, P.O Awang Sekmai, Distt. Kangpokpi, Manipur	26/04/2018
5	Installation of distillation unit for processing technology of aromatic plants under CSIR Aroma Mission	The Seraj Aromatics & Herbs Co-operative Marketing Society Ltd., Vill. Deori PO Kalbari, Tehsil Banjar Distt. Kullu (H.P.)	06/05/2018
6	Installation of distillation unit for processing technology of aromatic plants under CSIR Aroma Mission	Kishan Sahayata Samuh, Siyun Ghoghardhar, Vill. Siyun, PO and Tehsil Padhar, Distt. Mandi (H.P.)	06/05/2018
7	Installation of distillation unit for processing technology of aromatic plants under CSIR Aroma Mission	Chamunda Krishak Society Chakoli, Vill. Chakoli Maida, Gram Panchyat Suri, Tehsil Salooni, Distt. Chamba (H.P.)	06/05/2018
8	Installation of distillation unit for processing technology of aromatic plants under CSIR Aroma Mission	The Aroma KisanBagwan Sugandh AvmAushdhiya Podh Utpadan, Vidhayanavm Vipanan Bahudeshiya Sahkari Sabha (Society), V.P.O Choukath, Tehsil Jawalamukhi, Distt. Kangra (H.P.)	06/05/2018
9	Installation of distillation unit for processing technology of aromatic plants under CSIR Aroma Mission	Shakti Nagar Jan Kalyan Society, Vill. Badah, P.O. Mohal, Tehsil & Distt. Kullu (H.P.)	06/05/2018

Sr.	Title of Agreements/ MoUs	Name of company with whom agreement/MoU were signed and technology transferred	Date of Signing
10	Installation of distillation unit for processing technology of aromatic plants under CSIR Aroma Mission	Pragati Kisan Kalian Samiti, Vill. Talla, Gram Panchyat Surpada, Tehsil Sihunta, Distt. Chamba (H.P.)	06/05/2018
11	Production for floriculture plants (1.50 lakhs number per year) by using facilities at CSIR-IHBT premises for its commercial use.	Mr. Karan Bhalla M/s Maa Chamunda Flowers, V.P.O Kural, Tehsil Palampur (H.P.)	11/05/2018
12	Manufacturing / processing of multigrain high protein beverage mixes and soup mixes products.	M/s Access India Impex Centre Pvt. Ltd., 602, Naurang House 21, Kasturba Gandhi Marg, New Delhi	11/05/2018
13	Extraction of curcumin and essential oil from turmeric under " Chief Ministers Start up Scheme".	Mr. Paritosh Sharma s/o Sh. P.D. Sharma, Behind Masand Motel, Ward No.2, Vill. Sughar, P.O Bundla, Tehsil Palampur, Dist. Kangra (H.P.)	14/05/2018
14	Installation of distillation unit for processing technology of aromatic plants under CSIR Aroma Mission	Late Shree Amin Chand Memorial Self Help Group, Village Bandkardian, PO Khel, Tehsil Nurpur, Distt. Kangra (H.P.)	15/05/2018
15	Wild marigold (*Tagetes minuta*) variety "HIMGOLD" seeds	Ms. Reshma Sao, Indian Institute of Technology, Mandi (H.P.)	18/05/2018
16	50 kg seed of wild marigold (*Tagetes minuta*) variety "HIMGOLD”	M/s Social Action for People (SAP) Sanyasipali, P.O Kolabira, Distt. Jharsuguda, Odisha	25/05/2018
17	To utilize facility (Retort Unit) available at CSIR-IHBT for making/ producing Ready to eat food products	M/s Dexter Retail and Distribution Pvt. Ltd., 21 Kasturba Gandhi Marg, New Delhi	02/07/2018
18	Installation of distillation unit for processing technology of aromatic plants under CSIR Aroma Mission	Life Science Sector Skill Development Council, New Delhi	05/11/2018
19	Rooted plants of rosemary from CSIR-IHBT	M/s Mountain Bounties, Village Badah, P.O. Mohal, District Kullu (H.P.)	17/07/2018
20	Installation of distillation unit for processing technology of aromatic plants under CSIR Aroma Mission	The Amb Aroma Crop Processing cum Marketing Society Ltd., Saloi, Tehsil Amb, Distt. Una (H.P.)	27/07/2018

Sr.	Title of Agreements/ MoUs	Name of company with whom agreement/MoU were signed and technology transferred	Date of Signing
21	Utilizing the facility of CSIR-IHBT	M/s Prince Enterprise, F/331, City centre, Eidgah Circle, Asarwa, Ahmedabad	01/08/2018
22	Tissue culture flasks of Gerbera	Sashanka Agro Pvt. Ltd., Harihar Singh Road, Morabadi, Ranchi, Jharkhand	06/08/2018
23	To formulate stevia liquid drops at CSIR-IHBT	M/s Yujo agriculture and aquaculture farms society, 354(S) Green Heights, A to Z Colony, Pallavpuram, Meerut (U.P.)	08/08/2018
24	Tissue culture flasks of each "HIM PEACE/HIM SAUMYA/HIM KEERTI/ HIM GLOW for multiplication and cultivation	M/s Himalaya Action Research Centre, 744 Indira Nagar, Phase 2, P.O. New forest Dehradun, Uttarakhand	14/08/2018
25	Assisting the institute for establishing a demonstration plot of targeted medicinal plants at the sites suggested by the party	Shiv Aushdhiya Paudh Utpadan Society, Rajgarh (Gumna), Gram Panchayat Todsa, Tehsil Chirgaon, Distt. Shimla (H.P.)	23/08/2018
26	Utilizing the facility of CSIR-IHBT	M/s Uttam Biotech Pvt. Ltd., Mangal Bhuvan, 2nd Floor, 109, Vitthalbhai Patel Road, Near Chandsa Ram Ji Girls School, Mumbai	27/08/2018
27	Strategic partnership based on principles of mutual strength and benefits of livelihood promotions and rural development in N.E region.	North Eastern Region Community Resource Management Society, Sympli Building, Malki Dhankheti, Shillong-793001	01/09/2018
28	To formulate stevia liquid drops at CSIR-IHBT	M/s Harsh Organic Farms, Village Jankaur, Distt Una (H.P.)	06/09/2018
29	Rooted plants of rosemary	Ms Minakshi Sharma, Y.S Parmar University Nauni, Solan (H.P.)	25/09/2018
30	Utilizing the facility of CSIR-IHBT.	M/s Natural Biotech Products, V.P.O Baggi, Distt. Mandi (H.P.)	01/10/2018
31	To formulate stevia liquid drops at CSIR-IHBT	Mr. Abhishek Dhama S/o Late Sh. Dharmvir Dhama, Director-Ravitanya Farms Vill Kulakpur, P.O Palla, New Delhi	10/10/2018
32	Rural development in high altitude location in Uttarakhand	Association for peoples Advancement and Action Research (APAAR) C/o VSMD Enterprises, 1-97, Lajpat Nagar 1, New Delhi	24/10/2018

Sr.	Title of Agreements/ MoUs	Name of company with whom agreement/MoU were signed and technology transferred	Date of Signing
33	Tissue culture raised bamboo species	Mr. Vijay Patole, Production Manager, M/s H.U. Gugle agro Biotech co., Gate 562, Karmala Road, Jamkhed, Maharashtra.	29/10/2018
34	Plants of Him stevia	Mr. Anil Kumar Dhillo, S/o Sh. Daya Chand Dhillo, Building No. 7, Flat No. 1, Prateek Nagar, Co-operative Housing Society Near MSEB office, Alandi Road, Yerwada, Pune (6), Maharashtra.	30/11/2018
35	Rooted plants of damask rose variety " Jwala"	Mr. Chamkaur Singh, S/o Sh. Nazar Singh, Vill. & P.O. RureKe Kalan, Tehsil, Tapa, District Barnala, Punjab	03/12/2018
36	Rooted plants of damask rose variety " Jwala"	Mr. Vijay Kumar, S/o Sh. Amar Singh, 1720, Lodhi Road Complex, New Delhi	03/12/2018
37	Damask rose variety "Jwala" Cuttings, rooted plants "Jwala", rooted cuttings of *Rosa bourboniana* and seeds of *Matricaria chammomilla*.	Mr. Sudarshan Sampath, S/o Late Sh. Sampath Kumar, 163/146 Rosewood Cottage, Club Road, Udhagamandalam, The Nilgiris, Tamilnadu.	12/12/2018
38	Cuttings of damask rose variety "Jwala"	Mrs. Indu Dhulia M/s MDHP Ltd., Herbal Estate, G-14, Agrasen Nagar, Ring Road 1, Raipur, Chattisgarh.	17/12/2018
39	Cultivation by raising nursery of suitable aromatic crops covered under "CSIR Aroma Mission" at the site suggested by Subodh Thakur.	Subodh Thakur, Village and Post office Saloh, Tehsil Palampur, Distt. Kangra (H.P.)	18/12/2018
40	Large scale production of biofertilizers (NFB, PSB, KMB)	M/s Vandeep Greeen Globe Organic Venture Pvt. Ltd. Majitar, Opposite Himalayan Pharmacy Institute, Rangpo Post, East Sikkim, Sikkim	20/12/2018
41	Wild marigold, damask rose cutting & plants under "CSIR Aroma Mission) and stevia seeds	Mr. Anil Kumar S/o Anuj Kumar, Village & P.O. Puthar, Tehsil Israna Distt. Panipat, Haryana	21/12/2018
42	Rooted plants and cuttings of damask rose variety "Jwala", rooted plants of "HIMROZ", rosemary rooted plants, *Rosa bourboniana* cuttings, seeds of *Matricaria chammomila*, Wild Marigold	The Arunachal Aroma Agro Products, Kalaktang, District West Kameng, Arunachal Pradesh	24/12/2018

Sr.	Title of Agreements/ MoUs	Name of company with whom agreement/MoU were signed and technology transferred	Date of Signing
43	Stem cutting of damask rose variety "Jwala”	Mr. Charanjit Singh, S/o Ram Singh, House No 11/R, Nangal Township, District Ropar, Punjab	26/12/2018
44	To formulate stevia liquid drops at CSIR-IHBT	M/s Agri Natural India,107, New Model Town, Ludhiana, Punjab	02/01/2019
45	Cultivation of suitable aromatic and medicinal crops at Lahaul & Spiti	Society Shiv Dass Ram Dass Medicinal and Aromatic Plant Growers Co-operative Society Limited having official address at Udaipur, Tehsil-Keylong, Lahoul and Spiti (H.P.)	03/01/2019
46	Cultivate suitable crops under CSIR Aroma Mission	Mr. Om Prakash Kapoor Village Bharmat, Post Office Banoori, Tehsil Palampur, Distt Kangra (H. P.)	04/01/2019
47	Plants and cuttings of damask rose variety" HIMROZ”, rosemary and seeds of Wild Marigold	Mr. Pardeep Singh Gehlot, House No. 7, Omaxe City, Sector 28, Rohtak, Haryana	07/01/2019
48	Cuttings of damask rose variety "Jwala”	Mr. Ashwani Kumar, Village Ambari, P.O Malan, Tehsil Nagrota Bagwan, District Kangra (H.P.)	11/01/2019
49	Cuttings of damask rose variety "Jwala".	Mr. Joginder Singh, V.P.O. Malan, Tehsil NgarotaBagwan, District Kangra (H.P.)	11/01/2019
50	Startup to produce aloe vera health juices	Mr. Sunil Kumar S/o Mohinder Kumar, Bhadrin, Lahra (36/1), Hamirpur, Galore (H.P.)	24/01/2019
51	Rooted plants "Jwala" damask rose variety	Mr. Rajesh Rana, S/o Sh. Sansar Singh Rana, Village Tharu, Post office Bagga Tehsil Jawali, District Kangra, (H.P.)	24/01/2019
52	Stevia seeds	Mr. Ram Mehar Singh House No. 600/1, Jyotinagar, Jagadhari, District Yamuna Nagar, Haryana	28/01/2019
53	Startup to make Himalayan Nector (Detox Drink)	Dr. Swati Sharma, M-150, Jalwayu Vihar, Sector 25, Noida	01/02/2019
54	Stevia seeds, Him stevia plants and tissue cultures flasks	Dr. Narender Kumar, I-2/4, Sector 16, Rohini Delhi	06/02/2019

Sr.	Title of Agreements/ MoUs	Name of company with whom agreement/MoU were signed and technology transferred	Date of Signing
55	Stevia seeds	Mr. Parvinder Malik, V.P.O Rojhla, Tehsil Safidon, District Jind, Haryana	07/02/2019
56	Startup to produce tea based fermented beverage	Mr. Vipin Kumar Village Bharmat, Tehsil Palampur, District Kangra (H.P.)	11/02/2019
57	Planting material of damask Rose, rosemary, lavender, wild marigold and saffron	Mr. Narinder Singh Dawar, Ladakh Farmers & Producers Co-operative Ltd., Rambirpura, Thang, Thiksey, Leh, J&K	14/02/2019
58	Production of floriculture plants (Oriental Lilly) using facilities of CSIR IHBT	Mr. Nitesh Meena, Director, M/s Stembuds Agro Solution Private Limited, H.No 404, Brahman Vali Gali, Vijay Nagar, Colony, Bawana, New Delhi North West	18/02/2019
59	Cultivation of Shiitake mushroom and its implication at large scale as per technical know how of CSIR-IHBT	M/s Innotech Agro Postikum Pvt. Ltd., Guwahati Biotech Park, IIT Guwahati, Assam	18/02/2019
60	Vertical gardening and indoor air pollution abatement, making herbal cones from temple waste flowers.	Dr. Gaurav Aggarwal, Ward No. 8 Main Bazar , Kangra, (H. P.)	18/02/2019
61	Palmarosa crop at selected areas of Sundergarh Mayurbhanj, Keonjhar Malkangiri, Kalahandi and Rayagada districts of Odisha	M/s Social Action for People (SAP) Sanyasipali, P.O Kolabira, Distt Jharsuguda, Odisha	19/02/2019
62	Rooted plants of damask rose	Mr. Rajinder Singh Village & P.O Bhulana Tehsil Chadiar, District Kangra (H.P.)	25/02/2019
63	Incubation facility in cultivation of Himalayan plants and plants with flowers for indoor environment.	Mr. Sandeep Kumar S/o Sh Roshan Lal, Village Dehrian, P.O. Shamirpur, Tehsil and District Kangra (H.P.)	25/02/2019
64	Plants of *Picrorhiza kurroa, Podophyllumhexandrum, Dactylorhizahatagirea* and *Aconitum heterophyllum* and now interested in selling of material.	Mr. Dheeraj Kumar, S/o Sh. Deena Nath Village Suppa, P.O Ghared, Tehsil Bharmour, District Chamba (H.P.)	07/03/2019

Sr.	Title of Agreements/ MoUs	Name of company with whom agreement/MoU were signed and technology transferred	Date of Signing
65	Rooted plants of rosemary and rooted plants of rose geranium	Mr. Mohan Lal, Manager, Jagriti NGOA having official address at Village Badah, Post Office Mohal, District Kullu, (H.P.)	13/03/2019
66	Academic and research co-operation between CSIR-IHBT, Palampur (H.P.) and The Palampur Rotary Eye Foundation, (Maranda) Palampur, Kangra (H.P.)	The Palampur Rotary Eye Foundation, (Maranda) Palampur, Kangra (H.P.)	22/03/2019
67	Lab scale technology on cultivation of shiitake mushroom to its implementation at large scale as per technical know-how of CSIR-IHBT.	M/s Pravin Masalewale 44, Hadapsar Industrial Estate, Hadapsar, Pune, Maharshtra	22/03/2019
68	Rooted plants of rosemary, rooted plants of damask rose variety "Jwala", *Matricaria* seeds and wild marigold seeds	Association for Peoples Advancement and Action Research (APAAR) C/o VSMD Enterprises, 1-97, Basement, Lajpat Nagar 1, New Delhi	27/03/2019

Mission Mode Projects

CSIR AROMA MISSION

CSIR-Aroma Mission has been launched to strengthen the aroma sector through scientific interventions in the areas of cultivation, processing product development and rural employment. The aim is to bring about a transformation in the rural economy.

This Mission aims to achieve the following outcomes

a) Bring about 5500 ha of additional area under captive cultivation of aromatic cash crops particularly, targeting rain-fed /degraded land across the country.

b) Provide technical and infrastructural support for distillation and values-addition to farmers/growers all over the country.

c) Enabling effective buy-back mechanisms to assure remunerative prices to the farmers/growers.

d) Value-addition to essential oils and aroma ingredients for their integration in global trade and economy.

Under this mission, CSIR-IHBT is focusing on providing end-to-end technology and value-addition solutions for cultivation and processing of aromatic crops across the country. With an aim to extend cultivation of aromatic crops over 530 ha, the crops being targeted are wild marigold, damask rose, Indian valerian, lemongrass, palmarosa, lavender, rosemary and chamomile. Overall, cultivation of aromatic crops was spread over 256 ha in eleven states of the country viz., Himachal Pradesh, Jammu & Kashmir, Uttarakhand, Arunachal Pradesh, Manipur, Odisha, Punjab, Haryana, Uttar Pradesh, Chhattisgarh and Tamil Nadu. Eleven distillation units were installed at farmers' fields for empowerment of farmer groups to undertake processing of their produce. The main objectives under the mission program are:

- Promotion of cultivation and processing of aromatic crops, enhancing area under selected aromatic crops along with enabling interventions including setting up of distillation units and catalyzing setting up of cooperatives for marketing of the produce.
- Development of superior varieties and their agro-technologies and assessment of their suitability for specific agro-climatic regions.
- Value-addition of aromatic crops (High-end aroma chemicals and products).
- Skill development activities.

Promotion of cultivation and processing of aromatic crops

During this year, a total area of about 265.8 ha was brought under aromatic crops cultivation. Of this, *T. minuta* covered about 230.8 ha area in H.P, J & K, Uttrakhand, Manipur and U.P. An area of about 11 ha was covered in H.P, Punjab, Uttrakhand, Arunachal Pradesh and Chattisgarh for damask rose crop. Lemon grass was rejuvenated in warmer regions of H.P and Punjab. Aromatic crops like chamomile and palmarosa, covered an area of about 4.5 ha and 19.5 ha, respectively, in H.P, Uttrakahnd, U.P and Odisha.

Demonstration plot of damask rose nursery at Palampur, district Kangra

Plantation of lemon grass at district Kangra

Fig. 1 Demonstration plots of aromatic crops

Tagetes minuta crop at Kishtwar, J & K

T. minuta crop at Chamba, H.P

V. jatamansi at Lahooni, Chamba

T. minuta crop at Padhar, Mandi

Fig. 2 Crop performance of aromatic crops

Distillation unit at Jaunta, Kangra H.P.

Distillation of *T. minuta* at Padhar, Mandi

Distillation of lemongrass at Amb, Una

Fig. 3 Distillation unit installed for aromatic crops

Distribution of wild marigold seed to the farmers of Mukteshwar, Uttrakhand

Fig. 4 Distribution of planting material of aromatic crops

Generation of quality planting material

Given below is the detail of quantities of the planting material of the target aromatic crops generated during the year (Table 1)

Table 1 Planting Material generated

Crop	Planting material generated
Rosa damascena	90,000 cuttings
Tagetes minuta	600 kg
Valeriana jatamansi	2 lakh rooted slips
Artemisia maritima	30,000 rooted plants
Dracocephalum heterophyllum	25,000 rooted plants
Cymbopogon flexuosus	2 lakh rooted slips
Matricaria chamomilla	10 kg
Cymbopogon martini	100 kg
Lavandula officinalis	25,000 rooted plants
Rosmarinus officinalis	20,000 rooted plants

Training and awareness programmes for skill development

Seventy five awareness cum trainings programmes on cultivation and process technologies of aromatic crops were conducted during March 2018 to March, 2019 and more than 1648 unemployed youth, rural women and farmers were trained. Practical exposure on field preparation for nursery beds, plantation of crops, harvesting of crops at proper stage to obtain higher essential oil content and composition, essential oil extraction in Clevenger apparatus, mini distillation unit and pilot plant was imparted. Under this programme, the cultivation and price determination of aromatic crops namely damask rose, wild marigold, jatamansi, lavender and rosemary was undertaken in farmers field (Table 2 and Fig. 5).

Table 2. Awareness cum training programmes conducted under CSIR-Aroma Mission

Programme	Duration	Location	District	State	No. of Participants
Training programme on cultivation and processing of aromatic crops with focus on damask rose	21.04.2018	CSIR-IHBT	Kangra	H.P.	50
Cultivation and primary processing of economically important aromatic crops	22 to 24-04-2018	CSIR-IHBT	Kangra	H.P.	2
Awareness cum training programme on cultivation of aromatic crops	15.05.2018	Suppa	Chamba	H.P.	25

Programme	Duration	Location	District	State	No. of Participants
Awareness programme on cultivation of *Valeriana jatamansi*	16.05.2018	Jassourgarh	Chamba	H.P.	2
Awareness cum training programme on cultivation of aromatic crops	17.05.2018	Dibrugarh	Dibrugarh	Assam	27
Awareness programme on cultivation of *Valeriana jatamansi*	17.05.2018	Bharmour	Chamba	H.P.	4
Awareness programme on cultivation of *Valeriana jatamansi*	18.05.2018	Bharmour	Chamba	H.P.	13
Training cum demonstration of essential oil distillation	18.05.2018	CSIR-IHBT	Kangra	H.P.	13
Awareness programme on cultivation of *Valeriana jatamansi*	18.05.2018	Deool	Chamba	H.P.	10
Awareness cum training programme on cultivation of aromatic crops	19.05.2018	CSIR-IHBT	Kangra	H.P.	
Awareness cum training programme on cultivation of aromatic crops	19.05.2018	Chuwari	Chamba	H.P.	10
Awareness cum training programme on cultivation of aromatic crops	24.05.2018	Bheed	Una	H.P.	10
Awareness cum training programme on cultivation of aromatic crops	25.05.2018	Saloi	Una	H.P.	10
Awareness cum training programme on cultivation of aromatic crops	02.06.2018	Siraj	Mandi	H.P.	16
Awareness cum training programme on cultivation of aromatic crops	04.06.2018	Palampur	Kangra	H.P.	23
Awareness cum training programme on cultivation of lemon grass.	20.06.2018	CSIR-IHBT	Kangra	H.P.	26
Awareness programme on medicinal and aromatic plants	21.06.2018	CSIR-IHBT	Kangra	H.P.	25
Training programme on cultivation of aromatic crops	22.06.2018	Managher	Nainital	Uttrakhand	14

Programme	Duration	Location	District	State	No. of Participants
Awareness programme on cultivation of aromatic crops	23.06.2018	CSIR-IHBT	Kangra	H.P.	25
Awareness cum training programme on cultivation of wild marigold (*Tagetes minuta*)	23.06.2018	Purera	Bageshwar	Uttrakhand	14
Awareness cum training programme on cultivation of wild marigold	24.06.2018	Naugaon	Bageshwar	Uttrakhand	20
Awareness cum training programme on cultivation of aromatic crops	27.06.2018	Siraj	Mandi	H.P.	36
Training programme on cultivation of aromatic crops	28-29.06.2018	Batote	Ramban	J & K	20
Awareness cum training on cultivation of *Dracocephalum heterophyllum*	30.06.2018	Yulla	Kinnaur	H.P.	14
Awareness cum training on cultivation of *Dracocephalum heterophyllum*	1-7-2018	Ramni	Kinnaur	H.P.	8
Awareness cum training programme on cultivation of *Dracocephalum heterophyllum*	3-7-2018	Duni	Kinnaur	H.P.	15
Awareness cum training programme on cultivation of *Dracocephalum heterophyllum*	3-7-2018	Kalpa	Kinnaur	H.P.	12
Awareness cum training on cultivation of *Dracocephalum heterophyllum*	4-7-2018	Kothi	Kinnaur	H.P.	17
Awareness cum training on cultivation of *Dracocephalum heterophyllum*	4-7-2018	Pangi	Kinnaur	H.P.	20
Training cum awareness programme on cultivation and processing of aromatic crops	28-08-2018	Faridabad	Fatehpur	Haryana	34
Training cum awareness programme on cultivation and processing of aromatic crops	29-08-2018	Nuh	Nuh	Haryana	50
Awareness cum plant distribution programme on cultivation of *V. jatamansi*	29-08-2018	Ulansa	Chamba	H.P.	5
Awareness cum training programme on cultivation of aromatic crops.	29-08-2018	CeHAB	Lahaul	H.P.	12

Programme	Duration	Location	District	State	No. of Participants
Exposure cum awareness visit of medicinal and aromatic plants cultivator	01-09-2018	CSIR-IHBT	Kangra	H.P.	27
Training cum awareness program on cultivation and processing of lemongrass	01-09-2018	Chadiyar	Kangra	H.P.	50
Training imparted to the farmers by distilling 8 batches of lemongrass in newly installed unit.	07-09-2018	Bandkardian		H.P.	10
Training cum awareness program on cultivation and processing of lemongrass	15-09-2018	Chadiyar	Kangra	H.P.	50
Training imparted to the farmers of Saloi by distilling 2 batches of lemongrass in newly installed unit	17 to 21-09-2018	Saloi	Una	H.P.	10
Awareness programme on installation of processing unit for distillation of wild marigold.	22-09-2018	Mandi	Mandi	H.P.	
Awareness cum training programme on extraction of essential oil of wild marigold	20-09-2018	Mandi	Mandi	H.P.	16
Training cum awareness programme on cultivation and processing of aromatic crops	20-09-2018	Amb	Una	H.P.	6
Training cum awareness programme on cultivation and processing of *Valeriana jatamansi*	25-09-2018	Medal	Chamba	H.P.	15
Training cum awareness programme on cultivation and processing of *Valeriana jatamansi*	25-09-2018	Sanghani	Chamba	H.P.	5
Training cum awareness programme on cultivation and processing of *Valeriana jatamansi*	25-09-2018	Dhani	Chamba	H.P.	10

Programme	**Duration**	**Location**	**District**	**State**	**No. of Participants**
Training cum awareness programme on cultivation and processing of *Valeriana jatamansi*	25-09-2018	Surein	Chamba	H.P.	7
Awareness cum training program on cultivation of wild marigold (*Tagetes minuta*) crop	13-10-2018	Rajol	Kangra	H.P.	7
Training cum demonstration of lemongrass processing	23 to 24-10-2018	Garhjamula	Kangra	H.P.	50
Training cum demonstration of essential oil distillation	24-10-2018	Khargat	Chamba	H.P.	10
Exposure visit cum training in agro and process technologies of aromatic and industrial crops	28 to 30-10-2018	CSIR-IHBT	Kangra	H.P.	11
Training cum demonstration of essential oil distillation	29 to 31-10-2018	Sihunta	Chamba	H.P.	30
Exposure visit cum training in agro and process technologies of aromatic and industrial crops.	30-10-2018	CSIR-IHBT	Kangra	H.P.	26
Training cum demonstation on essential oil extraction of wild marigold	30-10-2018	Sihunta	Chamba	H.P.	10
Training cum demonstation on essential oil extraction of wild marigold	30-10-2018	Padhar	Mandi	H.P.	10
Training cum demonstation on essential oil extraction of wild marigold	31.10.2018	Ghogardhar	Mandi	H.P.	10
Training program on distillation unit	31-10-2018	Bhatiyat	Chamba	H.P.	10
Awareness cum training programme on agro and process technologies of aromatic crops	01-11-2018	CSIR-IHBT	Kangra	H.P.	30
Awareness cum training programme on cultivation of aromatic crops	08-11-2018	CSIR-IHBT	Kangra	H.P.	3

Programme	**Duration**	**Location**	**District**	**State**	**No. of Participants**
Awareness cum training programme on agro and process technologies of aromatic crops	14 to 16-11-2018	Mukteshwar	Nainital	Uttrakhand	66
Awareness cum training programme on cultivation of *V. jatamansi*	14-11-2018	Chamba	Chamba	H.P.	10
Awareness cum training programme on agro and process technologies of aromatic crops	13-12-2018	CSIR-IHBT	Kangra	H.P.	8
Awareness cum training programme on agro and process technologies of aromatic crops	24,25-12-2018	CSIR-IHBT	Kangra	H.P.	7
Awareness cum training programme on agro and process technologies of aromatic crops	26-12-2018	Salahan	Chamba	H.P.	7
Awareness cum training programme on agro and process technologies of aromatic crops	31-12-2018	CSIR-IHBT	Kangra	H.P.	13
Awareness and training programme for promoting aromatic crops	16-01-2019	Kalahandi	Kalahandi	Odisha	215
Awareness and training programme for promoting aromatic crops	30-01-2019	Bhedu Mahadev	Kangra	H.P.	33
Awareness cum training programme on agro and process technologies of aromatic crops	01-02-2019	CSIR-IHBT	Kangra	H.P.	30
Awareness-cum-training programme conducted for nursery raising, weed and fertilizer management	09-02-2019	Bharmat	Kangra	H.P.	7

Programme	Duration	Location	District	State	No. of Participants
An exposure cum awareness programme on cultivation, processing and marketing of aromatic crops	21-02-2019	CSIR-IHBT	Kangra	H.P.	35
Awareness cum training programme on agro and process technologies of aromatic crops	07-03-2019	Jhargaon	Nainital	Uttarakhand	43
An exposure cum awareness programme on cultivation, processing and marketing of aromatic crops	17-03-2019	Gumna	Shimla	H.P.	37
An exposure cum awareness programme on cultivation, processing and marketing of aromatic crops	18-03-2019	Rausie	Shimla	H.P.	40
Awareness cum training programme on agro and process technologies of aromatic crops	18-03-2019	CSIR-IHBT	Kangra	H.P.	26
Awareness-cum-training programme conducted for nursery raising, weed and fertilizer management	22-03-2019	CSIR-IHBT	Kangra	H.P.	7
An exposure cum awareness programme on cultivation, processing and marketing of aromatic crops	23-03-2019	CSIR-IHBT	Kangra	H.P.	14
An exposure cum awareness programme on cultivation, processing and marketing of aromatic crops	27-03-2019	CSIR-IHBT	Kangra	H.P.	55

Training programme on cultivation and processing at CSIR-IHBT, Palampur, H.P.

Skill development program on aromatic plants organized at CSIR-IHBT, Palampur, H.P.

Awareness cum training programme conducted at Dibrugarh, Assam

Awareness cum training programme on wild marigold at Naugaon, Uttarakhand

Awareness programme on cultivation of *Valeriana jatamansi* conducted at Bharmour, H.P.

Awareness cum training on cultivation of *Dracocephalum heterophyllum* at Kinnaur, H.P

Training cum awareness programme on cultivation and processing of aromatic crops at Fatehpur, Haryana

Exposure visit of medicinal and aromatic plants cultivator from Kathmandu, Nepal

Training of lemongrass processing at Kangra, H.P.

Training on distillation unit at Chamba, H.P.

Training cum awareness programme on aromatic crops at Okhalkanda, Uttarakhand

Awareness and training programme for promoting aromatic crops at Kalahandi, Odisha

Fig. 5 Snapshot of training and awareness programs conducted by CSIR-IHBT achievements

Ultra International

Team Award

Presented to

Dr. Sanjay Kumar (Director) & Team
CSIR-IHBT, Palampur

CSIR Aroma Mission

Attended International Congress & Expo 2018 "Navigating Future of Essential Oils" on August 3rd to 5th, 2018 at Bengaluru

CSIR-IHBT was awarded Ultra International team award in Bengaluru from 3-5 August 2018

Fig. 6 Achievements of CSIR-IHBT

Participation in Fairs

Team CSIR-IHBT participated in Jadibuti Sammelan at Bhedu Mahadev in Palampur, Kangra, HP on 30th January, 2019. More than 1000 farmers participated in this fair. Activities of CSIR-Aroma Mission were displayed by CSIR-IHBT. Hon'ble Minister for Health & Family Welfare and Science & Technology, Govt. of HP appreciated the efforts made by CSIR-IHBT for the welfare of farmers and rural population

Participitation in fairs

IHBT participated in Tribal fare-2018 held at Keylong (L&S) from 14-16 August, 2018

Participation of IHBT in Jadibuti Sammelan at Bhedu Mahadev, Kangra, HP on 30th January 2019

Fig. 7. Showcasing activities and products of CSIR-IHBT

CSIR PHYTOPHARMACEUTICAL MISSION

Botanical drugs are being used as medicines for the treatment of a range of diseases, since ancient times. According to the World Health Organization (WHO) about 65-80% of the world's population from developing countries depend essentially on plants for primary health care. To make India a global leader in Phytopharmaceuticals, the CSIR Mission Phytopharmaceuticals was launched wherein CSIR-IHBT is playing a vital role. Coordinated efforts are being made under CSIR-Phytophamaceutical mission with following verticals:

A: Captive cultivation of selected medicinal plants for production of quality planting material and development of region specific agrotechnologies.

B: Captive cultivation of selected high value rare, endangered and threatened medicinal plant species

C: Technology packages for production of GMP grade medicinal plant extracts.

D: Phytopharmaceutical development from important medicinal plants

E: Intellectual property generation, valuation and management

F: Showcasing CSIR technologies

During the year 2018-19, following key significant achievements were made at CSIR-IHBT:

Key Achievements at CSIR-IHBT

✓Area covered: ~40 acre (overall)

✓Collection/ Characterization: 701 genotypes/ 48 populations)

✓Gene bank creation: Initiated in all the 4 species

✓Genomic resource creation: 3/4 species

✓Phyto-chemical evaluation: (3/ 4 species)

✓Micro/ Macro propagation: (3/4 species)

✓Parameters for identification of quality plant materials (on going)

Training & awareness : 14 nos (H.P)

✓ MoUs with line departments : 4 nos

✓ MoUs (ToT-Agrotechnology): 7 nos.

Vertical A: Captive cultivation of selected medicinal plants

A. Mass multiplication of quality planting material:

Stevia rebaudiana: 1.5 crore quality planting materials have been generated for captive cultivation at different locations in India. The target was 15 lakhs.

Valeriana jatamansi: 60 thousand quality seedlings and 250 g quality seeds have been produced for captive cultivation in 1 ha land.

Saussurea lappa: 10 kg seeds and 30 thousand quality seedling have been generated to meet the 1st year target.

Inula racemosa: 50 thousand rooted plants and 10 kg seeds have been produced.

B. Area covered under captive cultivation:

For nation-wide cultivation, four important medicinal plants i.e., *Stevia rebaudiana*, *Valeriana jatamansi*, *Saussurea lappa*, and *Inula racemosa* were selected under CSIR Mission Phytopharmaceutical, India. Efforts were initiated in different parts of the country in collaboration with different private agencies, viz. M/s. Agri Natural India, Ludhiana, M/s. MS, Ludhiana, M/s. Harsh Organic Farms, Una, HP and M/s MDHP Ltd, Bastar, Chhattisgarh and progressive farmers from UP, Andhra Pradesh, Haryana and Uttarakhand. About 1 crore quality planting materials were raised (Fig. 1).

Fig. 1 Field view of large-scale stevia nursery and plantations at farmers' field

Further 75 acres of land has been covered under stevia cultivation throughout the India under this mission. The status of the efforts made so far for captive cultivation under targeted crops are depicted below:

Table 1 Status of captive cultivation of medicinal plants.

Plant	Area covered (ha): 2018-19	Location/region/state
Stevia rebaudiana	10 hectares area has been covered under stevia cultivation in farmer's field so far	Himachal Pradesh, Punjab, Chhattisgarh, Uttar Pradesh
Valeriana jatamansi	0.8 hectares area has been covered under valeriana cultivation in farmer's field Institutional land	Himachal Pradesh
Saussurea lappa	2000 m^2 area has been covered in farmer's field and Institutional land	Lahul & Spiti districts Himachal Pradesh
Inula racemosa	1000 m^2 area has been covered in farmer's field and Institutional land	Lahul & Spiti districts, Himachal Pradesh

Agrotechnology experiments for *Stevia rebaudiana* and *Valeriana jatamansi* are also in progress. Chromatographic finger print profiles were generated for *Valeriana jatamansi* and *Stevia rebaudiana.*

Further, reproducible, economical methods using HPTLC, UPLC, GC & GC-MS were developed for *Valeriana jatamansi* while isolation of marker compounds from *Saussurea lappa,* and *Inula racemose* was initiated for random quality check for selection of potential genotypes.

Vertical B: Captive cultivation of selected high value, rare, endangered and threatened (RET) medicinal plant species

Quantifiable outcomes achieved for targeted RET species are depicted in Table 2.

Table 2 CSIR-IHBT– Quantifiable achievements

Plant species	% progress vis -à-vis end point/ final deliverable				
	A-i	A-ii	A-iii	A-iv	A-v
Picrorhiza kurroa,	191/ 10P 36/ 2P (70 %)	50	8 compounds isolated (80 %)	100 % achieved (TCP)	30 %
Podophyllum hexandrum	250/ 24P 24/ 1P (50 %)	50	Marker procured (10 %)	100 % achieved (Ma_P)	30 %
Trillium govanianum	160/ 11P 50/ 2P (40 %)	50	3 new 8 compounds isolated (50 %)	10 % (TCP)	20 %
Fritillaria roylei	100/ 3P (20 %)	25	In progress (10 %)	10 % (TCP) 20 % (Ma_P)	15 %
P: populations ; TCP: Tissue culture-raised plants ; Ma_P: Macro-propagation					

Ma_P: Micropropagation; P: Population; TCP: Tissue culture raised

Diversity collection and characterization

Population diversity assessment was initiated implemented in three RETs species (*Podophyllum hexandrum, Picrorhiza kurroa, Trillium govanianum*). Fifty different populations representing 741 accessions representing H.P and J&K were collected and processed for genomic DNA isolations. While collecting the plant materials, all the GPS and environmental parameters were also collected. Of these, functionally relevant genomic resources were developed incase of the all the three species. Microsatellites markers (6000 nos.) were identified. Of these, 192 makers were successfully validated in random genotypes of targeted plant species. Species wise polymorphic SSR makers were successfully utilized for genetic diversity assessment and identification of core populations for implementation of conservation strategies.

Additionally, accessions capturing high level of phenotypic and genetic variations were included in the gene bank (Fig. 2).

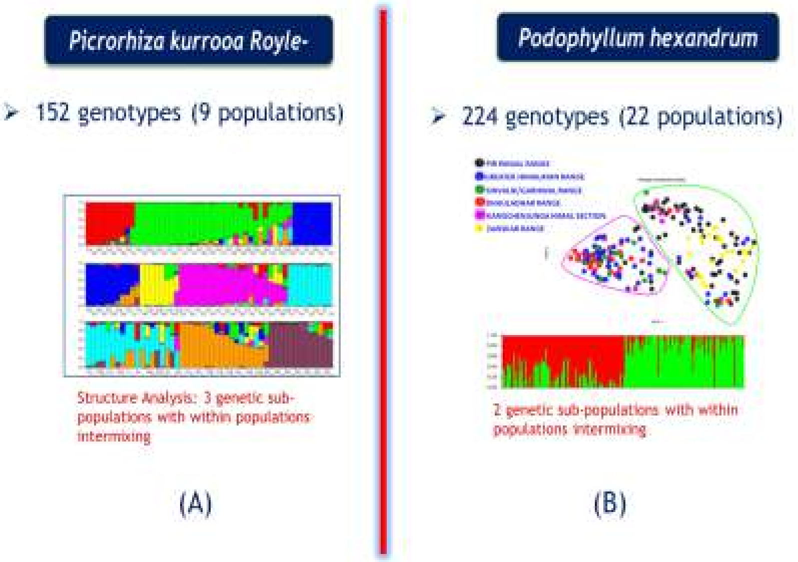
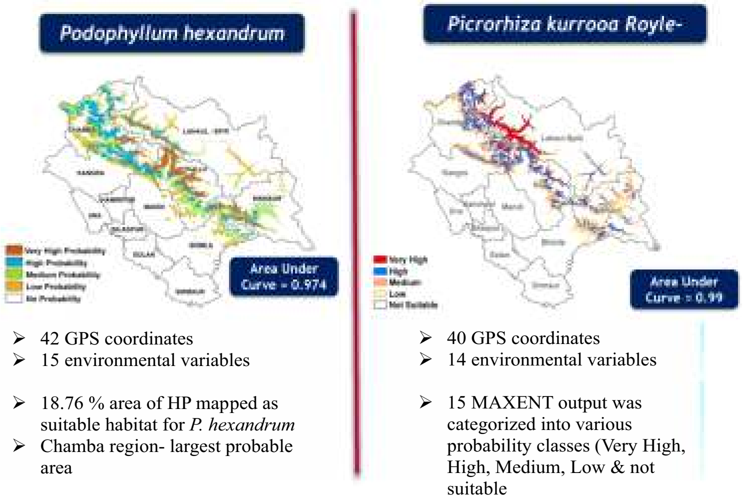


Fig. 2 Genetic diversity parameters: (A) of *Picrorhiza kurroa* (152 genotypes/ 8 population; (B) *Podophyllum hexandrum* (224 genotpes/ 22 populations

Ecological Niche Modelling (ENM) for in-situ conservation

ENM was used to expedite the conservation and identification of suitable locations for collection and *in-situ* conservation of targeted RETs. EN modelling in two important plant species *(Podophyllum hexandrum, Picrorhiza kurroa)* was reported. During the period under report, GPS data collected are being utilized for ENM in *Trillium govanianum*. Representative picture is depicted in Fig. 3.



- 42 GPS coordinates
- 15 environmental variables
- 18.76 % area of HP mapped as suitable habitat for *P. hexandrum*
- Chamba region- largest probable area

- 40 GPS coordinates
- 14 environmental variables
- 15 MAXENT output was categorized into various probability classes (Very High, High, Medium, Low & not suitable

Fig. 3 Ecological Niche Modelling (ENM) for in-situ conservation of *Podophyllum hexandrum* and *Picrorhiza kurroa*

Phytochemical Characterization

Under this vertical, quality control method using a minimum of four marker compounds was developed. These standards are not available commercially for most of these targeted species. Marker compounds were known for two targeted RET plant species. Hence, marker compounds were procured for *P. kurroa* and *P. hexandrum*. Quality control method was developed for *P. kurroa* during the period under report.

***Trillium govanianum*:** Extraction, fractionation and column chromatography led to the isolation of four marker compounds. Isolated compounds were characterized using 1D, 2D NMR, ESI-MS and IR spectroscopic techniques Borassoside D, borassoside E, clintonioside B and diosgenin (Fig. 4) were identified.

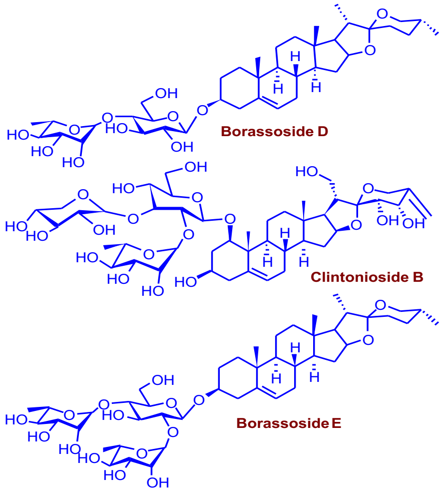


Fig. 4 Structure of compounds isolated and characterized from *Trillium govanianum*

Fritillaria roylei:

In case of *F. roylei* two marker compounds were isolated and characterized as peimine and sipeimine (Fig. 5)

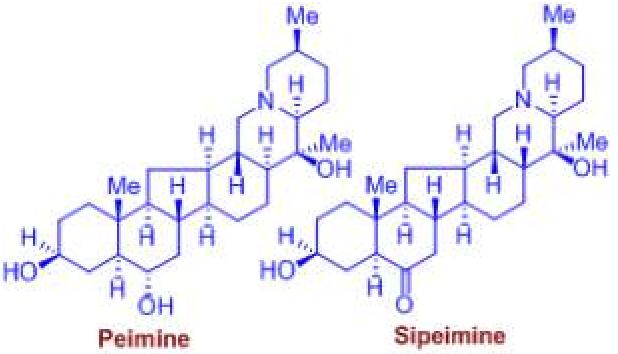


Fig. 5 Structure of compounds isolated and characterized from *F. roylei*

Micro and macro-propagation

Picrorhiza kurroa

Efficient micropropagation system using leaf explants was successfully developed and utilized for mass multiplication of *P. kurroa*. More than, 5000 plants were successfully transferred to the farmer's fields in Chamba region of Himachal Pradesh for captive cultivation (Fig. 6).

Fig. 6 Direct organogenesis from leaf tissue and field transfer in *P. kurroa*

Macro-propagation protocol development is in progress.

Podophyllum hexandrum

Macro-propagation system has been developed for *P. hexandrum*. A total of 3000 plants ready for transfer to farmer's field (Fig. 7).

Fig. 7 Direct organogenesis and field transfer *Podophyllum hexandrum*

Culture initiation and standardization of medium and PGRs are in progress in *F. roylei* and *T. govanianum* (Fig.8).

Fig. 8 Culture initiation in *F. roylei* and *T. govanianum*

Vertical C: Technology Packages for production of GMP grade medicinal plant extracts

Standardization of *P. kurroa* enriched in picrosides

P. kurroa extract enriched with picrosides was standardized at lab scale. Five marker isolated and characterized. Analytical methods for the quality control of prepared extract was developed by using nine analytical standard (Fig. 9).

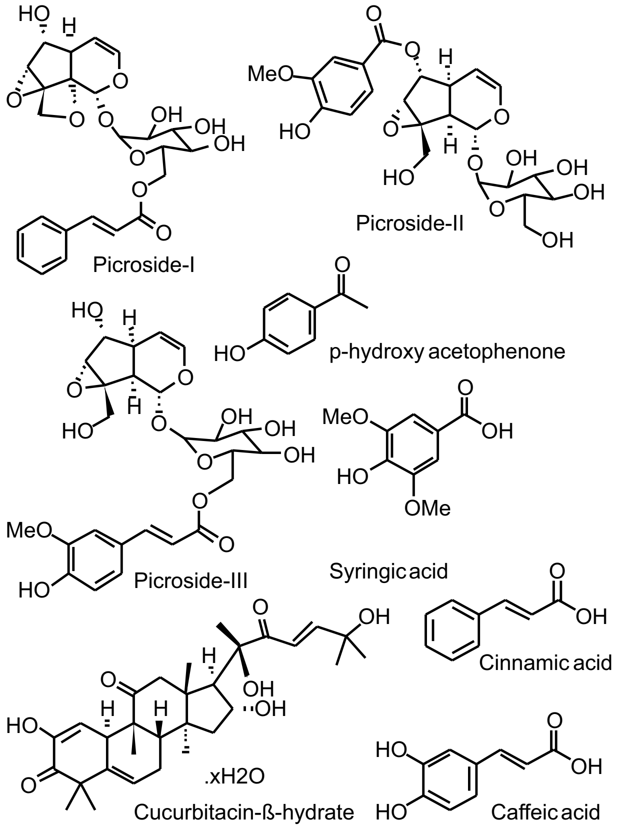


Fig. 9 Structure of standards used in the development of analytical method for the quality control of *P. kurroa*

Activity II: Standardized extract of *Ginkgo biloba* enriched in ginkgolides and flavonoids

Analytical method for the quantification of ginkgolides and flavonoids was developed. Optimization for the preparation of *G. biloba* extract enriched with ginkgolides and flavonoids is at the final stage. CMC parameters analysis of plant is under progress.

Vertical D: (IV): Phytopharmaceutical development of *P. kurroa* as per regulatory guidelines of DCG(I)

Chemistry of *P. kurroa* as per literature and our current studies on NMR metabolite profiling suggested that the *P. kurroa* extracts and fractions can play important role in liver health. Therefore, the present focus is to develop the product as per DCGI guidelines under phytopharmaceutical mode.

CSIR MISSION ON NUTRACEUTICALS AND NUTRITIONALS

(Health and Wellness Reach out through Nutraceuticals and Nutritionals)

CSIR capitalizing on its technological and scientific strength has taken the responsibility to develop nutraceuticals for overall human well-being with validations and compliance to FSSAI guidelines. The proposed nutraceuticals and nutritionals are mainly based on local resources and traditional wisdom prevailing for centuries in India. Presently, the majority of population confronting life-style associated diseases and disorders such as obesity, dyslipidemia, hypertension, inflammation, diabetes and cardio-vascular diseases. Age related neurodegenerative diseases, traumatic injuries and behaviour is dysfunction as a consequence of stressful life is affecting the quality of life. Considering the national need, CSIR is aiming to develop affordable health supplements and nutraceuticals in identified thematic areas in a mission mode (Fig. 1).

Fig. ion on
Nutr

CSIR-Institute of Himalayan Bioresource Technology is leading the mission and participating in five thematic areas to develop following Nutraceuticals and Nutritionals:

A) Vitamin D enriched formulation from *Lentinula edodes* (Shiitake):

Lentinula edodes, commonly known as Shiitake mushroom is a wood decaying edible basidiomycetes. This mushroom of highly nutritious and have a long history (over 2000 years) of medicinal use in traditional cultures of China and Japan. Natural cultivation of this mushroom takes 8-12 months for fruiting and the production period ranges from 3-8 years. However, the CSIR-IHBT has developed a technique with shorter cultivation cycle of about 2 months, with an yield of 0.5-0.6 kg fresh mushroom from 1 kg dry sawdust substrate (Fig. 2).

Fig 2 Shiitake mushroom fruiting bodies after 60 days of captive cultivation

CSIR-IHBT has developed a technology for enhanced production of ergocalciferols (vitamin D2) in Shiitake mushroom. The developed technology was transferred to M/s Innotech AgroPustikam Pvt Ltd, Guwahati Biotech Park, Assam; M/s Pravin Masalewale, Pune; and, M/s Ray's Tech Hamirpur, Himachal Pradesh

B) Nutrifoods for breakfast

Under the theme of enhancing nutrition, PAN India breakfast menu is being developed by different CSIR labs. CSIR-IHBT committed to develop technology for safe, hygienic, nutritious and convenient breakfast foods that can be served to school children in the country. It is involved in assessment of logistics for production & quality checking, and distribution mechanism to reach the schools. A nutritious and, spicy & sweet Khichdi mix with acceptable sensory quality is being developed at CSIR-IHBT (Fig. 3 & Table 1).

Fig. 3 Preservative free ready to eat foods - Kichdi

Table 1 Khichdi nutritional composition per 100

Parameters	Amount per 100g	% DV
Calories, Kcal	230 Kcal	8.6
Total Carbohydrates, g	32.0	25
Sugar, g	2.0	
Dietary Fiber, g	4.0	10%
Protein, g	8.0	12%
Total Fat, g	5.0-6.0	8%

C) Nutraceutical for boosting bone and cartilage health

A nutraceutical formulation based on traditionally known Himalayan plants (*Cissus quadrangularis* and *Vitex negundo*) was developed to manage bone disorders, especially in elderly population. The chemical characterization revealed biomarker compounds that possibly play role in bone health improvement (Table 2 & Fig. 4). In vitro and in vivo studies were conducted to scientifically validate the developed formulation. Water dispersible powder and syrup formulation were developed and patented to prevent bone and cartilage damage. In vivo efficacy evaluation of the product in surgically and chemically induced animal models is under progress.

Table 2 Biomarker compounds present in selected plants

Vitex negundo	*Cissus quadragularis*
Negundoside	Agnuside
Isoorientin	Isovitexin
Agnuside	Resveratrol
Isovitexin	

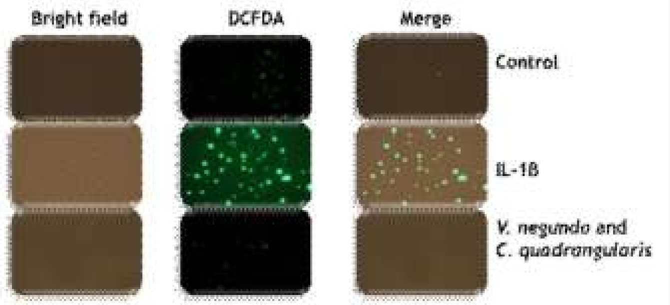


Fig. 4 Effect of extracts with reference drugs on ROS production

Inhibition of ROS production in IL-1β –induced (5ng/ml) mice chondrocyte was observed. Cells were treated with reference drugs and extracts followed by IL-1β stimulation, whereas DCFDA stain (2',7' –dichlorofluorescin diacetate) was used to measure the ROS accumulation. The acute toxicity study of the prepared extracts was done following OECD guidelines and no adverse effect was observed during course of the study.

D) *Punica granatum* based nutraceutical for cardio-protection

Punica granatum L. is a commercial crop cultivated in Maharashtra and in a few pockets of Gujarat, Rajasthan, Karnataka, Tamil Nadu, Andhra Pradesh, Uttar Pradesh. Punjab, Himachal Pradesh and Haryana. Different plant parts such as aril, seed, peel and juice were explored for presence of biomarker compounds, with maximum in peel. Therefore, the in vivo cardio-protective effect of the peel extract was validated in isoproterenol-induced myocardial infarction rat model. The extract showed cardio-protection via activation of nitric oxide-mediated antioxidant responsive element (Nrf2/ARE) signaling pathway and apoptosis inhibition (Fig. 5).

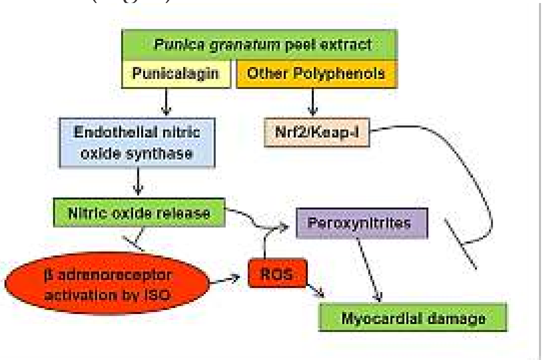


Fig. 5 Proposed cardio-protective mechanism of the nutraceutical

E) Nutraceutical for neurodegeneration linked cognitive impairments in elderly population

Neurocognitive disorders include delirium and mild and major neurocognitive disorders. Alzheimer's disease accounts for the majority of cases of neurocognitive disorders, however, medical conditions such as memory, thinking, and the ability to reason, including front temporal degeneration, Parkinson's disease also affect mental functions. Cognitive impairment in patients is characterized by trouble in remembering, learning new things, concentrating, or making decisions that affect their day-to-day life. Hence, to improve the quality of life of the elderly and to ease the economic and social burdens caused by dependence, it is imperative to develop approaches to prevent or reduce the age-related cognitive impairments and delay the onset of neurodegenerative diseases. The traditionally knownplants (*Withania, Bacopa* and *Mucuna*) were selected to develop a nutraceutical product for the management of neurological conditions. The efficacy of plant extracts for their cognitive analysis (alpha synuclein protein aggregation, dopamine and acetylcholine levels, nAchR health etc.) and anti-ageing activities (different ageing biomarkers) was done in *C. elegans* multicellular model system. The infrared spectroscopy was also carried out to study chemical compatibility among extracts for overall effect. The extracts of selected plants were studied and showed variable protection in acrylamide-induced neurotoxicity in zebrafish larva at different concentrations.

F) Formulation for management of sleep disorders

Sleep problems rank fifth among the health concerns affecting individuals, especially after a stressful day's work, body aches and pain, respiratory disorders, and old-age. The sleep problems include disorders of sleep initiation and maintenance (i.e., insomnia), hyper-somnolence, and others. Sleep is a complex neurological state, that provides rest and restores energy levels of the body. Therefore, a formulation based on bioactive rich tea extract (Fig. 6) is being developed under this mission.

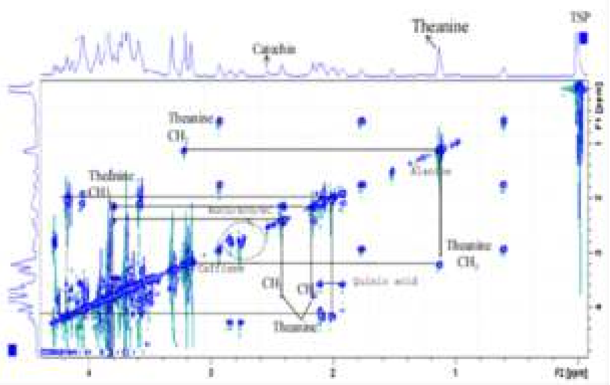
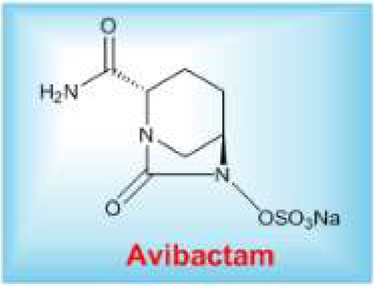


Fig. 6 Chemical characterization of bioactive constituent in tea

INNOVATIVE PROCESS AND TECHNOLOGIES FOR INDIAN PHARMACEUTICAL & AGROCHEMICAL INDUSTRIES

(INPROTICS-PHARMA & AGRO)

Objective: Development of a new lab-scale process for the synthesis of Avibactam .



The Indian chemical industry is a key constituent of the nation's economy accounting for about 1.38% of the GDP and influences various sectors such as health care, energy, transport infrastructure, food production, packaging and conservation, security applications, medical treatment and diagnostic technologies. The chemical industry is an essential part of modern textiles, dyes in print and painting, computers and mobile phones and other communication devices and significant for hygiene and cosmetics sector. Total production of the Indian chemicals industry was 21.2 million tonnes during 2014-15 with estimated market size of US$ 100 billion. Out of all these sectors, this mission addresses the needs of two vital sectors, *viz.*, Pharmaceutical and Agrochemical sectors.

According to Indian Brand Equity Fund, Indian pharmaceutical sector accounts for about 10 percent of global pharmaceutical industry in volume terms and 2.4 per cent in value terms. In FY 2016, India exported pharmaceutical products worth US$ 16.89 billion which may reach upto US$ 40 billion by 2020. Indian pharmaceutical products are exported to more than 200 nations in the world, with the USA as major market. Generic drugs account for 20 percent of global exports in terms of volume, making India the largest provider of generic drugs globally. Apart from business angle, research in this sector has also humanitarian face. Healthcare and wellbeing of people is among the top most priority of any government and it is imperative that new and improved drugs be made available to all on a regular basis. Thus this mission aspires to cater to both these objectives of creating value to pharmaceutical industry and also provide new, improved and more effective drugs to people of India.

Pharmaceutical industry is a very dynamic industry with new drugs, formulations and treatment methods being introduced at a steady pace to alleviate health related problems of people. Though India is lagging in new drug discovery, it is a world player in generic drugs. To retain this position, it has to continuously upgrade its portfolio with drugs and pharmaceuticals that come out of patent protection. Introduction of new and improved generic drugs is also important to the government because they are inexpensive and can directly benefit common man. In the present mission project CSIR wishes to develop non-infringing and free to operate processes for new drugs for different diseases such as Hepatitis C, Daclatasvir, Dolutegravir, Ledipasvir Cancer, Nilotinib and drugs for other diseases such as infectious diseases (Avibactam), cardiovascular diseases (Nicergolin) and epilepsis (Pregabalin) are also identified to be addressed in this mission.

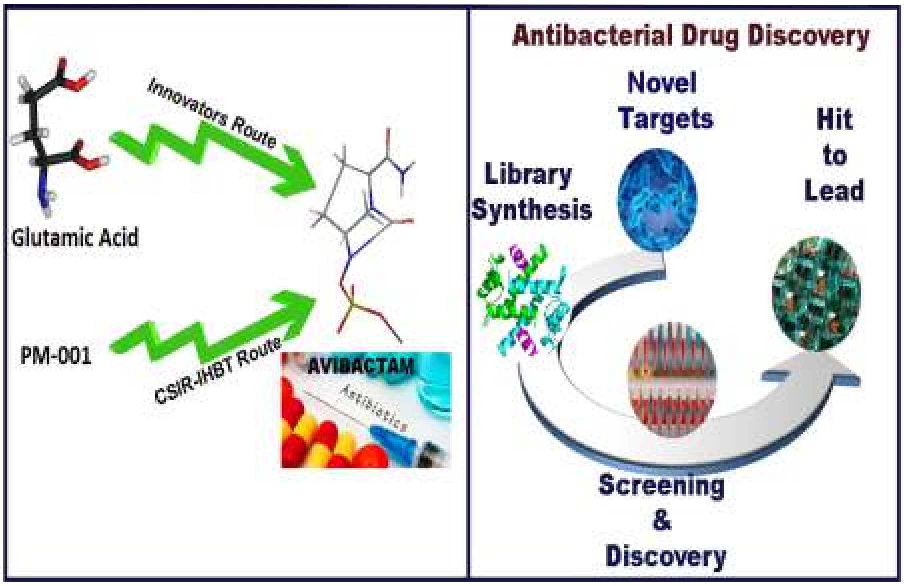
Target beneficiaries for the mission are:

(a) **APIs:** Indian generic pharmaceutical industry

(b) **Intermediates:** MSMEs and Pharmaceutical industry and

(c) **Agrochemicals:** Pesticide manufacturers and formulators.

Growing resistance against current line of treatment for bacterial infections has created an increasingly unmet need for new therapies. Among them, infections due to Gram-negative bacteria are associated with severe morbidity and mortality. β-lactamase inhibitors have been demonstrated to restore the efficacy of antibiotics against resistant pathogens. In this regards, Avibactam, a non-β-lactam β-lactamase inhibitor, in combination with Ceftazidime has been approved for treatment of complicated urinary tract infections (cUTI), complicated intra-abdominal infections (cIAI) and hospital-acquired pneumonia (HAP) including ventilator-associated pneumonia (VAP). CSIR-IHBT is involved in the development of a new lab-scale process for the synthesis of Avibactam.



Process Development for Avibactam

CROP PROTECTION CHEMICALS (CPC)

Objective: Development of a novel lab-scale process for the synthesis of epoxiconazole

Agrochemical Industry: Agrochemicals play a crucial role in ensuring food and nutrition security of the nation. Current consumption of products for crop protection in India is 0.6 kg per hectares (ha), which is much lower than the world average of 3 kg per ha. This offers immense opportunities for future growth. With several new products going off-patent globally, the sector is opening opportunities for generics, contract manufacturing and research. The sector is important both from the point of view of business as well as social responsibility. This mission wishes to provide know how and processes for key crop protection chemicals to assist Indian pesticide manufacturers thus enabling the farmer.

Epoxiconazole

Agrochemical Sector: With estimated 355 million metric tons per annum (MMTPA) food grain requirement in 2030 compared to the current 253 MMTPA, efficient usage of crop protection products and solutions for Indian agriculture are highly required. As per a knowledge paper prepared by Tata Strategic Management Group, Indian agrochemical industry is estimated to be worth US$ 4.4 billion in FY2015 and is expected to grow at 7.5 per cent per annum to reach US$ 6.3 billion by FY2020. Indian crop protection market is supported by strong growth drivers. Every year in India, pests and diseases eat away an average of 15-25% foods produced by the farmers. Due to the rising population and decreasing arable land, demand for food grains is increasing at a faster pace when compared to its production. This, therefore, necessitates putting more thrust on crop productivity enhancement as well as crop protection methods. Use of crop protection chemicals can increase crop productivity by 25-50%, by mitigating crop loss due to pest attacks. Thus, crop protection chemicals are also very essential to ensure food and nutritional security.

Indian crop protection market is dominated by insecticides, followed by fungicides and herbicides. The work has been initiated to develop a new process for the synthesis of epoxiconazole, a fungicide molecule for crop protection. This fungicide was developed by Nissan Chemical Industries, Ltd. Japan. It acts as an inhibitor of ergosterol biosynthesis, thereby interfering with fungal cell membrane synthesis. Sterol biosynthesis inhibitor epoxiconazole works as an eradicant by encapsulating fungal haustoria, which are then cut off from their nutrient supply. The work has been initiated for the development of a novel lab-scale process for the synthesis of epoxiconazole.

AGRI NUTRI BIOTECH THEME

With a mission to boost farmers' income, CSIR initiated the Theme Agri Nutri Biotech to develop (i) agrotechnologies of commercially important crops and (ii) value added products of industrial and societal relevance. Twenty CSIR labs are participating in the theme activities that cater to five sustainable development goals, i. e., No poverty, Zero hunger, Good health and well-being; Affordable and clean energy and Life on land. Projects having SMART goals, translational value, TRL levels, feasibility and innovative ideas, and alignment to national priorities, were finally selected. Out of these, CSIR-IHBT is participating in 10 Fast Track Translational (FTT) and 1 Fast Track Commercialization (FTC) projects.

Approved FTT projects committee:

Optimization of aeroponic and hydroponic conditions for increasing commercial crop productivity (IHBT)

2. Introduction of high value spice saffron (*Crocus sativus* L.) in unexplored areas (IHBT)
3. Development of applications of laccase for diverse (food, health and cosmetic) industries (IMTECH, IHBT, CFTRI, IITR, IIP)
4. Indigenous enzymes for degumming of rice bran oil and other vegetable oils (IICT, IHBT)
5. Rapid and point care microfluidic systems for multiplex diagnosis of viral diseases in tomato and apple (IMMT, IHBT)
6. Identification of improved clones of *Stevia rebaudiana* (Bertoni) (IHBT)
7. Development of bamboo composite structural elements (AMPRI, CSIO, CBRI,IHBT)
8. Design and development of indigenized lyophiliser for preservation of Indian fruits and vegetables (CSIO, IHBT)
9. Combating iron and zinc deficiency using microalgae based foods (IHBT)
10. Development of self- propelled specialty harvester for leafy crops with a minimum field capacity of a four acres/day (ex. stevia, mentha, vegetables) (CMERI, IHBT)
11. Technology development for Gellan gum production (IMTECH)
12. Non-thermal recycling of sugar syrup from osmotic dehydration of fruits and application of concentrated syrups for value added products (CFTRI)
13. Smart agroinformtics and green internet of things to enable agriculture-4.0 (NCL, CMERI)
14. Technology assessment and integration of CSIR's lignocellulosic ethanol programs/facilitating technologies for a feasible 2G ethanol technology (CSIR-2GE) (IIP, IICT, NCL, CFTRI, IITR, NEERI, CSMCRI, CGCRI)
15. Up scaling of high yielding / elite Samba Mahsuri mutant lines for product translation (CCMB). Among these, CSIR-IHBT is participating in 10 projects.

Approved FTC projects

1. L-Asparaginase with no glutaminase activity for food processing and therapeutic applications (IHBT)

FBR projects approved by the Committee:

FBR:

1 Apomixis technologies for increasing agricultural production (CCMB)

2 Towards product development in rice using mutants that have traits of agronomic importance (CCMB)

3 Data analytics based on diet diversity, food consumption and nutritional deficiency targeted to the selected aspirational districts in Karnataka and Kerala (CFTRI)

4 Establishment of 'National Analytical Facility' for analysis of nutraceuticals and chemical markers in food products (NAFANC) (CFTRI)

5 Translation of pre-clinically tested probiotic formulation to human population with emphasis on immuno-modulation and gut microflora (CFTRI)

6 Understanding structure-function relationships in enzymes critical for the survival of bacterial food pathogens (CFTRI)

7 Development of withanamide enriched high yielding, variety of Ashwagandha (*Withania somnifera*) (CIMAP)

8 DNA-free CRISPR-mediated Genome-editing in rose-scented Geranium (CIMAP)

9 Understanding the biosynthesis of bioactive triterpenes in the medicinal tree banaba (*Lagerstroemia speciosa*) for the development of yeast-based synthetic biology platform (CIMAP)

10 Identification of molecular targets towards improvement of root biomass and/or texture in *Withania somnifera* (CIMAP)

11 Development of mobile-soil-sensing-system and digital spatial repository for precision agriculture using fusion of proximity sensors and geo-statistics modelling (CSIO)

13 Genome sequencing of the halophyte *Salicornia brachiate* (CSMCRI)

14 UAV based high resolution remote sensing for modernized and efficient cultivation practices of commercially important medicinal and aromatic crops. (Acronym: Drone Agri) (IHBT, CIMAP, NAL)

15 Molecular mechanism underlying Apple scar skin viroid-whitefly interaction (IHBT)

16 Development of process for conversion of cellulosic biomass into nanocellulose (IHBT)

17 Creation of aroma bank by utilization of western Himalayan biodiversity (AROMA-BANK) (IHBT)

18 Microbiome of Indian Trans-Himalayan niches for functioning of ecosystems (IHBT)

19 Alternative *in vitro* system for production of naphthoquinone pigments from Arnebia species on sustainable basis (IHBT)

20 Development of high-throughput genotyping platform for next generation plant breeding in tea (IHBT)

22 Characterization and development of agro-technology for low calorie natural sweetener: Monk fruit (*Siraitia grosvenorii*) (IHBT)

23 Exploration of Himalayan plants for novel antimalarial agents; characterization of potential molecules (IHBT)

24 Vegetable oil-based gels as trans free fat (Oleogel) (IICT)

25 Sustainable production of Edible oils from Microalgae (IICT)

26 Green synthesis of silver nanoparticles against plant pathogens: An alternative

solution for chemical pesticides (IMMT)

27 Mega-genomic insights into co-evolution of rice and its microbiome (MICRA) (

28 Development of a microbial system for the production of neo-glycopeptides/ neo-glycoproteins for useful applications (IMTECH)

29 Genome-editing for enhanced yield and quality traits (GE-Plant) (NBRI)

30 Characterization and value addition of plant-based resins, gums and waxes (NBRI)

31 Small RNAs and associated factors for enhanced post-harvest life (sRNA-life) (NBRI)

33 Understanding the epigenetics of fitness advantage of high altitude *Arabidopsis thaliana* populations under new environments (NBRI)

34 Sub-genome dominance in endoreduplication and its implication in heterotic benefits to F1-hybrids for biomass and their adaptation in cotton and *Arabidopsis* (NBRI)

35 Design and development of indigenous strain portfolio for the productions of Penicillin V (Pen -V-IP) (NCL)

36 Development of sustainable brown spot (*Bipolaris oryzae*) disease resistance in rice through multiplex-multigene CRISPR-Cas9/Cpf1 genome editing system (NEIST)

37 Deciphering the microbiome of native wild coastal saline tolerant rice varieties of southern India and understanding the impact of seawater in structuring the root associated core microbiota using pokkali rice as a model plant (NIIST)

38 Enhancing live stocks of herbivore fishes through captive breeding to control the macroalgal dominance in coral reefs to sustain the fishing revenue (NIO)

NCP projects approved by the Committee:

- Conservation and bioprospecting of selected high altitude bioresources at CSIR– Centre for High Altitude Biology (IHBT)
- Development of customized flow hive for quality honey harvesting and extraction (CSIO, IHBT)

Outcomes expected from the above projects:

- Enzymes/products for health, food, textile and cosmetic industries (asparaginase, phospholipase, laccase, gellan gum, microalgae based foods, antimalarial agents, penicillin V), Aroma bank
- Value added products: bamboo, edible oils from microalgae, resins, gums, waxes
- Products for malnutrition
- Alternative areas for saffron production
- Alternative low calorie sweeteners (monk fruit and improved stevia)
- Sensors for precision agriculture
- Microbiome from trans-Himalayan niches, rice
- 2G Ethanol
- Honey flow hives, crispy fruit maker
- *In vitro* systems for sustainable production pigments from Arnebia
- Quality standards from medicinal plants
- Improved cultivars (rice, cotton, tomato, mustard, chickpea, ashwagandha, stevia, flower crops)
- Pointcare diagnostics for apple and tomato viruses

Some of the salient achievements of the year includes:

- A bioprocess for L-asparaginase (HimAspaseTM) with no glutaminase activity was developed for the reduction of acrylamide formation in the food products.
- Indigenous enzymes for vegetable and rice bran oil degumming, *Chyseobacterium polytricastri* ERMR1:04) from Manikaran Hotspring were isolated and found to have phospholipase activity.
- A consortia of efficient hydrolytic psychrotrophic bacteria and lab scale formulations were prepared using unique psychrotrophic bacterial strains for organic waste degradation in cold hilly regions. The technology was transferred to Vendeep Green Globe Organic Venture Pvt. Ltd., Majitar, East-Sikkim.
- Traditional fermented food samples like Lassi, Dahi, Chilra, Lugri were collected from different villages in Lahaul Valley for the identification of useful microbes with probiotic potential.
- A rapid and point care microfluidic system for multiplex diagnosis of viral diseases in tomato and apple is being developed, where capsid proteins from cucumber mosaic virus, apple stem grooving virus and spple chlorotic leaf spot virus have been expressed and purified.
- Protocol for hydroponic cultivation of flower crops i.e., lilium and tulip has been successfully developed using an optimized recipe. In another study, a spectral library consisting of hyperspectral signatures of lilium was prepared for discrimination between different stages of the plant.
- Nine lines showing high accumulation of specific glycosides were identified. Among these, four and two lines showed high rebaudioside-A and C content as compared to check variety 'Him Stevia'.
- MAXENT modeling was employed to identify potential areas across India for saffron cultivation. Saffron grown in Bharmour (H.P.) was found to yield good quality spice as compared to other locations.
- An algae cultivation method was developed for *Spirulina platensis* having increased the tolerance level up to 80 mg/litre with significant accumulation of carotenoids. Based on the studies, low cost iron and zinc enrich microalgae based foods are being developed to combat iron and zinc deficiency.
- Under niche creating projects and focused basic research, field genebank for *D. hatagirea* accessions from ~10 populations was established at CeHAB. *In vitro* protocols for several RET MAPs were also developed with an aim to rehabilitate them under natural habitat.
- Buckwheat noodles were developed as a value added product to give a new beginning to underutilized crop (buckwheat). The developed products were analyzed for their nutritional, functional, textural and sensory profiles.
- In order to create an aroma bank, essential oil from leaves, buds and flowers of *Callistemon citrinus* was extracted, characterized and deposited in AROMA-BANK.

Introduction of Low Chilling Varieties of Apple in North Eastern States

Introduction of Low Chilling Varieties of Apple in North Eastern States (Mizoram, Meghalaya and Manipur)

In continuation to previous years activity in north east region of India, this year low chilling varieties *viz*., Red Fuji, Early Fuji, Sun Fuji and pollinizer variety Scarlett Gala were introduced in Ukhrul district of Manipur and West Khasi Hills district of Meghalaya (Tables 1& 2).

Table 1 List of List of low chilling apple growers of in district Ukhrul, Manipur

Sr. No.	Name of farmers	Name of Village
1.	Augustina AS	Poi
2.	Phamei Kashung	Hunphun
3.	Ngalayo Makan	Koso
4.	Thanyaophy Elue	Kasom Khullen
5.	Yirshok Kaping	Hunphun
6.	S. Sorinchon	Shingkap
7.	Vima Vashum	N.Tusom
8.	Rinyapam Sareo	Hunphun
9.	Somipam Longleng	Paorei
10.	Resource Centre, UDCRMS	Ukhrul
11.	TS Ringphami	Hungpung
12.	Yurthing Vashum	Tallui
13.	Ringyuichon Vashum	Tallui
14.	Shimreingam Kasar	Nungshong
15.	Candid Asaiwo	Lunghar
16.	Chinaongam	Hunphun

Table 2 List of low chilling apple farmers in district West Khasi Hills, Meghalaya

Sr. No.	Name	Name of Village	Altitude (m)	Coordinates
1.	Ribiona Basaiawmoit	Mynsain	1746	32.34N 99.40E
2.	Phranding Nongrang	Mynsain	1746	32.34N 99.40E
3.	Elkin Kurbah	Dewsaw	1746	32.34N 99.40E
4.	Bristornongrum	Pungsanniang	1712	30.14N 97.20E
5.	Hossing Lawriniang	Pungsanniang	1712	30.14N 97.20E
6.	Arphinesstar Lawrinniang	Pungsanniang	1712	30.14N 97.20E
7.	Sterwalen Nongrang	Mawphyrnai	1712	30.14N 97.20E
8.	Lamdur Basaiawmoit	Mawphyrnai	1712	30.14N 97.20E
9.	Marcellinus Iawphniaw	Pyndengrei	1542	28.34N 65.00E
10.	Minisha Snaitang	Mawkadiang	1542	28.34N 65.00E

Fig. 1 Cultivation of low chilling apple plants in district Champhai, Mizoram

Fig. 2 Fruit bearing low chilling apple plants in district Champhai, Mizoram

Fig. 3 Harvesing of low chilling apple fruits in district Champhai, Mizoram

Fig. 4 Selection of site by CSIR-IHBT scientists for low chilling apple varieties in Ukhrul, Manipur

Fig. 5 Plantation of low chilling apple varieties in district Ukhrul, Manipur

Agrotechnology of Medicinal, Aromatic and Commercially Important Plants

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Farm Mechanization

Development of green tea leaf shoot sorter

Agricultural produce such as seeds, tubers and grains are elliptical or oval in shape and are easily separated and graded with sorting machines by using the property of static and dynamic friction of the material to roll on inclined surfaces. However, in case of agricultural produce which have uneven and flat surfaces like flowers, leaves, small branches of herbs and thin roots, there is resistance to separation and tendency of produce to stick to the separating surfaces and difficulty in segregation. This results in final product either of mixed quality or further processed materials of an average quality. Tea shoot (two leaves and a bud) is one such produce which grow under uneven soil type, fertility & productivity, stochastic nature of rainfall and weather condition and crop varieties. The variation in tea leaf fineness will create a lot of difficulties at every step of tea manufacture viz., withering, maceration, fermentation, uneven drying and final characteristics of made tea. To overcome this difficulty, a prototype green tea shoot sorting machine was designed fabricated and installed at Banuri Tea Experimental farm in CSIR-IHBT, Palampur. An adjustable slant machine was designed on principle of static and dynamic friction. The unit was fabricated by mild steel with spring steel oscillating parts. The length and width of the unit is 2570 mm and 1050 mm respectively with slanting height 1275x690 mm at head and tail end with variable adjustment of 300 mm. A detachable unit of three different mesh having size 900 x 600 mm was fabricated on MS angle iron which is easily attached and detached according to the separating requirement. The unit is connected with an adjustable hopper for uniform feeding of green tea leaves on the bed and is run by 3-phase induction motor with variable speed, for easy oscillating movement of unit. This unit is easily sorting 10 different grades of green tea shoots. The average capacity of the unit is more than 1500 kg per day. The performance of the machine can be judged based on proportion of three grades of tea in the sorted lots viz., cut leaves, fine leaves (1- leaf & bud, and 2 leaf & bud) and rough leaves (more than two leaf & bud).Results show that uniform grade green tea leaves are separated by the device (Table 1) and the uniformity percent very high which can be observed visually. The uniform grade of green tea leaves obtained from the sorter will improve the grade of made tea.

Table 1 Performance of tea shoot sorting machine

Sl. No	Mesh size	Nature of tea leaves	Replications							Average uniformity of leaves (%)
			R1	R2	R3	R4	R5	R6	R7	
1	15 x 30 mm	Cut	90	66	64	74	68	76	82	74
		Fine	10	34	36	26	32	24	10	25
		Rough	0	0	0	0	0	0	8	1
2	25 x 30 mm	Cut	66	62	60	48	28	44	66	53
		Fine	32	32	52	0	40	56	20	33
		Rough	3	6	6	0	32	0	14	9
3	30 x 30 mm	Cut	74	16	16	34	36	26	46	35
		Fine	26	56	70	66	46	72	22	51
		Rough	0	28	14	0	18	0	32	13
4	32 x 42 mm	Cut	54	4	4	8	24	20	20	19
		Fine	42	42	64	71	46	28	32	46
		Rough	4	32	25	0	30	52	48	27
5	37 x 42 mm	Cut	48	4	0	6	8	10	6	12
		Fine	52	64	70	42	42	42	44	51
		Rough	0	32	30	52	70	48	50	40
6	44 x 42 mm	Cut	10	18	10	8	6	18	20	13
		Fine	50	66	70	22	26	24	20	40
		Rough	40	20	20	70	68	58	70	49
7	46 x 53 mm	Cut	12	6	5	4	8	12	6	8
		Fine	48	46	47	46	28	24	40	40
		Rough	40	48	48	50	64	64	54	53
8	51 x 53 mm	Cut	0	0	0	0	4	6	6	2
		Fine	0	44	50	28	28	12	30	27
		Rough	0	56	50	72	68	82	64	56
9	55 x 53 mm	Cut	0	4	3	0	0	2	0	1
		Fine	0	28	27	15	4	16	22	16
		Rough	0	68	70	85	96	82	78	68
10	Remaining	Cut	0	0	0	0	0	0	0	0
		Fine	4	6	8	0	0	8	6	5
		Rough	96	94	92	100	100	92	94	95

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Plant Breeding

The present research work is focused on breeding efforts for the improvement of aromatic crops for development of new varieties under the CSIR-Aroma mission; collection of germplasm resources in medicinal crops under CSIR-Phytopharma mission. Besides, characterization of variations in breeding populations of stevia under Fast Track Translational project and improvement of tea under Tea Board of India sponsored project is also being undertaken.

Evaluation of breeding lines of aromatic plants in multi-location trials

Indian valerian *(Valeriana jatamansi* Jones)

V. jatamansi is popularly known as Indian valerian, and is a native plant of Himalayan origin. In order to improve productivity and essential oil content of the roots, a breeding programme has been undertaken to identify promising selections for commercial cultivation. Using progeny selection approach nine accessions were evaluated in multi-location trials for root biomass and essential oil content at four locations for two years in comparison with check (Himbala). Experiments were laid out in Randomized Block Design (RBD) with three replications. Results showed, CSIR-IHBT-VJ-05 was significantly superior to check for root biomass and essential oil (Table 1 and 2).

Table 1 Mean variations for root biomass in *Valeriana* accessions over different locations

S. No.	Accessions	Root biomass (kg/plot)			
		Location-1	Location 2	Location -3	Location -4
1.	CSIR-IHBT-VJ-01	1.60	1.58	1.81	2.05
2.	CSIR-IHBT-VJ-02	1.30	1.28	1.41	1.51
3.	CSIR-IHBT-VJ-03	1.63	1.61	1.79	2.03
4.	CSIR-IHBT-VJ-04	1.75	1.68	2.00	2.20
5.	CSIR-IHBT-VJ-05	2.20*	2.32*	2.94*	3.38*
6.	CSIR-IHBT-VJ-06	1.38	1.45	1.54	1.67
7.	CSIR-IHBT-VJ-07	1.59	1.56	1.79	2.06
8.	CSIR-IHBT-VJ-08	2.04	2.17	2.32	2.71
9.	CSIR-IHBT-VJ-09	1.66	1.67	1.84	2.02
10.	Himbala	1.91	2.08	2.12	2.33
	S. E. (d)	0.061	0.044	0.101	0.179
	C. D. (P=0.05)	0.129	0.094	0.213	0.377

*Significant

Table 2. Mean variations for essential oil content in Valeriana accessions over locations

S. No.	Accessions	Essential oil content (g/kg)			
		Location-1	Location 2	Location -3	Location -4
1.	CSIR -IHBT -VJ -01	2.54	2.43	2.37	2.70
2.	CSIR -IHBT -VJ -02	2.28	2.18	2.15	2.38
3.	CSIR -IHBT -VJ -03	2.66	2.54	2.50	2.72
4.	CSIR -IHBT -VJ -04	2.79	2.66	2.60	2.89
5.	CSIR -IHBT -VJ -05	3.17	3.02	2.94	3.39
6.	CSIR -IHBT -VJ -06	2.37	2.28	2.22	2.55
7.	CSIR -IHBT -VJ -07	2.57	2.47	2.43	2.68
8.	CSIR -IHBT -VJ -08	3.37*	3.16*	3.09*	3.63*
9.	CSIR -IHBT -VJ -09	2.69	2.57	2.51	2.80
10.	Himbala	3.02	2.88	2.82	3.19
	S. E. (d)	0.071	0.072	0.065	0.097
	C. D. (P=0.05)	0.150	0.152	0.138	0.204

*Significant

Damask rose (*Rosa damascena*)

R. damascena is an important essential oil bearing plant which has high demand globally in manufacture of perfumes, colognes and cosmetics. To improve productivity, four clones with check varieties (Jwala and Himroz) were evaluated for flower yield and essential oil content for four years. Accessions were evaluated in RBD with four replications. Results showed that, CSIR-IHBT-RD-04 was significantly superior to check with respect to flower yield, while essential oil content was at par with check varieties (Table 3). Clone CSIR-IHBT-RD-04 has extended flowering (40 days) and flower yield is 22.62% more than the check (Jwala).

Table 3. Mean variations for flower yield in damask rose accessions over locations

S. No.	Accession No.	Flower yield (kg /plot)			
		2014 -15	2015 -16	2016 -17	2017 -18
1.	CSIR -IHBT -RD -01	5.1	4.3	4.85	4.325
2.	CSIR -IHBT -RD -02	3.8	3.2	3.525	3.3
3.	CSIR -IHBT -RD -03	5.15	4.05	5.05	3.675
4.	CSIR -IHBT -RD -04	5.3*	4.675*	5.1*	4.6*
5.	Jwala	4.575	3.8	4.3	3.375
6.	Himroz	3.975	2.85	3.85	3.425
	S. E. (d)	0.419	0.243	0.305	0.255
	C. D. (P=0.05)	0.894	0.518	0.651	0.543

*Significant

Evaluation of disease resistant clones of tea (*Camellia sinensis*)

About 13 tea clones resistant to blister blight disease were planted under field conditions to select disease resistance with high productivity. Among them, clone 03-6, 03-69, 03-37 and 03-55 reported significantly high shoot number, while clones 03-55 and 03-70 showed significantly long shoot length. Clones 03-10, 03-1, 03-101 and 03-104 showed significantly large leaf sizeas compared to the mean leaf size of other clones.

Evaluation of purple tea clones

Purple tea is rich source of anti-oxidants in form of anthocyanins. Sixteen clones of anthocyanin rich tea (Fig.1) were morphologically evaluated for plant height, number of shoots, shoot length, leaf length, leaf width, internode length and plant spread diameter.

Clones PT-1, PT-3, PT-6, PT-9 and PT-16 reported significantly high number of shoots, while PT-3, PT-6, PT-8 PT-9 and PT-17 had significantly long shoot length compared to the respective mean values of the group. Clones PT-3, PT-5, PT-9, PT-10, PT-11, PT-12 and PT-16 had significantly large leaf size compared to the mean leaf size of this group.

Fig. 1 Purple tea clone rich in anthocyanin (at Banuri farm)

Publications

Pal PK, Singh S and Sud RK(2019) Advances in Weed Management in Tea. In: Weed Control: Sustainability, Hazards, and Risks in Cropping Systems Worldwide (Eds. Nicholas E. Korres, Nilda R. Burgos, Stephen O. Duke), Taylor & Francis Group, CRC Press, pp 664.

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Development of agrotechnologies

Wild marigold (*Tagetes minuta*: Asteraceae)T. minuta is an aromatic herb, commercially grown and harvested for its essential oil present in leaves and flowers. A field experiment was conducted to study the effect of drying condition and drying hours of biomass on essential oil content. Results revealed that sun drying for 72 lead to significantly higher essential oil content, β-ocimene and lower dihydrotagetone (Fig. 1).

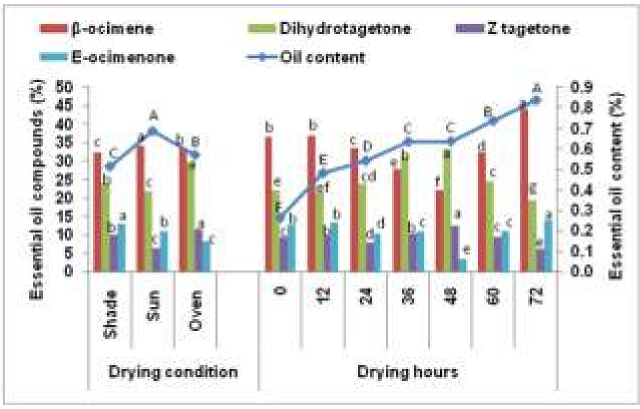

Fig. 1 Effect of drying method and drying hours on essential oil content and major compounds of *T. minuta*

Altitudinal variation on essential oil of *T. minuta* from four different altitudinal zones {L1 (489 m amsl), L2 (1325 m amsl), L3 (1928 m amsl) and L4 (2591 m amsl)} of western Himalayas was studied. Results showed that essential oil content increased significantly with increase in altitude. Essential oil content was significantly higher at higher elevation in location 4 (L4). β-ocimene increased significantly with increase in altitude, however, dihydrotagetone decreased with increase in altitude (Fig. 2).

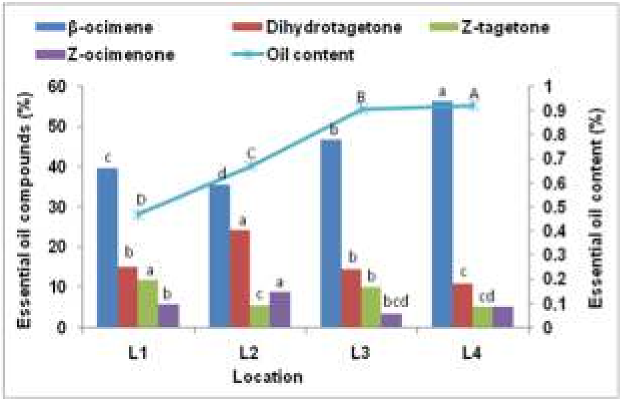

Fig. 2 Effect of altitudinal variation on essential oil content and major compounds of *T. minuta*

Rosemary (*Rosmarinus officinalis*)

R. officinalis is a woody, evergreen perennial herb, used in perfumery and flavor industry. To study the effect of different seasons on essential oil content and its composition, an experiment was laid out. Essential oil content and composition of major compounds of *R. officinalis* varied with seasonal variability (Fig. 3). Essential oil content was significantly higher in accession 1 during autumn. Similarly, higher significantly higher 1,8-cineole and beta pinene content was recorded during rainy season in accession 2.

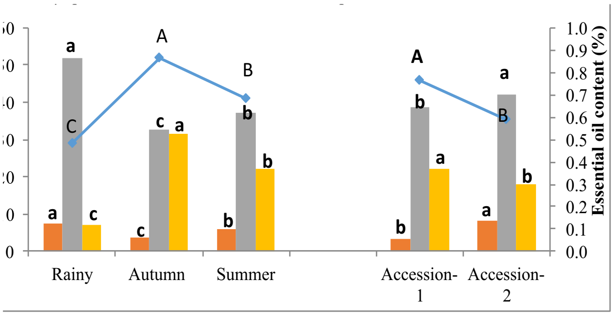

Fig. 3 Effect of harvesting season on essential oil content and composition of *R. officinalis* accessions

Lemongrass (*Cymbopogon citratus*)

C. citratus is an aromatic, evergreen, clump-forming, perennial grass growing around 1.5 meter tall. To standardize the post harvest storage hours of biomass, an experiment was conducted. The highest essential oil content was recorded after 48 hours of storage under sun (Fig. 4). Citral and geranial increased significantly with increase in storage duration for 36 hours.

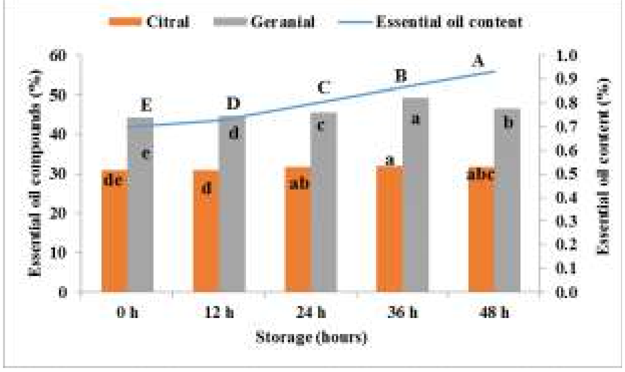

Fig. 4 Effect of storage on essential oil content and composition of lemongrass

Cultivation and processing of aromatic crops for socio-economic development in rural areas of Himachal Pradesh

The farmers of the state are facing problem of low agricultural income from traditional farming, cropping system and animal menace (wild boar, monkey etc.). Thus, there is an urgent need to introduce new crop not affected by wild animals, which have higher economic return. Under this activity, high value aromatic crops were introduced to improve the livelihood of the hilly farmers. Various training cum seeds distribution programmes were organized at Ghat Panchayat, block Siraj, Distt. Mandi (H.P) and 88 farmers were trained. Thereafter, demonstration plots of *Valeriana jatamansi, Rosa damascena, Rosmarinus officinalis* and *Tagetes minuta* were raised at farmers' field (Table 5 and Fig. 4).

Table 1 Trainings conducted and plants distributed

Training/ awareness programme	Date	Plants distributed	Area covered (ha)	Number of farmers	Place
Awareness and training programme on cultivation of Aromatic plants.	02/06/2018	*R. officinalis*	0.052	20	Ghat Panchayat, Mandi (H.P.)
Awareness programme on cultivation of Aromatic plants.	26/06/2018	*V. jatamansi*	0.008	36	Ghat Panchayat, Mandi (H.P.)
Awareness programme on cultivation of Damask rose	04/04/2019	*R. damascena*	0.06 0	32	Ghat Panchayat, Mandi (H.P.).

Awareness programme related to aromatic crops. Raising up of demonstration plot

Fig. 5 Snapshots of training and awareness programmes at Ghat Panchayat, Mandi

Introduction of high value spice saffron (*Crocus sativus* L.) in unexplored areas (FTT Project)

C. sativus L. is known as the most expensive golden spice around the world due to its medicinal properties, colour, taste and aroma. Major chemical constituents are safranal, crocin and picrocrocin. In this activity, cultivation sites as identified through MAXENT modelling were screened for their potential to support saffron growth PAN India during 2018-19. (Table 2). Results showed that yield and major chemical constituents of crocin and safranal was highest in saffron grown in Bharmour (H.P.) in comparison with other locations (Figs. 6-9).

Table 2 Introduction of saffron in the different sites across Pan India

Location	Latitude	Longitude	Altitude (m amsl)	Soil Analysis			
				N (kg/ha)	P (kg/ha)	K (kg/ha)	Soil type
Bharmour, H.P.	76°34′14″	32° 26′47″	2195	313.6	49.6	662.36	Clay loam
Bageshwar, Uttarakhand	79° 53′58″	30° 5′5″	2400	313.6	109.7	146.03	Sandy loam
Munsyari, Uttarakhand	80° 15′17″	30° 3′11″	2200	344.96	157.9	332.88	Sandy loam
Moorang, H.P	78° 27′4″	31° 36′10″	2591	282.24	56.13	132.76	Sandy loam
Sangla, H.P	78° 18′8″	31° 24′23″	2696	188.16	134.5	190.26	Sandy loam
Ooty, T.N	11° 30′23″	76° 65′36″	1980	344.96	171	259.91	Sandy clay loam
Shipgyer, Sikkim	88° 38′5″	27° 33′18″	1942	250.88	141	150.45	Clay loam
Kullu, H.P	77° 12′36″	31° 93′76″	2100	282.24	202.3	458.92	Clay loam

Fig. 6 Saffron crop at flowering stage at Palampur (H.P.)

Fig. 7 Saffron crop at vegetative stage, Bharmour (H.P.)

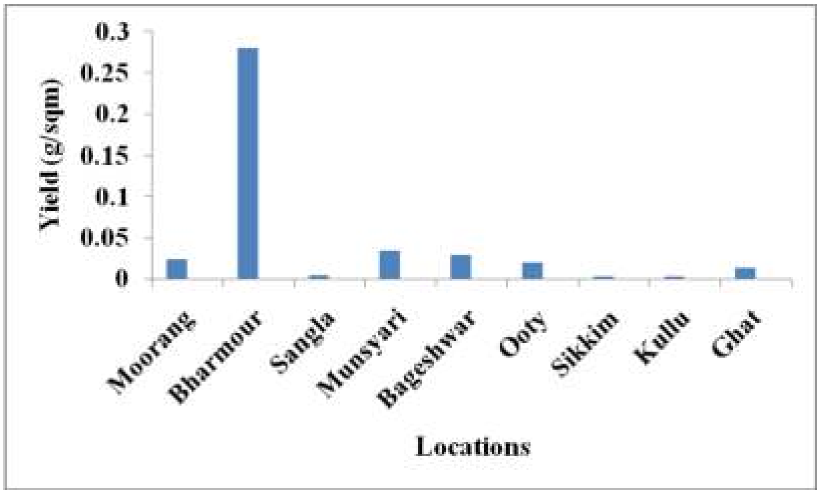

Fig. 8 Effect of location on saffron yield

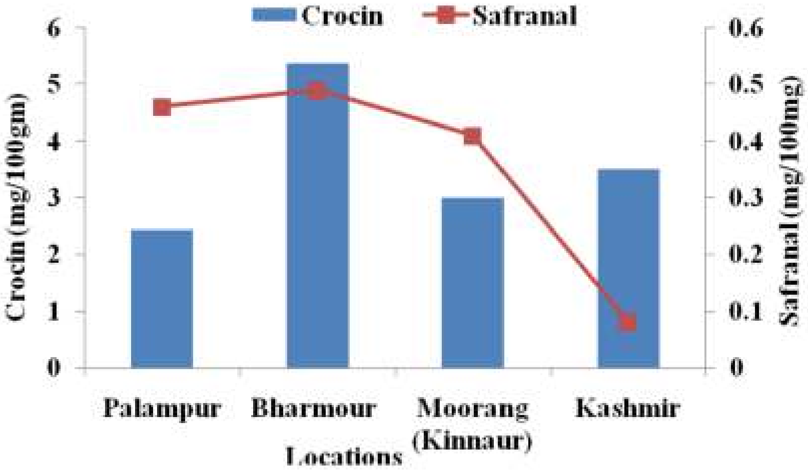

Fig. 9 Quality analysis of saffron from different locations

Publications

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Left to right, 1st Row: Mr. Yog Raj, Mr. Kuldip Singh, Dr. Rakesh Kumar, Ms. Shikha Sharma, Ms. Shalika Rathore, Ms. Meenakshi Thakur, Mrs. Swati Walia, Ms. Renu Devi, Mr. Sanjeet Kumar, Mr. Pritam Debnath, 2nd Row: Dr. Kiran Saini, Mr. Rajesh Kumar, Mr. Chirag Sharma, Mr. Deepak Guleria, Mr. Sahil Salaria

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Improvement of salinity tolerance of *Stevia rebaudiana*

The worldwide demand for *S. rebaudiana* is steadily increasing as a low caloric natural sweetener, since main regulatory authorities have approved the use of steviol glycosides (SGs) extracted from stevia leaves as a dietary supplement. However, biomass yield and accumulation of SGsin leaf are negatively affected when the growing environment is adverse including salinity stress. However, relatively little is understood of adaptation, physiological and metabolic changes of stevia under salinity stress. On the other hand, the degree of salinity also depends upon plant spices, extent and mechanism of tolerance in stevia is not clear. It is hypothesized that exogenous application of potassium (K^+) could elevates the salinity tolerance through ions homeostasis.

The results of this study suggests that the performance of stevia in terms of biomass yield and biosynthesis of SGs was better under mild salinity (NaCl at 40 mM) condition as compared with high salinity stress and non-saline irrigation. The detrimental effects of moderate and higher salinity (NaCl ≥ 80 mM) on stevia plant were observed due to the reduction of photosynthetic pigments, induction of oxidative stress, and ions imbalance in plant tissues. The uptakes of important ions (K^+, $Ca2^+$, and N) were significantly reduced at higher salinity level (NaCl at 120 mM), whereas the accumulations of Na^+ and Cl^- ion in plant tissues were substantially increased. Proline content in leaf was also increased substantially in response to salt stress. However, dry leaf biomass did not show significant reduction under moderate salinity (NaCl at 80 mM) level when KNO_3 at 10.0 g $L^{-1}$was applied as compared with absolute control. The exogenous application of K^+ under moderate salinity stress maintained ion balance in cytosol, particularly K: Na. The salinity tolerance of stevia can be elevated to some extent through exogenous application of potassium with appropriate dose.

Development of stevia-based intercropping system

The most widespread objective of intercropping is to produce a higher yield from a given piece of land by utilization of resources. The initial growth rate of stevia is very slow, when planted in a wider spacing. To utilize the space between the rows, intercropping may be a good option. Thus, the effects of quinoa (*Chenopodium quinoa*) as intercropping with main crop stevia have been investigated under the western Himalayan conditions. Both the additive replacement series were tested. The analyzed data revealed that the quality of main stevia (main crop) in term of steviol glycosides (SGs) accumulation was not significantly ($P \leq 0.05$) affected due to interference of quinoa as an intercrop.

Fig. 1 Stevia-quinoa intercropping at Palampur

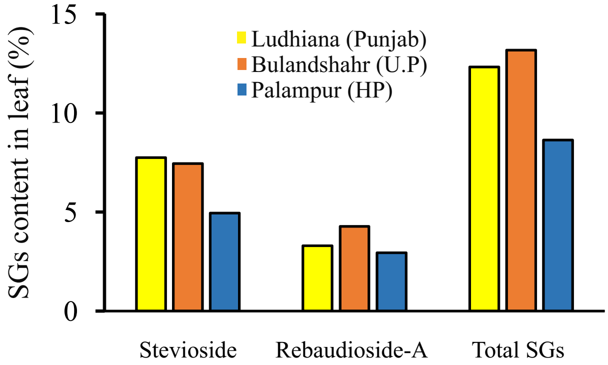
Evaluation of stevia under different agro-climatic conditions

The performances of stevia in terms of biomass yield and accumulation of SGs under different agro-climatic conditions were evaluated. The leaf sample were collected from three locations namelyLudhiana (Punjab), Bulandshahr (UP), and Palampur (HP). The analyzed data revealed thatclimatic conditions of Ludhiana and Bulandshahr are suitable for optimum biomass yield (Table 1).

Table 1 Dry biomass yield of stevia

Location	Dry leaf yield (g plant^{-1})
Ludhiana (Punjab)	44.65
Bulandshahr (UP)	35.44
Palampur (HP)	9.91

Steviol glycosides accumulation at these two locations are also high as compared with Palampur (Fig. 2).



Evaluation of population of *Valeriana jatamansi*

Six populations of *V. jatamansi* were evaluated under Palampur conditions. The essential oil was extracted from the roots through hydro-distillation method with clevenger type apparatus. Out of six, three populations enriched with patchouli alcohol, and γ-Cucurmene was present in higher concentrationin the other three populations.

Morphological characterization of monk fruit

The monk fruit, *Siraitia grosvenorii* (*Cucurbitaceae*) has been used for centuries in traditional chinese medicine. However, monk fruit is recognized now throughout the world for its intense sweet taste due to presence of cucurbitane-type triterpene glycosides known as mogrosides, and it has been used as a non-caloric natural sweetener in some countries. CSIR-IHBT introduced seeds of monk fruit from China through ICAR-NBPGR, New Delhi. However, scientific information is lacking about the plant. Morphological characterization of monk fruit has been initiated to understand the growth behavior.

It is a perennial herb having tendrils for climbing. The plant height varies from 5-15 meters. Heart shaped leaf showing multiicostate reticulate venation and hair like outgrowth on both the surface. Stem is weak, herbaceous, climber, angular, solid, hairy and green in color. Stem is pentangular with ridges and furrows and covered by small multicellular hair like outgrowth. Nodes and internodes are clearly visible and from each node one tendril, one leaf and an axillary bud develop. Root is branched tap root. During growing period main root is gradually becomes swollen due to the accumulation of storage material for future uses. It appears like a napiform root (Fig. 3).

Fig. 3 Napiform root of monk fruit at Palampur

The unisexual flowers of monk fruit are either solitary or racemose clusters in some cases (Fig. 4).

Fig. 4 Solitary and racemose clusters

Both male and female flowers are yellowish in colour. Petals of female flowers are smaller and thinner than the petals of male flower. Staminodes are present in female flower whereas pistilloides are absent in male flowers. Stigma is trifid and five anthers are arranged in whorl. Ovaryis trilocular with axile placentation (Fig. 5).

Fig. 5 Microscopic view of transverse section of ovary

Publications

Pal PK, Singh S and Sud RK (2019) Advances in Weed Management in Tea. In: Weed Control: Sustainability, Hazards, andRisks in Cropping Systems Worldwide (Eds. Nicholas E. Korres, Nilda R. Burgos, Stephen O. Duke), Taylor & Francis Group, CRC Press, pp 664.

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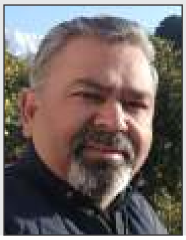
Dr. Probir Kumar Pal's Group



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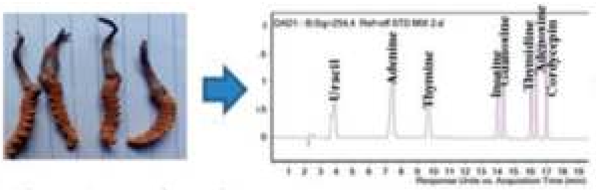
Development of method for metabolite analysis and nucleoside determination in *Ophiocordyceps sinensis*

A fast, reliable and reproducible UHPLC-IMS method was developed and validated for simultaneous determination of eight nucleosides (adenine, adenosine, cordycepin, guanosine, inosine, thymidine, thymine and uracil) in natural *Ophiocordyceps sinensis*. These nucleosides showed good linearity (r^2>0.99), LOD (0.28–0.97ng/mL), LOQ (0.79–3.20 ng/mL), recoveries (88.3 and 103.2%), reproducibility, stability and intra- and inter-day precision (<2.87%). Method was validated using three samples of natural *Ophiocordyceps* collected from different geographical region (Fig. 1). PCA analysis depicted that adenine, adenosine, guanine, guanosine, uracil and uridine were major components contributing to total variance. Highest nucleosides content (5124 µg/ g) was detected in STD-1. The presence of cordycepin, an important marker compound was identified for first time using ion mobility mass spectrometry (IMMS) technique (Fig.2). Metabolomics approach resulted 18, 12 and 9 metabolites in three samples (STD-1, STD-II and STD-III, respectively) using METLIN database which opened the new avenues to identify and explore more novel biomarkers in *Ophiocordyceps*. We anticipate that these methods may be applied to verify/certification of *Ophiocordyceps* containing marker nucleosides suggesting its great potential in health care.



Ophiocordyceps sinensis **UPLC-QTOF-IMS**

Fig. 1 ***Ophiocordyceps*** **sample and chromatogram**

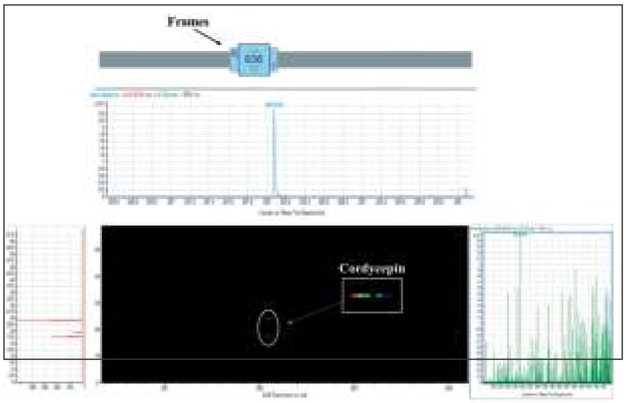


Fig. 2 An IMMS plot showing the cordycepin detected in sample

Identification of a parasitoid from *Pulvinaria floccifera* infesting Kangra tea

Cottony camellia scale, *Pulvinaria floccifera* (Westwood, 1870) (Hemiptera: Coccidae) is one of the important soft scale species infesting more than 80 host plant species in the tropical and sub tropical environment in the world. It is observed as a major pest of tea in Kangra Valley, HP. These scales are parasitized by some parasitoids. Therefore, a simple and quick molecular approach was developed to detect and identify a parasitoid of *P. floccifera* within the host. About 658 bp fragment of mitochondrial COI was amplified using universal primers. The blast analysis showed its

99% similarity with the parasitoid, *Lysiphlebia japonica*, the most important natural enemies of aphids. However, interestingly, in the present study, *Lysiphlebia* has been observed and reported from *P. floccifera* infesting tea.

Development of Biopesticides

In the direction of development of biopesticides, efficacious native isolates of entomopathogenic fungi *Beauveria* were identified from larval cadavers and associated soils collected from H.P. Trainings imparted to B.Sc. and MSc. students : 05 nos.

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Left to Right: Aakriti Sharma, Pooja Kumari, Gireesh Nadda, Sahil Sharma and Aditya Singh Ranout

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Plant Breeding

Efforts are focused on the improvement of aromatic crops under the CSIR-Aroma mission and collection of genetic resources of medicinal plants under CSIR-Phytopharma mission. I am also working on characterization of new variations in stevia and other selected floricultural crops. Work has also been commenced on introduction of Heeng as a new plant species which will be cultivated in high altitude regions of Indian Himalayas.

Introduction of Heeng (*Ferula assafoetida* L.)

F. assafoetida is a well-known condiment and has medicinal properties related to digestive system. The pungently flavoredoleo gum-resin is obtained from the fleshy roots. It is a perennial herb indigenous to Iran, Afghanistan and Turkmenistan. Six accessions of *F. assafoetida* were introduced in the country with due approval from ICAR- NBPGR, New Delhi (Import Permit No. 318/2018 and 409/2018). The seeds were sown at CeHAB, Ribling and six accessions are being grown under the vigil of ICAR-NBPGR.

Wild marigold (*Tagetes minuta*)

T. minuta is an aromatic herb, commercially cultivated for its essential oil present in aerial parts of the plant. With an aim of varietal development, selective breeding of wild marigold was done using progeny selection approach. Out of 334 accessions of diverse origin, 18 accessions with high biomass were identified. Preliminary yield trials of 18 accessions were carried out by raising progeny rows of each accession with three replications. Nine potential selections of *T. minuta* identified on the basis of biomass yield were evaluated in multi-location trials along with check variety ('Him Gold') in a RBD with three replications at four different locations. Results showed that, significantly high biomass yield of was recorded in accession CSIR-IHBT-TM-09 as compared to check (Table 1 & 2). In accession CSIR-IHBT-TM-03, significantly higher essential oil content was observed over the check.

Table 1 Biomass yield (kg/plot) of *T. minuta*

Selections	Multi location Trials			
	Location -1	Location -2	Location -3	Location -4
CSIR-IHBT-TM-01	56.25*	52.05*	53.32	41.33
CSIR-IHBT-TM-02	52.57	48.36	50.27	39.32
CSIR-IHBT-TM-03	60.23*	54.67*	57.55*	46.04*
CSIR-IHBT-TM-04	50.72	46.02	48.26	37.33
CSIR-IHBT-TM-05	58.31*	52.80*	55.82*	43.09*
CSIR-IHBT-TM-06	51.84	47.30	50.10	37.10
CSIR-IHBT-TM-07	52.04	47.58	51.05	39.61
CSIR-IHBT-TM-08	50.23	45.29	47.76	38.30
CSIR-IHBT-TM-09	63.07*	58.54*	61.80*	49.03*
Check (Him Gold)	51.08	46.58	49.57	39.08
Mean	54.62	49.92	52.55	41.03
SE	1.78	1.89	1.84	1.84
CD (P=0.05)	3.73	3.96	3.87	3.86

*Significant

Table 2 Oil yield (g/kg) in biomass of *T. minuta*

Selections	Multilocation Trials			
	Location -1	Location -2	Location -3	Location -4
CSIR -IHBT -TM -01	3.14	3.11	3.15	3.18
CSIR -IHBT -TM -02	3.27	3.26	3.20	3.26
CSIR -IHBT -TM -03	3.67*	3.79*	3.73*	3.83*
CSIR -IHBT -TM -04	3.42	3.41	3.42	3.52
CSIR -IHBT -TM -05	3.19	3.21	3.19	3.17
CSIR -IHBT -TM -06	3.44	3.34	3.34	3.37
CSIR -IHBT -TM -07	3.23	3.24	3.23	3.25
CSIR -IHBT -TM -08	3.09	3.13	3.14	3.13
CSIR -IHBT -TM -09	3.43	3.44	3.41	3.45
Check (Him Gold)	3.35	3.36	3.37	3.42
Mean	3.32	3.33	3.32	3.36
SE	0.078	0.087	0.038	0.081
CD (P=0.05)	0.164	0.182	0.079	0.170

*Significant

Sea wormwood (*Artemisia maritima*)

In order to improve biomass production and essential oil, breeding of sea wormwood was undertaken using progeny selection approach. Eight accessions were evaluated at four locations in mid and high-altitude regions over a period of two years in RBD with four replications. Results showed that, CSIR-IHBT-AM-02 was significantly superior for aerial biomass (Table 3).

Table 3 Mean variations for aerial biomass in *A. maritima*

S. No.	Accession No.	Aerial biomass (kg/plot)			
		Location -1	Location -2	Location -3	Location -4
1.	CSIR -IHBT -AM -01	7.93	7.15	6.56	7.00
2.	CSIR -IHBT -AM -02	8.96*	8.4*	7.49*	7.85*
3.	CSIR -IHBT -AM -03	6.67	5.65	5.11	5.69
4.	CSIR -IHBT -AM -04	7.21	6.17	5.68	6.26
5.	CSIR -IHBT -AM -05	7.79	6.65	6.16	6.46
6.	CSIR -IHBT -AM -06	8.32	7.3	6.84	7.17
7.	CSIR -IHBT -AM -07	7.44	6.15	5.84	6.30
8.	CSIR -IHBT -AM -08	6.97	5.67	5.13	5.55
	Mean	7.66	6.64	6.10	6.54
	SE(d)	0.170	0.105	0.209	0.295
	CD (P=0.05)	0.355	0.264	0.436	0.615

*Significant

White Dragonhead *(Dracocephalum heterophyllum)*

D. heterophyllum is an aromatic herb of high altitude region in Himalayas. With an aim of to improve aerial biomass and essential oil content, progeny selection approach was followed. Six accessions were evaluated at four locations in mid and high-altitude regions over a period of two years along with check variety (Himsurabh) in RBD with three replications. CSIR-IHBT-DH-04 was significantly superior to check with respect to aerial biomass, while essential oil content was observed to be at par with check (Table 4).

Table 4 Mean variations of aerial biomass in *D. heterophyllum* in different locations

S. No.	Accessions	Aerial biomass (kg /plot)			
		Location-1	Location-2	Location-3	Location-4
1.	CSIR-IHBT-DH-01	2.10	2.03	2.16	2.19
2.	CSIR-IHBT-DH-02	2.30	2.09	2.38	2.40
3.	CSIR-IHBT-DH-03	2.63	2.60	2.69	2.52
4.	CSIR-IHBT-DH-04	3.11*	2.96*	3.19*	3.18*
5.	CSIR-IHBT-DH-05	2.38	2.17	2.48	2.38
6.	CSIR-IHBT-DH-06	2.59	2.52	2.63	2.54
7.	Himsurabh	2.75	2.64	2.62	2.78
	SE (d)	0.048	0.047	0.046	0.041
	CD (P=0.05)	0.104	0.102	0.101	0.091

*Significant

Evaluation of polyploid stevia genotypes

Stevia line CSIR-IHBT-ST-03 (C-7-3-4) developed through colchicine treatment of stevia seeds was analyzed for stability of polyploidy through flow cytometry and the ploidy status was observed to be tetraploid. The genotype CSIR-IHBT-ST-03 (C-7-3-4) was evaluated for morphological as well as biochemical traits (Table 5) and observed significantly superior leaf size as compared to the control (diploid plant).

Table 5 Morphological features of tetraploid stevia genotype CSIR-IHBT-ST-03 (C-7-3-4)

Traits	2014-15		2015-16		2016-17		2017-18	
Biochemical traits	C-7-3-4	Control	C-7-3-4	Control	C-7-3-4	Control	C-7-3-4	Control
Stevioside (%)	6.25	5.44	7.62	6.93	7.23	6.67	7.61	6.25
Rebaudioside-A (%)	3.31	2.27	3.57	2.74	3.18	2.45	3.29	2.36
Morphological trait								
Plant height (cm)	81.58	105.36	91.62	115.54	86.25	105.48	96.43	109.52
Branches/plant (no.)	6.23	8.25	8.52	12.43	9.37	8.62	10.22	8.74
Stem thickness (mm)	8.13	6.42	6.48	5.35	7.37	6.46	7.64	6.28
Internode length (cm)	5.53	4.19	6.21	3.25	4.89	3.37	5.42	3.61
Max. leaf length (cm)	11.34*	7.83	12.27*	8.35	10.29*	7.14	11.47*	7.86
Max. leaf width (cm)	5.64*	3.84	6.51*	3.52	5.21*	3.26	5.64*	3.17

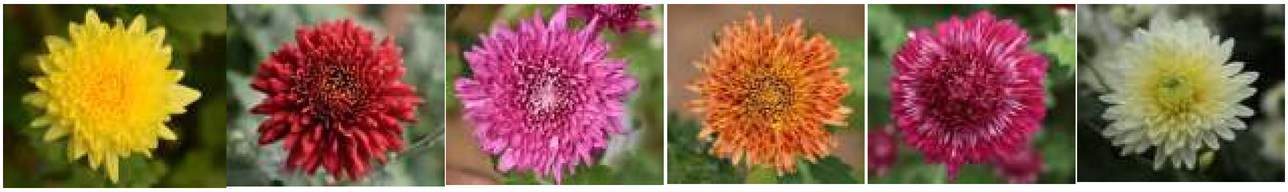
*Significant (P=0.05)

Chrysanthemum breeding

Chrysanthemum is one of the important ornamental cut flower in the world and is ranked second among top ten cut flowers sold in the global market. With an objective to develop unique flower types in chrysanthemum,19 F1 hybrids developed through controlled crossing program and multiplied through clonal propagation were morphologically characterized under protected cultivation with respect to floral traits (Table 6) and evaluated for field performance over a period of four years from 2014-15 to 2017-18 along with check in three replications and identified six potential selections (Fig.1 & Table 7). Results indicated that, CH-14-1,CH-14-4,CH-14-6 andCH-14-8 were significantly superior for flower head diameter and total number of flowers/plant as compared to the check (Poornima).

Table 6 Details of floral features of potential F_1 hybrid selections

Sr. No.	F_1 hybrid selections	Pedigree	Flower colour	Flower shape	Flower type
1.	CH-14-1	YP/WS-5	Yellow	Double	Spray
2.	CH-14-2	YP/S-19	Brick Red	Double	Spray
3.	CH-14-4	YP/S-40	Pink	Double	Spray
4.	CH-14-6	YP/S-23	Dark Peach	Double	Spray
5.	CH-14-8	P/S-14	Dark Pink ray floret with pink disc floret	Double	spray
6.	CH-14-18	YP/P-2	Creamish white	Double	Spray



IHBT-Chr-14-1 IHBT-Chr-14-2 IHBT-Chr-14-4 IHBT-Chr-14-6 IHBT-Chr-14-8 IHBT-Chr-14-18

Fig. 1 Potential F1 hybrid selections of chrysanthemum

Table 7 Performance of six F_1 selections of chrysanthemum under field conditions

Traits	F_1 hybrid selections	Pedigree	Year			
			2015	2016	2017	2018
Flower head Diameter (cm)	CH-14-1	YP/WS-5	6.98	8.01*	8.70*	9.74*
	CH-14-2	YP/S-19	6.52	7.05	5.67	5.50
	CH-14-4	YP/S-40	10.25*	10.87*	8.71*	9.92*
	CH-14-6	YP/S-23	7.65	7.89*	5.58	7.31
	CH-14-8	P/S-14	7.54	9.07*	6.91	8.45*
	CH-14-18	YP/P-2	7.36	7.24	6.46	6.59
	SE(d)		0.2835	0.3361	0.3336	0.2986
	CD		0.5699	0.6755	0.6706	0.6003
Total Number of flowers	CH-14-1	YP/WS-5	52.92*	58.27*	55.29*	52.56*
	CH-14-2	YP/S-19	48.75*	45.84*	50.82*	48.84*
	CH-14-4	YP/S-40	48.91*	42.78*	45.15*	47.63*
	CH-14-6	YP/S-23	49.78*	48.44*	54.60*	52.46*
	CH-14-8	P/S-14	29.89	31.12	31.14	39.77*
	CH-14-18	YP/P-2	44.33*	43.18*	45.83*	47.64*
	SE(d)		1.5455	1.3064	1.8595	2.0820
	CD		3.1065	2.6259	3.7376	4.1847

*Significant at P=0.05

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Entomology, Pest Management and Development of Biopesticides

Insect pests play a major role in reducing the economic yield if control measures are not initiated timely. Indiscriminate and non-judicious application of synthetic pesticides for the control of pests led to insecticide resistance, resurgence, harmful to beneficial insects, environment etc. Use of bio-pesticides for pest management has increased globally. In the present work, studies were carried out for screening of plant extracts/essential oils/fractions/ compounds for their insecticidal properties. Similarly, identified and screened native strains of entomopathogenic fungi (EPF) for their efficacy against target pests. The process was also developed by using apple pomace as substrate for the multiplication EPF (*Lecanicillium lecanii*). Under aroma mission plant extracts/essential oils were screened against target crop and stored grain pests for the development of botanical formulation. Work also under progress for the development and evaluation of customized flow hive for quality honey extraction.

Identification of promising native strains EPF for the management of insect pests

Field surveys were carried out for collection of insect cadavers'/soil samples of different agriculture/horticulture/forest ecosystems in Himachal Pradesh, Punjab and Jammu & Kashmir for isolation, characterization and evaluation of identified strains against target pests for their bio-efficacy. Among them, IHBF-15 & 16 showed promising efficacy against second instar larvae of diamondback moth (*Plutella xylostell*a) under laboratory conditions. The isolated strains will be further evaluated against target pests under greenhouse/field conditions for validation and development of bio-pesticide formulations.

Multiplication of entomopathogenic fungus (*Lecanicillium lecanii*) on apple pomace (AP) and its efficacy against aphid (*Aphis craccivora*)

AP was tested for the multiplication of *L. lecanii* and evaluated for its efficacy against A. craccivora. Results showed that, AP medium at 2% recorded more mycelial growth and were at par with AP 3, 4 and 5% as compared to other concentrations (Fig. 1). The spore yield was also significantly higher in AP 5% ($16x10^6$ spores/mL) and was at par with AP 0.5%. *L. lecanii* at $1x10^9$ spores/ mL showed maximum mortality (43.33 to 93.33%) against *A. craccivora* and was followed by $1x10^8$ spores/mL (36.67 to 86.67% mortality). AP can be used as alternate substrate for multiplication of *L. lecanii*.

Seasonal incidence of black scale (*Saissetia oleae*) on the fern (Thelypteris tylodes) from western Himalaya

Seasonal incidence of *S. oleae* on *T. tylodes* was reported throughout the year (May 2012 to April 2013) at weekly interval. Incidence of *S. oleae* was first observed during first week of May 2012 (5.4 scales/rachis).The infestation increased gradually from second week of May (6.6 scales/rachis) and attained peak (Fig. 2) during last week of July 2012 (27.8 scales/rachis) which may be due to high temperature (20-27 °C) and relative humidity (74-83%). The infestation was starts declining gradually from August-November 2012 (24.7 scales/rachis to 3.4 scales/rachis). The lowest scale incidence was observed during the last week of December 2012 (0.50 scales/rachis) and second week of January

2013 (0.2 scales/rachis). The scale population was not observed from third week of January 2013 to entire March 2013 (Fig. 3). *S. oleae* population showed significantly positive correlation with temperature, relative humidity and rainfall (Fig. 4-9).

Insecticidal activity and structure activity relationship of sugar embedded macrocycles for the control of *A. craccivora*

Sugar embedded macrocycles were screened for their efficacy against nymphs of *A. craccivora* under controlled conditions. The activity of different macrocycles varied depending on the nature and position of various functional groups possess by these compounds. Among them, compound 3c found more effective against A. craccivora (LC_{50}=413 mg/L) and was followed by 3b (LC_{50}=442.6 mg/L) and 3e (LC_{50}= 480.19 mg/L).

Insecticidal activity of plant extracts/ essential oils/fractions/compounds

Essential oil (EO) of ginger and oleoresins isolated from solvent extraction by GC-MS. Zingiberene was the major constituent in all the samples, ethanol could extract the maximum quantity (21.2%) in ethanol extract from dried de-oiled cake rhizomes (EDD) followed by EO (20.3%) as compared to oleoresins. Hydro distilled EO contains higher oxygenated monoterpenes (22.4%) than oleoresins. EDD showed more toxicity to larvae of *P. xylostella* (LC_{50}=4957 mg/L) after 96 h and was followed by ethanol extract from wet de-oiled cake rhizomes-EDW (LC_{50}=5067 mg/L–1) and ethanol extract from fresh rhizomes-EF (LC_{50}=6631 mg/L). EO was also showed promising efficacy (LC_{50}=5875 mg/L) and repellency (97.1%) against larvae of *P. xylostella*.

EO of *Curcuma aromatica, Hedychium spicatum, Mentha piperita, M. spicata, M. longifolia, Cinnamomum camphora* and *Cymbopogon flexuosus* were evaluated for their insecticidal activities against larvae of *P xylostella*. Among them, *M. longifolia* was found more effective (LC_{50}=1.06 mg/mL) against second instar larvae and was followed by C. aromatica (LC_{50}=1.35 mg/mL) and *M. piperita* (LC_{50} =1.37 mg/mL). *M. piperita* and *M. spicata* also showed promising repellent (RC_{50}=1.33 mg/mL) and feeding deterrence activity (66%) to third instar larvae.

Fig. 1 Growth of *L. lecanii* on AP medium (20 days after inoculation)

Fig. 2 Infestation of *S. oleae* on *T. tylodes*

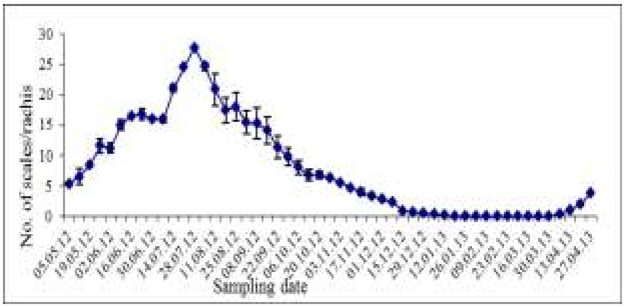


Fig. 3 Incidence of *S. oleae* on *T. tylodes* at weekly interval

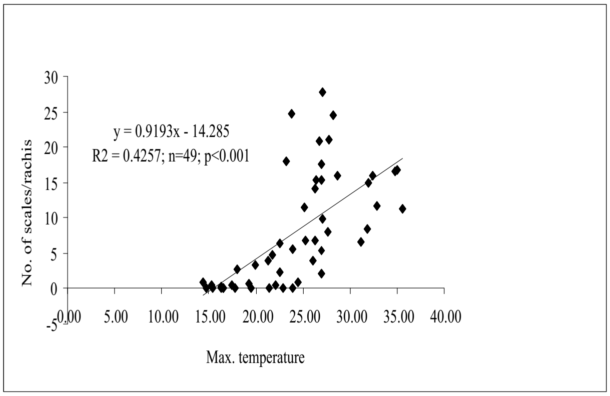


Fig. 4 Correlation between S. oleae populations with maximum temperature

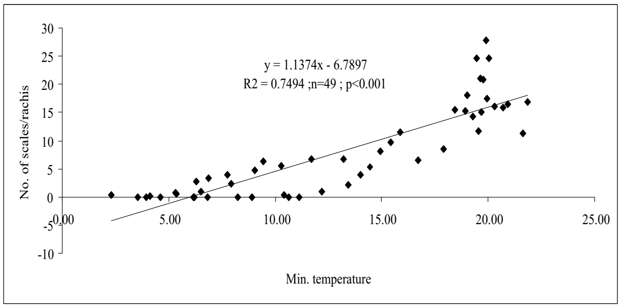


Fig. 5 Correlation between S. oleae populations with minimum temperature

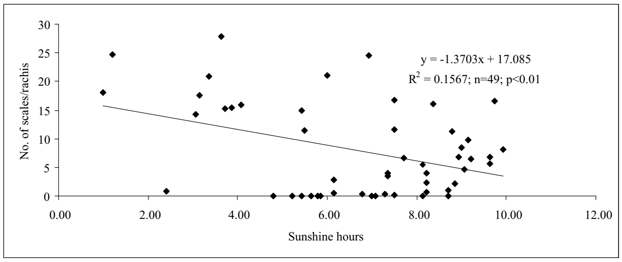


Fig. 8 Correlation between S. oleae populations with sunshine hours

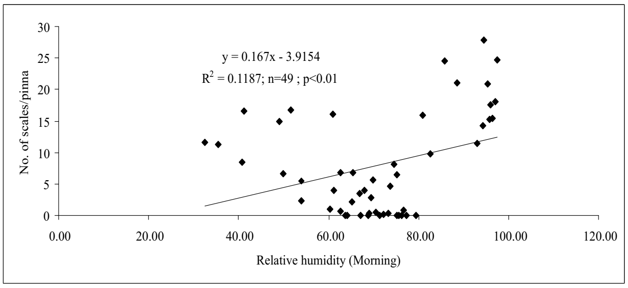


Fig. 6 Correlation between S. oleae populations with relative humidity (Morning)

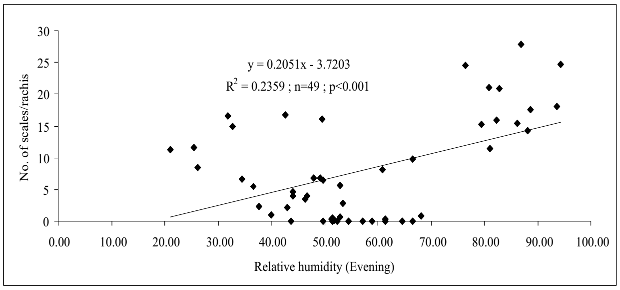


Fig. 7 Correlation between S. oleae population with relative humidity (Evening)

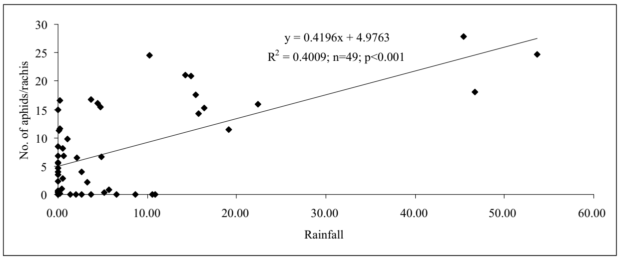
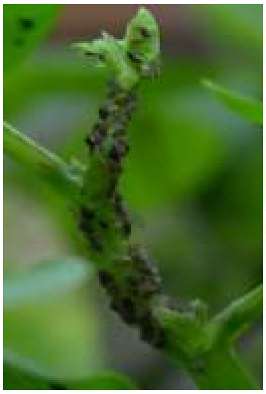


Fig. 9 Correlation between S. oleae populations with rainfall

Development of botanical formulation for the control of pests

Indiscriminate application of synthetic insecticides for the control of pests led to insecticide resistance, resurgence and pesticide residues in agricultural produce affect consumer's health. Use of bio-pesticides for the control of insect pests has increased the global attention. Therefore, it is necessary to develop alternate botanical formulation by using essential oils/plant extracts for the control of pests. Based on screening, the selected essential oils showed promising fumigant activity against stored grain pests (rust red flour beetle and pulse beetle) and residual toxicity against crop pests (aphids and lepidopteron pests) under controlled conditions in the laboratory. Further the selected essential oils for their bio-efficacy against target pests in the field and stored grain pests in the Food Corporation of India (FCI) Go downs are under progress for the preparation and development of botanical formulations.

Diamondback moth in cabbage,



Aphid in cowpea

Rust red flour beetle in wheat

Publications

Koundal R, Dolma SK, Chand G, Agnihotri VK and Reddy SGE (2018) Chemical composition and insecticidal properties of essential oils against diamondback moth, *Plutella xylostella* (L.). Toxin Reviews, DOI:10.1080/ 15569543. 208. 1536668.

Rana R, Dolma SK, Maurya SK and Reddy SGE (2018) Insecticidal activity and structure–activity relationship of sugar embedded macrocycles for the control of aphid (*Aphis craccivora* Koch). Toxin Reviews, DOI:10.1080/ 15569543. 2018.1498897.

Reddy SGE and Kumari A (2019) Seasonal incidence of black scale, Saissetia oleae (Olivier) on the fern, Thelypteris tylodes (Kunze) from western Himalaya. Indian Journal of Experimental Biology, 57: 59-62.

Reddy SGE and Sahotra S (2018) Multiplication of entomopathogenic fungus (*Lecanicillium lecanii*) on apple pomace and its toxicity against aphid (*Aphis craccivora*), Toxin Reviews, DOI:10.1080/15569543.2018.1504222.

Left to Right: Ms. Nandita Chauhan, Ms. SK Dolma, Dr. SGE Reddy, Mr. C.S. Jayaram and Mr. Neeraj Kumar

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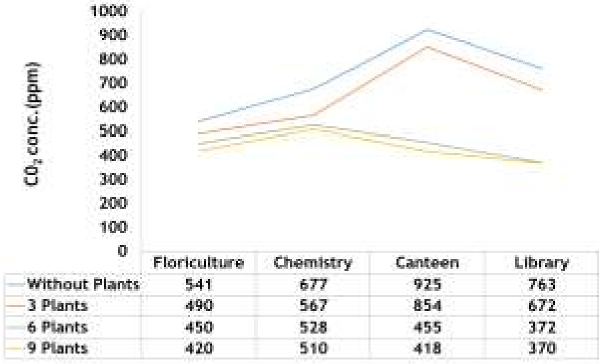
Floriculture

Indoor Air Pollution Abatement

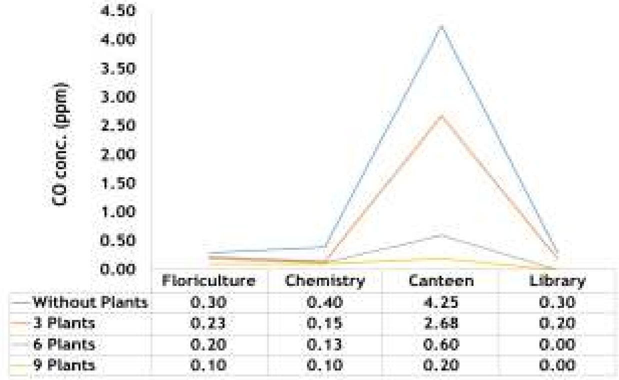
Indoor air pollution is a major environmental threat as the indoor air contains a large consortium of volatile organic compounds (VOCs) that are rendered harmful to human health. Several common house plants can improve the health by helping to fight these pollutants indoor.

The real time readings of total volatile organic compounds (TVOCs), CO2 and CO with three, six and nine potted plants of areca palm (*Dypsis lutescens*) at weekly interval were recorded at four different sites i.e. Floriculture lab, Chemistry lab, Canteen and Library of CSIR-IHBT using Q-TRAK Indoor Air Quality Monitor (Model 7575, TSI Corp.). The data depicted the effectiveness of areca palm plants in reducing the levels of TVOCs, CO2 and CO from all the sites with the increase in number of plants to a maximum of nine plants. Areca palm was successful reduced CO2 up to 54.80% in canteen site followed by library (51.50%), chemistry laboratory (24.70%) and floriculture laboratory (22.40%) whereas, CO reduction was observed maximum (100%) in library followed by canteen (95.30%), chemistry laboratory (75%) and floriculture laboratory (66.70%). The highest reduction of TVOCs was observed in library (87.4%) followed by canteen (83.20%), floriculture laboratory (73.30%) and chemistry laboratory (43.70%) Fig. 1-3.



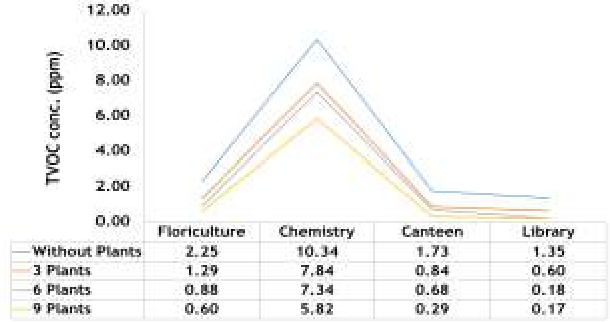
	Floriculture	Chemistry	Canteen	Library
Without Plants	541	677	925	763
3 Plants	490	567	854	672
6 Plants	450	528	455	372
9 Plants	420	510	418	370

Fig. 1 Variations in indoor CO2 concentration (ppm)



	Floriculture	Chemistry	Canteen	Library
Without Plants	0.30	0.40	4.25	0.30
3 Plants	0.23	0.15	2.68	0.20
6 Plants	0.20	0.13	0.60	0.00
9 Plants	0.10	0.10	0.20	0.00

Fig. 2 Variations in indoor concentrations of CO (ppm)



	Floriculture	Chemistry	Canteen	Library
Without Plants	2.25	10.34	1.73	1.35
3 Plants	1.29	7.84	0.84	0.60
6 Plants	0.88	7.34	0.68	0.18
9 Plants	0.60	5.82	0.29	0.17

Fig. 3 Variations in indoor concentrations of TVOCs (ppm)

Effect of foliar application of gibberlic acid (GA3) on flowering of Calla Lily (*Zantedeschia aethiopica* var 'Him Shweta')

Four different concentrations of GA3 (viz. 25, 50, 100 and 200 ppm) in three durations i.e. S1 (One time), S2 (Two times) and S3 (Three times) was sprayed on two years old Calla lily plants at 15 days' interval. The perusal of data depicted tallest spike (86.61 cm), spathe length (15.98 cm), spadix length (9.69 cm) for T1S2 whereas, largest spathe width (10.97 cm) and spike diameter in T3S2 and control, respectively (Table 1).

Table 1 Effect of foliar application on morphological characters of *Calla lily*

Treatments	No. of spikes	Spike length (cm)	Spathe length (cm)
T_1S_1	6	56.14	11.26
T_1S_2	10	86.61	15.98
T_1S_3	6	51.74	12.46
T_2S_1	5	58.43	12.74
T_2S_2	7	63.41	12.84
T_2S_3	6	55.08	11.28
T_3S_1	5	57.83	12.54
T_3S_2	5	48.18	11.20
T_3S_3	5	52.63	11.74
T_4S_1	5	51.99	11.79
T_4S_2	4	54.38	11.00
T_4S_3	3	54.83	11.41
CONTROL	6	70.39	14.45

Conservation of *Eremostachys superba* Royle ex Benth.

E. superba (Lamiaceae) distributed in lower Himalayan belt at an altitude of 700-1400m. The species is vulnerable due to its overexploitation (tuberous roots used to increase lactation in cattle) and habitat loss (natural habitat encroached for cultivation). In India it is nearly extinct from its type locality (Kheree Pass, Dehradun, Uttarakhand) and is now known only from ten localities of Jammu & Kashmir, Himachal Pradesh and Uttarakhand in India. For its conservation and multiplication, five field tours were conducted to Khundian, Mahadev, Mor and Jakhlad villages of Kangra district (HP). About 60 plants were collected and planted in Botanical Garden of CSIR-IHBT, Palampur and phenological changes were recorded. Plant is robust, softly hairy, perennial herb up to 1.5 tall, root thick, stems simple, 40-80 cm; leaves oblong outline, ovate-lanceolate to lanceolate, spinulose; calyx broadly ovate-campanulate, 12-15 mm, teeth ending in 1-2 mm spines, corolla 25-30 mm, yellow; lower lip sub equal to or longer. Nutlets 7 x 3.5 mm, brown, black and trigonous.

Fig. 4 E. superba plant in polyhouses

Fig. 5 Flowering Stage

Micro-propagation of orchids

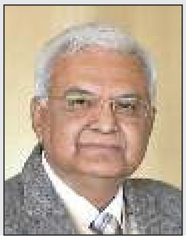
For the in-vitro propagation of orchids, full strength MS medium and Knudson C Orchid medium were selected. The percentage success of propagation was reported maximum (90%) in full strength MS medium as compared to Knudson C Orchid medium (82.5%). For shoot multiplication, Full strength MS medium + 0.2mg/L TDZ + 0.1mg/L BAP and Knudson C Orchid medium+ 0.2mg/L TDZ + 0.1mg/L BAP were selected and the best shoot growth was found in full strength MS medium (Fig. 6-7).

Fig. 6 Initiation of in vitro cultures of orchids

Fig. 7 Shoot multiplication

Left to Right: Balwant Raj, Saurabh Kumar, Dr. Bhavya Bhargava Seema Chauhan, Anjali Chandel, Ujala, Diksha Sharma, Anjali Rakwal.

Biotechnology



Sanjay Kumar, Director
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Plant Adaptation and High Altitude Biology

Novel mechanism to reduce photorespiratory losses

Efforts to improve photosynthesis in crop plants to enhance yield continues to be of research interest globally. One of the ways to do so is by minimising photorespiratory loss of carbon (C) and nitrogen (N) in the form of CO_2 and NH_3, respectively. Rubisco engineering and transfer of C_4 genes in to C_3 plants for photorespiration reduction in plants has met limiting success especially when improvement in growth and yield is considered. Significantly, our previous work identified a photosynthetic shift in high altitude (HA) grown plant which tends to conserve both C and N in the harsh environment of HA. Plants at HA exhibited higher activities of phosphoenolpyruvate carboxylase (PEPcase), aspartate aminotransferase (AspAT), glutamine synthetase (GS), ribulose-1,5-bisphosphate carboxylase/oxygenase (Rubisco). While PEPcase could sequester CO_2 from atmosphere and/or that generated metabolically, combined activities AspAT and GS would channelize oxaloacetate towards aspartate synthesis using glutamate as a source of ammonia (Kumar et al., Photosynthesis Research, 2006, 88(1) : 63-71). In order to provide functional evidence for the efficiency of proposed C sequestration pathway observed at HA, transgenic lines of *Arabidopsis thaliana* coexpressing *PEPcase*, *AspAT* and *GS* were successfully developed. Transgenic lines showed improved photosynthetic rates, higher shoot biomass accumulation, and improved seed yield in comparison with wild-type plants under both optimum and limiting N conditions (Fig.1). Tracer experiments using $NaH_{14}CO_3$ suggested that the coexpression of *PEPcase*, *AspAT* and *GS* resulted in a higher flux of assimilated CO_2 toward sugars and amino acids. More significantly, transgenic lines showed higher capacity to re-assimilate both CO_2 and NH_3 evolved during the process of photorespiration (Kaachra et al., 2018). The work therefore showed an alternative strategy to tackle the loss of C and N associated with photorespiration and is well appreciated by the F1000 prime group (a faculty of more than 8,000 international leading experts in biology and medicine).

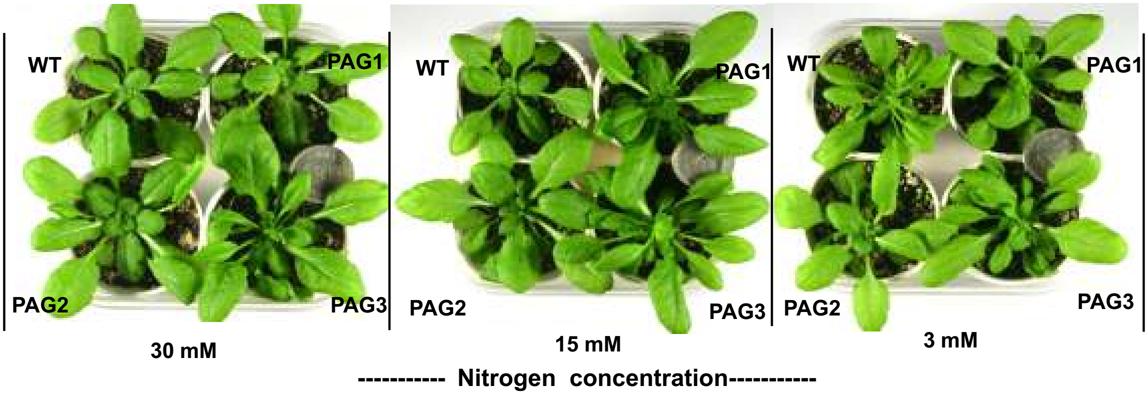

Fig. 1 Effects of different N treatments on the growth of 50-d-old plants of the wild type (WT) and transgenic lines (PAG1, PAG2, and PAG3) of *Arabidopsis* coexpressing *PEPcase, AspAT* and GS

My group is also involved in metabolic engineering for secondary metabolites including biotransformations, genomics, improvement of superoxide dismutase (SOD) and assessing it's role plants, establishing role of polyphenol oxidase (CsPPO) in plants, and understanding the biology of interesting processes in plants in Himalayas

Publications

Kaachra A, Vats SK and Kumar S (2018) Heterologous expression of key C and N metabolic enzymes improves re-assimilation of photorespired CO_2 and NH_3, and growth. Plant Physiology, 177(4): 1396-1409.

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Kumar R, Acharya V, Singh D and Kumar S (2018) Strategies for high-altitude adaptation revealed from high-quality draft genome of non-violacein producing Janthinobacterium lividum ERGS5: 01. Standards in Genomic Sciences, 13(1): 11.

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In vitro systems for generation of sustainable plant resources of western Himalaya and their improvement

Major focus of the group is conservation and improvement of commercially important plants of western Himalaya. Therefore, studies are being undertaken to gain basic understanding of the biology of medicinal plants, saffron and ferns, with an aim to develop *in vitro* systems of plant regeneration, secondary metabolite production and genetic modification of crop plants. Significant contributions are being made towards *in vitro* mass multiplication and rehabilitation of rare, endangered and threatened medicinal plants. These activities are being carried out under the CSIR-Phytopharmaceutical Mission and the CSIR-Niche Creating Project entitled 'Conservation and sustainable resource generation of high altitude bioresources at CSIR-Centre for High Altitude Biology'. In addition, *in vitro* propagation of potato, apple rootstocks, bamboo, flower and other crops is being undertaken to cater to the demands of the industry. Other major activities of the group include incubation of new entrepreneurs and training of young graduates/post-graduate students in plant tissue culture in order to increase their employability.

Production of disease free planting material of saffron through *in vitro* approaches

In continuation to our previous activity, disease free corms of saffron were produced under *in vitro* conditions. A total of 600 g of tissue culture raised cormlets ranging from <1.0 to 4.5 g were sown in farmers field during November, 2017. The corms were allowed to sprout in winter and grow vegetatively for 5-6 months. Finally, 1.5 kg corms were harvested during March, 2018 and graded into 1.0, 3.0 and 4.5 g categories. These were stored at 15±2°C for 6 months and then re-sown in farmers field during November, 2018. After a span of six months, harvested corms showed two fold increase in weight and multiplication rate. About 1.5 kg of corms ranging from 7.0-12g and about 1.0 kg of corms weighing below 7.0 g were harvested. The study showed that the *in vitro* protocol developed at CSIR-IHBT can be used to raise disease free corms of commercial size within a span of 18 months. This can reverse the progressive decline in the yield of saffron due to acute un-availability of good quality, disease free corms - the only planting material in saffron (Fig. 1).

Fig. 1 Harvesting and grading of corms (initially raised through tissue culture) after 18 months of sowing

Development of alternative systems for *Nardostachys jatamansi*– An endangered medicinal plant of western Himalaya

N. jatamansi is an economically important medicinal plant of the Himalayan region. Roots and rhizomes of the plant are used in traditional systems of medicine. Hair oils made from the rhizomes are sold in global markets for their hair growth and good texture promoting properties. The rhizomes are the source of important sesquiterpenes like jatamansone, valerenic acid, nardin, jatamanshic acid etc. The plant has become critically endangered according to IUCN Red list of Threatened plant species due to indiscriminate harvesting of under-ground parts. Therefore, cell cultures of *N. jatamansi* from leaf explants were developed as an alternative system for secondary metabolite production. Non-targeted metabolite profiling/UPLC-MS analysis of the callus cultures revealed the presence of important metabolites including terpenoids and phenolics (Fig. 2).

Fig. 2 Development of callus cultures from leaf explants of *N. jatamansi* growing under green house conditions

Transcriptome of bamboo during floral transition facilitate the conservation of juvenile plants

All clonal populations of bamboo remember their age and die *en masse* after gregarious flowering. It is impossible to identify juvenile plants from the ones that are ready to flower and die. This is because of the total absence of specifiers of floral transition. Conservation of physiologically mature germplasm of bamboo is not possible, as yet. In order to overcome this problem, the transcriptome of *in vitro* shoots of bamboo during their transition from vegetative to flowering phase was studied. The aim was to identify specifiers/markers differentiating juvenile and about-to-flower shoots. A total of 128 differentially expressed genes of floral transition were identified. Among these, ZCO14, ZCO15, VIN3, GR6 and AP2 were selected as major specifiers of floral transition. All the five genes were validated through real time using *in vitro* as well as *in vivo* tissues. RACE PCR was performed to obtain the full length sequence of only GR6, a key gene in the GA pathway and floral transition. After sequencing, the gene was found to have a full length sequence of 2600 bp. For future validation of the floral transition genes of bamboo, a genetic transformation method for HPR2143 variety of rice was standardized using the PDS 1000/He biolistic gun. Optimized parameters like target distance (9.0 cm), gap distance (0.6 cm), micro carrier flight distance (0.16 cm) and variable burst pressures (900, 1100 and 1350 psi) were used for the transformation of the somatic embryos. As opposed to untransformed control, strong fluorescent signals of *gfp* was recorded only in somatic embryos bombarded at 1100 psi. This paved the way for future validation of floral transition genes in rice (Fig. 3-4).

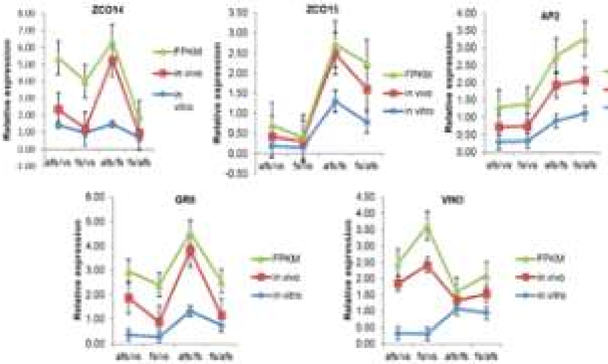


Fig. 3 Relative expression pattern of floral transition genes, identified through transcriptome and qRT-PCR of *in vitro* and *in vivo* systems (a) ZCO14 (b), ZCO15 (c), AP2 (d) GR6 and (e) VIN3

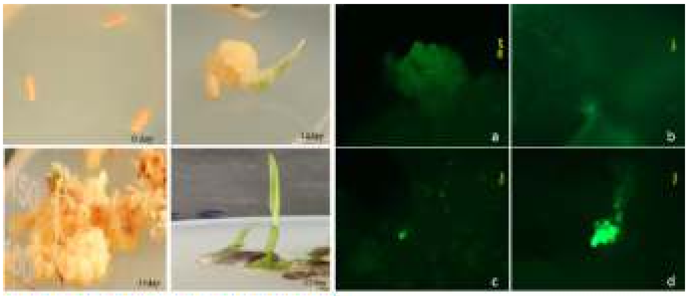


Fig. 4 Indirect somatic embryogenesis (a-d) *gfp* expression in putatively transformed somatic embryos of HPR2143 variety of rice after (a) 12 h (b) 24 h (c) 48 h and (d) 120 h

Proteome of haploid gametophytes of *Diplazium maximum* reveals the mechanism underlying gametophyte multiplication and sexual mode of reproduction

Gametophytes being small, haploid, free-living and exploratory entities in the life cycle of ferns were expected to sense even mild changes in their micro environment. Thus, when gametophytes of *Diplazium maximum*, an edible Himalayan fern of family, Athyraciae were subjected to 1 and 3% sucrose, major changes in their morphogenetic responses were recorded. The two-dimensional green prothallial stage of gametophytes changed into rapidly multiplying clumps of three-dimensional prothalli at 3% sucrose. As a result, the water retention ability of the gametophytes was considerably, enhanced. In proteomics of the gametophytes, significant up-regulation of a number of drought tolerant proteins was recorded. While normal and healthy sporophytes developed from gametophyte notches at 1% sucrose, only spindly sporophytes developed at 3%. This was associated with up-regulation of proteins involved in sporophyte formation. Besides having immense potential in crop improvement programs, the identified proteins can be used to modulate the morphogenetic response in *D. maximum*, a fern known for its high nutraceutical potential (Fig. 5).

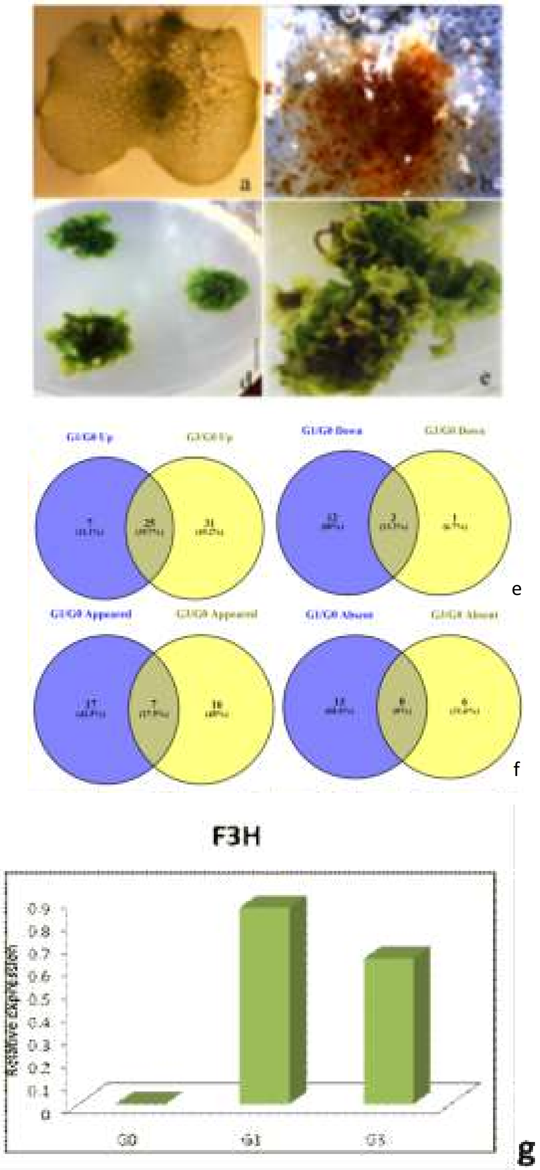


Fig. 5 *D. maximum* gametophytes in response to 1 and 3% sucrose (a-e) *In vitro* response (f) Venn's diagram showing differential expression of proteins in response to sucrose (g) qRT-PCR expression of F3H gene

Rescuing medicinal plants of Himalayas from their rare endangered and threatened status

In continuation to our work under the CSIR-Phytopharmaceutical Mission, and the CSIR-Niche Creating Project entitled 'Conservation and sustainable resource generation of high altitude bioresources at CSIR-Centre for High Altitude Biology', several thousand plants of

Picrorhiza kurroa and *Aconitum heterophyllum* were rehabilitated in their natural habitats of H.P. Moreover, efficient protocols for shoot cultures and bulb production in *Fritillaria roylei,* the endangered medicinal herb of family Liliaceae was developed and transferred to natural habitat (Fig. 6).

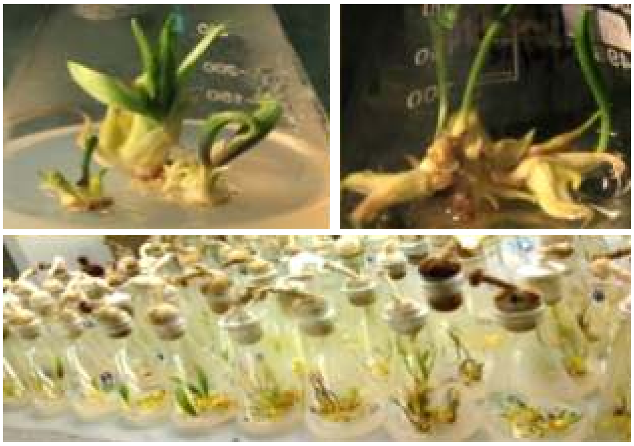


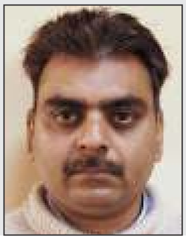
Fig. 6 Micropropagation of *Fritillaria roylei*

Skill Development Program on Advanced Diploma in Plant tissue culture

Under a DBT sponsored project, 15 students from different parts of the country are being trained in advances in plant tissue culture. Applications received after advertisement in national dailies were screened, and eligible candidates were called for a written test at the institute. Students who qualified the test were then enrolled for the training. The aim is to motivate the students towards entrepreneurship (Fig. 7).

Fig. 7 Training on advances in plant tissue culture

Left to Right: Isha Sharma, Rimpy Dhiman, Preksha, Sunaina, Neetu Gautam, Parveen Sharma, Ajay Kumar and Om Prakash
Back 2nd Row: Nisha Dhiman, Amiraj, Bhuvnesh Sareen, Surinder, Titak, Sundeep and Asheesh



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Plant microbe interaction of plant viral pathogens

The lab works in the area of Plant microbe interaction involving viral pathogens, molecular characterization, epidemiology and farmer friendly diagnostics for commercially important crop viruses. Current projects where the lab is associated deals with plant microbe vector interaction of apple scar skin viroid-whitefly system and point of care diagnostics against apple and tomato viruses (both projects part of Agri Nutri Biotech theme).

Ficus palmata is natural host of Apple stem grooving virus

Ficus palmata was found to exhibit necrotic and chlorotic spots, chlorosis, leaf deformation and marginal chlorosis (Fig. 1). Results of the three detection techniques revealed the presence of ASGV in 15/30 tested samples, thereby confirming the presence of ASGV in 50% of the samples. When tested for other apple viruses, viz., *Apple stem grooving virus* (ASGV), Apple chlorotic leafspot virus (ACLSV), *Apple stem pitting virus* (ASPV) and *Apple mosaic virus* (ApMV) by multiplex RT-PCR, only ASGV could be found in these Ficus samples. The five characterized isolates grouped into two separate clusters and shared 88.5–100% (nt) and 95.3–100% (aa) sequence identity among themselves. The isolate could be transmitted to *C. amaranticolor*, *C. quinoa*, *Cucumis sativus*, *Phaseolus vulgaris*, *Nicotiana benthamiana* and *N. glutinosa*.

Picrorhiza kurroa plantations are naturally infected by alternanthera yellow vein virus and cotton leaf curl Multan betasatellite

Picrorhiza kurroa is an ethnopharmacologically important endangered medicinal herb and is traditionally used in Indian Ayurvedic medicine in several preparations. The plant grows as a wild population at an altitude between 3200 and 4500 m.

Leaf curl, yellow mosaic and leaf puckering symptoms were observed on *P. kurroa* grown in a greenhouse at CSIR-IHBT, Palampur, Himachal Pradesh, India (Fig. 2). Work done in collaboration with the Agrotechnology division of the institute has identified the presence of a begomovirus and a betasatellite in all symptomatic plants. The complete sequence analysis of begomovirus and betasatellite characterized their identity as alternanthera yellow vein virus (AlYVV) and cotton leaf curl Multan betasatellite (CLCuMuB), respectively.

Rumex nepalensis as off season host of Tomato leaf curl virus

Rumex nepalensis (Nepal Dock) is an Indian traditional medicinal herb of the Western Himalayas. Typical begomovirus-like symptoms were observed on *R. nepalensis* growing in the forests in Bandla region of Palampur, Himachal Pradesh. Tomato leaf curl virus and cotton leaf curl Multan betasatellite (CLCuMuB) were identified from the sample collected. Infectious clones of the virus and betasatellite were agro-infiltrated on both natural (*R. nepalensis*) as well as experimental (*Nicotiana benthamiana*) hosts. At 25 days post infiltration (dpi), *N. benthamiana* developed typical virus symptoms in DNA-A+DNA-B and DNA-A+DNA-B+CLCuMuB-infiltrated plants, whereas the plants infiltrated with DNA-A alone did not show any diseased phenotype. However, in combination with CLCuMuB, mild symptoms were observed. Agro-infiltrated *R. nepalensis*, plants did not show visible symptoms but were found to be positive by PCR and southern blot analysis. The present report shows *R. nepalensis* as a new natural host of the bipartite TLCV associated with CLCuMuB. It also demonstrated the efficient *trans*-replication compatibility of CLCuMuB by TLCV in both of its natural and experimental hosts.

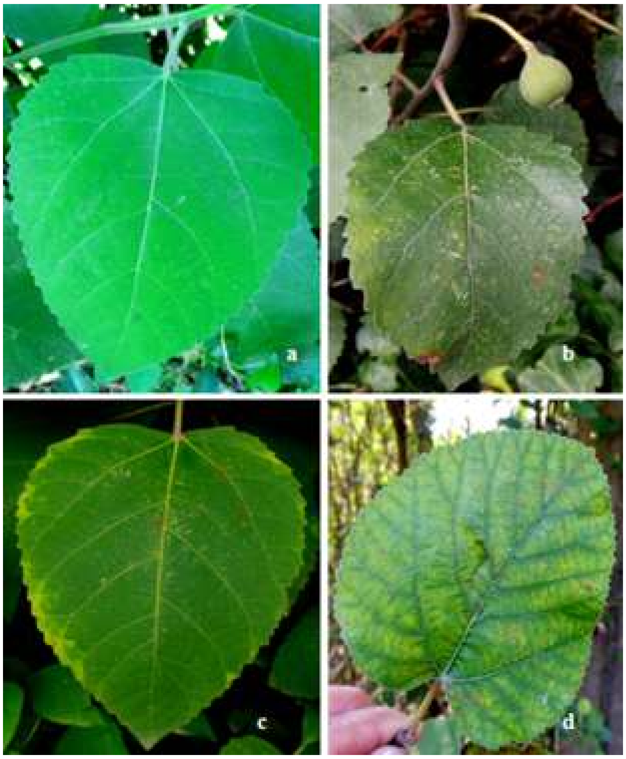


Fig. 1 Virus-like symptoms on *Ficus palmata* a) Healthy leaf, b) Chlorotic and necrotic spots along with leaf deformation, c) Chlorotic spots along with the chlorosis along the margin of the leaf, d) Chlorosis

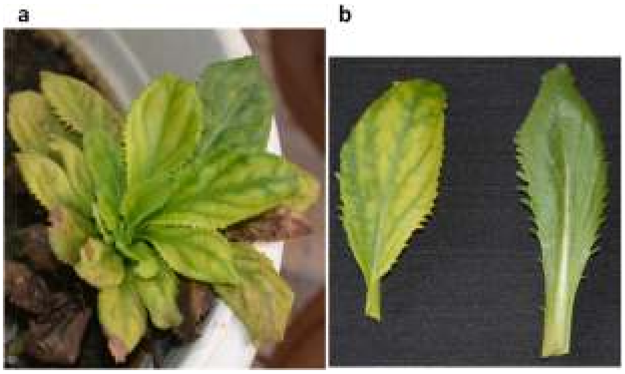


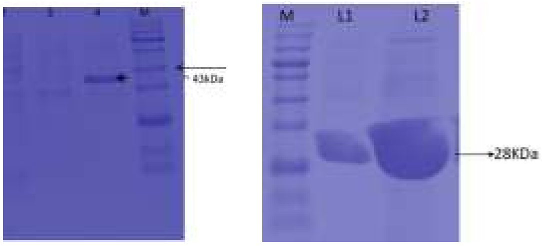
Fig. 2 Typical leaf curl, yellow mosaic and leaf puckering symptoms on *P. kurroa* (a), closeup view of a leaf from infected (left) and healthy plant (right)

FAST TRACK TRANSLATIONAL PROJECTS

1. Rapid and point care microfluidic systems for multiplex diagnosis of viral diseases in tomato and apple (CSIR-IMMT Nodal lab and CSIR-IHBT-participating lab)

The project aims at development of "Point of Care" diagnostics for plant viruses infecting apple and tomato. The existing diagnosis of plant diseases is being carried out at laboratories and at some farmer supporting centers. Such services are still not yet reached to the knowledge and vicinity of major farmer communities, particularly to remote villages. In this context, the vision of this proposal is to bring the diagnosis from laboratory to the field of farming; that too, to be performed by farmer at his / her least affordable price. Such diagnosis should be available starting from seedling stage to harvesting.

A microfluidic kit has been proposed to be developed for such kind of diagnosis of common viral diseases in both tomato and apple. Essentially this proposal is an interdisciplinary product development with proven readiness of key technologies. For example, the design of kit with network of multiple parallel arrays as required for diagnosis of multiple viruses at a time is well demonstrated for multiplex format of sample splitting. Similarly, the color development along the transparent micro arrays of PDMS is well demonstrated by sandwich ELISA. Also, a simple method for bulk fabrication, and contamination free coating of antibodies and other necessary bio chemicals



Heterologous expression of Apple chlorotic leaf spot virus and Cucumber mosaic virus in pET28 vector system

even in bulk of kits is well demonstrated. However, the demonstration for multiplex diagnosis is yet to be attempted for which we have a simple work plan for integration of the well practicing concept of lateral flow assay with multiplex format of capillary action as we demonstrated the later one in our proposed microfluidic kit. Then we can conduct common laboratory practices for optimization of protocol in order to achieve the standards of sensitivity and specificity for diagnosis at both laboratory and field trials. The performance of these kits will be validated with those available for laboratory practices like ELISA kits for similar diagnosis.

Currently, development of antisera for testing at lab level for efficacy is in process. Capsid Proteins from Cucumber mosaic virus, Apple stem grooving virus and Apple chlorotic leaf spot virus have been expressed and purified. Process for development of antisera has been started.

Molecular mechanism underlying apple scar skin viroid-whitefly interaction (NCP)

Viroids are the smallest known plant pathogens known to cause serious damage and deformities, especially to the fruits and flowers in a range of crops. Induced effects include small size, crinkling, russeting, flatness, colour breaking, deformation etc. Recently, it has been shown (in this lab) that Apple scar skin viroid (ASSVd) is transmitted by greenhouse whitefly (WF) Trialeurodes vaporariorum (Tv). Evidences show that ASSVd is acquired and transmitted by the fly as a ribonucleoprotein complex. However, association of the viroid RNA with factors such as proteins from Tv for Acquisition, Replication, Processing and Transmission (ARPT) are not known. The project aims to understand viroid-insect association keeping in view the above. The work will be helpful in identifying whitefly proteome dynamics, replication of the viroid in WF and model insect and animal cell systems and factors/ proteins which are absolutely required for the various functions. Following results have been obtained:

The multiplication of ASSVd transcript in Chinese hamster ovary cell (CHOK-1) cells has been achieved.

Viroid interacting whitefly protein small heat shock protein (SHSP) has been identified by Northwestern and MALDI-TOF analysis.

Molecular docking of ASSVd viroid and small Heat shock protein (SHSP) was carried out by ZDOCK tool available in BIOVIA Discovery Studio software package and found that the SHSP-site3 - RNA-site1 complex had more affinity towards Viroid RNA

NCP & FBR

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The multiplication of ASSVd transcript in animal cells has been achieved.

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Publications

Bhardwaj P and Hallan V (2018) Molecular evidence of Apple stem grooving virus infecting *Ficus palmata*. Trees, DOI.org/10.1007/s00468-018-1752-6.

Chaudhary P, Kumari R, Singh B, Hallan V and Nagpal AK (2018) First report of potato virus M, potato virus Y and cucumber mosaic virus infection in *Solanum nigrum* in India. Journal of Plant Pathology, DOI.org/10.1007/s42161-018-0194-8.

Chaudhary P, Kumar S, Singh B, Hallan V and Nagpal AK (2018) Infection of potato virus S and M in tomato in North-western India. Journal of Plant Pathology, DOI: https://doi.org/10.1007/s42161-018-0194-8.

Sharma D, Kulshreshtha A, Kumar R and Hallan V (2018) First report of natural infection of alternanthera yellow vein virus and cotton leaf curl Multan betasatellite on a new host *Picrorhiza kurroa*, an important endangered medicinal herb. Journal of Plant Pathology, DOI.org/10.1007/s42161-018-0123-x.

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Our current efforts to utilize Next -Generation Molecular Genetics and Genomics approaches for harnessing natural diversity for genetic improvement of Himalayan plant genetic resources and commercial important plant species. I am the Key Investigator to CSIR Mission projects on Phytopharmaceutical, Aroma, and Fundamental Basic Research (FBR), and various projects sponsored by DST, DBT and NTRF, including international Indo-Sri Lanka joint research project on tea.

During the period under report following achievements were made by the group:

Genome-wide transcriptional dissection of self-incompatibility (SI) and fertilization in tea

The incapacity for self-pollination impeding self-fertilization is defined as self-incompatibility (SI). Tea (*Camellia sinensis* (L) Kuntze), despite of the high economic value, breeding efforts made for its genetic improvement are obtuse due to high outcrossing nature (allogamy), profuse phenotypic variation, perennial, long gestation periods, high inbreeding depression and self-incompatibility contributing tremendous heterozygosity in tea. Hence, conventional clonal propagation is preferred over natural propagation to maintain the quality lines.

The study explicates molecular insights commencing self-incompatibility (SI) and CC (cross-compatibility/fertilization) in self (SP) and cross (CP) pollinated pistils of tea. The fluorescence microscopy analysis revealed ceased/deviated pollen tubes in SP, while successful fertilization was observed in CP at 48 HAP (Fig. 1).

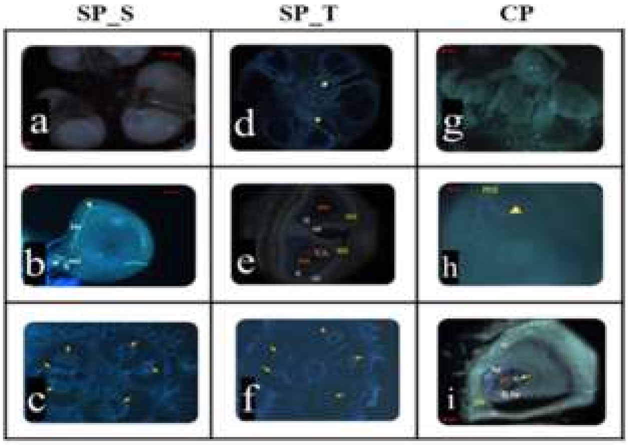

Fig. 1 PTs cessation (a,d,e) and deviation (b) at 48 HAP with abortive ovules (c, f) at 144 HAP in SP ovaries; PT (callose fluorescence) inside ovules (g), PTs infiltrating embryo sac (h), fertilized ovule with degenerated synergid (i) at 48 HAP CP ovaries

Global transcriptome sequencing of SP and CP pistils generated 109.7 million reads with overall 77.9% mapping rate to draft tea genome. Further, concatenated *de novo* assembly resulted into 48,163 transcripts. Functional annotations and enrichment analysis (KEGG & GO) resulted into 3793 differentially expressed genes (DEGs). Among these, *de novo* and reference-based expression analysis identified 195 DEGs involved in pollen-pistil interaction. Interestingly, presence of 182 genes [PT germination & elongation (67), S-locus (11), fertilization (43), disease resistance protein (30) and abscission (31)] in major hub of protein-protein interactome network suggests a complex signalling cascade commencing SI/CC (Fig. 2).

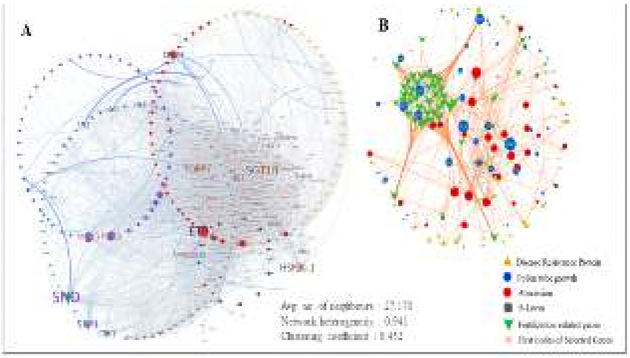

Fig. 2 Predicted protein-protein interactome network of DE transcripts involved in fertilization or Self Incompatibility in tea. (A) A major hub of 182 genes interacting with 343 first neighbours (B) Co-expression network of 169 genes extracted from 182 genes

The higher expression of Exo70A1 in SP_style possibly responsible for the wet type of stigma with higher stigma receptivity in SP than CP at 48 HAP. Furthermore, lower PT density in SP_style can be attributed by upregulated expression of SI related transcripts (csRNS, SRK, SKIP, ADF, pectin lyase, PGLR and Exo-PG). Moreover, csRNS and S-locus related transcripts can be considered as key regulators due to its interactions with many compatibility and incompatibility factors in PPI network analysis. Additionally, indirect interaction of csRNS with ADF suggests its possible role in programmed cell death (PCD) by depolymerization of actin cytoskeletons, hence arresting the self PT growth during GS. Considering an indicator of self-incompatibility, significantly higher expression of Ca+2 transporters recorded in SP pistils may be responsible for higher concentration of Ca+2

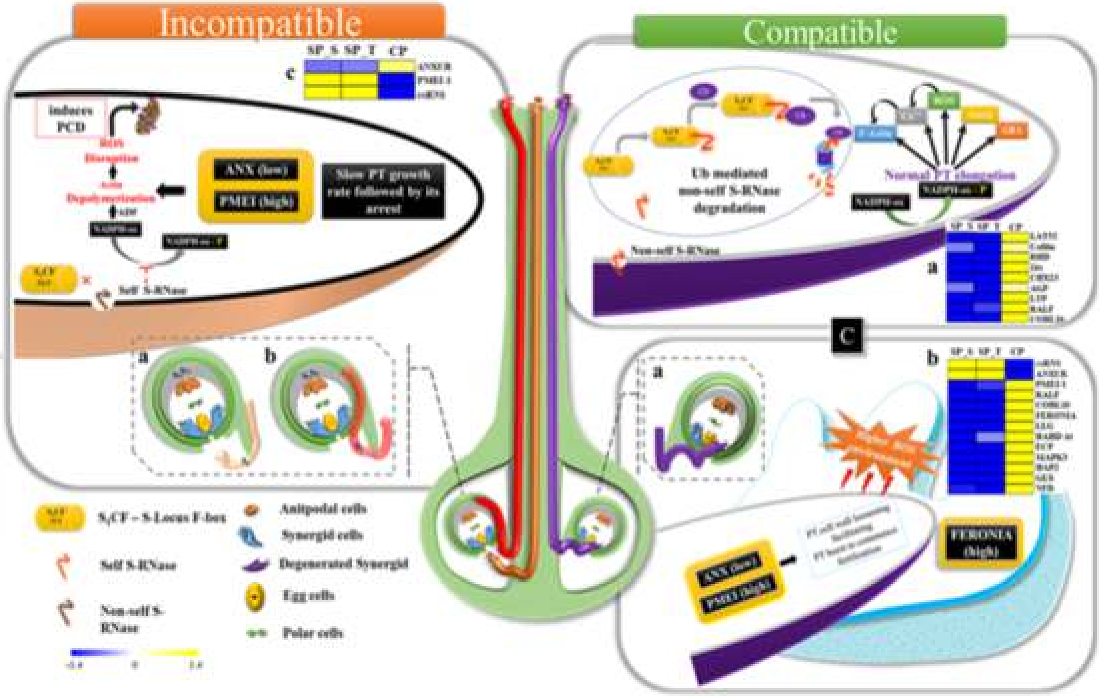

Fig. 3 Summarized illustration representing self-incompatibility and cross-compatibility with tissue specific expression. The PT elongation within self and cross-pollinated pistil [Self PT: deviated (red) and creased (brown), cross PT fertilization (purple)] (A) Ceased (a) and deviated pollen tubes presenting incompatible interactions in style; (B) Normal PT elongation in style in CP as non-self S-RNase undergoes ubiquitin mediated protein degradation.(C) Cross PT growth arrest followed by its burst within synergids commencing fertilization

ions in SP. Nonetheless, the upregulated expression of transcripts involved in normal PT elongation (ANXUR-rlk, LAT52, cysteine rich proteins and RHD) and Ubiquitin-mediated S-RNase degradation (20s, 26s proteasome and SCF complex) may attribute to higher PT density in the CP style. Further, tissue-specific qRT-PCR analysis affirmed localized expression of 42 DE putative key candidates in stigma-style and ovary, and suggested that LSI initiated in style and sustain up to ovary with active involvement of csRNS, SRKs & SKIPs during SP. Nonetheless, COBL10, RALF, FERONIA-rlk, LLG and MAPKs were possibly facilitating fertilization (Fig. 3A, B). The current study, comprehensively unravels molecular insight of phase-specific pollen-pistil interaction during SI and fertilization, which can be utilized to enhance breeding efficiency and genetic improvement in tea.

Functional annotation and characterization of hypothetical protein involved in blister blight tolerance in tea

The efforts were made for assigning functions to HPs derived from RNA-Seq data and successfully identified novel putative candidates involved in BB defense in tea. Domain and family based characterization identified 9390 HPs representing 2867 protein families and 953 super families. Of these, 213 HPs were assigned with novel putative defense related functional categories (LRR, WRKY, NAC, chitinases and peroxidases). Further, sub-cellular localization (cytosolic,133 HPs; transmembranic, 80 HPs) with abundance of HPs exhibiting of acidic (133) and basic (80) nature suggests their wider functional range. 36 HPs upregulated in tolerant genotype having significant interactions with defense responsive candidates in Protein–Protein Interaction Network analysis possibly suggests their key regulatory role in BB defense (Fig. 4).

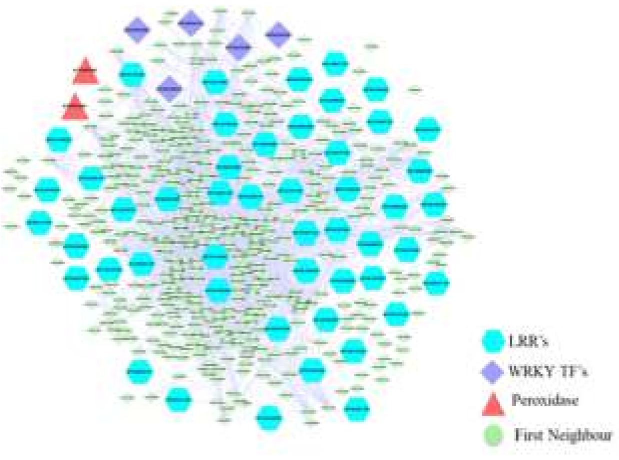

Fig. 4 Representation of protein–protein interaction network of functionally characterized hypothetical proteins related to defense categories

Interestingly, 12 stereo-dynamically stable structures [LRR (5), NAC (4), WRKY, Chitinase & Peroxidase (1 each)] of HP's were successfully modelled based on their conserved signature sequences and empirically validated using qRT-PCR analysis, therefore, can be potential novel candidates possibly involved in signal transduction and pathogen recognition during BB defense in tea. Futuristically, novel genes identified in this study can be potentially utilized to expedite genetic improvement efforts in tea.

Creation of genome-wide functionally relevant EST-SSR Marker Resource for Genetic Diversity and Population Structure Analyses of a Subtropical Bamboo, *Dendrocalamus hamiltonii*

Dendrocalamus hamiltonii is a giant bamboo species native to Indian subcontinent with high economic importance. Nevertheless, highly outcross nature and flowering once in decades impose severe limitation in its propagation. Identification and mixed cultivation of genetically diverse genotypes may assist successful breeding and natural recombination of desirable traits. Characterization of existing genetic diversity and population structure are indispensable for efficient implementation of such strategies, which is facing a major challenge due to non-availability of sequence-based markers for the species. In this study, 8121 EST-SSR markers were mined from D. hamiltonii transcriptome data. Among all, tri-repeats were most represented (52%), with the abundance of CCG/CGG repeat motif (Fig. 5).

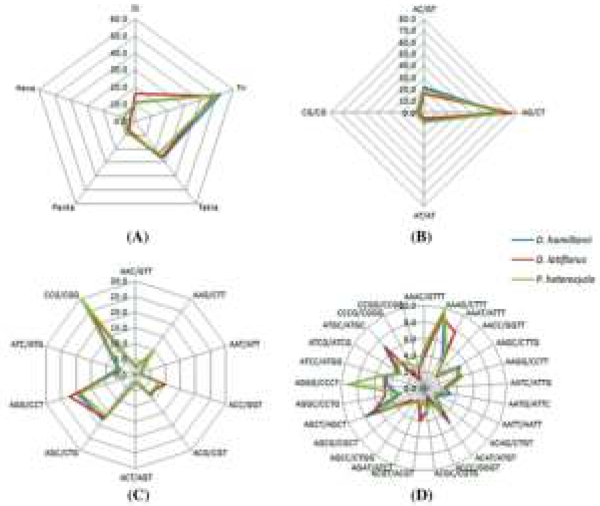

Fig. 5 Comparison of microsatellites in coding regions of three bamboo species: a repeat type and b–d.

A set of 114 polymorphic markers encompassing epigenetic regulators, transcription factors, cell cycle regulators, signaling, and cell wall biogenesis, detected polymorphism and interaction (in silico) with important genes, that might have role in bamboo growth and development. Genetic diversity and population structure of the three D. hamiltonii populations (72 individuals) revealed moderate to high-level genetic diversity (mean alleles per locus: 5.8; mean PIC: 0.44) using neutral EST-SSR markers. AMOVA analysis suggests maximum diversity (59%) exists within population. High genetic differentiation (Gst = 0.338) and low gene flow (Nm = 0.49) were evident among populations. Further, PCoA, dendrogram, and Bayesian STRUCTURE analysis clustered three populations into two major groups based on geographical separations (Fig. 6).

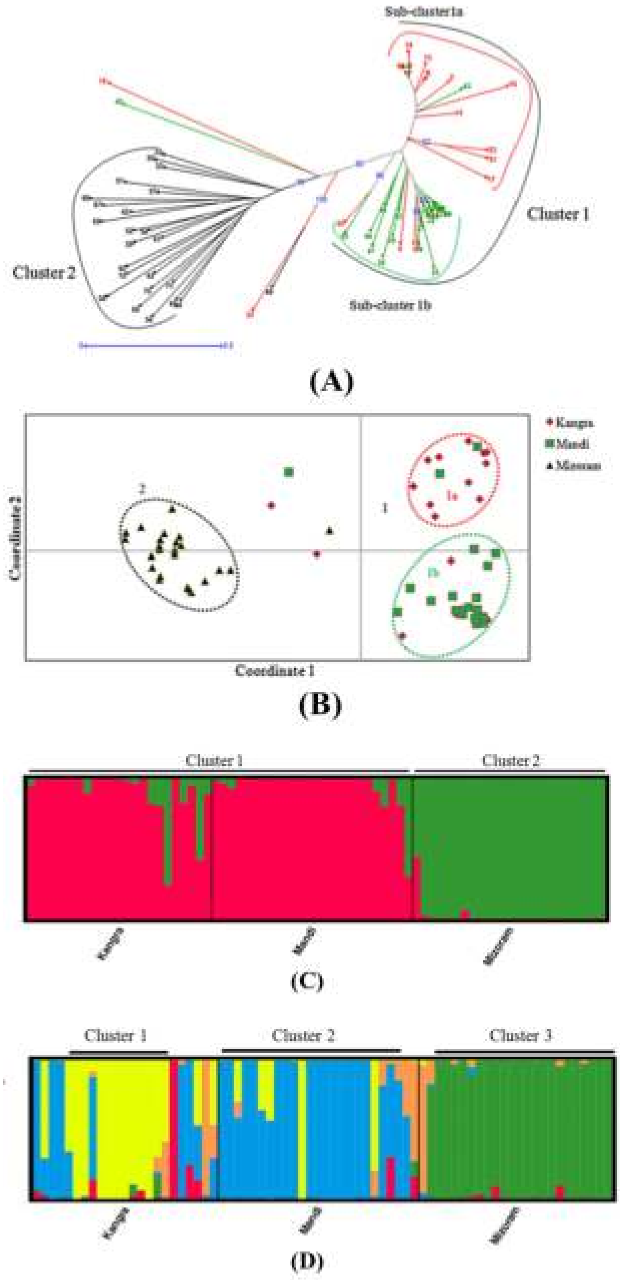

Fig. 6 Clustering pattern and Bayesian model of population genetic structure of 72 D. hamiltonii genotypes: A Neighbor Joining dendrogram based on Jaccard dissimilarity coefficient; (B) Principal coordinates analysis; (C) Genotype wise population structure (K = 2); (D) Genotype wise population structure (K = 5)

In future, SSR marker resources created can be used for systematic breeding and implementation of conservation plans for sustainable utilization of bamboo comple, amongst the most serious leaf diseases, significantly affecting the commercial production of tea. Besides affecting the quality of tea significantly, it causes more than 40% total yield loss. Therefore, it is important to breed tea plants resistant to blister blight. Marker assisted breeding can be of particular importance in this regard.

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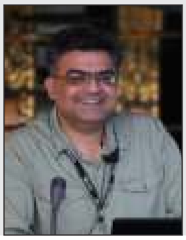

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miRNA miR-876 emerges as the master regulatory of Insulin Resistance

miRNA has been known to regulate diverse cellular and molecular functions. In an earlier study, It was reported that adipocytes differentiated from human mesenchymal stem cells (hMSC) on 72-h chronic insulin (CI) treatment exhibit insulin resistance (IR). Present study has further explored above model to investigate the role of early expressed miRNAs within human adipocytes to modulate differential adipokine expression as observed during IR. Our results highlight that miR-876-3p regulates glucose homeostasis and its dysregulation leads to IR. We found that miR-876-3p level is a critical determinant of adiponectin expression by virtue of its target within adiponectin 3'UTR. Regulatory effect of miR-876-3p impacts crosstalk between adiponectin and insulin signaling. Rosiglitazone treatment in CI-induced IR adipocytes drastically reduced miR-876-3p expression and increased adiponectin level. In line with this, lentiviral-mediated inhibition of miR-876-3p expression ameliorated CI and high-fat diet (HFD)-induced IR in adipocytes differentiated from hMSC and C57BL/6 mice, respectively. Our findings thus suggest that modulating miR-

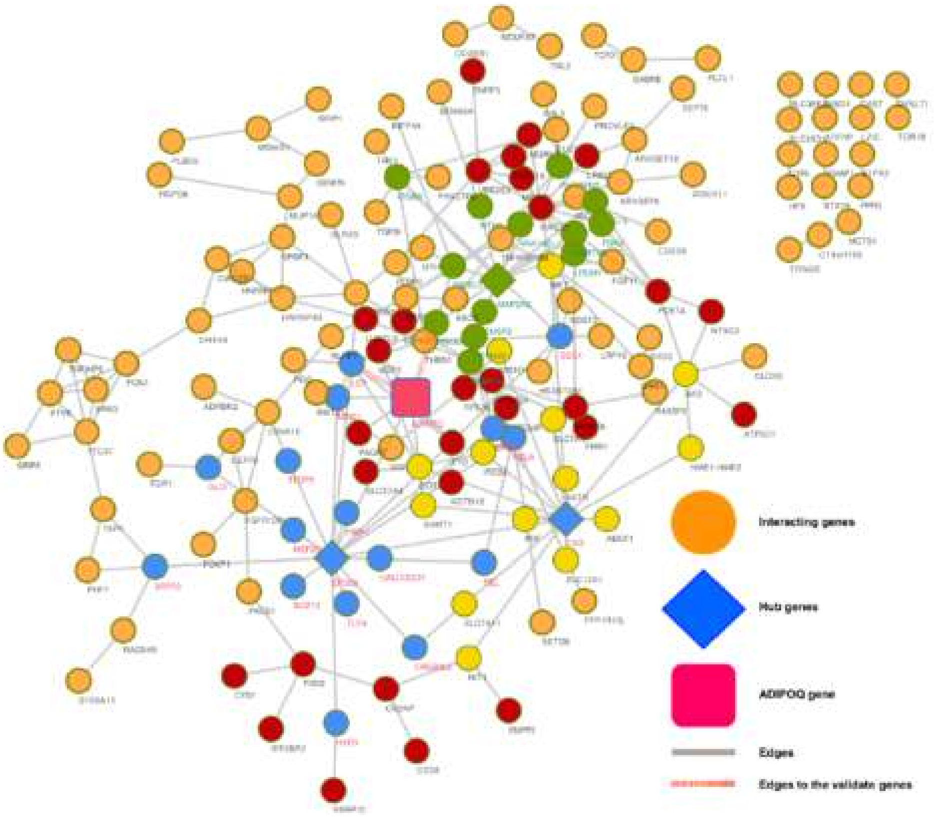

Fig. 1 The miR-876 centric cluster of genes which were found highly enriched for glucose and fatty acids related metabolism

876-3p expression could provide novel opportunities for therapeutic intervention of obesity-associated metabolic syndrome.

A close look with network approach while using miR-876 targets and genes interacting with them revealed that miR-876 is a centre to ~300 genes which are mainly associated with glucose and fatty acids related metabolism. Even Adiponectin also belonged to this same cluster (Fig. 1) shows the miR-876 specific cluster. The entire work was done while performing Next Gen High throughput Sequencing on human samples.

Patent

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Biotechnology (Bioinformatics)

Our group is actively involved in three major areas. First is the target identification of natural bioactive molecule, secondly is the identification of potential lead molecules for plant viruses, and third is the designing & implementing the computational strategies to reduce the bitterness of stevioside. Apart from this, we are also working on several aspects of the structural dynamics of important enzymes. Under Agri-neutri biotech theme, our group is exploring the viroid RNA and its interactions with plant proteins.

Target identification and its validation for Himaliyan bio-active molecules

During last year we worked upon potential lead compounds from a set of pyrrolone-fused benzosuberenes as natural analogues that would facilitate the treatment of epilepsy. Computational approaches were used to identify the target molecule and assist in the screening of active chemical compounds following which the potential anti-seizure effect of these compounds were evaluated using a zebrafish model. α,β,γ-Himachalenes extracted from essential oil of *Cedrus deodara* from which pyrrolone-fused benzosuberene (PBS) compounds were semi-synthesized following amino-vinyl-bromide substituted benzosuberenes as intermediates. These PBSs compounds classified as an attractive source of therapeutics. The α-isoform of PI3K which is a pivotal modulator of PI3K/AKT/mTOR signaling pathway, responsible for neurological disorders like epilepsy, found as a potential target molecule against these 17 PBS compounds using *in silico* ligand-based pharmacophore mapping and target screening. The compounds screened using binding affinities, ADMET properties, and toxicity; which were accessed by *in silico* docking simulations and pharmacokinetics profiling. Ultimately two compounds viz., PBS-8 and PBS-9 were selected for further *in vivo* evaluation using a zebrafish model of pentylenetetrazole (PTZ)-induced clonic seizures. Additionally, gene expression studies were for the genes of the PI3K/AKT/Mtor pathway which was further validated the molecules. In conclusion, these findings suggested that PBS-8 is a promising candidate that could be used in the treatment of epilepsy. Lead molecules showed anti-seizure effect better than the commercially available drug, Wortmannin.

Many anti-epileptic drugs are available in the market which possess significant adverse effects on the health of the individual. This necessitates an urgent need for an effective therapeutic drug against epilepsy with minimal or no side effects. These demands initiated an enormous interest in screening the active therapeutic agents for the treatment of epilepsy. Our present study suggested a potential lead compound that could be used to treat epilepsy by compressing PI3K-α activation. In this direction, we screened and evaluated benzosuberene classes of compounds by *in silico* approaches. To evaluate the activity of the computationally suggested compound(s) against epilepsy, we administered these compounds in clonic seizure modeled zebrafish. The study identified a potential lead compound against epilepsy, and this workflow is presented in Fig. 1. As this compound is naturally derived, therefore it could probably be a better candidate for the therapeutic purpose with more bio-compatibility and less toxicity.

Our group also successfully reported potential molecule which could improve the kinase activity lost due to a key onco-mutation. Aurora A is a mitotic serine/threonine kinase protein that is a proposed target of the first-line anticancer drug design. It has been found to be overexpressed in many human cancer cells, including hematological, breast, and colorectal. Here, we focused on a particular somatic mutant S155R of Aurora kinase A protein, whose activity decreases because of loss of interaction with a TPX2 protein that results in ectopic expression of the Aurora kinase A protein, which contributes chromosome instability, centrosome amplification, and oncogenic transformation.

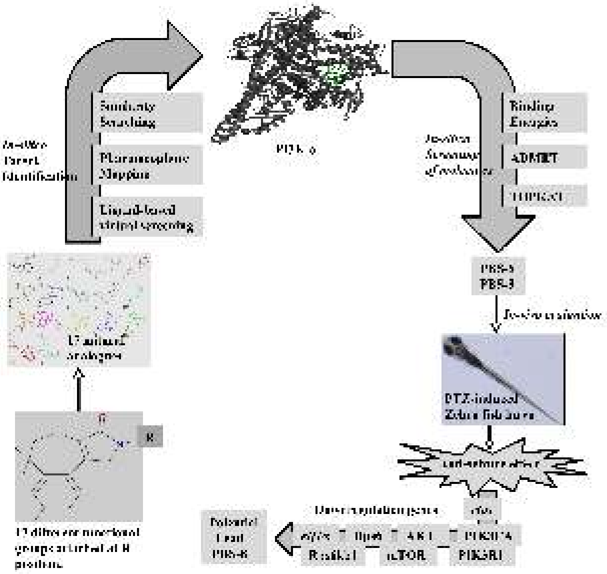

Fig. 1 Overview of computational and experimental analysis of potential lead compounds

The primary target of this study is to select a drug molecule whose binding results in gaining S155R mutant interaction with TPX2. The computational methodology applied in this study involves mapping of hotspots (for uncompetitive binding), virtual screening, protein–ligand docking, postdocking optimization, and protein–protein docking approach. The study workflow of the analyses is depicted in Fig. 2.

In this study, we screened and validated ZINC968264, which acts as a potential molecule that can improve the loss of function occurred because of mutation (S155R) in Aurora A. Our approaches pave a suitable path to design a potential drug against physiological condition manifested because of S155R mutant in Aurora A.

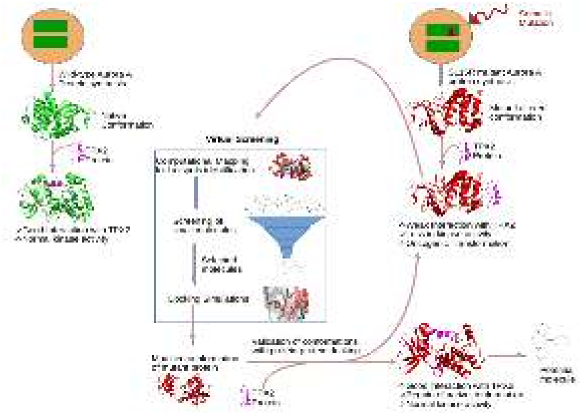

Fig. 2 Flowchart depicting the overall workflow of the study

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Molecular and Microbial Genetics

My lab is trying to understand the functional genomics of high altitude microbes with the major focus on enzymes of industrial relevance. Currently, we are working on therapeutic and lignocellulolytic enzymes from higher altitude microbes. Our research work has been supported under CSIR agri-nutri biotech theme for CSIR-FTC and CSIR-NCP mission mode projects.

Bioprospection of Microbiome from Himalayan Niches (CSIR-NCP)

Indian trans-Himalayan regions extending at the elevation of 2100m to more than 5000m provides unprecedented opportunities for microbial exploration. These locations are remote, virgin and unexplored in term of microbial diversity assessment though they have rich source for alpine, glacier, wetland lakes and inhabitant regions. In the past, our findings on culturable bacteria has laid the foundation for the identification of novel extremophiles producing unique enzymes/proteins from Indian Himalayan niches.

Although, Earth Microbiome Project (EMP) was founded in 2010 to understand the patterns in microbial ecology across the biomes and habitats of our planet but incidentally, Indian Himalayan regions are not included in EMP. Therefore, now we have taken initiative using culture independent approach to explore the microbiome of Himalayan region of Himachal Pradesh for bioprospecting enzymes/proteins or molecules of industrial importance.

Scientific documentation of culturable bacteria and culture independent metagenomic analysis of the microbial diversity from Himalayan niches will create the repository of bacterial wealth for isolation of extremozymes of biotechnological applications. Environment of high altitudes has challenges like radiation, excessive UV exposure, desiccation, freezing and subsequent warming, high or low pH, high osmotic pressure and low nutrient availability. Such challenging environment and the pristine niches in the Himalayas provides unique opportunity of exploring the novel microbes with novel properties and bioactivities.

Followings are the objectives:

- Sample collections from unique niches such as glaciers, glacier forefield, lakes, alpines, plant decomposed waste, forest soils and rocks in the Indian trans-Himalayas.
- 16S based metagenome sequencing to decipher bacterial diversity.
- Shotgun sequencing of at least 100 novel microbial isolates to identify their molecular adaptive features and to unlock the biotechnological potentials.

Fig. 1 Environmental samples collection from Himalayan niches for metagenome analysis

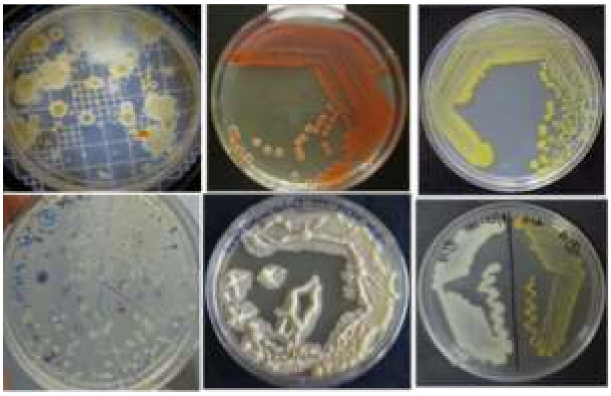

Fig. 2 Representative plates of culture dependent bacterial isolation and pure culture

Fast Track Commercialization Project

L-Asparaginase (HimAspaseTM) with no Glutaminase Activity for Food Processing and Therapeutic Applications

L-Asparaginase is well known for its chemotherapeutic properties. It catalyzes the hydrolysis of amino-acid asparagine into aspartate and ammonia, essentially required for the growth of the some tumour cells. It has been effectively used in the treatment of acute lymphoblastic leukemia (ALL, childhood blood cancer), pancreatic carcinoma and bovine lymphomosarcoma. In addition, L-asparaginase finds its role in food processing industries in reducing the accumulation of acrylamide formation in starch based food products upon heating and frying, that may also cause cancer.

Anticipated deliverables

- Application and bioprocess development for L-asparaginase in the reduction of acrylamide formation in the food products.
- Immunogenic response and in vivo anti-cancer evaluation (preclinical testing).

Market potentials

It has been estimated that world enzyme market will grow $6.2 billion by 2020 and 40% will account for therapeutic enzymes whereas Asparaginase contribute to 1/3rd of total sales (0.82 million USD equivalent to 5576 crores INR). Besides its use as a therapeutic agent, this has application in food processing industry. Therefore, reflects huge market potential.

Based upon our current standarized protocol, HimAsnaseTM is able to reduce more than 60% of acrylamide formation in starch based food products. We are optimzing various parameters to increase the efficiency of our protocol.

Also, the cost of production of L-asparaginase is very low as compared to the commercial brand. We are providing a cost effective and indigenous source of L-asparaginase for therapeutic and food processing applications.

Lignocellulolytic enzyme

More than 250 bacteria were isolated from high altitude specific niches and were screened for laccase activity. Twenty-eight (28) isolates were found positive for laccase activity based on qualitative plate assay. Further, five (05) isolates were reconfirmed for laccase activity based on quantitative assay. Optimization for maximum enzyme production was first done on synthetic growth media components and further optimized for enzyme production using natural substrate such rice husk. Currently, evaluation for breakdown products of kraft lignin upon laccase production by HPLC and FTIR is an ongoing activity (Fig. 3).

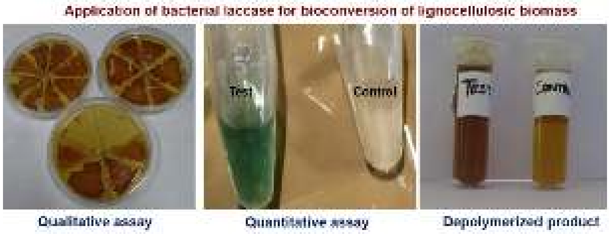

Fig. 3 Application of bacterial laccase for bioconversion of lignocellulosic biomass

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Chemical Nanotechnology and Nanobiology

Our research interests lie in the interdisciplinary area of Chemistry, Biology and Nanotechnology. Currently we are focused towards synthesis and characterization of functional nanomaterials and studying their surface chemistry for bio-conjugation, development of theragnosis probes for simultaneous detection and therapy of disease sites, synthesis of nanomatrices for biomolecule immobilization for improved biomedical application, monitoring nanoparticle-cell/protein interactions and nanomaterials based detection of biomolecules/analytes.

Engineered carbon dots (CDs) for biomedical applications

In our continuous efforts to look for biocompatible, near-infra red fluorescent probes for imaging of disease sites, we have developed fluorescent carbon dots (Cds). The development of biocompatible, widely applicable fluorescent imaging probe, with emission beyond the cellular and tissue auto-fluorescence interference, is a challenging task. In this regard, a series of 28 different fluorescent carbon dots (CDs) were synthesized using carbohydrates as carbon, and cysteine (Cys) and o-phenylenediamine (OPD) as nitrogen source. The screened CDs showed photostability with bright blue (~505-520 nm) and red (~588-596 nm) emission and high fluorescence quantum yield (QY, 72.5±4.5 %). FTIR and NMR studies suggested presence of carboxylate and ester group for Cys and OPD based CDs, respectively. HRTEM results showed particle size of ~3.3 - 5.8 nm for all the developed CDs. The anti-bacterial studies suggested that the developed CDs showed preferential anti-bacterial activity against E.coli, with IC50 value of ~200µg/ml. Cytotoxicity and confocal microscopy studies of HeLa cells reflected that these CDs showed both anti-cancer activity and imaging ability. Agarose gel electrophoresis, together with SOSG assay and thiol estimation studies suggested oxidative stress induced DNA degradation to be the primary cause for cell death. These hemocompatible CDs can thus be used as simultaneous imaging probe and photo dynamic therapeutic agent for both anti-bacterial and anti-cancer activity (Fig. 1).

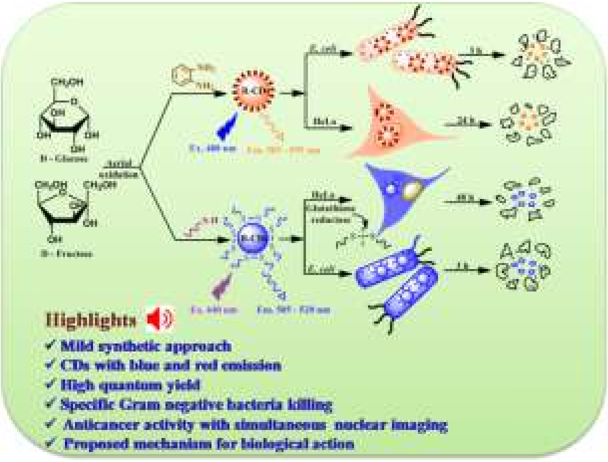

Fig. 1 Schematic representation of the synthesis of CDs and their applications. Reprinted with permission from ACS [Copyright © 2019, American Chemical Society)

Citronellal nano-emulsion with improved selectivity and anti-bacterial efficacy

How can we improve the bioefficacy of the poorly water soluble active ingredients to enhance their therapeutic potential? Essential oils (EO), the so-called "green pesticides," possess strong anti-microbial activities due to their characteristic aroma; but low efficacy, instability, and high cost of production, mostly restrict their use in food and pharma industry.

In this context, citronellal (CL) nano-emulsification process was optimized using different concentrations of Brij-58 and leaf extracts of *Lantana camara*. Results suggested that uniform droplet size of 35–70 nm can be achieved when CL concentration was maintained at 2% (v/v). Efficacy of both the prepared nano-emulsions was tested against two different strains of bacteria viz., *Staphylococcus aureus* and *Pseudomonas aeruginosa* using TEM and confocal microscopic techniques. Studies indicated an early and selective killing of both the bacteria by citronellal nano-emulsion as compared to pure citronellal. It is being proposed that noncovalent interactions and presence of aquaporins on the bacterial membrane were largely responsible for such selectivity (Fig. 2).

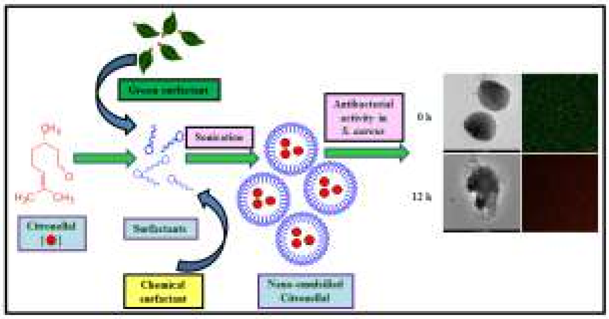

Fig. 2 Schematic representation of the synthesis of citronellal nano-emulsion using chemical and green surfactants and their corresponding biological activities. Reprinted with permission from Wiley-VCH. [Copyright © 2018, Wiley-VCH)

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Research areas focus on a variety of topics but basic themes includes Evolution, Comparative genomics, system biology as well as functional genomics. We are focusing on evolution of immune system in plants, artificial intelligence (AI) & system biology approaches for genome-wide investigation of disease resistance in plants. We are also involved in genomic and evolutionary insights into the cold adaptation enzymes of microbes isolated from Himalayas as a part of CSIR-Mission project- "Bisoprospection Microbiome from Himalayan niches (BioprosPR)". This research lab is mainly a part of establishment of bioinformatics infrastructure facility for biology teaching through bioinformatics (BIF-BTBI) under the BTISnet, Government of India.

Plant STAND P-loop NTPases: A current perspective of genome distribution, evolution, and function

STAND P-loop NTPase is the common weapon used by plant and other organisms from all three kingdoms of life to defend themselves against pathogen invasion.

NB-ARC ATPases/AP-ATPases/nucleotide-binding site-leucine-rich repeats (NBS-LRRs), are the only members of STAND P-loop NTPase class, employed by plants to control disease infestation. Intriguingly, by means of the stringent computational approaches, few predicted candidates of mammalian NACHT NTPases were reported in the early green plant lineages (green algae, bryophyte, and lycophyte) which might have acquired through apparent horizontdal gene transfer in their genomes. However, the functional biochemical activity of these NACHT NTPases in early green plants has yet to be elucidated for confirmation of their potential role. Furthermore, an unconventional GTPase and OsYchF1 (homolog of YchF in rice) have been recently demonstrated to be involved in disease resistance, thereby counts for a novel plant STAND P-loop NTPase and expanding the dimension for the definition of plant STAND P-loop NTPase.

The plant STAND P-loop NTPase exhibited polymorphism to cope up with pathogen populations. The plant genomes exhibit multiple to hundred gene copies for NBS-LRRs. This tremendous increase in NBS-LRR number is lineage specific that also depends on type of genome duplication pattern events. A "moderate tandem and low segmental duplication" trajectory is followed in majority of the plant genomes with few exceptions.

The abundance of NBS–LRR proteins in plant species might result in several distinct mechanisms for pathogen or pathogen effectors perception by either direct physical interaction (direct recognition) or mediated by effector-targeted host proteins (indirect recognition). Since the past decades, systematic research is being investigated into NBS–LRR function supported the direct recognition of pathogen or pathogen effectors by the latest models proposed via 'integrated decoy' or 'sensor domains' model (Fig. 1). All models proposed for the mechanism of pathogen effector perception by NBS–LRRs are important in understanding plant disease resistance. While direct recognition of pathogen effectors is gaining recognition, in nature and *in vivo*, the NBS–LRR sentry recognizes invaders (effectors) using diverse strategies, contributing to a stronger plant immune system. In conclusion, plants are in a continuous process of evolution to adapt themselves against biotic stresses through diverse and rapid evolutionary mechanisms of action (either through molecular genetics or epigenetic variation) for NBS–LRRs to improve immunity.

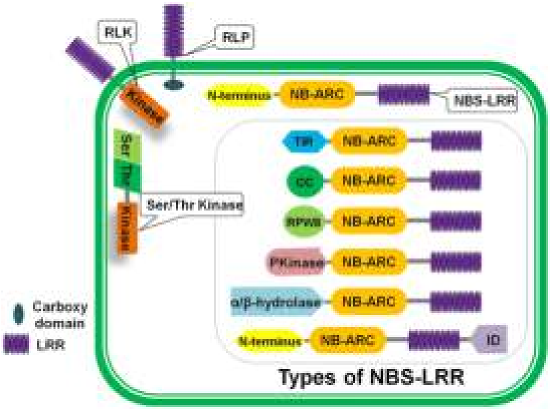

Fig. 1 Schematic diagram of disease-resistance (R) gene products

Transcriptome and Co-Expression Network Analyses Identify Key Genes Regulating Nitrogen Use Efficiency in *Brassica juncea* L.

Present study was aimed to understand nitrate regulatory mechanism in *Brassica juncea* cultivars, with contrasting nitrogen-use-efficiency (NUE) viz. Pusa Bold (PB, high-NUE) and Pusa Jai Kisan (PJK, low-NUE), employing RNA-seq approach.A total of 4031, 3874 and 3667 genes in PB and 2982, 2481 and 2843 genes in PJK were differentially expressed in response to early, low (0.25 mM KNO_3), medium (2 mM KNO_3) and high (4 mM KNO_3) nitrate treatments, respectively, as compared to control (0 mM KNO_3). Genes of N-uptake (NRT1.1, NRT1.8, and NRT2.1), assimilation (NR1, NR2, NiR, GS1.3, and Fd-GOGAT) and remobilization (GDH2, ASN2–3 and ALaT) were highly-upregulated in PB than in PJK in response to early nitrate treatments. We have also identified transcription factors and protein kinases that were rapidly induced in response to nitrate, suggesting their involvement in nitrate-mediated signaling. Co-expression network analysis revealed four nitrate specific modules in PB, enriched with GO terms like, "Phenylpropanoid pathway", "Nitrogen compound metabolic process" and "Carbohydrate metabolism".The network analysis also identified HUB transcription factors like mTERF, FHA, Orphan, bZip and FAR1, which may be the key regulators of nitrate-mediated response in *B. juncea*. The details of our lab can be accessed at http://14.139.59.212/fgcsl/index.php.

Publications

Kumar R, Acharya V, Mukhia S, Singh D and Kumar S (2018) Complete genome sequence of *Pseudomonas frederiksbergensis* ERDD5: 01 revealed genetic bases for survivability at high altitude ecosystem and bioprospection potential. Genomics, DOI.org/10.1016/j.ygeno.2018.03.008.

Left to Right: Abhishek Khatri, Ravi Kumar, Neeraj Kumar, Dr. Vishal Acharya, Meetal Sharma, Ekjot Kaur, Dr. Ankita Shukla

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Plant Microbe Interaction and Molecular Biology

My group is involved in the field of Molecular plant pathology with in broad research topic of plant-microbe interaction. Aim of our research is to identify member of TIR-NBS-LRR gene family from potato plant and also from solanaceae group members and their characterization to ascertain putative resistance genes. Another focus area is to understand the development biology of saffron through microbial and biotechnological approaches.

Genome wide identification of TIR-NBS-LRR gene family in potato (*Solanum tuberosum* L.) and understanding their role during early blight disease

Early blight disease caused by fungal pathogen *Alternaria solani* is one of the severe diseases of potato causing losses in crop yield, worldwide. The disease is more prominent in tropical and subtropical countries and characterized by necrotic lesions in leaf and stem. The symptom spreads during winter season ultimately causing plant death. The fungal spores over winter in soil leading to fresh infection next year. Though many are working to identify the remedy, resistance genes against the pathogen is yet to be identified. One way of identifying possible source of imparting resistance against this disease is by identification and characterization of NBS-LRR gene family members. The members of NBS-LRR gene family are most widely identified genes involved in the scope of plant pathogen interaction and 80% of all resistance proteins belong to them. As NBS-LRR proteins belong to a large gene family consisting of anywhere between 250-600 members in family Solanaceae as reported earlier, in our present work we are focusing on one sub set of the family TIR-NBS-LRR (TNL) characterized by their N-terminal TIR domain. To identify the members, an in-silico approach was formulated resulting in identify ~60 peptides, from available sub species Phureja genome (Solanaceae. plantbiology.msu.edu/pgsc_download). These were further assessed for their chromosomal localization and were mapped on potato genome at different chromosomes encoded by a pool of 44 genes, distributed across the genome. Our work also showed two significant clusters of TNLs at chromosome 1 and chromosome 11 with in ~1.5 MB range. In future, characterization of selected TNLs based on their transcript expression data will help in identification of putative resistance genes against early blight disease (Fig. 1).

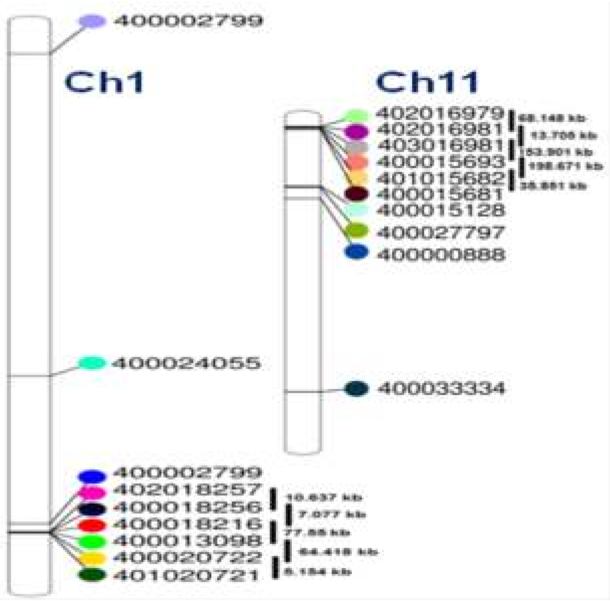

Fig. 1 Chromosomal localization of TNLs identified by *in-silico* genome mapping at Ch.1 and Ch.11

Understanding the saffron growth and development biology through morphological approaches *in vivo* and by application of chemical (growth regulators) and microbial intervention

Saffron (*Crocus sativus* L.) is a triploid plant from family Iridaceae that has long been used in traditional medicines. The plant produces tripartite stigma which is utilised as valuable spices in many dishes of East and South Asia along with many countries of Mediterranean and Europe. The spice is also valuable for source of many compounds of medicinal importance including crocin, safranal and picrocrocin. As plants are being raised since hundreds of years through vegetative propagation through corms various factor have started affecting growth of plants due to biotic/abiotic stress along with loss of vigour. Unfortunately, being triploid the plant cannot be improved through traditional breeding approaches. In these circumstances it is imperative to think innovative and need to apply biotechnological intervention for sustenance of growth and vigor. To reach this goal two important rhizobacteria *Pseudomonas azotoformans* and *Bacillus siamensis* was identified from Kashmir soil with plant growth promoting (PGP) attributes. Both the rhizobacterial have shown positive response under lab based assays for multiple attributes including ACC deaminase, Siderophore and IAA production. This year the cultures were taken to field study for their assessment under shade-net facility. Field trial with multiple controls in a RBD design has been initiated in shade-net condition at CSIR-IHBT and open field at TERI, Uttaranchal. The growth assessment of plants through various parameters is under progress (Fig. 2).

Fig. 2 Saffron trial under shade net facility at CSIR-IHBT

Furthermore, to understand the corm development in saffron, plants were uprooted each month from October to April and morphological features were studied. We were able to identify two kinds of roots in saffron a) Normal adventitious roots b) contractile roots (Fig. 3). Further study revealed that presence of contractile root is inconsistent in saffron and not all corms bear the structure making their role unclear during saffron development. We hope to unravel the mystery of their inconsistent presence and role with further work.

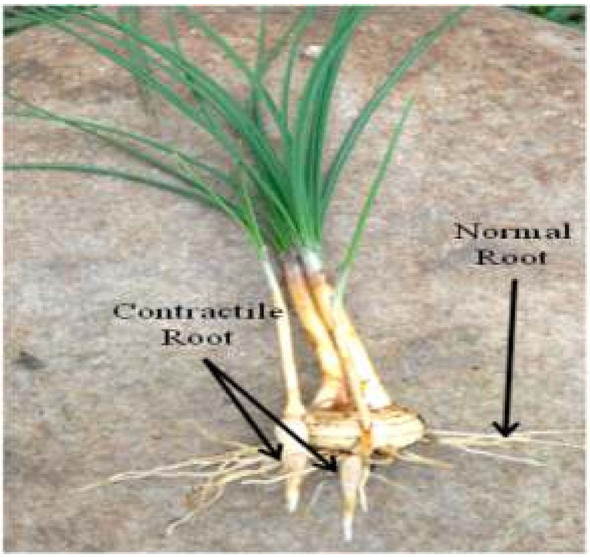

Fig. 3 Normal and contractile root in saffron

Field trial using PGPR formulation previously identified from Lahul on Onion and Garlic crop to assess their effectiveness for plant growth

Two plant growth promoting rhizobacteria *Arthrobacter psychrochitiniphilus* and *Pseudomonas trivialis* formulations based on previous studies were prepared and applied on Onion and Garlic crop at farmer's field. Growth parameters such as crop yield, plant height and leaf number were analysed. Based on work, both the cultures showed promising result under first year trial for onion crop. Second consecutive year trial has also been initiated and result will confirm the effectiveness.

Reviews/ Proceedings/ Book Chapters

Dubey N and Singh K (2018) Role of NBS-LRR Proteins in Plant Defense. In: Molecular Aspects of Plant-Pathogen Interaction (Eds. Singh A and Singh I), Springer-Nature, Singapore.

Left to Right: Dr Kunal Singh, Dr Umesh Pankaj, Kanchan Yadav, Nilofer, Pooja Yadav, Anjali Chaudhary, Namo Dubey, Pooja Sharma

Ashish Warghat, Scientist
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Plant cell culture, Hydroponic and aeroponic cultivation and Molecular biology

Lab is working on production of quality biomass in terms of metabolite enrichment of medicinal plants using plant cell culture, hydroponic and aeroponic cultivation techniques. Lab is engaged in fast tract translational projects i.e. Year round crop production of flower crops and quality biomass production in spice crops. Also, involved in micropropation of RET species under Phytopharmaceutical mission mode projects.

Cultivation of *Picrorhiza kurroa* Royle ex Benthin aeroponic system

Efforts were made to cultivate medicinally important herb *Picrorhiza kurroa* for the production of quality biomass in aeroponic system. The growth biomass and alterations in metabolite content were measured in *in-vitro* raised and nursery plants, after 12–14 weeks of cultivation under the system (Fig. 1). The maximum growth biomass and picroside I contents were observed in nursery plants; plant height (6.51 cm), leaf length (4.09 cm), leaf width (1.59 cm), stem diameter (2.72 mm), picroside I content in leaf (3.79%) (Table 1). The results revealed that *P. kurroa* cultivation is suitable under the aeroponic system for the production and enhancement of picroside content. These hi-tech farming have tremendous potential, round a year for the quality biomass production which is otherwise insufficient in its natural habitat. These farming systems open an avenue to meet industry standard and commercial scale production of quality material in term of picrosides within short time.

Fig. 1 Cultivation of *P. kurroa* under aeroponic cultivation

Table 1 Detection of picroside I content in *P. kurroa* cultivated under aeroponic system

Cultivation conditions	***In vitro* aeroponic cultivated**		**Nursery grownaeroponic cultivated**	
Plant parts	Leaves	Rootlets	Leaves	Rootlets
Picroside I (%)	3.34	1.58	3.79	1.45

Cell culture studies in *P. kurroa*

Iridoid glycosides are the main constitutents of *P. kurroa* and are commonly known as picrosides. Roots, rhizome and leaves contain picrosides, which has been used to cure the hepatic disorders, gastric troubles, anaemia, asthma and pregnancy related problems. *P. kurroa* is being over-harvested from the natural habitat and thereby becoming endangered. Therefore, callus culture of *P. kurroa* were established for *in vitro* production and enhancement of picroside content under different culture conditions (i.e. 25°C dark/light & 15°C dark/light). Maximum callus proliferation frequency (94 %) was observed in MS media containing 0.5mg/L TDZ and 0.3 mg/L IBA. Growth of callus was observed over a period of 30 days of culture (Fig. 2). The maximum fresh and dry matter accumulation (7 times increment over the initial inoculum weight after 21 days) in the cultured callus grown in 25°C in dark condition. Study revealed that callus culture of *P. kurroa* may offer a cost effective and environmentally friendly platform for sustainable production of picrosides and potentially other important metabolites.

Fig. 2 Callus culture of *Picrorhiza kurroa*

Establishment of callus cultures of *Stevia rebaudiana*

The leaves of *S. rebaudiana* contains steviol glycosides majorly stevioside and rebaudioside A, hence leaves were selected as explant for callus induction. MS media enriched with 10 various combinations of PGRs were subjected for callus induction. Among these, 3 mg/L NAA and 3 mg/L BAP hormone concentration found 90.5% callus frequency rate (Fig. 3). Further, callus cultures were used for biomass studies and steviol glycoside metabolites production.

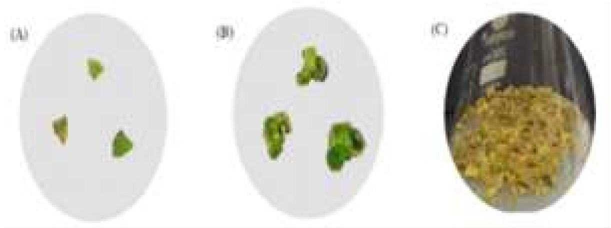

Fig. 3 Established callus culture of *S. rebaudiana* (A) Inoculated leaf explant, (B) Induction of calli in optimized media (C) Callus biomass

Callus culture of *Siraitia grosvenorii*: A low-calorie sweetener

Siraitia grosvenorii (monk fruit or luo han guo) is a herbaceous perennial climber of the cucurbitaceae family, native to southern China and northern Thailand. The plant is cultivated for its fruit as extract is nearly 300 times sweeter than sugar and has been used in China as a low-calorie sweetener for cooling drinks and in traditional Chinese medicine. The sweet taste of the fruit comes mainly from mogrosides, a group of triterpene glycosides that make up about 1% of the flesh of the fresh fruit. In the present study, series of experimentation designed to determine the effect of different plant growth regulators on the initiation and proliferation of callus and metabolites especially mogroside V content in stem and fruit callus culture of Siraitia grosvenorii. Maximum callus initiation frequency (84%) were reported in MS media containing TDZ (3mg/L) and picloram (3 mg/L) (Fig. 4). Mogroside content quantification in fruit, stem, fruit callus and stem callus were performed by UPLC technique. Highest mogroside content were observed in fruit and its 1/4th part was observed in fruit derived calli. Therefore, it indicated that callus culture is an alternative way for the production of these sweetener compounds to meet industry demand.

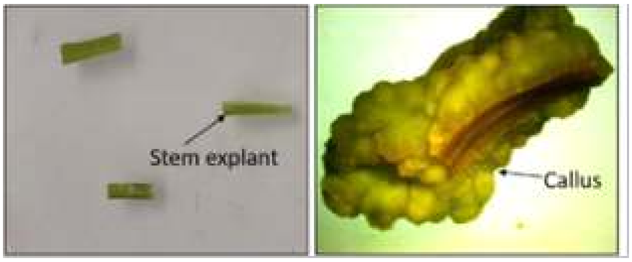

Fig. 4 Callus culture of *S. grosvenorii*

Metabolites quantification in different tissues of *Rhodiola imbricata*

R. imbricata is a high-altitude medicinal plant which isused in the stimulation of the nervous system, enhancing work performance, eliminating fatigue, preventing high-altitude sickness and as anti-depressant. Callus cultures were established from in vitroleaf explant using 0.5mg/L TDZ and 1mg/L NAA hormone concentration with 100% induction rate. Plant is rich in secondary metabolites like salidroside, rosarin and P-tyrosol (Table 2). Therefore, cell culture studies were undertaken to produce commercially important metabolites of this less explored medicinal plant for pharmaceutical applications.

Table 2 Metabolite quantification in different tissues

Tissues	Conc. (µg/mg) DW of tissues			
	Salidroside	Tyrosol	Rosarin	Gallic acid
 Field shoot	9.56	0.99	7.93	1.04
 *In-vitro* shoot	2.27	0.43	1.89	1.04
 Callus	4.52	0.21	0.39	1.34

Enhancement of dactylorhin content in *Dactylorhiza hatagirea*, a medicinal orchid of North-Western Himalayas

Dactylorhiza hatagirea (D. Don) Soo is a high value medicinal orchid due to the presence of a glucoside, dactylorhin in the tuber. In spite of reports on the potential use of dactylorhin, the limited amounts of dactylorhin that can be extracted from natural source has produced unmet market demand. In addition, dactylorhin yield improvement requires information of its biosynthetic pathway, which has not been elucidated till date. After optimization of callus induction through tubers, cell suspension culture approach was followed to enhance metabolites using different elicitors (Fig. 5). It was observed that dactylorhin content was enhanced significantly with some concentrations of elicitors. Also, transcriptomes of different tissues have been generated through RNA-Seq approach using NovaSeq (Illumina) platform. Bioinformatics based analysis and annotation is being performed to elucidate dactylorhin biosynthetic pathway.

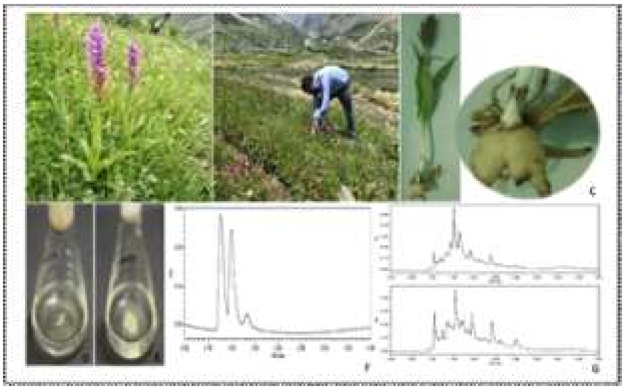

Fig. 5 (A) *Dactylorhiza hatagirea* population (plants with violet flowers) in natural habitat at Keylong, Lahaul & Spiti, Himachal Pradesh (B) Collection of *D. hatagirea* plants (C) *D. hatagirea* plant with inflorescence, leaves, stem, tuber and roots (D) Cell suspension culure (E) Cell suspension culture obtained after one month (F) UPLC chromatogram showing dactylorhin standards (G) UPLC chromatograms of elicitors treated cell suspension cultures

Cell culture studies in *Fritillaria roylei* - critically endangered Himalayan medicinal herb

Fritillaria roylei (known as Jangli lahsan) is an important medicinal plant of Astavarga group, contains steroidal alkaloids as a bioactive ingredients. It is widely used in traditional Chinese medicine for the treatment of cough, phlegm and lung-related disease. Due to limited wild resources, over exploitation of this medicinal herb has drastically reduced its availability in its natural habitats and putting it into critically endangered category in Himachal Pradesh. Therefore, for its conservation and sustainable use, reliable and efficient in vitro culture establishment is prerequisite. Bulb scales were used as explant for the establishment of in vitro cultures (Fig. 6). High frequency callus induction and in vitroplantlets regeneration protocol has been optimized using Murashige and Skoog (MS) medium containing different concentrations and combinations of plant growth regulators i.e. BAP+NAA; KIN+NAA, thidiazuron, meta-topolin, dicamba and picloram.

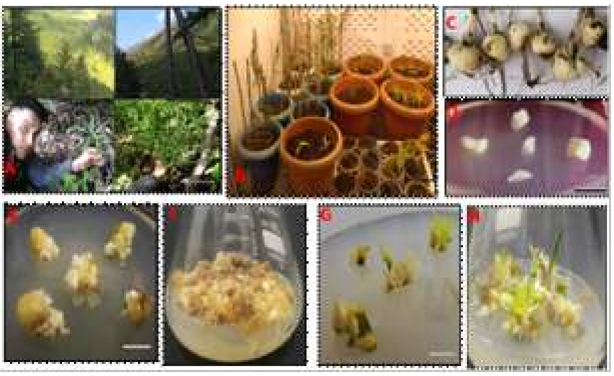

Fig. 6 (A-G): Establishment of *in vitro* cultures in F. royeli A) Collection of plant material, B) maintenance of plant inside plant growth chamber, C) *F. roylei* complete bulbs, D) bulb scales as explant source E-F) Callus induction and proliferation in *F. royeli*, G-H) Direct plantlets regeneration in *F. royeli*

Optimization of aeroponic and hydroponic conditions for increasing commercial crop productivity (FTT Project)

In our previous experiments with lilium, hydroponic cultivation reduced the days to flowering. Keeping in view the results obtained, we tried to study the possibilities of year round production of lilium flowers at commercial scale in accordance with the market demand. The Bavistin treated lilium bulbs were planted in hydroponic and open field conditions. Nutrient recipe was standardized at lilium commercial scale cultivation. Seven cycles at an interval of 15 days were planned to cultivate lilium simultaneously in both hydroponic and field condition and the plants were analysed for height and number of days taken to flower. The results revealed that plant height was significantly increased in hydroponic conditions with less number of days for flowering as compared to those planted in the open field (Fig. 7 & 8). The flowering time got reduced by 25-30% in hydroponics as compared to the open conditions.

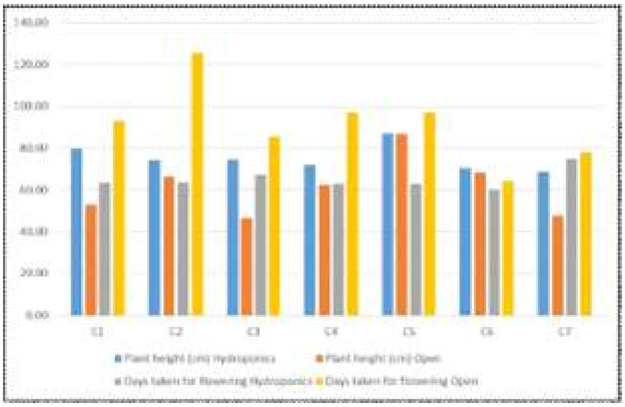

Fig. 7 Graph depicting the morphological variation in hydroponics and open field

Fig. 8 Hydroponic cultivation of Lilium

Publications

Thakur K, Partap M, Kumar D and Warghat AR (2019) Enhancement of picrosides content in *Picrorhiza kurroa* Royle ex Benth. mediated through nutrient feeding approach under aeroponic and hydroponic system. Industrial Crops and Products, 133: 160-167.

Bhardwaj AK, Naryal A, Bhardwaj P, Warghat AR, Arora B, Dhiman S, Saxena S, Pati PK and Chaurasia OP (2018) High Efficiency in vitro Plant Regeneration and Secondary Metabolite Quantification from Leaf Explants of *Rhodiola imbricata*. Pharmacognosy Journal, 10(3): 470-475.

Reviews/Proceedings/book chapters

Warghat AR, Thakur K and Sood A (2018) Plant stem cells: what we know and what is anticipated. Molecular Biology Reports, 45:2897-2905.

Kapoor S, Bhardwaj AK, Warghat AR, Kumar K, Naryal A and Chaurasia OP (2019) Ethnobotanical, phytochemical and pharmacological properties of genus rhodiola (l.) in India: a high-altitude plant with potential medicinal applications. In: Assessment of Medicinal Plants for Human Health Phytochemistry, Disease Management, and Novel Applications (Eds. Goyal MR, Chauhan DN), Apple Academnic Press, USA.

Left to Right: Dr Archit Sood, Dr. Pankaj Kumar, Mahinder Partap, Dr. Ashish R Warghat, Kanika Thakur, Ashrita, Pooja Thakur, Shiv Rattan, Praveen Kumar, Rakesh Kumar

Rajiv Kumar, Scientist
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Biotechnology and Proteomics

Research Activity: Currently, I am involved to dissect *Picrorhiza kurroa* adaptive response to abiotic stress along altitude gradient and medicinal value at peptide level using system biology approach.

Mission mode activities: Involved in Niche creating project entitle "Molecular mechanism underlying Apple scar skin viroid-whitefly interaction".

Research progress: Identification of a novel bioactive peptide from *Picrorhiza kurroa* and their potential therapeutic implications.

Medicinal plants are rich source of "bioactive peptides" that have been used for development of modern therapeutics. In recent years, it has been reported that peptide extract from soybean, whey, maize, buckwheat, and potato not only provide sufficient nourishment to the human body but also play a significant role in preventing diseases such as cardiovascular diseases, diabetes, cancers, high blood pressure, and obesity among others. Bioactive peptides with multifunctional health benefits are in demand of the health sectors across the world. Several pharmaceutical, biotech and food industries are involved in the development of peptide-related products. For this reason, the search of plant-derived bioactive peptides has increased exponentially in recent years.

Picrorhiza kurroa is a medicinal plant of Himalayan region having numerous health benefits. To the best of our knowledge, bioactive peptide in *P. kurroa* plant remains obscure and has yet to be explored. In this context, the major question being asked, "Is there any therapeutic bioactive peptides present in the are there in *P. kurroa* extract? If yes, then how can we experimentally validate their potential therapeutic values? What are the mechanistic

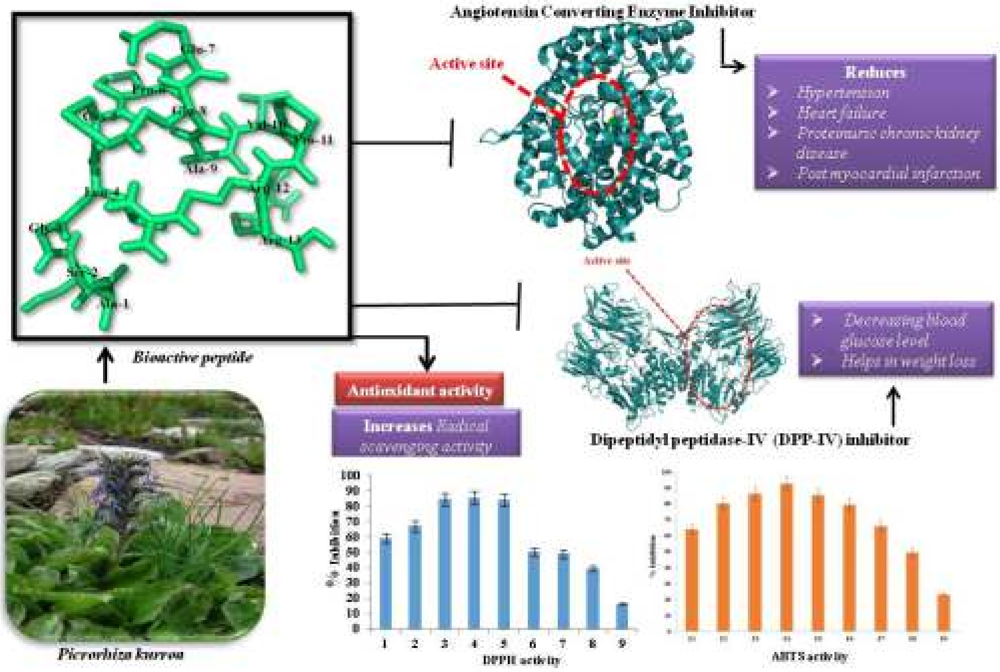

Fig. 1 Identification of bioactive peptides and *in silico* analysis in *P. kurroa*

role the peptides in modulating the function of the cell? Can we develop the high-value pharmaceuticals/nutraceuticals/food supplements from bioactive peptides? These are challenging questions that needs to be addressed.

Using peptidomics approach we are aiming to screen bioactive peptides from *P. kurroa* and their potential role in prevention and treatment of diverse chronic disease. Briefly, *P. kurroa* proteins were hydrolyzed with trypsin, fractionated with size exclusion chromatography into nine fractions and evaluated its antioxidant activity using DPPH and ABTS assay (Fig. 1). We selected 3rd, 4th and 5th fractions having similar antioxidant activity for HPLC fractionation and mass spectrometry analysis leading to the identification of 25 common peptides present in all three biological replicates. Among 25 peptides 13 peptides having significant bioactivity score >0.5 assigned as "bioactive peptides". The biological activity of the 13 peptides were determined using BIOPEP-UWM tool that includes antioxidative, antihypertensive, antidiabetic, alpha-glucosidase inhibitor, antithrombotic, and antiamnestic. The peptides were further assessed for their toxicity and allergenicity using multiple predictive approaches (ToxinPred and Allergenicity tools) and found all are non-toxic. However, 12 out of the 13 bioactive peptides were identified as potential allergens. Further, we found a novel bioactive peptide comprised of 13 amino acid having sequence "Ala-Ser-Gly-Leu-Cys-Pro-Glu-Glu-Ala-Val-Pro-Arg-Arg" were non allergic and non toxic and posses Angiotensin converting enzyme (ACE) and dipeptidyl peptidase-IV(DPP-IV) inhibitory activity. The molecular docking studies revealed that the amino acid residues 'Pro-6' (with binding energy -4.8 kcal mol-1) strongly binds to the active binding pocket of Ace (S2-His 353) whereas 'Arg-12' (with binding energy -6.9 kcal mol-1) more efficiently binds to DPP-IV (S3-Ser209). The docking results between amino acid residue Arg-12 of peptide and ABTS (with binding energy -4.3 kcal mol-1) and DPPH (binding energy -4.2 kcal mol-1) revealed strong antioxidant activity. Overall our findings provide an evidence that this novel peptide might possess potential antioxidant activities other than its inhibitory activity against DPPIV and ACE enzymes and thus herald a fascinating opportunity that will be useful in prevention and treatment of diabetes and hypertension diseases.

Left to Right: Rajiv Kumar, Robin Joshi, Shweta Thakur, Manglesh Kumari and Swati Bhuria

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High Altitude Microbiology

Our research aims at exploring the microbial community from high altitude extreme environments from both eastern and western Himalaya. At present, we are unraveling the potential of psychotropic bacteria for bioprospection. We have started by sequencing genomes to identify bioprospection potential and adaptational strategies. With the efficient hydrolytic psychrotrophic/psychrophilic bacterial community of Himalaya, we have targeted organic waste degradation in cold-hilly regions. Another potential enzyme being explored in our lab is phospholipase for oil degumming. Our lab is also exploring other important aspects of Himalaya that includes probiotics from traditional fermented foods and enrichment of Vitamin D in Shiitake mushroom. The main focus of our lab can be summarized in the following broad themes:

- Study changes in community composition in different Himalayan glacier to understand its adaptational strategies and to reveal the response of microorganisms to environmental change.
- Exploration of bacteria from alpine regions of Himalaya for bioprospection-organic waste management & industrial enzymes
- Exploration of mushrooms and its enrichment/ fortification for value addition

Adaptation strategies and potential bioprospection of the bacterial community of Eastern and Western Himalaya

Extreme environments of the alpine regions of Himalayas are known to harbor diverse polyextremophilic organisms called psycrophiles/psychrotrophs which have evolved adaptive traits against stress factors associated with such environment such as desiccation, excessive UV radiation, frequent freezing and thawing, high osmotic pressure and low nutrient availability. The organisms inhabiting such cold and radiation rich environments are economically viable as the poly-adaptational strategies endow them with extremozymes which finds applications ranging from detergents, pharmaceuticals, antioxidants, cosmetics, sunscreens, paper, food and feed industries. Bacterial diversity was explored from the alpine region of Sikkim Himalaya encompassing East Rathong Glacier in the Eastern Himalaya, and Trilokinath Glacier in the Lahaul region of Western Himalaya.

Sampling was done from different points of proglacial and glacial regions of East Rathong and Trilokinath Glacier (Fig. 1). The environmental samples were processed to obtain many unique morphotypes, among which the characterized bacteria comprised of Actinobacteria, Alpha, Beta and Gamma Proteobacteria,Bacteroidetes. Further work on cultivable bacteria from Sikkim Himalaya revealed observation of a dominant bacterial species of Pseudomonas antarctica in the supraglacial ecosystem. These bacteria tolerated cold and UV-C radiation (300 Jm-2) much better as compared to the mesophilic P. aeruginosa MTCC 2453. Quantification of the extracellular protease produced by the strains revealed enzyme production in the range of 7.25 U/mg to 9.7 U/mg at 20.C that can be explored for biotechnological applications.

Fig. 1 Sample collection from sites in the Eastern and Western Himalayas

The taxonomy of another cold resistant bacteria was re-evaluated using Multilocus sequence analysis (MLSA), in silico DNA-DNA hybridization (DDH) and average nucleotide identity (ANI) value. The bacteria was identified as non-violacein producing Janthinobacterium lividum ERGS5:01 (MCC 2953)

The genomic data of J. lividum ERGS5:01 (Fig. 2) provided insights into the molecular strategies adopted by the psychrotrophic bacteria to survive the cold and radiation stress at high altitude environment.

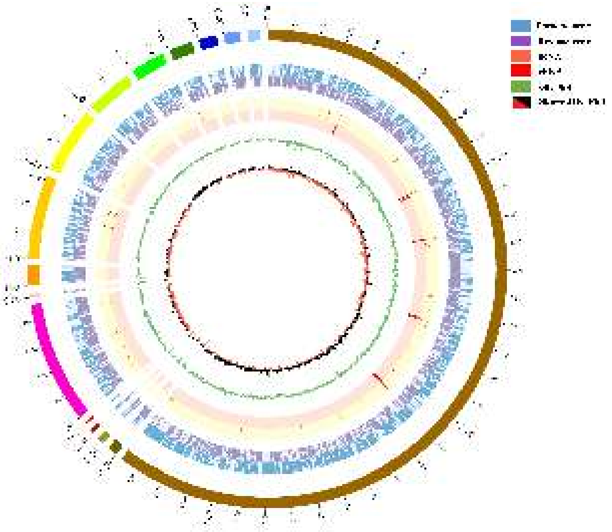

Fig. 2 A circular chromosomal map of the draft genome of strain J. lividum ERGS5:01

Another psychrotrophic bacteria Pseudomonas frederiksbergensis ERDD5:01 was isolated from the glacial stream (4718 masl) in Sikkim Himalaya. The bacteria showed physiological adaptational attributes against freezing, freeze-thaw cycles and, radiations. Complete genome of the strain provided insights into adaptational strategies and industrial enzymes. The multiple copies of cold-associated genes encoding cold active chaperons, general stress response, osmotic stress, oxidative stress, membrane/cell wall alteration, carbon storage/starvation and, DNA repair mechanisms supported its adaptability at extreme cold and radiations corroborating with the bacterial physiological findings. The molecular cold adaptation analysis in comparison with the genome of 15 mesophilic Pseudomonas species revealed functional insight into the strategies of cold adaptation. So far 10 whole genome DNA data repository of psychotropic bacteria were made accessible to scientific community through NCBI GenBank.

Development of bacterial formulations and organic dustbin for organic waste degradation in cold hilly regions (FTT Project)

Compost samples of different maturity stages were collected from Lahaul valley and Palampur region from Western Himalaya and from organic farmlands in West Sikkim of Eastern Himalaya (Fig. 3).

Fig. 3 Sample collection and isolation of bacteria

The psychrotrophic bacterial diversity of the compost were explored to screen out the indigenous efficient decomposers. We made sure that the ambient temperature of the sampling site was below 15 C. A total of ~300 unique psychrotrophic bacterial strains were isolated of which 20 were anaerobes. Among these, 150 bacteria possessed at least one hydrolytic enzyme (protease, cellulase, amylase, phospholipase, lipase, pectinase and xylanase) (Fig. 4).

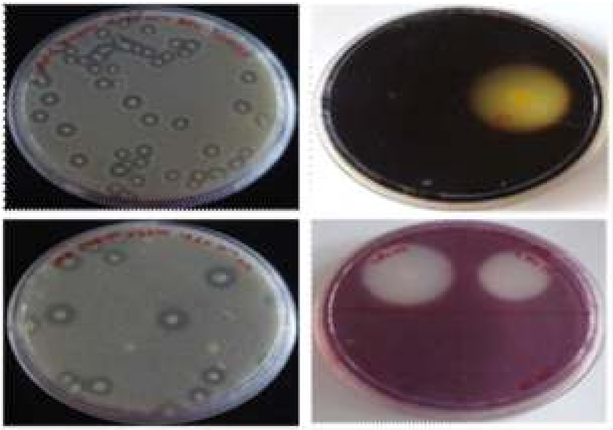

Fig.4. Psychrotrophs with hydrolytic enzymes

Bacterial strains positive for different hydrolytic enzymes were affiliated to Actinobacteria, Betaproteabacteria, Gammaproteobacteria and Bacteriodetes. The characterized and efficient hydrolytic bacteria were further tested for synergistic activity to be used as consortia for organic waste degradation studies at lab scale. Further two sets of the consortium have been tested so far as potential decomposers. Consortia of efficient hydrolytic psychrotrophic bacteria (active at <15°C) is observed to reduce the longest phase of composting (i.e the initial mesophilic phase) to half. From the organic farmlands of Sikkim the native efficient nitrogen fixing, potash mobilising and phosphate solubilizing bacterial strains were characterized and lab scale formulations were prepared. The native biofertilizers formulations are under field trial at Sikkim in collaboration with Vendeep Green Globe Organic Venture Pvt. Ltd., Majitar, East-Sikkim

Vitamin D enriched Shiitake mushroom

Lentinula edodes, commonly known as Shiitake mushroom is a wood decaying edible basidiomycetes. This mushroom is highly nutritious and medicinal and have long history of use over 2000 years by traditional oriental cultures, especially in China and Japan. Shiitake is regarded as a major edible and medicinal source and it is the second most commonly cultivated mushroom in the world. Natural cultivation of this mushroom takes 8-12 months for fruiting and the production period ranges from 3-8 years. We have standardized captive cultivation technique for shorter cultivation time to 2 months (Fig. 5). The yield achieved so far ranges from 0.5-0.6 kg fresh mushroom from 1 kg dry sawdust substrate.

Synthetic Log (30 Days) Fruiting bodies (60 Days)

Fig. 5 Captive cultivation of Shiitake mushroom

The shiitake mushroom is rich source of ergosterol (vitamin D precursor) and other micronutrient. We have developed a technology for enhanced production of ergocalciferols (Vitamin D2) from Shiitake mushroom. The mushroom is the only vegetarian source of Vitamin D. The mushroom and its nutraceutical products may efficiently cater to the vegetarian population deficient to vitamin D.

Indigenous enzymes for vegetable and rice bran oil degumming

Under this program, IHBT is exploring Himalayan sources of phospholipase. In this direction, phospholipase producing bacteria thriving in Western and Eastern Himalaya were explored. Samples collected from Western and Eastern Himalaya and from Manikaran

Hotspring were used to screen bacteria for phospholipase activity on phospholipase agar media (PAM). Extracellular phospholipase activity was tested at broad temperature range for 7 to 10 days. Significant zone of clearance was observed in 15/209 bacteria.

Antibacterial activities of essential oils from cultivated clones of *Juniperus communis* and wild *Juniperus species*

The antibacterial activity of the essential oils (EOs) from three wild Juniper species of high altitudes (JC, JI, JR) and seven cultivated clones from lower altitudes (C1-C7) were evaluated using six bacterial strains. The EOs of C6 inhibited the growth of five out of six bacteria tested. Clone, C7 exhibited the highest zone of inhibition against *Staphyloccocus aureus* MTCC 96. Both wild and cultivated species exhibited antibacterial activities against S. aureus MTCC 96 and *Micrococcus luteus* MTCC 2470 but the growth of *Klebsiella pneumoniae* MTCC 109 was not inhibited. The study concluded that the EOs from studied plant species have potential antibacterial activity against important pathogenic strains and can be exploited for their utility as natural antimicrobial agents.

Identification of useful microbes with probiotic potential

Traditional fermented food samples like Lassi, Dahi, Chilra, Lugri were collected from different villages in Lahaul Valley (Table 1). 95 bacteria were screened with potential WHO recommended probiotic attributes.

Table 1 Sampling of traditional fermented foods from villages of Lahaul valley

Collection	Food Samples
Upper Sumnam	Lassi I
	Lassi II
	Lungri (Rice)
	Chang(Hajni)
	Chilra(luhar)
	Chang I(Masala)
	Chilra (Dough)
Miyar Valley	Dahi (Urgosh)
	Lassi III
	Lungri
Urgosh	Lugri(Barley)
	Lugri(Wheat /khadum)
Phunkiyar	Chilra(Dough1)Buckwheat
	Lungri(Rice)
	Chang(Fresh)

Technology/Know-how transferred

Characterization of efficient Nitrogen fixing (NFB), Phosphorous solubilizing (PSB) and Potash mobilizing (KMB) bacteria from organic farmlands of Sikkim. The need based technology has been commercialized to Vendeep Green Globe Organic Venture Pvt. Ltd, Sikkim.

Cultivation of Shiitake mushroom and its enrichment with Vitamin D2. Technology transferred to M/s Innotech AgroPustikam Pvt Ltd, Guwahati Biotech Park, Assam; M/s Pravin Masalewale, Pune; and, M/s Ray's Tech Hamirpur, Himachal Pradesh

Publications

Kumar R, Acharya V, Mukhia S, Singh D, Kumar S (2019). Complete genome sequence of Pseudomonas frederiksbergensis ERDD5: 01 revealed genetic bases for survivability at high altitude ecosystem and bioprospection potential. Genomics. DOI: https://doi.org/10.1016/j.ygeno.2018.03.008

Kumar R, Acharya V, Singh D and Kumar S (2018) Strategies for high-altitude adaptation revealed from high-quality draft genome of non-violacein producing Janthinobacterium lividum ERGS5: 01. Standards in Genomic Sciences, DOI: 10.1186/s40793-018-0313-3.

Maurya AK, Devi R, Kumar A, Koundal R, Thakur S, Sharma A, Kumar D, Kumar R, Padwad YS, Chand G, Singh B and Agnihotri VK (2018) Chemical composition, cytotoxic and antibacterial activities of essential oils of cultivated clones of Juniperus communis and wild Juniperus Species. Chemistry and Biodiversity, DOI: 10.1002/cbdv.201800183.

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Left to right, 2nd row: Dr. Rakshak Kumar, Kiran Dindhoria, Dr. Rajni Devi, Shruti Sinai Borker, Srijana Mukhia, Kumari Anu

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Algal Biotechnology and Nutraceuticals

Microalgae based nutraceuticals and functional food

Microalgae are polyphyletic group of photosynthetic organisms that convert solar energy and CO_2 to myriad molecules of high commercial value. Microalgae are the primary producers of the aquatic ecosystems and are ubiquitous in their distribution. Microalgae have been advocated as potential source of high value nutraceuticals such as pigments, antioxidants, and polyunsaturated fatty acids (PUFAs). The primary advantage in industrial exploitation of microalgae for production of these nutraceuticals is that these organisms are photosynthetic in nature and can be cultivated in non-arable land using non-potable waters. The photosynthetic efficiency and surface area productivity of microalgae are 3–4 times higher compared to terrestrial crop. Further, the ease of scalability and continuous biomass production throughout a year gives microalgae an edge over other industrial crops.

Isolation and purification of microalgal strain

Algal strains from local freshwater bodies were isolated and maintained axenically and evaluated for their nutraceutical potential. A cocktail of anti-microbial composition was developed for axenization and maintenance of microalgae strains. Presently, 8 microalgae strains–*Spirulina platensis*, *Chlorella pyrenoidosa*, *Chlorella sorokiniana*, *Scenedesmus obliquus*, *Scenedesmus abundans*, *Scenedesmus acutus*, *Monoraphidium sp.*, *Desmodesmus sp.* are being maintained axenically at CSIR-IHBT (Fig. 1).

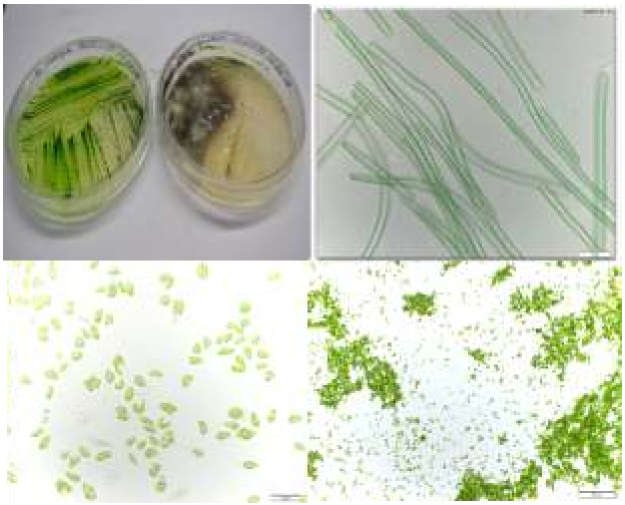


Fig. 1 Axenization of microalgae

1a) Purification of strains

1b) Photomicrograph of *Spirulina platensis*

1c) *Scenedesmus abundans*

1d) *Chlorella pyrenoidosa*

Characterization of pigments from microalgae

The microalgae strains were evaluated for their total carotenoid and pigment composition using various chromatographic and spectro-photometric techniques. The pigment accumulation kinetics for all the strains were recorder over the growth period (Fig. 2).

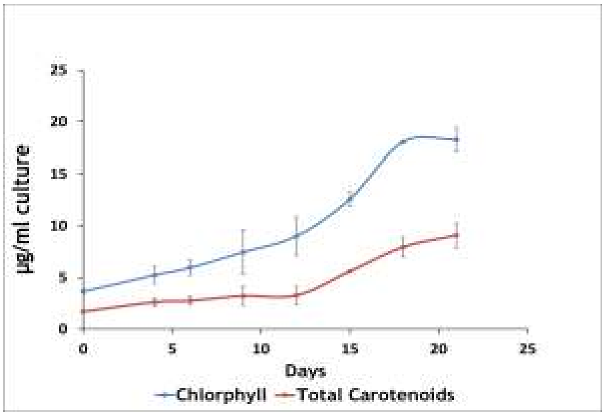


Fig. 2 Pigment accumulation in representative strain – Spirulina platensis

The total carotenoids content was 9 µg ml^{-1} live culture, yielding 14 mg g^{-1} Spirulina dry biomass. Among the carotenoids, beta carotene and lutein were predominant. Among the various solvents, use of acetone resulted in maximum yield (Table 1, Fig. 3 & 4).

Table 1 Carotenoid yield in *Spirulina platensis* with different organic solvents

Solvent	Carotenoid yield (% w/w)
Acetone	1.41±0.02
Methanol	0.72±0.04
Ethyl Acetate	0.99±0.09
Hexane	0.49±0.06

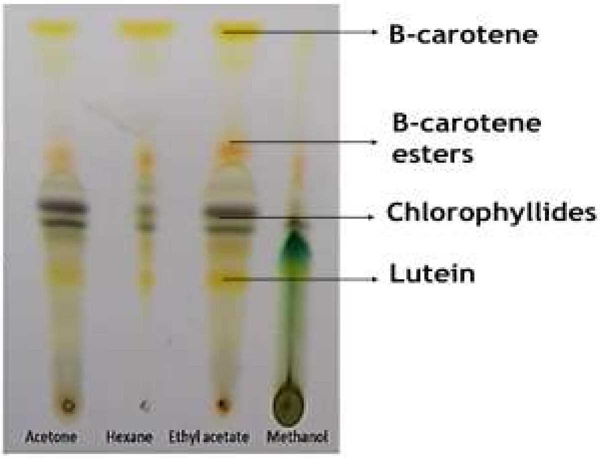


Fig. 3 Thin layer chromatogram of carotenoid extracts of *Spirulina platensis*

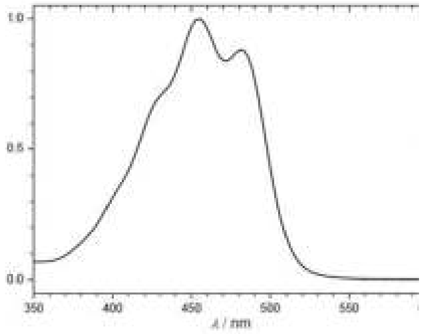


Fig. 4 Absorption spectrum of *Spirulina* carotenoid extract indicating presence of beta carotene

Optimization of C-phycocyanin extraction from *Spirulina platensis*

C-phycocyanin (C-PC) is a water soluble phycobiliprotein (a pigment-protein complex) with fluorescent properties. The pigment has a royal blue colour and its absorption maxima is at 620 nm. C-PC has been demonstrated with antioxidant properties (Fig. 5). A cost-effective process for bulk extraction of C-PC is being optimized with wet and dry biomass of *Spirulina platensis*.

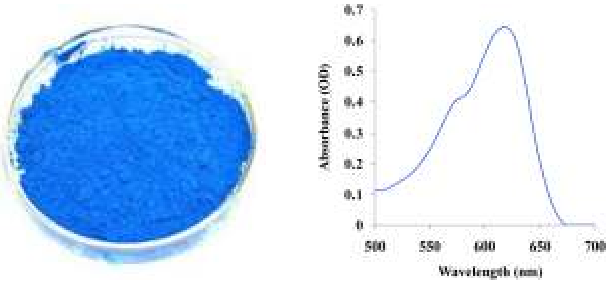
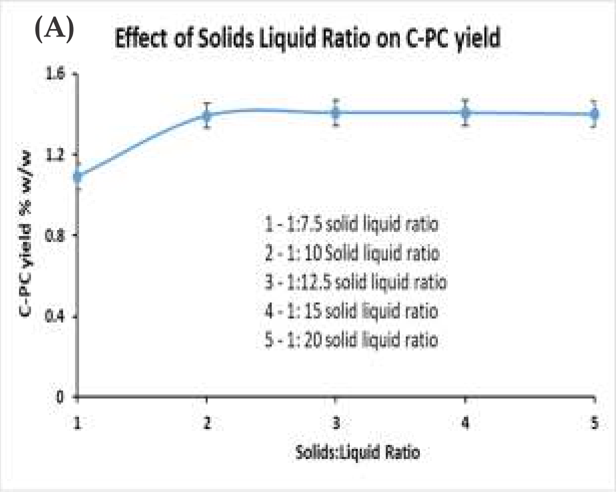


Fig. 5 Dry C-phycocyanin powder and Absorption spectrum of crude C-phycocyanin extract

Various process parameters such as solid to liquid ratio, extraction solvent, extraction pH, extraction time, physical pre-treatment of biomass, no. of extraction cycles are being standardized for pilot scale extraction and purification process. A C-PC yield of 1.6% w/w dry biomass with 78% purity was achieved by optimizing the aforesaid parameters (Fig. 6 A-D).



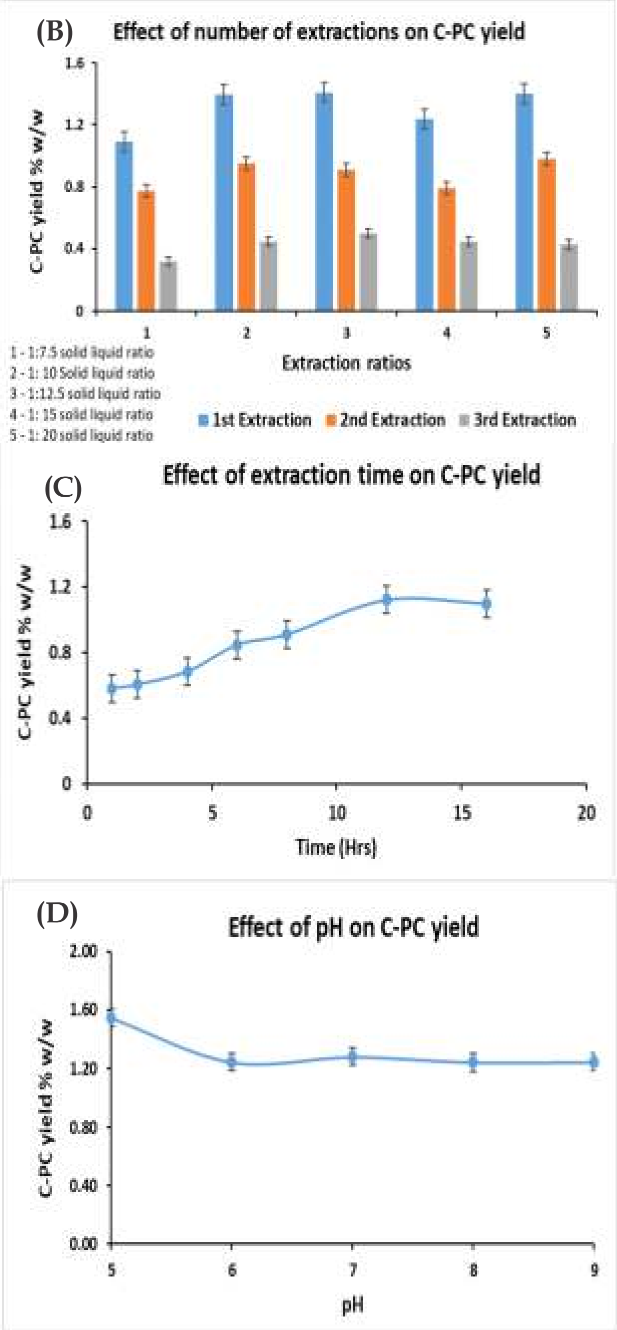


Fig. 6 Optimization of process parameters for C-phycocyanin extraction

Combating iron and zinc deficiency using microalgae based foods

Conventional micronutrient fortification and supplementation involves direct feeding of trace metals in the form of inorganic salts and synthetic vitamins or by fortification through food systems such as cereals and oils as per FAO/WHO recommendations. However, these synthetic supplements have several drawbacks such as a) Chemical instability; b) Reduced bioavailability and c) Binding of anti-nutrition factors such as phytic acid and polyphenols like tannins during cereal based fortification. Alternatively, edible microalgae such as *Spirulina platensis* and *Chlorella sp*. (*Chlorella vulgaris*/ *Chlorella pyrenoidosa*) have been considered as potential source of micronutrients. Microalgae accumulate micronutrients (Fe/Zn) and vitamins (Vit. A, Vit. B12) when cultivated under autotrophic conditions. Some of the advantages associated with use of microalgae are 1) Easily digestible – *Spirulina* does not have cellulosic cell wall; 2) No antinutrition factors like phytic acid; 3) Accumulation of nutraceuticals like carotenoids, omega fatty acids.

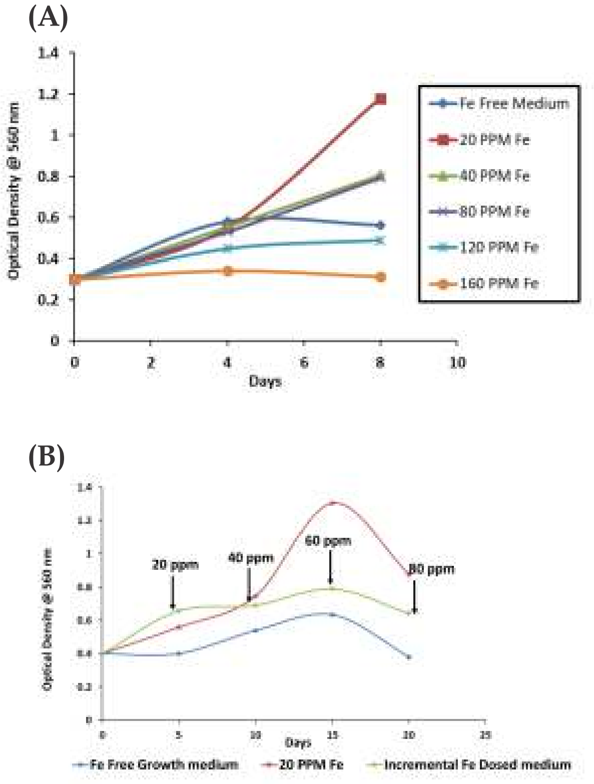


Fig. 1A Effect of direct iron (Fe) addition and 1B Effect of incremental iron (Fe) addition on growth of *Spirulina platensis*

In this regard, a cultivation strategy is being developed for simultaneous enhancement of micronutrients - iron and zinc and nutraceuticals like beta carotene, phycocyanin and omega 6 fatty acid (C18:3, n-6) gamma linolenic acid (GLA). In addition, development of low cost iron and zinc enriched food products incorporating iron and zinc enriched algae biomass are being developed.

Effect of external iron supplementation on growth and composition of *Spirulina platensis*

The standard *Spirulina* growth medium consists of ferrous sulfate ($FeSO_4.7H_2O$) at 20 mg L^{-1} concentration. The ability of *Spirulina platensis* to grow under different levels of iron ranging from 10 mg L^{-1} to 160 mg L^{-1} was studied and found that *Spirulina* could not tolerate levels beyond 40 mg L^{-1}. However, a cultivation method of continuous incremental iron dosing during growth increased the levels of toleration up to 80 mg L^{-1} with significant accumulation of total carotenoids (Fig. 7 A-B).

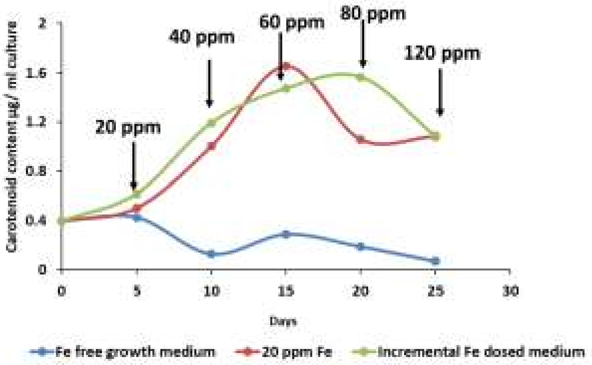


Fig. 7 Effect of iron (Fe) supplementation on carotenoid profile of *Spirulina platensis*

Iron and zinc fortified microalgae based food products

Spirulina based fortification of Fe/Zn was achieved by developing an energy bar with different matrix such as peanuts, sesame, cereals. The energy bar of serving size 25 grams

- Meets 25% RDA levels of Iron and Zinc per serving
- *Spirulina platensis* *Spirulina* energy bar
- Meets 8% RDA level of beta carotene (pro-vitamin A) per serving
- Meets 6-8% RDA of proteins per serving
- Contains phycocyanin at 4 mg per serving)
- Product has shelf life of 4 months

Spirulina platensis

***Spirulina* energy bar**

Development of low cost Nutrifoods for breakfast

The prevalence of malnutrition in India is one of the highest in the world affecting majorly the rural population. According to National Family Health Survey 4 (2015-16), malnutrition assessed by the proportion of underweight children below the age of five was 43% and 36% in the hard working women in India, higher than in sub-Saharan Africa (28%) and South Asia (42%). Malnutrition contributes to approximately 2.1 Million child deaths before the age of five every year. Inability to achieve minimum dietary intake levels of energy, protein along with deficiency of essential nutrients such as vitamin A, iron, zinc is linked to a higher risk of death. Although programs such as midday meal scheme are successful, it was observed that almost 30% of children who benefit from midday meals do not have economic means to have proper breakfast. Hence under CSIR-Nutraceuticals and Nutritional mission several protein rich breakfast products are being developed such as

- Multigrain high protein mix
- Protein and fibre enriched cereal bars

Multigrain high protein mix

Instant flavoured drink mixes rich in proteins were developed providing 200-250 Kcal when reconstituted and up to 10 g protein and 4 g fibre per serving (50g). The product is developed using 100% natural ingredients like wholegrains, millets, pulses. The product is preservatives, malto-dextrin and thickeners free. The product is non-hygroscopic and free flowing with a shelf life of 10 months. The product meets 20% recommended dietary allowances (RDA) of protein and dietary fibre and meets greater than 10% RDA of iron and calcium.

Multigrain high protein mix and beverage

Protein and fibre enriched cereal bars

A technology for commercial production of protein and fibre enriched cereal bars meeting at-least 20% recommended dietary allowances (RDA) of protein and fibre. The global protein and energy bars market is currently USD 2.3 billion growing annually at 8.4% and expected to reach USD 3.5 billion by 2025.

The product is ready to eat food providing 150 - 200 Kcal energy and 6-8 g protein per serving (40g). The product is developed using 100% natural ingredients like wholegrains, millets, pulses, dehydrated fruits and nuts and are preservative or additive free. The product has high unsaturated fats to saturated fat ratio (4:1) and sugar content less than 7 g. The product has shelf life of 4 months.

Photographs of products manufactured by CSIR-IHBT technology partners

Left to Right, 1st Row: Ms. Priyanka Parmar, Dr. Vidyashankar, Ms. Sampa Das, Ms. Anika

Left to Right, 2nd Row: Mr. Saurav Gurung, Mr. Nishant, Mr. Kartik Sharma, Mr. Raman Kumar

Food and
Nurtraceuticals

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Food and Nutraceuticals

Himalayas are known for rich heritage of medicinal and aromatic plants with wide applications in healthcare, food, cosmetics and pharmaceutical industries. However, this diversity is under the threat of extermination owing to indiscriminate collection, poor regeneration process and meagre attempts to replenish the dwindling plant population. In this regard, a concerted effort is being made at CSIR-IHBT to develop sustainable alternative systems for mass production of bioactive ingredients employing *in vitro* plant cell and organ culture technology. It will not only subsidize the mounting pressure on natural habitats, but also help in meeting the rising industrial demand of such bioactive ingredients on sustainable basis. Also, one Niche Creating Project entitled, "Non-invasive technology for production of naphthoquinone pigments from *Arnebia* species on sustainable basis" funded by CSIR under the theme of Agriculture Nutrition Biotechnology is undertaken during this period.

In addition, CSIR has launched a new mission on Nutraceuticals and Nutritionals for health and wellness of the people of India in 2018-19. CSIR-IHBT is the nodal laboratory for the mission and therefore, our group is coordinating the mission activities within a network of 10 CSIR institution across India.

Alternative systems for production of industrially important plant metabolites

In vitro adventitious root cultures of *Picrorhiza kurroa* as an alternative source of nutraceutical ingredients (Funded by Department of Science and Technology, Ministry of Science and Technology, Government of India)

In continuation of previous activities, adventitious roots were induced from the leaves of established *in vitro* shoot culture of *Picrorhiza kurroa.* Among various media, Murashige and Skoog (MS) and Gamborg's B-5 (B5) medium showed higher rhizogenic potential (Fig. 1). The metabolic profiling revealed varied accumulation of marker compounds in different plant part as well as accessions. In addition, induced adventitious roots had similar metabolic profile to that of mother plants (Table 1). Therefore, these roots could be a potential alternative method to obtain bioactive ingredient in shorter period throughout the year. This method of plant ingredient generation will definitely offer various advantages including controlled supply of biochemical independent of plant availability (cultivation season, pests and politics), well defined production systems on sustainable basis.

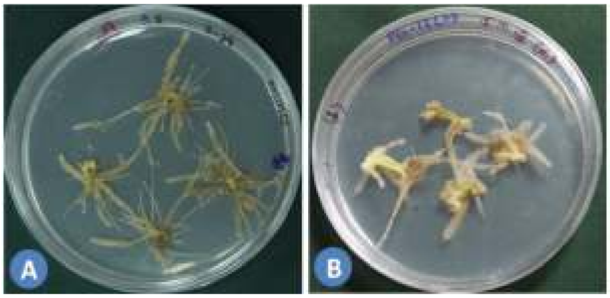

Fig. 1 Effect of medium on induction of adventitious roots from leaf explants of *P. kurroa*: A) Murashige and Skoog (MS) & B) Gamborg's B-5 media

Table 1 Quantitative analysis of Picroside I, II and III *in vitro* induced AR of *P. kurroa*

Sample	Picroside I (% DW)	Picroside II (% DW)
Leaves (mother culture)	5.65±0.34	0.47±0.10
In vitro induced AR	0.37±0.04	0.44±0.08

Non-invasive technology for production of naphthoquinone pigments from *Arnebia* species on sustainable basis (Niche Creating Project funded by CSIR under the theme of Agriculture Nutrition Biotechnology)

Establishment of adventitious root (AR) cultures of *Arnebia euchroma*

Leaf explant were inoculated on Murashige and Skoog (MS) and Schenk & Hidebrandt (SH) medium supplemented with different concentrations of IBA (1.5, 2.0, 2.5 & 3.0 mg/L). Amongst both medium, SH was found to be effective for the induction of ARs. The maximum AR induction (91.67 %) was obtained in 2.5 mg/L indole-3-butysic acid (IBA) after 4 weeks of inoculation (Fig. 2). The average number and length of AR in this medium was 24.66±5.43 and 0.84±0.13 cm, respectively. In both the cases, leaves showed swelling and little callusing at the mid rib as well as cut edges after five days of cultivation. AR formation was visible after 8-10 days of inoculation (Fig. 3).

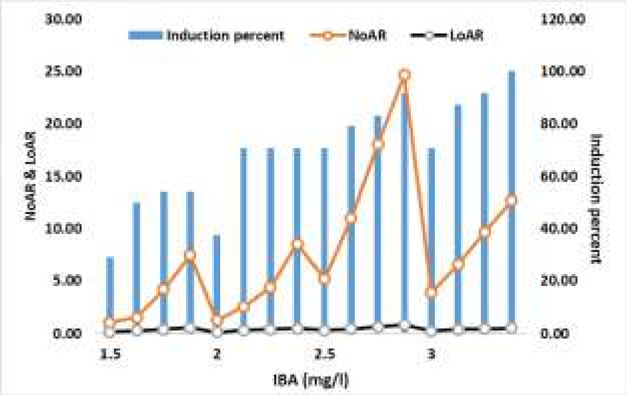

Fig. 2 Establishment of adventitious root (AR) cultures from *A. euchroma*; NoAR – Number of AR, LoAR – Length of AR

Fig. 3 Induction and multiplication of adventitious root (AR) cultures Production of naphthoquinone pigment from adventitious root cultures

AR and Callus was inoculated in APM for the accumulation of secondary metabolite. Results showed that maximum accumulation of shikonin in cell culture at 12th day of cultivation period. However, pH of the medium was gradually decreases upto 12th day during production phase (Fig 4).

Fig. 4 Naphthoquinone pigment production from induced AR cultures

The pH of media (6.00), agitation (100 rpm), temperature (25 ± 2°C) and dark conditions favour the pigment production (Fig 5).

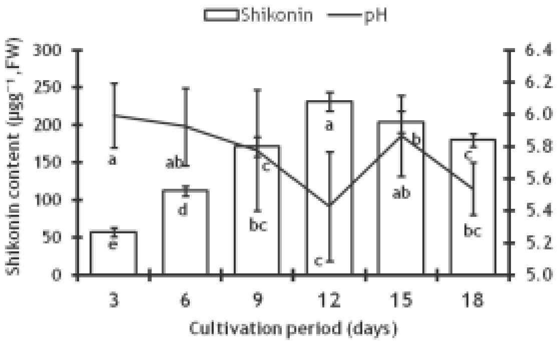

Fig. 5 Shikonin production and pH variation in cell culture of *Arnebia benthamii*

Establishment of adventitious root (AR) cultures of *Valeriana jatamansi*

In vitro adventitious roots were induced from leaf explant of *V. jatamansi* on SH medium supplemented with different concentration of Indole-3-butyric acid (IBA). About 90% AR induction was obtained on SH medium supplemented with 9.84 µM IBA (Fig. 6). Further multiplication of these expressed roots was achieved in liquid SH medium supplemented with 4.92 µM IBA.

Fig. 6 Induction and multiplication of adventitious root (AR) cultures of *Valeriana jatamansi*

In addition, a low cost indigenized bioreactor facility was established for scale up studies of the protocols developed at laboratory scale to produce industrially important plant metabolites (Fig. 7).

Fig. 7 Indigenized bioreactor facility established at CSIR-IHBT

Left to Right: Neha Kumari, Khem Singh, Shashi Bhushan, Ashok Gehlot, Jyoti Devi and Pooja Sharma

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Food Science and Technology

My current research area is in the development of functional food and nutraceutical particularly prebiotic and probiotics, traditional and nutritionally rich food products from underutilized food bioresources of Himalayan region. I also involved in the nutrition and nutraceutical mission of CSIR for development of food for cardio-protection and Agri Nutri Biotech Theme of CSIR for development of indigenous lyophilizer for drying of fruits and vegetables.

Optimization of Instant Khichdi

Khichdi is a wholesome meal that has the perfect balance of nutrients and considered as national cuisine. It is traditionally prepared by combination of rice, whole green gram/yellow split moong dal with addition of edible oil and salt. The instantization process of making khichdi was optimized using different combination of rice and dal. Rice is pre-processed to a moisture content of approximately seven percent or less, that needs 4-5 minutes to reconstitute. It is often consumed as a breakfast food and is considered as a health food. The digestive property of instant khichdi after rehydration is also important to consumers, especially those suffering from metabolic disorders. Selective uptake of foods that induce lower glycemic index (GI) is advantageous reduce fat accumulation and dietary management of the metabolic disorders. CSIR-IHBT developed instant khichdi is a balanced product that has rice, dal, spices and shredded coconut. This is a nutritious and staple food that provides wholesome with carbohydrates (9.9%), proteins (11.7%), fat (26.7%), dietary fiber (13.33%) and vitamin (5.25%), respectively. The overall acceptability of instant khichdi by the consumers is very good.

Key features of instant khichdi:

- Easy to digest,
- Good rehydration capacity (5-6 min),
- Suited in delicate health situation,
- Convenient packaging that can be easy to open and serve
- Shelf life up to 4 months.

Nutrition Facts

Table 1

NUTRIENTS	%DV per serving
Energy	10.5
Protein	11.7
Fat	26.7
Carbohydrates	9.9
Fiber	13.33
Vit C.	5.25

DV-Daily Value*-Calculated based on RDA for adult man on a 2000kcal diet as per Dietary guidelines of ICMR-NIN, Indian &Nutritive Value of Indian Foods, ICMR-NIN RDA- Recommended Dietary Allowance; ICMR-NIN—Indian Council of Medical Research-National Institute of Nutrition.

Fig. 1 Instant Khichdi Mix

Identification of two novel antioxidant peptides from finger millet (*Eleusine coracana*) protein hydrolysate.

Two novel antioxidant peptides were identified from trypsin digested finger millet protein hydrolysate. Different chromatographic techniques such as ultrafiltration, gel-filtration and reverse-phase ultra- flow liquid chromatography were used to purify the peptides. Antioxidant activity was significantly increase upon separation of peptides and found to be higher in comparison to protein isolate. The amino acid sequence of the antioxidant peptides was identified as TSSSLNMAVRGGLTR and STTVGLGISMRSASVR using MALDI-TOF-MS/MS. Further, synthetic peptides with the same sequence were synthesized to confirm their antioxidant activity. Hence, current study suggested that peptides identified from finger millet possess potential antioxidant activity and may be used as a promising source of functional food ingredient.

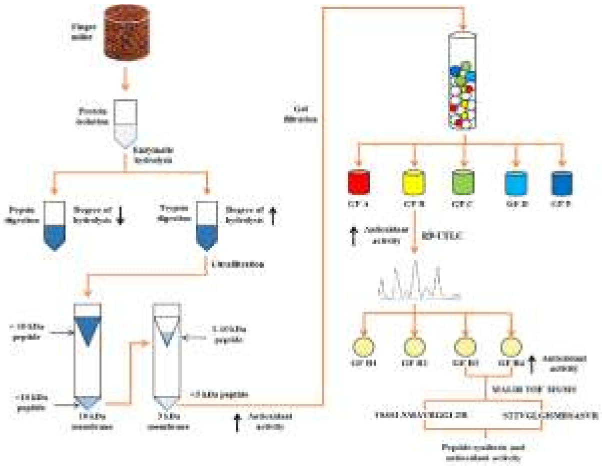

Fig. 2 Methodology used for the purification and identification of antioxidant peptides from finger millet

Characterization of phytochemical constituents of high altitude crab apple (*Malus baccata*)

Malus baccata found in the high altitude region of Himachal Pradesh, India is usually recognized as 'wild apple' or 'crab apple' and known for its small and astringent nature. It is a small sized, cold field fruit with traditional medicinal values. *Malus baccata* (Himalayan crab apple) was collected from Keylong, Himachal Pradesh (3080 m) and its different parts (seed and pulp) were analysed for phytochemical constituents. Total phenolics and flavonoid contents were observed in both the pulp and seed extracts followed by higher antioxidant activities (DPPH, ABTS scavenging assay). Major phenolic compounds were found as phloretin and phloridzin in a significant amount as analyzed by UPLC. Both pulp and seed extract possess good amount of soluble sugars especially in the form of inositol and arabinose as quantified using HPEAC. Similarly, pulp extract contain significant amount of free amino acids with a higher content of cysteine and tyrosine. Furthermore, GC-MS analysis also showed the higher content of linolein in seed extract. Overall the study signifies *Malus baccata* is a good source of antioxidants and rich in essential fatty acids, amino acids and sugars. This can be used for making functional food and nutraceutical for various health promoting benefits.

Fig. 3 Phytochemical profiling of Himalayan crab apple (*Malus baccata*)

Extraction optimization of soluble polyphenols from *C. reticulate* (Kinnow) peel

Indian fruits market consists of variety of citrus fruits (*Citrus sinensis*, *Citrus paradisi*, *Citrus limon*, *Citrus aurantiifolia*). The Mandarin orange (*Citrus reticulate*) is the most common citrus fruit which occupies 40% of the total citrus cultivation in India. About half of the total dry weight of mandarin fruit is due to peel fraction, which is reportedly known for richness in antioxidants and other bioactive constituents. In our study, phenolic extraction yield was enhanced by optimizing extraction conditions including techniques (maceration, ultrasonication, homogenization and hot water extraction) and varied parameters such as solvent ratio, time and temperature. Further, the phenolic rich fraction was evaluated for cytotoxic study using cancer cell lines including skin cancer (A-431), lung cancer (A-549) and colon colorectal cancer (HCT-116). Results of this study showed that ultrasonic assisted extraction (UAE) showed higher amount of phenolic acids, more yield and high antioxidant activity. The total phenolic content (TPC) and total flavonoid content (TFC) determined in UAE were 76.16 µg GAE/ mg and 10.46 µg RU/mg respectively with a phenolic yield of 29.0%. The maximum recovery of polyphenols and flavonoids was observed at 80°C for 30 min extraction time. *In vitro* study revealed that *C. reticulate* (Kinnow) extract is more effective against skin cancer cells (A-431) followed by lung cancer (A-549).

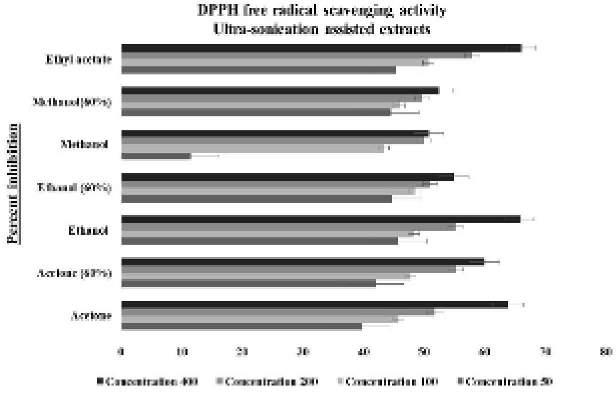

Fig. 3 Free radical scavenging activity (DPPH) of *C. Mandarin*

Design and Development of Indigenized Lyophilizer for preservation of Indian Fruits and Vegetables

CSIR-CSIO and CSIR-IHBT jointly propose this project for the development of lyophiliser. The project envisages design, development and testing of indigenized lyophiliser for preservation of Indian Fruits and Vegetables. The developed unit would be suitable for application in domestic industries that are involved in the freeze drying processing of Indian fruits and vegetables. The proposed freeze drying setup also exhibits significant potential as it will be designed to be customizable and the process controls are planned to be programmable as per the processing requirements of the specific fruits and vegetables developed by CSIR-IHBT.

Current Output

- Review of existing state-of-art lyophilizer available in market jointly by both labs.
- Preliminary laboratory scale experiments performed using imported systems installed at CSIR-IHBT.
- Achieved encouraging results in experimentation for modification in the proposed design.
- Modular designs are being prepared by CSIR-CSIO.

Value added food products from native and traditional crops

Hull less barley, buckwheat and underutilized crops of high altitude region have been selected and analysed to check their nutritional composition and use further for product development. Formulation of barley coffee and buckwheat noodles has been done. Buckwheat noodles were developed as a value added product to give a new beginning to underutilized crop buckwheat. The Buckwheat Noodles were prepared by adding optimized quantity of buckwheat flour to get good cooking quality without compromising the taste and nutritional value. The developed product was then analyzed for its nutritional, functional, textural and sensory profile.

Table 2 Composition of media used for phospholipase/ lipase production

Component	(g/L)
Yeast extract	5
KCl	0.50
NaNO3	3
MgSO 4.7H 2O	0.50
K2HPO4	0.10
FeSO4	0.01
Oil (substarte)	10 ml
Distilled water	1000 ml

Publication:

Agrawal H, Joshi R and Gupta M (2019) Purification, identification and characterization of two novel antioxidant peptides from finger millet (Eleusine coracana) protein hydrolysate. Food Research International, 120: 697-707.

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Pharmacology and toxicology lab works in the area of safety/toxicity and efficacy evaluation of phyto-formulations and active principles by addressing their underlying molecular mechanism with special emphasis on inflammation, diabetes and cancer.

Identification of green tea catechin epigallocatechin gallate (EGCG) as potential modulator of cell senescence

Cellular senescence is a state of irreversible growth arrest characterized by a specific set of physiochemical changes and cellular functions. A gradual accumulation of senescent cells, and senescence-associated secretory phenotype (SASP) is considered as a causative agent leading to familiar macroscopic consequences of tissue dysfunction and aged phenotype. Cellular senescence can be induced by a variety of factors, but the age-associated accumulation of reactive oxygen species (ROS) is a potent modulator of inflammatory and nutrient sensing pathways that ultimately culminate into the acceleration of cellular senescence program.

EGCG is a major component of green tea with several purported health beneficial effects. We and others have previously shown that EGCG is effective in improving age-associated disorders such as immunosenescence, inflammation and organ functions, as well as extending lifespan in experimental animals. However, there appears to be a distinct dearth of studies pertaining to understanding the anti-senescence mechanisms of EGCG and, in particular, its influence in modulating nutrient sensing pathways vis-a-vis senescence and senescence-associated secretory phenotype (SASP). To account for these lacunae, a study was designed to assess whether and how EGCG mitigates progression of cellular senescence using preadipocytes. Premature senescence was established in cells by repeated exposure of H2O2 at a sub-lethal concentration (150µM). H2O2 treated cells showed characteristic senescence-associated features including increased cell size, senescence-associated β galactosidase activity (SA-β-gal), development of SASP, activation of reactive oxygen species (ROS) and pathways, DNA damage as well as induction of cell cycle inhibitors (p53/p21WAF1/p16INK4a). In addition, a robust activation of PI3K/Akt/mTOR and AMPK pathways was also observed in H2O2 treated cells (Fig 2). Presence of EGCG (50 and 100 µM) showed significant downregulation of PI3K/Akt/mTOR and AMPK signaling along with the suppression of ROS, iNOS, Cox-2, NF-κB, SASP and p53 mediated cell cycle inhibition in preadipocytes (Fig 2). In addition, EGCG treatment also suppressed the accumulation of anti-apoptotic protein Bcl-2 in senescent cells thereby promoting apoptosis mediated cell death. Our results collectively showed that EGCG acts as an mTOR inhibitor, SASP modulator as well as a potential senolytic agent thereby indicating its multi-faceted attributes that could be useful for developing antiaging or age-delaying therapies (Fig. 3).

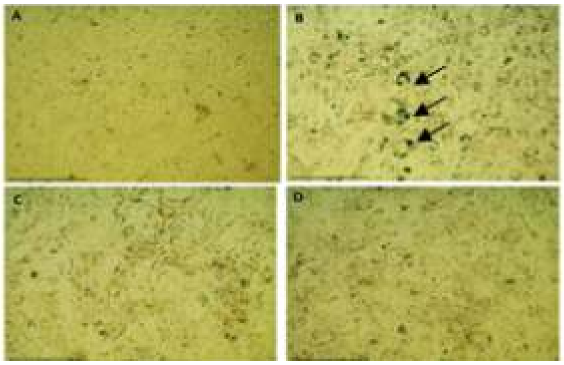

Fig. 2 EGCG treatment inhibits senescence induced activation of mTOR pathwayFig. 1 EGCG treatment suppresses SA-β-gal activity marker of senescence

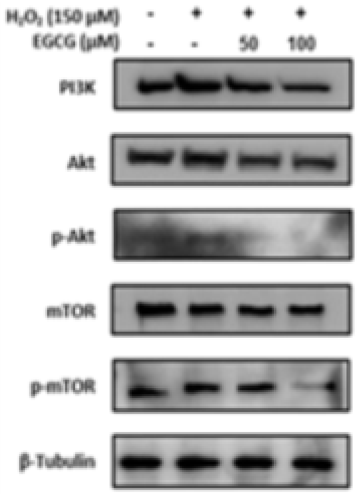

Fig. 2 EGCG treatment inhibits senescence induced activation of mTOR pathway

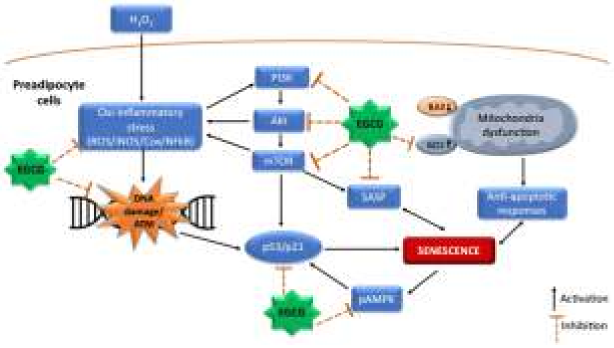

Fig. 3 Proposed mechanism of EGCG action in alleviating senescence in preadipocytes

Role of Berberis lycium Royle fruits in mitigating oxi-inflammatory stress

Inflammation is a physiological immune response to invading pathogens and injury, but the process is also implicated in the pathogenesis of various chronic inflammatory disorders, such as rheumatoid arthritis, inflammatory bowel disease and neurodegenerative disorders. Inflammatory responses involve both innate and adaptive immune cells, well as effector ROS molecules such as NO and various cytokines and chemokines including TNF-α, IL-1β, IL-6, MCP-1 and regulated on activation, normal T expressed and secreted (RANTES). These responses are under tight transcriptional regulation involving both NF-κB-dependent and -independent inflammatory pathways such as ERK, p38 MAPK, and JNK.

Berberis lycium Royle, also known Indian berberry, is a valuable medicinal plant that is wildly distributed in the Himalayan region at 2000–2700 m altitude. Preliminary investigations have indicated that different parts of this plant (especially bark and roots) exhibit anti-microbial, anti-inflammatory, anti-carcinogenic and hepatoprotective activities which are thought to be due to the presence of various bioactive phytomolecules such as alkaloids, phenolics and anthocyanins. However, despite these emerging findings, there appears to be a distinct dearth of studies pertaining to understanding the molecular mechanism(s) governing the putative anti-inflammatory and anti-oxidant effect of this plant. Therefore, keeping the foregoing discussion in view, we hypothesized that B. lycium fruit extract (BLFE) could ameliorate inflammatory aggravation in innate immune cells by modulating NF-κB and MAPK mediated signalling pathways. To test our hypothesis, in the present study we assessed the efficacy of Berberis lycium Royle fruit extract (BLFE) in the attenuation of lipopolysaccharide (LPS)-induced oxi-inflammatory aggravation and concanavalin A (Con-A)-induced proliferation in murine peritoneal macrophages and lymphocytes, respectively. BLFE strongly suppressed production of the oxidative and inflammatory effector molecules nitric oxide (NO), reactive oxygen species (ROS), inducible nitric oxide synthase (iNOS), inflammatory cytokines (TNF-α/IL-6/IL-1β/IFN-γ) as well as chemokines (MCP-1 and RANTES), with a concomitant enhancement in heme oxygenase-1 (HO-1) and IL-10 levels. Subsequent mechanistic analysis revealed that BLFE strongly inhibited the phosphorylation of IκBα as well as MAPKs such as extracellular signal-regulated kinase (ERK), p38 MAPK, and c-Jun NH2-terminal kinase (JNK), thereby directly resulting in the suppression of nuclear factor-κB (NF-κB) and c-Jun activation, ultimately culminating in the observed attenuation of inflammatory molecules. Additionally, BLFE appeared to mitigate Con-A-induced proliferation of Tregs (CD3+CD4+CD25+) thereby suggesting its modulatory effects on adaptive immune cells. UPLC–DAD–ESI-QTOF-MS/MS of BLFE revealed the presence of major bioactive phenolics and alkaloids including chlorogenic acid, rutin, catechin and quercetin 3-d-galactoside, berberine and magnoflorine, which could have synergistically contributed to the above findings. Overall, these obseravations provide evidence that BLFE may be effective in the mitigation of inflammatory disorders, especially those associated with NF-κB/MAPK activation (Fig 4&5).

Fig. 4 Effect of Berberis lycium Royle fruit extract (BLFE) in the attenuation of lipopolysaccharide (LPS)-induced oxi-inflammatory aggravation and concanavalin A (Con-A)-induced proliferation in murine peritoneal macrophages and lymphocytes

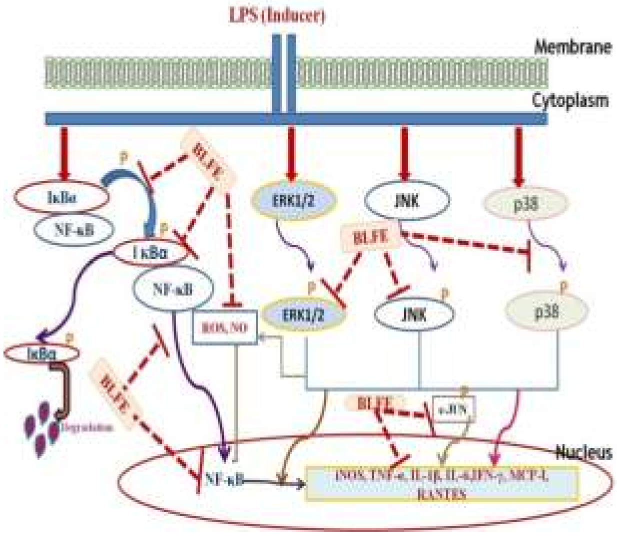

Fig. 5 Schematic diagram of probable signaling cascade mediating BLFE induced anti-inflammatory effects. LPS stimulation augments inflammatory response by enhancing NO, ROS, cytokines and chemokines through activation of NF-κB, c-Jun and MAPKs (ERK, JNK and p38). BLFE suppresses LPS induced IκBα as well as MAPKs dependent NF-κB activation, which culminates in the suppression of inflammatory effector molecules. Notwithstanding this, the inhibitory effect of BLFE on c-Jun, ERK, JNK and p38 activation could also directly result in inhibition of iNOS, cytokines and chemokine level

Development of applications of laccase for Diverse (Food health and cosmetic) Industries (DALDI).

Laccase is commercially important enzyme. It is not easily available for developing its industrial applications. Being expensive enzyme not many people are working on the development of varied application of laccase. This gap can be filled if laccase is made available at low cost and its applications are demonstrated resulting in high demand for laccase enzyme. This is exactly being addressed through this project. laccase is import substitute and its application are innovations in the food, cosmetic and medical field. import substitute and having export potential which will be use in a process for production of Theaflavin rich functional tea/sliming tea.

Publications:

- Sharma R, Kumari M, Kumari A, Sharma A, Gulati A, Gupta M and Padwad YS (2019) Diet supplemented with phytochemical epigallocatechin gallate and probiotic Lactobacillus fermentum confers second generation synbiotic effects by modulating cellular immune responses and antioxidant capacity in aging mice. European Journal of Nutrition, DOI: 10.1007/s00394-018-01890-6.
- Sharma A, Sharma R, Kumar D and Padwad YS (2018) Berberis lycium Royle fruit extract mitigates oxi-inflammatory stress by suppressing NF-κB/MAPK signalling cascade in activated macrophages and Treg proliferation in splenic lymphocytes. Inflammo-pharmacology. DOI: 10.1007/s10787-018-0548-z.

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Left to Right, Bottom Row: Mr. Shiv Patil, Mr. Abhishek Goel, Ms. Anamika Sharma, Ms. Jyoti Chhimwal, Ms. Kajal Sinha, Ms. Sanyukta Darnal, Ms. Smita, Mr. Ravi Thakur

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Our group is involved in understanding the novel targets to identify leads for comprehensive management of epilepsy. The group is working under Phytopharmaceuticals Mission of CSIR for development of plant based anti-snake venom. The group efforts, in association with another CSIR lab have identified a novel herbal combination as nutraceutical to combat age-linked cognitive impairments under Nutraceuticals and Nutritionals mission of CSIR.

Apigenin for suppression of epilepsy associated neurobehavioral conditions

Bioactive metabolites from natural products have been emerged out to be a better substitute for the management of chronic diseased conditions due to their multi-targeted nature. One of the major class of plant polyphenolic compounds constitute flavonoids that has wide range of pharmacological activities. 4′,5,7-trihydroxyflavone (Fig. 1), known as apigenin is a bioflavonoid present in vegetables and fruits.

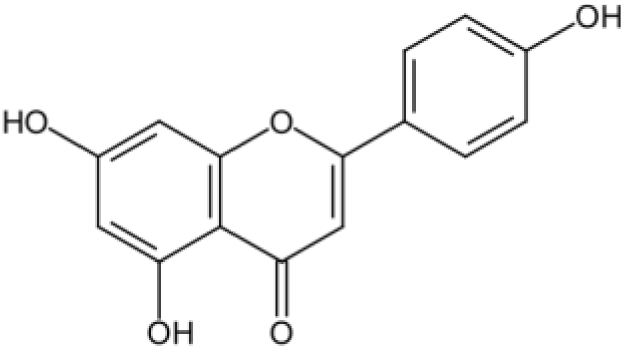

Fig. 1 Chemical structure of 4′,5,7-trihydroxyflavone (apigenin)

It has shown a wide variety of neurolo-pharmacological effects in experimental animal models following oral administration. Based on the literature reports, the effect of apigenin was studied in pentylenetetrazole (PTZ) kindling development and associated neurobehavioral impairments in mouse. Its neuroprotective effect is also well reported. (Sharma *et al*., 2018). The animals were subjected to kindling by repeated administration of a sub-convulsive dose of PTZ (35 mg/kg) at 48 ± 2 h. The kindled animals were further post-treated with apigenin (10 and 20 mg/kg) for 20 days. Each animal was challenged a sub-convulsive dose of PTZ at every 5th of apigenin treatment to record seizure severity. At the end of the treatment memory and behavioral functions were studied using different paradigms.

Apigenin treatment failed to show a significant effect on seizure severity in kindled mice as compared to control, at both the studied doses. Interestingly, its treatment showed a significant increase in the spontaneous alterations in T-maze test. Furthermore, its treatment reduced the seizure-liked anxiety-like behavior indicated by a marked decreased in anxiety index in elevated plus maze test. The treatment also attenuated depression-like behavior, as there was a significant decrease in the duration of immobility period in both tail suspension test and forced swim test. However, no change in total locomotion among different groups was observed in the open field test. The hippocampal protein expression of cAMP response element binding protein (CREB), phosphorylated CREB and brain-derived neurotrophic factor (BDNF) factor was found increased. Furthermore, HPLC-based electrochemical detection system showed a significant increase in serotonin level of the hippocampus. The results concluded that apigenin administration attenuated seizures linked cognitive deficit and behavior impairments. From the results of biochemical and protein expression studies the protective effect of apigenin can be correlated with CREB-BDNF upregulation in the hippocampus (Fig. 2).

Mycophenolate mofetil prevents seizures in rat model of temporal lobe epilepsy

Central neuroinflammatory pathways play a crucial role in the pathogenesis of epilepsy, particularly temporal lobe epilepsy. Several agents that inhibits neuroinflammatory processes have been found to be effective in supression of epileptic seizures. Mycophenolate mofetil (MMF) is used as an immuno-suppressant in organ transplantation to avoid body rejection. It is a type of a prodrug that after absorption gets metabolized into its active form, mycophenolic acid, which act as a non-competitive inhibitor of the *de-novo* purine biosynthesis. Apart from immunosuppressant activity, it showed neuroprotective effects, reported to interact with inflammatory pathways. Hence its effect in a rat model of temporal lobe epilepsy was studied (Mazumder et al., 2019).

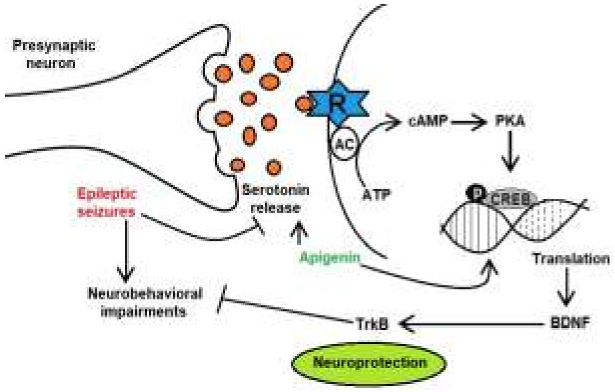

Fig. 2 Proposed mechanism of apigenin in suppression of seizures-associated neuro-behavioral impairments. AC: Adenyl cyclase; ATP: Adenosine triphosphate; BDNF: Brain-derived neurotrophic factor; cAMP: Cyclic adenosine monophosphate; PKA: Protein kinase A; pCREB: phosphorylated cAMP response element binding protein; R: Receptor and; TrkB: Tropomyosin /tyrosine receptor kinase B

We used lithium pilocarpine-induced spontaneous recurrent seizures model that imitates human diseased condition to study the effect of MMF. Its treatment (10 and 20 mg/kg; *p.o.*) reduced the severity of spontaneous recurrent seizures. Improvement in spatial and recognition memory functions in epileptic rats was also observed following treatment with MMF. Interestingly the treated rats showed decreased aggression and depression-like behavior in comparison to vehicle control group. Histopathological studies showed reduction in the number of dark neurons (marker of neuronal damage) and decreased mossy fibre sprouting in the hippocampus. Immunohistochemistry showed increased NeuN, with decrease in mTOR, S6, pS6 and GFAP protein level in the hippocampus of rats treated with MMF. The treated rats also showed decrease in hippocampal mRNA level of *HIF-1a, IL-2, IL-1β, PI3K, AKT, RAPTOR, mTOR, Rps6* and *Rps6kb1.* Based on the results it was concluded that there was inhibition of IL-1β and IL-2 associated PI3K/AKT/mTOR signaling pathway hyperactivation by MMF that led to suppression of spontaneous recurrent seizures and abolition of neurobehavioral impairments (Fig. 3).

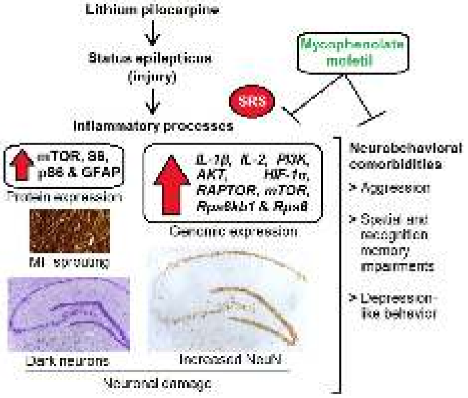

Fig. 3 Schematic representation of lithium pilocarpine induced spontaneous recurrent seizures and proposed mechanism of mycophenolate mofetil in seizure suppression and

associated comorbidities. associated neurobehavioral impairments. mTOR: Mammalian /mechanistic target of rapamycin; IL: Interleukin; HIF: Hypoxia-inducible factor; MF: Mossy fibre and; SRS: Spontaneous recurrent seizures

Publications

Mazumder AG, Patial V, Singh D (2018) Mycophenolate mofetil contributes to downregulation of the hippocampal interleukin type 2 and 1β mediated PI3K/AKT/mTOR pathway hyperactivation and attenuates neurobehavioral comorbidities in a rat model of temporal lobe epilepsy. Brain, Behaviour and Immunity DOI.org/10.1016/j.bbi.2018.09.020.

Sharma P, Sharma S and Singh D (2018) Apigenin reverses behavioral impairments and cognitive decline in kindled mice via CREB-BDNF upregulation in the hippocampus. Nutritional Neuroscience. DOI:10.1080/1028415X.2018.1478653.

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Our research group is involved in the area of scientific validation and safety/toxicity assessment of various natural products, nutraceuticals and nanomaterials in laboratory animal models. The preclinical toxicity studies are conducted as per standard International guidelines.

Picrorhiza kurroa for the management of non-alcoholic fatty liver disease

The non-alcoholic fatty liver disease (NAFLD) is characterized by hepatic steatosis, steatohepatitis, and cirrhosis. The prevalence of NAFLD is reported between 10-30% worldwide. *Picrorhiza kurroa* is a well-known plant for its hepatoprotective activity and we have further explored its potential against NAFLD.

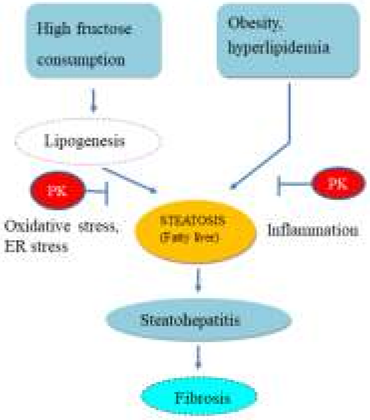

Fig. 1 Proposed mechanism of action of *Picrorhiza kurroa* (PK) against NAFLD

The extract and iridoid glycoside rich fraction from *Picrorhiza kurroa* were screened in the fructose induced NAFLD model of zebrafish. The extract as well as fraction found to lower the fat deposition in the liver of zebrafish larvae but the effect was more pronounced in the extract. Further, the extract more effectively lowered the expression of various genes involved in the pathogenesis of NAFLD in the diseased fish larvae. The effect of extract was also evaluated in the over feeding induced NAFLD model of adult zebrafish. The extract was found to lower the body weights and body mass index of zebra fish significantly. The histopathology study showed that extract lowered the fat droplet accumulation in the livers of adult zebrafish. Further, the extract also normalized the expression various genes in the liver tissue. Overall, the plant has shown potential against NAFLD in zebrafish model.

Efficacy of dendrimer conjugated podophyllotoxin against hepatocellular carcinoma

The dendrimer conjugated podophyllotxin (DPODO) was evaluated for its efficacy against diethyl nitrosamine (DENA) induced hepatocellular carcinoma (HCC) in mice. The microscopic changes like necrosis, karyomegaly, anisocytosis and inflammation were observed in the liver of DENA treated mice. DPODO treatment at 10 mg/kg bw and 20 mg/kg bw dose significantly improved the liver histopathology. IL-6 and NF-κB are the key markers for the prognosis of HCC. DPODO treatment significantly found to lower the levels of inflammatory markers IL-6 and NF-κB in serum and liver tissues respectively. Further, the molecule also reduced the fibrous tissue deposition in the liver, which was further confirmed by the reduced mRNA levels and tissue expression of fibrogenic markers TFG-β and α-SMA in liver tissues of mice. In conclusion, DPODO prevented the HCC progression by regulating the inflammatory and fibrogenic factors.

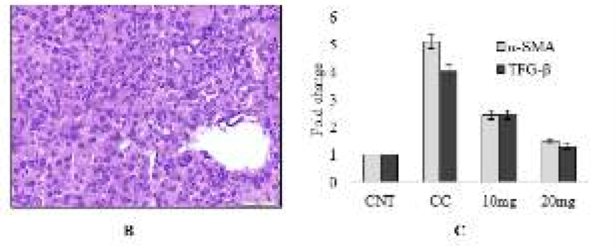

Fig 2 (A) HCC development in the liver of mice; (B) effect of DPODO on the mRNA levels of TGF β and α SMA in liver tissue of different groups. CNT-Control; CC - Carcinogen Control.

Regulatory studies

In Regulatory studies, we evaluated the acute oral toxicity of various natural colors (PBNS-CB, PBNS-PUR and PBNS-IP) developed at CSIR-IHBT. Similarly, the acute dermal toxicity of creams developed at CSIR-IHBT was also done.

Collaborating work

In collaborative work, we studied the therapeutic effect of Mycophenolate mofetil (MMF) in temporal lobe epilepsy (TLE) in rats. MMF suppressed recurrent seizures, and improved its associated behavioral impairments and cognitive deficit in rat model of TLE. The observed effects of MMF be correlated with the inhibition of IL-2 and IL-1β linked PI3K/AKT/mTOR signaling pathway hyperactivation.

Publications

Mazumder AG, Patial V, Singh D (2018) Mycophenolate mofetil contributes to downregulation of the hippocampal interleukin type 2 and 1β mediated PI3K/AKT/mTOR pathway hyperactivation and attenuates neurobehavioral comorbidities in a rat model of temporal lobe epilepsy. Brain, Behaviour and Immunity DOI.org/10.1016/j.bbi.2018.09.020.

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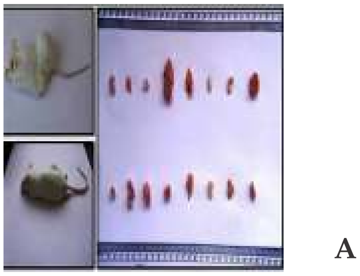
Laboratory Animal Breeding and Toxicology

Major R&D activities (involved in)

- Management of laboratory animal facility of the institute
- Development Laboratory animal model for various clinical conditions
- Development of nutraceutical formulation for bone and cartilage health (Nutraceutical mission)

Development of animal models for assessment of nutraceuticals and novel enzymes

Animal models have been used to address a variety of scientific questions, from basic science to the development and assessment of novel vaccines, or therapies. The use of animals is not only based on the vast commonalities in the biology of most mammals, but also on the fact that human diseases often affect other animal species. We have developed biologically relevant heterotopic xenograft model of head and neck squamous cell carcinoma (HNSCC) in immunocompromised mice (NOD/SCID mice). For xenograft generation, one million cultured cells suspended in 100 µl of 1X PBS were injected subcutaneously in the right flank of the animals. The tumors were well circumscribed, totally encapsulated and did not show metastasis to any other organ or interaction with surrounding tissues till our study period of seven weeks post-grafting (Fig. A & B).



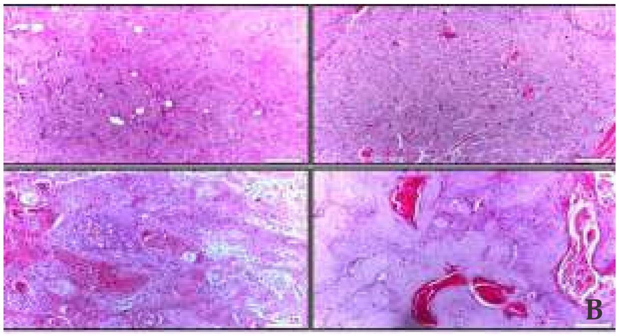


Fig. 1 (A) Gross and histopathological (B) examination of xenograft showed less differentiated and aggressive tumors compared to knock out group

We also developed mice model of adjuvant induced arthritis. On day zero, arthritis was induced in BALB/c mice by injecting Complete Freund's Adjuvant below the plantar aponeurosis of the foot paw of the mice. Development of paw oedema was regularly monitored. There was significant inflammation of paw in the initial phase i.e. upto 14 days. The histopathological studies of hind leg joints in the arthritic control group showed the prominent abnormalities like destruction of the bone marrow and extensive infiltration of the cells in the articular surface (Fig. 2 A-D).

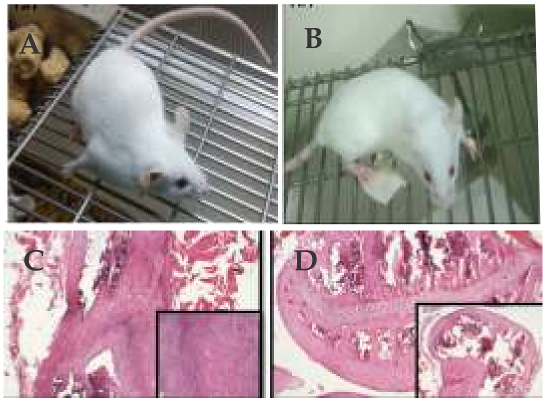


Fig. 2 (A) normal, (B) diseased (C) histopathological examination revealed

destruction of the bone marrow and (D) extensive infiltration of the cells in the articular surface

Interstitial lung disease (ILD) comprises a large number of chronic lung conditions, characterized by varying degrees of inflammation and fibrosis. The include idiopathic pulmonary fibrosis (IPF), which is a specific characterized by progressive fibrosis disorder leading to end-stage lung disease, respiratory failure, even mortality. Intratracheal instillation (IT) of bleomycin is a widely used experimental model for lung fibrosis. C57Bl/6J mice were treated with a single IT dose of bleomycin or control saline to mimic the pathophysiology of IPF. The bleomycin induced group showed areas of inflammation, epithelial hyperplasia and fibrosis not limited to subpleural foci.

N-nitrosobis(2-oxopropyl) amine (BOP)-induced pancreatic ductal carcinomas and early ductal lesions in syrian hamsters have been reported to show histopathological resemblance to those in humans. In order to check the efficacy of novel enzymes developed in the institute, we are in the process to develop animal model for pancreatic cancer induced in Syrian golden hamsters by N-nitrosobis(2-oxopropyl) amine (BOP).

Nutraceutical formulation for boosting bone and cartilage health

Osteoarthritis is the most common disease of joints in adults around the world with prevalence of 22% to 39% in India. Hydroethanolic extracts of *Vitex negundo* and *Cissus quadrangularis* were prepared by extraction with different combination of hydroethanolic solutions, following the percolation method. For chemical characterization of selected plants, analysis with respect to 12 molecular markers was carried out. Plants showed presence of these markers which are proven to have beneficial effect on bone and cartilage. Primary murine chondrocyte cells were isolated for *in vitro* efficacy evaluation. *In vitro* evaluated effect of combination as well as individual extracts at different concentration was done on murine osteocytes / chondrocytes for product/formulation development. The extracts in combination showed better effect compared to individual extracts.

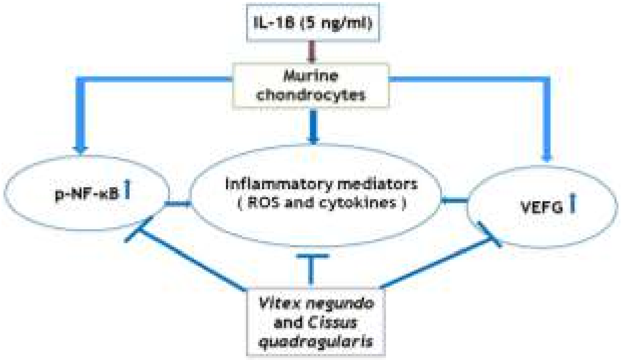


Fig. 3 Schematic representation of *in vitro* efficacy of combination of extracts

We developed mice model of monosodium iodoacetate (MIA) induced osteoarthritis (OA) model for *in vivo* validation of the combination of extracts. Our results in the *in vivo* study also revealed that selected extracts showed better results in combination when compared with individual extracts. The results were also comparable with standard NSAIDs like dexamethasone. Acute toxicity study of the prepared extracts was done following OECD guidelines. No adverse effect was observed during course of the study. All parameters i.e., clinical signs, body weight and gross pathology observations suggested prepared extracts were safe at different doses.

Left to Right: Neha Bharadwaj, Narendra Vijay Tirpude, Monika Kumari

High Altitude Biology

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Biodiversity Conservation, Ecology, and Traditional Knowledge

Our group is involved in conducting field surveys to the Himalayan hinterlands for biodiversity characterization, folk knowledge documentation, and participatory resource management. This year, in addition to herbarium enrichment & updation, we focussed on characteristics of Himalayan treelines, spatial distribution of heavy metals in soils, eradication of invasive species, and documenting resource use patterns amongst the *Bhangalis* & *Gujjars* tribes. A gist of the same is presented below.

Biodiversity & knowledge documentation

During the reporting period, 15 surveys were carried out to different localities of Himachal Pradesh for sampling plant resources and documentation of folk knowledge. The herbarium (PLP) of the Institute was enriched by addition of 20 species new to it.

Sampling plant populations: Plant functional Traits (PFTs) are critical life-history traits that influence success, distribution, and adaptation of species. Analyses of traits in *Morina longifolia* reported positive correlation between flower size, seed mass and altitude while flower count and seed count decreased with increasing altitude.

Treeline characterization: Treelines represent an ecotone from closed-canopy forests to open grasslands. They are highly sensitive to climate change and consequently studying treelines is a contemporary issue. Sampling of a tree line site in Chamba revealed the presence of 34 vascular plant species. These plant species belong to 20 families of which Asteraceae (18%) was found to be the dominant family (Fig. 1) Compared to the forested area, higher number of species were recorded in open areas above treeline.

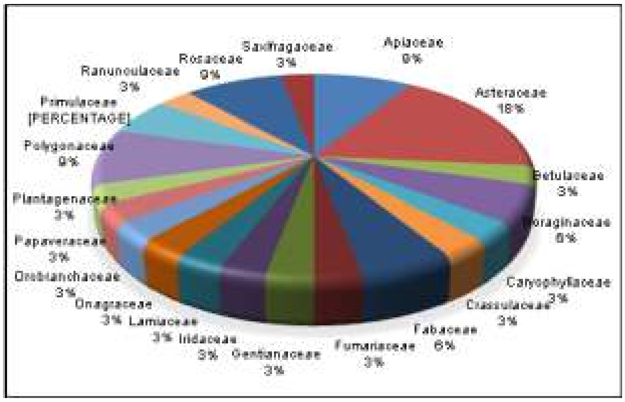

Fig. 1 Family characteristics of treeline vegetation

Distribution of heavy metals in habitation land-use soils: A total of 72 soil samples representing urban, peri-urban, and rural land-uses were collected and assayed for cadmium, chromium, lead, manganese, nickel and zinc contents. As opposed to Cd (4.956), Cr (17.299), Mn (76.473) and Ni (82.225) that reported highest concentrations (mg/kg) in urban land-use; Pb (44.882) and Zn (192.613) had maximum concentration in peri-urban and rural land-use soils, respectively. Similarly, high values of contamination factor and geo-accumulation index in urban and peri-urban land-use indicated contamination in order of Cd>Ni > Zn.

Eco-restoration through community involvement: With the involvement of local people, 10 hectare of land was cleared of invasive species *Ageratina adenophora* (Fig. 2). In the cleared land fodder grasses, primarily *Penisettum* spp. were planted. Permanent monitoring and repeat observations are being documented.

Fig. 2 Eradicating invasive species

Traditional knowledge documentation: Questionnaire recordings (n=240) were carried out amongst the *Bhangalis* for docomenting information on indigenously developed tools, their use, characteristics, and species required for making them. A total of 34 plant derived tools are made by the *Bhangalis* for which 15 species belonging to 11 families are used. *Quercus semecarpifolia* and *Cotoneaster bacillaris* were the most commonly used species.

Similarly, use of 83 plant species belonging to 75 genera and 49 families was reported among the Gujjars of Churah state. The highest number of species used belonged to the family Rosaceae followed by Polygonaceae and Betulaceae. Amongst the plant parts, leaf followed fruits and roots were the most used (Fig. 3). On the basis of use value (UV) *Pteridium aquilinum*, *Juglans regia*, *Corylus jacquemontii*, *Urtica dioica*, *Diplazium maximum*, and *Angelica glauca* were the most important plant species in the study area.

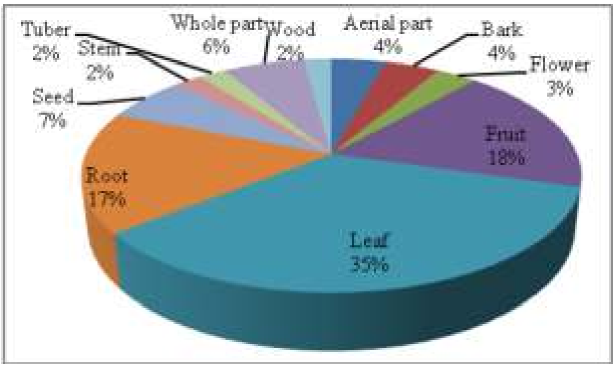

Fig. 3 Statistics of plant parts used

Publications

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Sharma A, Uniyal SK (2019). Mulling over mills: The Gharat. Dream 2047 21(5): 31-32.

Reviews/ Proceedings/ Book Chapters

Ahmad M, Kashyap R and Uniyal SK (2019) Pattern of Plant Functional Traits (PFTs) Variation between Two Populations of *Morina longifolia* Wall. at Western Himalaya. Proceedings of 1st Himalayan Researchers Consortium, 1: 111-118.

Sharma R and Uniyal SK (2019) Vegetation Patterns of Treeline Ecotone in the Pangi Valley, Western Himalaya". Proceedings of 1st Himalayan Researchers Consortium, 1: 31-39.

Left to Right, Front Row: Mustaqeem Ahmad, Dipika Rana, Sanjay Kr. Uniyal, Alpy Sharma, Neha Chilwal

Left to Right, Back Row : Vijay Negi, Puneet Sharma, Rohit Sharma

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Geospatial mapping

Our work focused on developing hyperspectral library of Himalayan tree species; modeling distribution of *Betula utilis* in response to climate−warming scenarios in the Hindu−Kush Himalaya. Additionally, mapping of forest fires was initiated along with analyzing altitudinal distribution of fern species.

Recording of Hyperspectral signatures of Himalayan flora

A hyperspectral library (Fig. 1) (http://nisa.geos.iitb.ac.in) consisting of spectral signatures of 42 tree species recorded during field surveys from various localities of Himachal Pradesh was prepared. The Hyperspectral library of vegetations is simultaneous collection of its reflectance in hundreds of narrow adjacent spectral bands. Higher number of bands are advantageous for discriminating species and can also be correlated to their chemical constituents, growth behaviour, and ambient ecology.

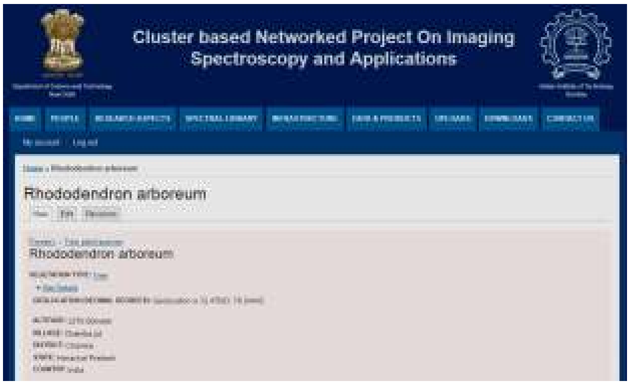


Fig. 1 Spectral Library Webportal

During surveys, the spectral reflectance of cut leaves from tree species were recorded using ASD handheld spectroradiometer (350-2500 nm). The spectroradiometer was calibrated with white spectrum before and during each observation in order to minimize the effect of change in sun illumination. The readings were taken during stable wind conditions to avoid the effect of wind on spectral reflectance. In addition to the recording of cut leave reflectance spectra, the collateral data on targeted tree species such as GPS coordinates, tree height, girth at breast height, canopy spread, photographs, fresh weight, CCI, *etc*., were also recorded. These information were uploaded on spectral library web-portal of Cluster Based Network project on Imaging Spectroscopy and Applications (NISA) of Department of Science and Technology, Government of India.

Modeling *Betula utilis* distribution in response to climate−warming scenarios in Hindu−Kush Himalaya

The warming and snowmelt induce the treeline species to migrate towards higher elevation zones of high mountain summits providing them a newer niche. This can result in extinction of herbs and shrubs species in the peaks. Therefore, random forest algorithm was employed to predict the potential distribution of *Betula utilis* (treeline species) niche in the Hindu-Kush Himalayan (HKH) region. The potential distributions were simulated in the Last Inter-Glaciation (LIG), present (the year 1970–2000) and future (the year 2061–2080) environmental conditions. It was found that the high suitability of *B. utilis* occurrence in the LIG, current and the future scenario were more likely in the elevation ranges 2601–2800 m, 3801–4000 m, and 4201–4400 m, respectively. Thus, *B. utilis* was projected to become vulnerable to 21st century climate changes.

Mapping of species richness of fern along altitudinal gradients in Himalayan region

The distributional pattern of ferns along elevational gradient (500-4000 m) in seven forested landscapes of Himachal Pradesh was studied (Fig. 2). The importance of different variables such as geographical area, mean annual rainfall, mean annual temperature, number of rainy days, potential evapo-transpiration (PET), actual evapotranspiration (AET), moisture index (MI), soil moisture and soil pH in governing the fern species richness along elevational gradient was also examined. Among 255 observed species (54 genera and 23 families), the 208 species were terrestrial, 35 were canopy epiphytes, and 5 were low-trunk epiphytes. The 05 species were aquatic and 02 species were climber.

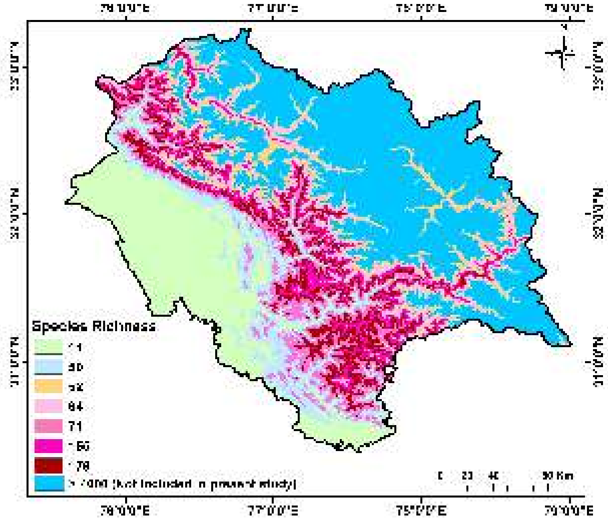
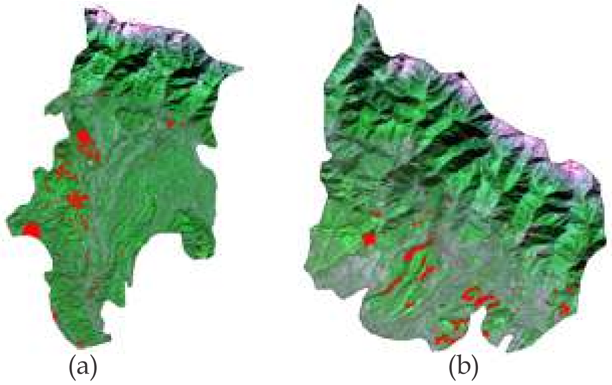


Fig. 2 Species richness of ferns along altitudinal gradient in H.P.

The beta diversity analysis showed high replacement rate of fern species up to 2000-3000 m amsl and presence of unique species at elevation higher than 3000 m amsl. The species richness peaked at 2000-2500 m amsl and reflected hump shaped distribution pattern. The positive correlation was observed between fern species richness with mean annual rainfall, rainy days, soil moisture and moisture index. The species richness showed negative correlation with mean annual temperature, potential evapo-transpiration, actual evapo-transpiration, soil pH and geographical area. The influence of number of rainy days was significant on species richness between 500 to 4000 m. It was found to be controlled by AET and MI between 500 to 2500 m and mean annual temperature and PET between 2000 to 4000 m. The best polynomial curve fit of species richness was also observed with MI, rainy days, AET, mean annual temperature and PET.

Forest fire studies

The fire affected forests were mapped using near-infrared (NIR) and shortwave-infrared (SWIR) spectral regions of Sentinel satellite images of Palampur and Dharamshala tehsils of district Kangra, H.P. acquired in 2017 (Fig. 3).



(a) (b)

Fig. 3 Forest fire affected areas (depicted in Red) in a) Palampur and b) Dharamshala tehsils, Kangra, Himachal Pradesh

The map revealed that in the Palampur tehsil total fire affected area was 1503.63 ha. (9.57%). It was 630.57 ha (2.31%) in Dharamshala tehsil.

Retrieving Hyperspectral signatures of Lilium

The hyperspectral image (182 bands) of various stages of Lilium cultivation, such as nascent plantations (stage 1: consisting of small buds), young plantations (stage 2: consisting of immature buds), buds ready to harvest (stage 3), and flowering (stage 4), was recorded using

'HySpex VIS-NIR 1800 (400–1000 nm)' hyperspectral imaging sensor during February 2019. A spectral library consisting of hyperspectral signatures of above stages of Lilium was prepared from the acquired image. It was found that the library thus prepared was able to discriminate between various stages of Lilium based on its spectral characteristics. This work is advantageous for automatic and rapid extraction of Lilium buds on a regional scale.

Fig. 4 False Colour Hyperspectral Image of Lilium cultivation

Publications

Mohapatra J, Singh CP, Hamid M, Verma A, Semwal SC, Gajmer B, Khuroo AA, Kumar A, Nautiyal MC, Sharma N, and Pandya HA (2018) Modelling Betula utilis distribution in response to climate-warming scenarios in Hindu-Kush Himalaya using random forest. Biodiversity and Conservation, DOI:.org/10.1007/s10531-019-01731-w.

Book Chapters/Review:

Kumari A, Benerjee A, and Kumar A (2018) Distribution and species richeness of ferns along an elevational gradient in Himachal Pradesh, western Himalaya. In: Pteridology today: Challenges and opportunities (Eds. Verma SC, Khullar Sp, Benniamin A, Lakshminarasimhan P, and Singh P), Botanical Survey of India, pp 360-377.

Upadhyay V and Kumar A (2018) Hyperspectral Remote sensing of Forests: Technological advancements, Opportunities and Challenges. Earth Science Informatics, DOI: 10.1007/s12145-018-0345-7.

Left to Right: Sonam Bahuguna, Shambhvi, Shikha Rana, Meenakshi, Shivani, Manisha Chaudhary, Mamta Devi, Amit Kumar, Sunil Kumar, Kishor C Kandpal and Shubham Anchal.

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Ecology

Research Interests: Studying functional ecology, eco-physiology and adaptation strategies of high altitude plants; conservation of threatened medicinal plants and undertaking long term ecological research for assessing climate change impacts on high altitude vegetation.

Ecological characterization of high altitude plants

Himalayas are considered as white spots with limited information on plant species distribution and diversity. This knowledge gap is even more wider in case of high altitude plant species, most of which have a presumable risk of extinction due to changing climate. We undertook a study to determine the ecological amplitude of high altitude species. By laying elevational transects and recording the occurrence and abundance of various species, the altitudinal range, niche width and rarity were estimated for 418 species. Further, 26 species such as *Saussurea gossypiphora*, *Saussurea obvallata*, *Primula rosea*, *Delphinium cashmerianum*, etc. were identified to be having relatively higher extinction risks due to changing climate.

Functional diversity patterns of high altitude vegetation

The functional diversity of high altitude vegetation was reported for the first time in Himalaya. Plant communities at higher elevations and at South aspects were found to have low functional diversity (lesser resource use, niche differentiation, complementarity, and number of functionally specialist species) because of harsh environmental conditions. Hence, diverse plant species at higher elevations exhibit relatively similar traits to cope up the harsh environments.

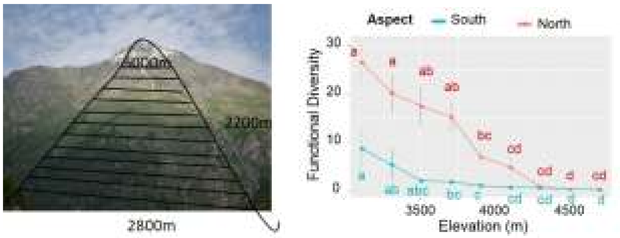

Fig. 1 Ecological characterization of vegetation along elevation gradient. Left: elevation range investigated; Right: decrease in functional diversity of high altitude plant communities along elevation

Adaptation Strategies of High Altitude Plants

By measuring leaf traits (area and mass) of large number of high altitude plants, a key adaptation strategy was deciphered. It was found that plants possess high leaf water high altitude mass along with high leaf dry mass so that maintaining 3D geometry of leaf is preferred rather than maintaining constant thickness of leaves. This led to the inference that increase in light interception cost and metabolic mass component of leaves are coupled for efficient resource use. Hence, in high altitude plants, there is a preference of leaf trait combinations best suited for maintaining high metabolic activity to complete their growth cycle in stressful environments.

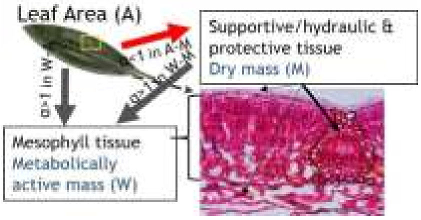

Fig. 2 Scaling relationships among leaf area, dry mass and water content for dominant species of

high altitude, which indicate increase in water dry mass with increasing elevation and increase in water mass with increasing dry mass

Eco-physiological studies of an evergreen woody shrub of high altitude

Morpho-physiological changes in leaves of *Rhododendron anthopogon* (a high altitude evergreen shrub) along the season gradient were elucidated, hoping to gain insight into their potential adaptive significance to tolerate low temperatures. It was found that morpho-physiological traits are closely associated with plant adaptation to seasonal changes, and the plants show more tolerance to low temperatures towards the end of their growing season.

Conservation and Bioprospecting of Selected High Altitude Bioresources at CSIR-Centre for High Altitude Biology

Under this project, the following targets were achieved through a team effort comprising of various investigators: -

Establishment of field genebank and *in vitro* banks

Field genebank for *D. hatagirea* accessions from ~10 populations has been established at CeHAB. Further, *in vitro* repository has also been initiated for *D. hatagirea* with germplasm collected from different locations. *In vitro* shoot cultures of *Nardostachys jatamansi* are being established. And, *ex situ* repository and field nursery of *Aconitum heterophyllum* is being established through seed germination.

Fig. 3 Field genebank for *Dactylorhiza hatagirea* accessions

Quality planting material generation

Six different accessions of *Ferula asafoetida* (Heeng) have been procured. Germination and viability tests on seeds have been conducted. Percentage of viable seed was 60 %. Seeds of different accessions were subjected to germination tests.

Fig. 4 Germination test of Heeng seeds under lab conditions

Field trials were conducted for Tulip which suggested that that Tulip bulbs are multiplied in good numbers and size. Keeping in view, a discussion meeting was held at Shansha with President, Pattan Valley Floriculture Society Ltd, Shansha, Lahaul on 11-12-2018. Outcome of the meeting was that Tulip bulbs will be provided to famers on certain agreement will be trained for its multiplication. The institute will help the society in finding the market for selling of these bulbs.

Ongoing External Sponsored Research Projects

Understanding the nature of alpine timberlines of Himalaya: integrating ecological and scenario studies for assessing the impact of climate change; sponsored by National Mission on Himalayan Studies; w.e.f. 1st April 2018 onwards (for three years).

Trade chain, trade pattern and economic valuation of 15 RET valuable medicinal plant species; sponsored by HIMCOSTE Shimla w.e.f. 08 Aug 2018.

Sustainable harvest and value addition protocols for 5 bulk traded and high value medicinal plant species; sponsored by HIMCOSTE Shimla w.e.f. 08 Aug 2018

Publications

Rathore N, Thakur D and Chawla A (2018) Seasonal variations coupled with elevation gradient drives significant changes in eco-physiological and biogeochemical traits of a high altitude evergreen broadleaf shrub, *Rhododendron anthopogon*. Plant Physiology and Biochemistry, DOI: https://doi.org/10.1016/j.plaphy.2018.08.009.

Thakur D and Chawla A (2019) Functional diversity along elevational gradients in the high altitude vegetation of the western Himalaya. *Biodiversity and Conservation*, DOI: 10.1007/s10531-019-01728-5.

Thakur D, Rathore N and Chawla A (2019) Increase in light interception cost and metabolic mass component of leaves are coupled for efficient resource use in the high altitude vegetation. Oikos. DOI: 10.1111/oik.05538.

Left to Right, Row 1: Dinesh Thakur, Amit Chawla, Elennie Hopak, Nikita Rathore; Left to Right, Row 2: Nandita Mehta, Dipika Verma, Kumari Sita, Diksha; Left to Right, Row 3: Neeraj Kumar, Anupam Bhatt, Rahul Kumar, Lakhbeer Singh, Manish Sharma, Vaneet Kumar.

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Crop and Carbon Modeling

Research Area: Generation of indices for development & simulation of crop model, and carbon dynamics assessment of temperate forests of western Himalaya through process-based BIOME-BGC model & ground measurements

Generation of different indices for *Picrorhiza kurroa* for model development and simulation

Crop models are essential to simulate the plant performance under a climate change scenario. It not only helps to assess the impact of elevated CO_2 and high temperature on growth, morphology, biomass partitioning, but also on secondary metabolites. Therefore, we aimed at generating different morphological and ecophysiological indices of *Picrorhiza kurroa* under different environmental condition; which is essential to develop a crop model. The response of *P. kurroa* to elevated CO2 (550±50 μmol mol-1) and elevated temperature (2.5-3.0˚C higher than ambient) was studied simultaneously at polyhouse and FACE-FATI experimental site of the Institute. For control, the average temperature was maintained at 18.7°C inside the polyhouse. Further, FACE-FATI experimental site consist four different environmental conditions: (i) Ambient, (ii) Free-air CO_2 enrichment (FACE) (iii) Free Air Temperature Increase (FATI) and Interaction of both (*i.e*. FACE×FATI). In FACE ring [CO_2] was maintained at 550 ppm and temperature according to ambient. For FATI, the temperature was increased around 2.5-3.0˚C from ambient with the help of infrared heaters while for (FACE×FATI) *i.e.* interaction ring the CO_2 concentration and temperature increased up to 550 ppm and 2.5-3.0˚C from ambient, respectively. *Picrorhiza kurroa* collected from high altitude regions of the Himalaya was transplanted into plastic pots having soil, sand and farmyard manure (FYM) in a ratio of 1:1:1 mixture. These were then placed in polyhouse and FACE and FATI experimental setup (Fig. 1). Thereafter, different parameters of morphological and ecophysiological were recorded.

Fig. 1 Experimental setup (a & b) and FACE-FATI experimental site [(c) Ambient ring, (d) Free Air CO_2 enriched ring i.e. FACE (iii) Free Air Temperature increased ring i.e. FATI, (d) interaction i.e. FACE × FATI]

In the polyhouse, plant height of *P. kurroa* ranged between 8.3 to18.6 cm. Plant fresh weight (g) reported a mean value of 7.3±1.99 with total number of leaf per plants ranging between 11 to 20. Average leaf fresh mass was 4.02 g while total leaf dry weight (g) was between 0.008-0.08. Mean length and width of the leaf (cm) was 6.01 and 1.29 cm, respectively. The specific leaf area (cm^2/g) and specific root length (cm/g) ranged between 73.7 to 213.7 and 19.3 to 94.2, respectively. Photosynthesis value ranges between 8.8 to 19.2 µmol/m^2/s where as stomatal conductance recorded an average value of 0.19±0.03 mol/m^2/s. Similarly, average value of transpiration was found to be 5.62±0.95 mmol/m^2/s. Mean leaf nitrogen (%), leaf carbon (%) and leaf CN ratio (%) were 2.74±0.16, 43.34±0.58 and 16.08±1.1, respectively. On the other hand, root nitrogen (N), root carbon (C) and root C:N ratio (%) ranged between 0.5 to 2, 36 to 42 and 35 to 70, respectively.

FACE-FATI experimental site: Plant height of *P. Kurroa* ranged between 4-10.2 cm in the month of March. Average leaves numbers was 9.86±1.70. Similarly, plants kept in the FATI, FACE and FATI × FACE rings were also evaluated for their morphological data. The average plant height was 7.52±1.66, 3.94±0.97 and 4.2±1.9 cm, respectively. No. of leaves ranged between 14 to 85 for ambient, 9-120 for FATI, 12-45 for FACE and 2-35 for FACE × FATI ring. The mean plant height for the April month was 9.4±0.5, 10.18±0.7, 8.7±0.9 and 7.08±1.5 for ambient, FATI, FACE and FATI × FACE, respectively. The no. of leaves for the April month ranged from 15-120, 20-190, 25-60 and 7-75 for FATI, FACE, and FATI × FACE, respectively. The plant spread ranged between 11.6-25.5 cm (ambient), 11-28.5 (FATI), 10-21.5 (FACE) and 4-19 (FACE × FATI) cm, respectively. Leaf thickness ranged between 0.64±0.03 (ambient ring), 0.74±0.02 (FATI), 0.82±0.01 (FACE) and 0.70±0.02 (FACE × FATI). After harvesting, mean value of root fresh weight (g) was 1.4±0.42 for ambient, 1.3±0.5 for FATI, 0.4±0.08 for FACE and 0.77±0.27 for FACE × FATI. Root dry weight (g) ranged between 018-0.83 for ambient, 0.12-0.82, 0.2-0.7 and 0.1-0.65 for FATI, FACE, and FACE × FATI, respectively. The average value of photosynthesis (µmol$CO_2m^{-2}s^{-1}$) was 13.44±0.32 (ambient), 17±0.38 (FACE), 15.4±0.2 (FATI) and 17.4±0.4 (FACE × FATI), stomatal conductance was highest in FATI rings with the mean value of 0.29±0.003 (mol/m^2/s). The transpiration (mmol/m^2/s) value in FATI ring was the highest with an average of 11.3±0.12 and lowest in the interaction ring of FACE × FATI with a mean value of 7.69±0.23 (Fig. 5). The WUE (Water use efficiency) was highest in the FACE × FATI plants with a value of 2.3±0.18 (µmolCO_2 $mmol^{-1}H_2O$). The morphological and physiological data obtained from this study under different environmental condition will be used for the development of crop indices to run the existing model and development of new model.

Publications

Kumar Manoj (2018) *Himalaya ke Paristhikee Tantra Par Jalvayu Parivartan ka Dushprabhav*, Visvigyan Sandesh, 29, 51-55.

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Ecology

My work is focussed on field surveys for generating quantitative information of plant species and establishment of plant conservatories.

Ecological surveys

Conducted field surveys in the high altitude regions of western Himalaya for status evaluation and population estimation of endangered Himalayan plant species (Fig .1).

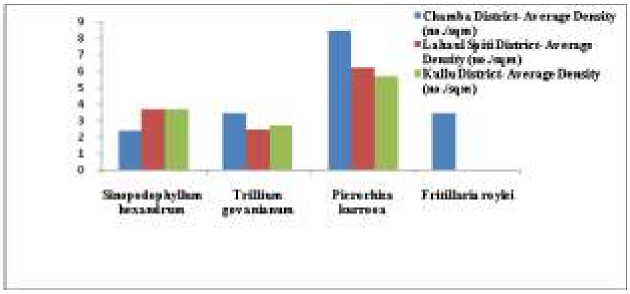

Fig. 1 Density estimates of *Sinopodophyllum hexandrum, Trillium govanianum, Picrorhiza kurrooa,* and *Fritillaria roylei*

Germplasm Conservation

Field gene bank (1.5 ha area) of for species such as *Sinopodophyllum hexandrum* (10 accessions), *Picrorhiza kurrooa* (5 accessions), *Fritillaria roylei* (2 accessions), *Trillium govanianum* (2 accessions), *Rheum australe* (10 accessions), *Saussurea costus* (captive cultivation 1.5 bigha land), *Inula racemosa* (captive cultivation 1 bigha land), *Valeriana jatamansi* (captive cultivation 400 sqm land area) has been initiated. A large scale nursery of *Artemissia maritima* (about 0.7 ha) has been raised at Ribling (Fig. 2-5).

Fig. 2 Demonstration and mass cultivation of *Valeriana jatamansi* in the CSIR-IHBT CeHAB Ribling Farm, Lahaul-Spiti (HP)

Fig. 3 Demonstration on high tech greenhouses and high productivity of *Saussurea costus* at CSIR-IHBT CeHAB Ribling farm, Lahaul-Spiti (HP)

Fig. 4 Captive and mass cultivation of *Inula racemosa* at CSIR-IHBT CeHAB, Lahaul-Spiti (HP)

Fig. 5 Nursery raising of *Artemissia maritima* in the greenhouses at CSIR-IHBT CeHAB farm, Lahaul-Spiti (HP)

Nursery of 43 Medicinal & Aromatic plants has been prepared. Additionally, demonstration plots of *Aconitum heterophyllum* (1200 sqm area), *Picrorhiza kurrooa, Salvia sclarea* in the CeHAB and farmers field have also been set up in Mohani Panchayat of Banjar, Kullu (2065 m amsl) Fig. 6.

Fig. 6 Gene-bank establishment of RET Plants at Mohani Panchayat, Banjar Block Kullu (HP) (2265m amsl)

Publications

Kumar P, Singh V and Singh A (2018) Seabuckthorn (Hippophae spp.) Conserve Plant Diversity in the Fragile Mountain Ecosystem of Cold Desert Himalaya. Journal of Biodiversity, DOI: 11.258359/KRE-180.

Left to Right, Row 1: Ms. Kanika Kiran; Mr. Umesh Thakur; Mr. Anuj Kaushal; Mr. Gaurav Katoch; Mr. Narender Kumar;

Left to Right, Row 2: Mr. Rajat Bhardwaj; Mr. Mohit Kashyap, Mr. Pribrat and Ashok Singh

Natural Product Chemistry
and Process Development

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Organic Synthesis and Product Development

Supported palladium nanoparticles catalyzed amino-carbonylation of aryl halides with amines using oxalic acid as a sustainable CO source: Polystyrene-supported palladium (Pd@PS) nanoparticles (NPs) were used for the first time to catalyze the amino-carbonylation of aryl halides with amines using oxalic acid as a CO source for the synthesis of amides. Furthermore, this protocol was applied to *o*-iodoacetophenones, which participated in aminocarbonylation and cyclization reactions to give isoindolinones in a single step following a concerted approach. Oxalic acid has been used as a safe, environmentally benign and operationally simple *ex situ* sustainable CO source under double-layer-vial (DLV) system for different aminocarbonylation reactions. Catalyst stability under a CO environment is a challenging task, however, Pd@PS was found to be recyclable and applicable for a vast substrate scope. Easy handling of oxalic acid, additive and base-free CO generation, catalyst stability and effortless separation from the reaction mixture by filtration and introduction of DLV are the added advantages to make the overall process a sustainable approach (Fig. 1).

Fig. 1 Pd@PS catalyzed cyclic and non-cyclic amides synthesis

Hypervalent iodine(III)-mediated counter anion controlled intra-molecular annulation of exocyclic *β*-enaminone to carbazolone and imidazo[1,2-a]pyridine synthesis: A highly efficient and flexible protocol for intra-molecular annulation of exocyclic *β*-enaminones has been disclosed for the synthesis of carbazolones and imidazo[1,2-a]pyridines through a counter-anion-controlled free-radical mechanism promoted by hypervalent iodine(III). The co-operative behaviour of HTIB and $AgSbF_6$ plays a crucial role in the intra-molecular annulation process through C-C and C-N bond formation to give the targeted products. The mechanistic insights suggest that the two competitive reactions involved in the system are guided by the nature of the counter anion, which determines the formation of the final products. A wide variety of carbazolone and imidazo[1,2-a] pyridine molecules have been prepared and isolated in good to excellent yields (Fig. 2).

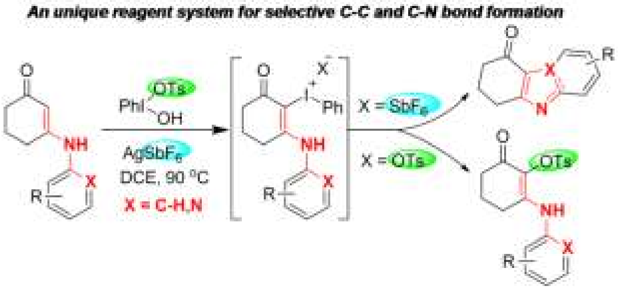

Fig. 2 Carbazolone and imidazo[1,2-a]pyridines synthesis

Supported rhodium (Rh@PS) catalyzed benzimidazoles synthesis using ethanol/methanol as C_2H_3/CH source: An effective and stable polystyrene supported rhodium (Rh@PS) nano-nanoparticles (NPs) was synthesized by following reduction-deposition approaches and applied for the selective benzimidazoles synthesis from 1,2-phenylenediamines and ethanol/ methanol as C_2H_3/CH source. The ethanol/methanol in the presence of trace amounts of aerobic oxygen under Rh@PS catalyzed condition, first participated in oxidation of alcohol followed by consecutive condensation, cyclization and hydrogen elimination reactions with 1, 2-phenylenediamine to give the targeted products, benzimidazoles in good to excellent yields. The Rh@PS catalyst in a single system performed both oxidation and reduction reactions in a selective/ specific manner and applied for vast substrate scope. Easy recovery, handling, stability and recyclability of the catalyst and less chance of metal contamination with the products are the added advantages of the present process (Fig. 3).

Fig. 3 Rh@PS catalyzed benzimidazoles synthesis

Hydrogenation of nitroarenes to anilines in a flow reactor using polystyrene supported rhodium in a catalyst-cartridge (Cart-Rh@PS): The present methodology described the chemo-selective hydrogenation of various nitroarenes in a flow reactor system under polystyrene supported rhodium in a catalyst-cartridge (Cart-Rh@PS) as a heterogeneous nano-catalyst. The polystyrene supported rhodium (Rh@PS) nanoparticles (NPs) were prepared by following our earlier reported protocol and packed inside the catalyst-cartridge (Cat-Cart) to obtain Cart-Rh@PS, which is compatible with Thales Nano's H-Cube Pro flow system. The advantages of the pre-packed catalyst Cart-Rh@PS are as follows: no need for catalyst activation up to 12 runs, negligible metal leaching detected by ICP-AES analysis, significantly less back pressure generated under the flow conditions and the same catalyst, Cart-Rh@PS, was also effective up to 1gram scale for the reduction of nitroarenes to anilines (Fig. 4). The hydrogenation in the flow reactor system is a greener approach for the reduction of nitroarenes to their corresponding anilines in good to excellent yields.

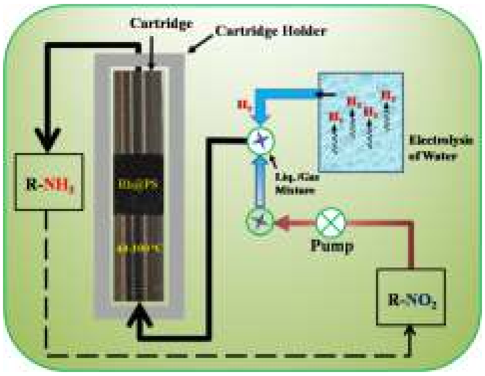

Fig. 4 Reduction of nitroarenes to anilines in a flow reactor

Supported palladium nanoparticles-catalyzed synthesis of 3-substituted 2-quinolones from 2-iodoanilines and alkynes using oxalic acid as C1 source: 3-Aryl/alkyl-2-quinolones were synthesized employing microwave assisted multi-component reaction of *o*-iodoanilines, terminal alkynes and oxalic acid dihydrate under polystyrene supported palladium (Pd@PS) nanoparticles (NPs) catalyzed conditions. The use of a heterogeneous palladium catalyst was explored first time for 2-quinolone synthesis involving carbonylation reaction employing oxalic acid dihydrate as a solid and bench stable carbon monoxide (CO) source. The reaction exhibited good substrate generality for *o*-iodoanilines and alkynes with wide functional group tolerance and good regio-selectivity. The ligand free operation, recyclability of heterogeneous Pd@PS catalyst and use of bench stable C1 source are the invaluable merits of the present protocol (Fig. 5).

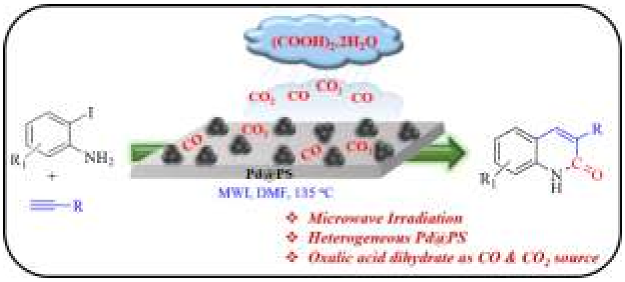

Fig. 5 Pd@PS catalyzed synthesis of 3-substituted 2-quinolones

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Left to Right: Sheetal, Shaifali, Yamini, Shankar Ram, Ajay Kumar Sharma, Dr. Pralay Das, Dhananjay Bhattacherjee, Arvind Singh Chauhan, Ajay Kumar, Ashish Kumar

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Natural products and essential oils bioprospection

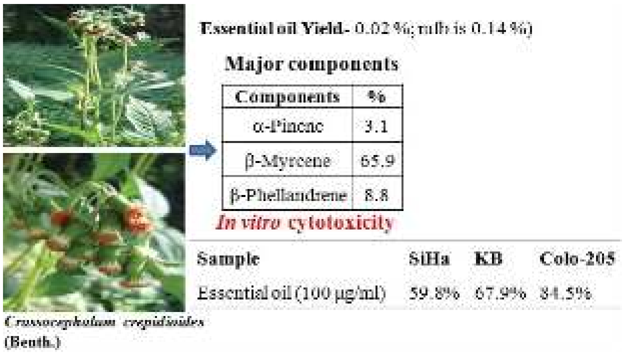
Chemical Composition, Cytotoxic and Antibacterial Activities of Essential Oils of Cultivated Clones of *Juniperus communis* and Wild *Juniperus* Species

Needles of seven cultivated clones of *Juniperus communis* at lower altitude and three wild *Juniperus* species (*J. communis*, *J. recurva* and *J. indica*) at higher altitudes were investigated. The essential oils (EOs) yield varied from 0.26 to 0.56% (v/w) among samples. Monoterpene hydrocarbons (49.1 – 82.8%) dominated in all samples (α-pinene, limonene and sabinene as major components). *J. communis* (wild species) displayed cytotoxicity against SiHa (human cervical cancer), A549 (human lung carcinoma) and A431 (human skin carcinoma) cells (66.4%, 74.4% and 57.4%), respectively, at 200 µg/ml. EOs exhibited better antibacterial activity against Gram-positive bacteria than against Gram-negative bacteria with the highest zone of inhibition against *Staphylococcus aureus* MTCC 96 (19.2 mm) by clone-7 (Fig. 1).

Fig. 1 Extraction of essential oils from *J. communis* clones and their biological activities

Volatile Composition and Cytotoxic Activity of Aerial Parts of *Crassocephalum crepidioides* growing in Western Himalaya, India

The composition of the essential oil of *Crassocephalum crepidioides* was characterized using GC/GC-MS techniques. The essential oil of *C. crepidioides* was dominated with *β*-myrcene (65.9 %) and *β*-phellandrene (8.8 %). The obtained essential oil was tested against human cervical cancer (SiHa), human oral epidermal carcinoma (KB) and human adenocarcinoma (Colo-205) cell lines at 48 h, which showed significant results against all cell lines (59.8%, 67.9% and 84.5%, respectively at 100 µg/ml) (Fig. 2).



Essential oil Yield- 0.02 %; mfb is 0.14 %)

Major components

Components	%
α-Pinene	3.1
β-Myrcene	65.9
β-Phellandrene	8.8

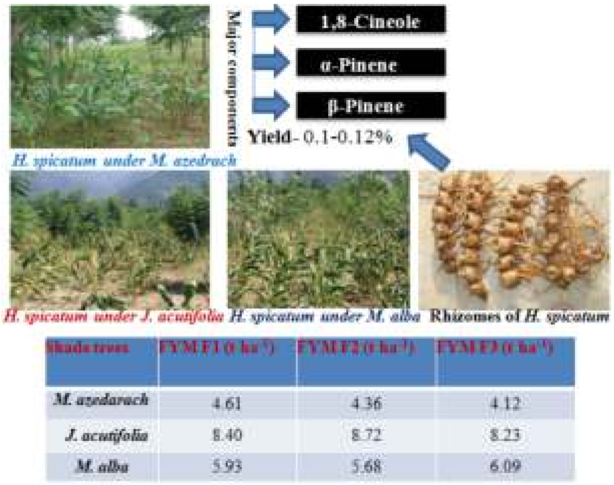
In vitro cytotoxicity

Sample	SiHa	KB	Colo-205
Essential oil (100 µg/ml)	59.8%	67.9%	84.5%

Fig. 2 Extraction of essential oil from *C. crepidioides* and its cytotoxic activity

Standardization of agro-techniques on the growth, yield and chemical composition of ginger lily (*Hedychium spicatum* Smith) in western Himalaya.

RBD (randomized block design) trial was laid out using *Melia azedarach*, *Jacaranda acutifolia* and *Morus alba* as shade trees to study the growth parameters of *Hedychium spicatum* plants. First trial was planted in January, 2005 under *M. azedarach*, *J. acutifolia* and *M. alba* shade. Growth parameter was recorded during 2006, 2007 and 2008 respectively. In the year 2008, under *J. acutifolia* shade we had recorded the highest yield (8.45 t ha^{-1}) of rhizomes. Third trial was planted in January, 2014 under same natural condition. Essential oil was extracted from rhizomes during 2017 under three different shade and recorded the presence of 28 volatile components with the major constituent including 1,8-cineole (60.7-65.7) and *7-epi-a-*eudesmol (8.5-11.3%) (Fig. 3).



Shade trees	FYM F1 (t ha^{-1})	FYM F2 (t ha^{-1})	FYM F3 (t ha^{-1})
M. azedarach	4.61	4.36	4.12
J. acutifolia	8.40	8.72	8.23
M. alba	5.93	5.68	6.09

Fig. 3 Effect of *M. azedarach*, *J. acutifolia* and *M. alba* as shade trees on growth parameters of *H. spicatum*.

Comparative metabolic profiling of *Costus speciosus* leaves and rhizomes using NMR, GC-MS and UPLC/ESI-MS/MS

This metabolic study resulted in the identification of 91 and quantification of 69 metabolites. Caffeic acid derivatives previously unreported in *Costus speciosus* were also identified. High quantity of steroidal saponins namely methyl protogracillin (297.97 ± 0.07 mg/g dried wt.) and dioscin (158.72 ± 0.27 mg/g dried wt.) were observed in butanol fraction of rhizomes. Health care metabolites including caffeic acid (37.88 ± 0.04 mg/g dried wt.) and trehalose (75.12 ± 0.08 mg/g dried wt.) were also detected in ethyl acetate and aqueous fractions of rhizomes, respectively (Fig. 4).

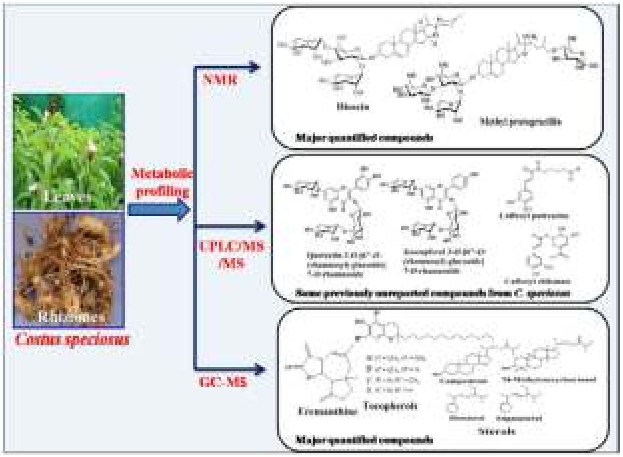


Fig. 4 Metabolic profiling of leaves and rhizomes of *C. speciosus*

Metabolites of nutraceutical and biological significance including eremanthine (5.14 ± 0.68%), tocopherols (~22%), sterols (~25%) were also identified from hexane fractions of rhizomes and leaves using GC-MS.

UPLC-DAD quantification of chemical constitutents of *Potentilla atrosanguinea* roots and their antioxidant activity

A simple and sensitive quantification method developed for seven compounds however only four compounds; *p*-coumaric acid (4), rutin (7), tiliroside (14) and kaempferol (16) were quantified as others were in lesser amount present in *Potentilla atrosanguinea*. Total polyphenolic and flavonoid contents were determined to be 21.75 mg of gallic acid equivalent and 8.57 mg of quercetin equivalent per gram of dry plant material, respectively. Antioxidant activity of extract was assessed using DPPH, ABTS and FRAP. The IC_{50} values; 35.75 µg/ ml and 30.35 µg/ml by DPPH and ABTS

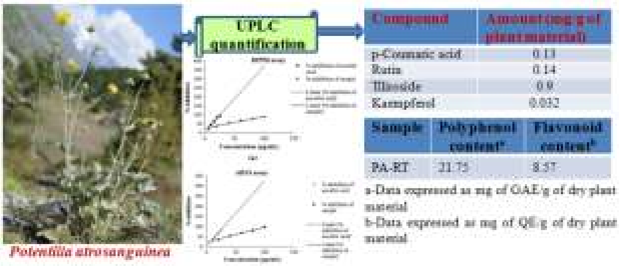


Fig. 5 Quantification and biological assessment of constituents of *P. atrosanguinea*

assays for ethanolic extract showed excellent free radical scavenging potential of its root part. The ferric reducing ability (FRAP) value, 26.67 mg of ascorbic acid per gram also indicated its higher antioxidant potential (Fig. 5).

Synthesis of New Heterocyclic Amino Derivatives of Alantolactone and Their Cytotoxic Activity

In this study, a series of new alantolactone (AL) amino scaffolds (AL1–AL13) had been synthesized and evaluated for *in vitro* cytotoxicity against three human cancer cell lines: human cervical cancer (SiHa), human epidermoid carcinoma (KB), and human lung cancer (A549). This study also provides a correlation on the structure activity relationship of AL and derivatized analogues against tested cells. Our data revealed that derivatized amino adducts enhance water solubility (Fig. 6).

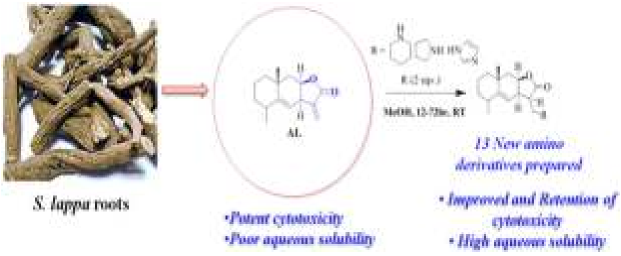


Fig. 6 Preparation of derivatives of alantolactone for SAR studies on cancer calls

Sequential Pd(0)/Fe(III) Catalyzed Azide-Isocyanide Coupling/Cyclization Reaction: One-Pot Synthesis of Aminotetrazoles

A rapid and efficient synthesis of aminotetrazole from aryl azides, isocyanides, and $TMSN_3$ is developed. The reaction is promoted by sequential Pd(0)/ Fe(III) catalysis. The reaction sequence utilizes the Pd catalyzed azide-isocyanide denitrogenative coupling reaction to generate unsymmetric carbodiimide *in situ*, which reacts with $TMSN_3$ in the presence of $FeCl_3$ in a single pot (Fig. 7).

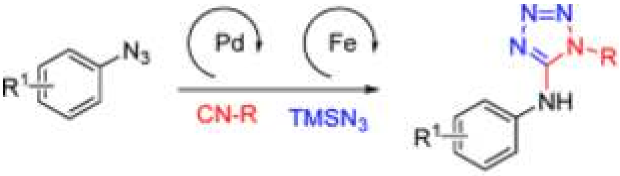


Fig. 7 Synthesis of Aminotetrazoles

Iodine-catalyzed cross-coupling of isocyanides and thiols for the synthesis of *S*-thiocarbamates

A novel and efficient metal free, redox-neutral method for the synthesis of secondary thiocarbamates by cross-coupling of readily available thiophenol and isocyanides has been developed (Fig. 8).

Fig. 8 Synthesis of *S*-thiocarbamates

Pd-Catalyzed Multicomponent Reaction for the Synthesis of Pyrazolo[1,5-*c*]- quinazolines and Quinazoline 3-oxides

Synthesis of biologically relevant scaffolds from four easily available precursors is presented through a one-pot 4-CR via Pd-catalysis. The bimetallic relay cascade forges five new chemical bonds by concatenating six discrete chemical steps. Pyrazolo[1,5-*c*]- quinazolines selectively inhibit EGFR, exhibit apoptosis through the ROS-induced mitochondrial-mediated pathway, and arrest the cell cycle at the G1 phase (Fig. 9).

Fig. 9 Synthesis of Pyrazolo[1,5-*c*]- quinazolines and Quinazoline 3-oxides

Quinazoline 3-oxides in a one-pot fashion. The 3-CR mainly involves concatenation of azide–isocyanide denitrogenative coupling, condensation with hydroxylamine and 6-*exo-dig* cyclization.

Creation of aroma bank by utilization of western Himalayan biodiversity

Essential oils (EOs) (also called volatile or ethereal oils) are aromatic oily liquids obtained from aromatic plant materials (flowers, buds, seeds, leaves, twigs, bark, herbs, wood, fruits and roots). They are derived from complex metabolic pathways. Due to the aromatic feature of EOs, they have been widely used in perfumery and pharmaceutical industries. Considering their importance, it is important to systematically evaluate the unexplored /underutilized Himalayan flora for the search of new aroma molecules for various applications.

In this year we had worked on *Callistemon citrinus*. The plant has also been used ethno medicinally to treat conditions like gastrointestinal distress, pain and infections from various parasites. The essential oil of the plant is used as antimicrobial and antifungal agent. Besides its medicinal uses, the plant is widely gardened throughout the world for its ornamental value and is one of the most important bee-flora due to its richness in nectar and pollen (Fig. 10).

Fig. 10 *Callistemon citrinus* plant

The essential oil was collected from the fresh aerial parts of *Callistemon citrinus*. The plant material used was included leaves along with buds and flowers and identified by the taxonomist of the institute (Voucher number: PLP-15347). The oil was analyzed using GC and GC-MS. The present compounds were identified using RI-FID and MS. Total 100 mL essential oil was isolated from plant and deposited in AROMA-BANK.

Value-addition of aromatic crops (High-end aroma chemicals and products)

Anti-acne cream development by utilization of western Himalayan aromatic crops

Acne or Acne vulgaris is a common skin disease of pilosebaceous unit, which afflicts, approximately 90% of adolescent population in westernized countries. In India 38.13% of girls and 50.6% of boys in the age group of 12-17 years are afflicted with this disease. Acne, a prevalent disorder of skin, is found to increase the incidence of suicidal ideation in the acne patients (7.1%). *Propionibacterium acnes* (*P. acnes*) is a Gram-positive, anaerobic bacterium that plays a major role in the pathogenesis of acne. There are many different treatments including topical retinoids, topical or synthetic antibiotics or hormonal therapies or oral isotretinoin mostly available for acne depending on the type of clinical lesions. Benzyl peroxide or topical antibiotics like erythromycin, clindamycin or oral isotretinoin or combination of all these mediators are available for mild to moderate inflammatory acne. Currently, some of these treatments are producing adverse effects. The emergence of resistant strains with the consistent usage of antimicrobials has led to use of essential oils against micro-organisms *in vitro* and *in vivo*. To address the problems of multi drug resistance of *P. acnes* by the excess use of antibiotics and promising antimicrobial activity of essential oils. Our research activities have been implemented to develop a topical acne control product that is effective to inhibit the growth of *P. acnes* using western Himalayan aromatic plants (Agnihotri, Vijai Kant; Kumar, Bipul; Gautam, Hemant Kumar. Process for Preparing Synergistic Formulation Against Acne by Using Essential Oils of Western Himalaya. Application no. 0193NF2018 dated 14.12.2018. Country Code: IN, Application No. 201911012430, Provisional filing date 29.03.2019) (Fig. 11).

Fig. 11 Anti-acne creams developed at CSIR-IHBT

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Synthetic Organic Chemistry, Medicinal Chemistry, Chemical Biology

Development of methods for C-N bond formation for medicinal chemistry applications

Avoiding the implication of hazardous solvent and using environmentally benign solvents in the organic transformations is an important and promising alternatives according to the principles of green chemistry. In this quest, chemists have done enthusiastic efforts to perform clean, atom-economical and environmentally safe organic transformations. Amines such as benzylamines occupies privilege position in the medicinal chemistry and are the important precursors for the synthesis of drugs, agrochemicals, polymers, natural products. Hence, an efficient, green and economical route for the preparation of various amines is of the paramount active area in medicinal chemistry as well as in modern organic synthesis. Several approaches such as reductive amination of carbonyl compounds; addition of amine with unsaturated hydrocarbons and borrowing hydrogen transfer methodology (BHTM) in which alcohols were chosen as alkylating agents have been developed for the synthesis of benzyl amines. However, despite of significant progresses, synthesis of tertiary benzylamines via enamine or iminium ion intermediate still a daunting task. N-Alkylation of aromatic amines with alcohols is an efficient route for the synthesis of higher benzylamines. We explored an efficient catalytic activity of tin(II) triflate for the N-alkylation of secondary anilines with alcohols for the synthesis of tertiary benzylamines. Mechanistic studies suggest that the developed protocol follows direct nucleophilic substitution pathway instead of imine or enamine pathway. The method was also utilized for the synthesis of secondary amines as well as late stage functionalization of naturally occurring alcohols and a broad range of primary alcohols were utilized.

2-Aminoquinazolin-4-one based efficient organocatalytic, eco-friendly reductive amination approach was developed for the mono N-alkylation of anilines using hydrosilane as a reducing agent under neat reaction conditions utilizing non-toxic environmentally benign acetic acid as a dehydrating agent. The developed protocol has several advantages, such as broad substrate scope, wide functional group tolerance, short reaction time, and absence of metal catalyst in the reaction (Fig. 1).

Fig. 1 Organocatalytic, eco-friendly reductive amination approach for N-alkylation

Tin catalysed synthesis of 3-methyleneisoindolin-1-ones

Isoindolin-1-one is an important heterocyclic scaffold possesses important biological activities such as 3-methyleneisoindolin-1-one is an important subunit found in a variety of natural and biologically active molecules e.g. aristolactams, fumaridine, magallanesine, narceine imide, pagoclone and a key intermediate for the synthesis of alkaloid such as lennoxamine. These heterocycles are used as anesthetics, antipsychotic, anti-inflammatory and anti-viral in pharmaceuticals molecules. Considering synthetic utility and attractive biological activities for these molecules, their synthesis garnered special attention. A novel and simple and straight forward tin(II) triflate catalyzed facile protocol for the synthesis of 3-methyleneisoin-dolin-1-ones was developed. The method was applied to broad range of substrates, which simultaneously offers the functional group tolerance of the reaction and the stability of these scaffolds to the reaction conditions. Various anilines, aliphatic amines, hetero-cyclic amines, and benzylamines were used as substrate under developed methodology. Additionally, in situ reduction of the exocyclic double bond in 3-methyleneisoindolin-1-ones using PMHS was also explored. The developed method is straightforward which doesn't require any additive and special technique (Fig. 2).

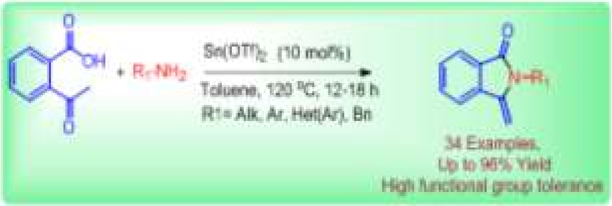

Fig. 2 Synthesis of 3-methyleneisoindolin-1-ones

Sugar embedded Macrocycles were synthesized and evaluated for their toxicity against nymphs of aphid, Aphis craccivora Koch under laboratory conditions. Most of the compounds synthesized showed toxicity to *A. craccivora*. However, SAR studies revealed that the activity of different macrocycles varied depending on the nature and positions of various functional groups possess by these compounds.

WHO has categorized the Gram-negative superbugs, which are inherently impervious to many antibiotics, as critical priority pathogens due to lack of effective treatments. The breach in our last resort antibiotic (i.e. colistin) by extensively drug-resistant and pan drug-resistant Enterobacteriaceae demands the immediate development of new therapies. We have done structure elucidation of a novel molecule tridecaptin M, a polypeptide molecule isolated from mud bacterium. The antibacterial potential of tridecaptin M was valuated against colistin-resistant Enterobacteriaceae *in vitro* and *in vivo*. The work also emphasizes the importance of natural products in our shrunken drug-discovery pipeline.

Growing resistance against current antibiotics and crop protection chemicals is of global concern. Therefore, in the current year, two mission mode projects on pharmaceutical and agrochemical development were initiated. In this regard, Avibactam - a β-lactamase inhibitor was demonstrated to restore the efficacy of antibiotics against resistant pathogens. Under CSIR mission project INPROTICS: pharma and agro, a novel lab scale process for the synthesis of Avibactam was undertaken. Agrochemicals such as insecticides, fungicides and herbicides play a crucial role in ensuring food and nutrition security of the nation. Recognizing this problem, development of a new process for epoxiconazole, a fungicide molecule is being undertaken under crop protection chemical (CPC) mission.

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Left to Right: Amita Kumari, Shashi Thakur, Rahat Khan, Rahul Kumar, Aakriti Sood, Dr. Sushil Maurya, Dr. Maheshwar Thakur, Arti Sharma, Deepak Dabur, Shreya Guleria, Rohit Rana, Rahul Upadhyay

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Chemical Engineer, Natural Plant Products & Process Development

Area of expertise: Development, Designing and up scaling of improved technologies for processing of bioactive materials from medicinal and aromatic plants. Preparation of Techno economic feasibility and project reports for prospective entrepreneurs.

Development of process for converting raw cellulosic biomass into textile fiber and nanocellulose

Best cellulose source has been identified on the basis screening of different underutilized Himalayan bio resource. Attempts were made to explore best and economically viable sources for the isolation of cellulose. In addition, lab scale process for isolation of pure cellulose was developed and standardized which will further be converted into textile fiber and nanocellulose (NCs).

Setting up of distillation units and catalyzing setting up of farmer's cooperatives for marketing of the produce: Mission Aroma

Essential oils are the main economic ingredient of the aromatic crops which are extracted by means of distillation. To enable farmers to distill the oil from their crop eleven multipurpose essential oil distillation units were designed, fabricated, installed commissioned to various registered societies (Fig. 1)

Fig. 1 Installation and commissioning of different capacities distillation units at farmers' sites under Aroma Mission.

Mission Phytopharma

Process development for standardized herbal extract from *Gingko biloba* and *Picrohizza kurroa* at lab scale. Physico chemical parameter of raw material was done and extraction method was standardized.

Development adoption of green technology for commercial production of tea catechin and its formulations DBT- BIRAC

Tea leaves contains 15-20 % of total polyphenols of which catechins constitute up to 80%. Epigallocatechin (EGC), epicatechin (EC), epigallocatechin gallate (EGCG) and epicatechin gallate (ECG) are the major catechins. These catechins are high value antioxidants with nutraceutical properties. Optimization and validation of 100 kg per batch green tea leaf processing capacity plant. The plant was successfully run for production of tea catechins with purity > 60% at M/s Baijnath Pharmaceutical Pvt. Ltd., Paprola. This technology is beneficial for upliftment of tea industry through value addition of tea leaves. (Fig. 2)

Fig. 2 Production of tea catechins from green tea shoots

Development and upscaling of process for extraction of steviol glycoside from *Stevia rebaudiana* leaves

Experiments were conducted for enrichment of Reb A purity in total SGs. Various solvents were tried for selective crystallization of SGs. Preliminary results are compiled below. (Fig. 3)

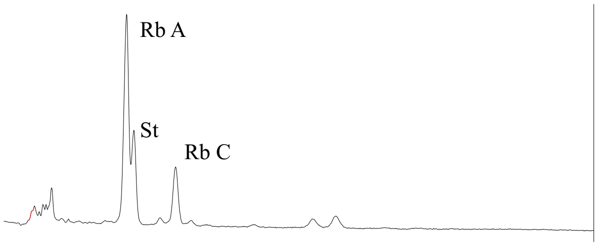

Fig. 3 HPLC profile of enriched Rebaudioside A

Formulation of stevia liquid drops

A green process is developed for direct processing of dry stevia leaves into formulated liquid drops. The process capacity of MoU is signed with following parties for production of Stevia liquid against processing charges

- M/s Himalayan natural, Palampur
- M/s Harsh Organics, Una
- M/s Yuzo Farms, Ghaziabad
- Mr. Virender Singh, Bulandshar
- M/s Agri Natural, Ludhiana

Fig. 5 Process for Stevia liquid formulation

Patent(s)

Gupta Mahesh, Dwivedi Jai Prakash, Rana Akshay and Sharma Mohit (2019) Development of low-calorie herbal mouthwash using Himalayan herbs. (Filed 0058NF2019)

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Left to Right: Vikas Kumar, Arvind Kant, Vivesh Sood, Mohit Sharma, Harish Goyal, Aman Pathania, Shivani Thakur, Mehak

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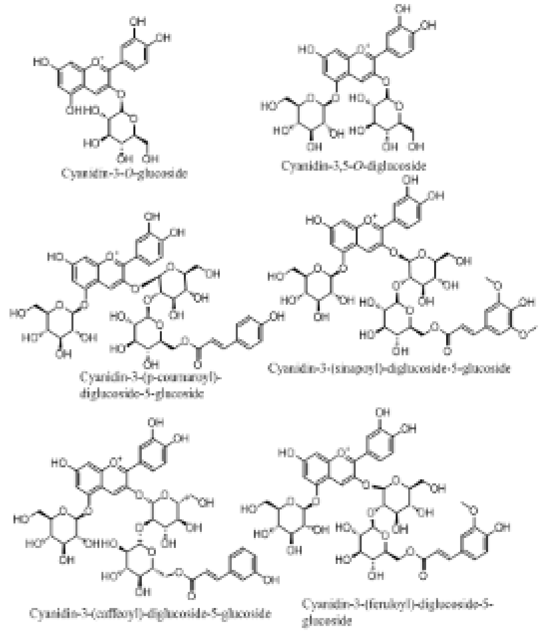
Natural Product Chemistry & Process Development

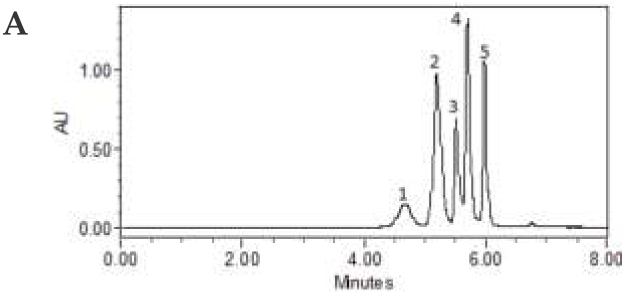
Bioprospection of potential natural colours/dyes from Himalayan flora

Synthetic colours/dyes are characterized by high environmental pollution and high risk of allergies, cancers and toxicity. Natural colours/dyes become important commodities in today's global forethought because of hazardous effects of synthetic dyes to human, animals as well as to environment. Increased consumer's demand for natural colours/dyes enthused researchers to explore new sources with eco-friendly processes. These are considered safe to humans, animals as well as to the environment (non-toxic, biodegradable and non-carcinogenic) and have high potential as alternative to synthetic colours. Owing to their potential, our research focused on the exploration and optimization of processes for natural colours/dyes from plants & vegetables to serve as a substitute to the synthetic colours. In this aspect, we have explored numerous anthocyanins, naphthoquinones and anthraquinones containing plant species to purify and characterize the compounds/ fractions through hyphenated techniques. The intensive analysis of *Brassica oleracea* resulted in purification of fractions which can be used for food and cosmetics colouration. The characterization of chemical constituents of the discussed plant resulted into the identification of eight acylated and non acylated cyanidin compounds namely, cyanidin-3- *O*-glucoside, cyanidin-3-*O*-diglucoside-5-glucoside, cyanidin-3-(6′′-sinapoyl)- diglucoside-5-glucoside, cyanidin-3-*O*-diglucoside-5- (6′′-caffeoyl)glucoside, cyanidin-3-*O*-diglucoside-5-(6′′-coumaric) glucoside, cyanidin-3-*O*-diglucoside-5-(sinapoyl) (coumaroyl)glucoside, cyanidin-3-*O*-diglucoside-5-(sinapoyl) (feruloyl) glucoside and cyanidin-3-*O*-diglucoside-5-(sinapoyl) (sinapoyl) glucoside.



Structures of the characterized molecules by LC - ESI -MS/MS

Besides, purification and characterization, an UPLC method was developed and validated for quantitative analysis of anthocyanins in *B. oleracea* (Fig. 1). The observed results indicate that the extract is dominated by cyanidin-3,5-*O*-diglucoside and present in the range of 5.3-5.9%.



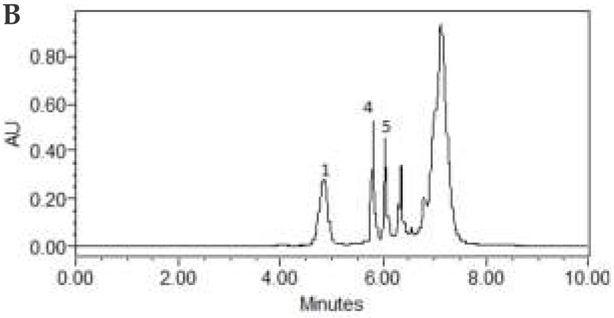


Fig. 1. UPLC chromatogram of Standard (A) (1=Cyanidin-3,5-*O*-diglucoside, 2=Delphinidin-3-*O*-glucoside, 3= Cyanidin-3-*O*-galacoside, 4= Cyanidin-3-*O*-glucoside, 5= Peonidin-3-*O*-galactoside) and Sample of *B. oleracea* (B).

For the evaluation of biological activity, the extract of *B. oleracea* was evaluated for antioxidant activity by DPPH method and found to be potent antioxidant (*B. oleracea* (IC50 = 18.50 µg/ml), standard ascorbic acid (IC50 = 14.30 µg/ml) (Fig. 2).

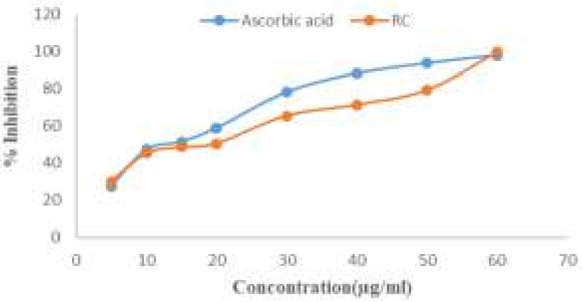
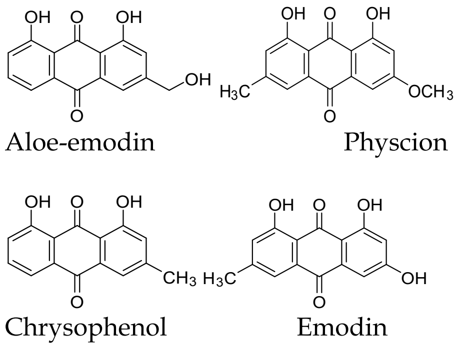


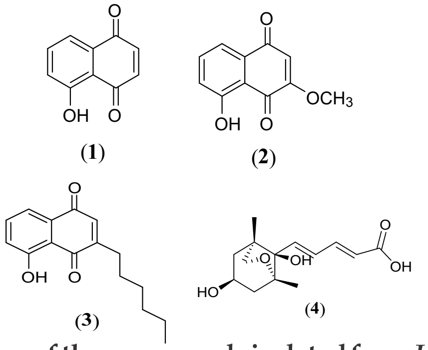
Fig. 2 Antioxidant activity of *B. oleracea*

Similarly, *Rheum emodi* commonly known as Himalayan Rhubarb, is traditionally used to cure various ailments. This plant has tremendous scope in the area of natural colours/dyes. Hence, the root parts of the *R. emodi* were processed and resulted into the purification of brilliant yellow coloured anthraquinone compounds/fractions. The structures of compounds/fractions were characterized and used for colouration in cosmetics.



Exploration of plants of Himalayan region for cognition impairment

In continuation of isolation and characterization of bioactive molecules from traditionally important plants growing in Himalayan region, *Juglan regia*, commonly known as Akhrot, was evaluated for cognitive impairment and results revealed that the ethylacetate extract of *J. regia* exhibit excellent neuroprotective activity. This ethylacetate extract was then further examined for its bioactive constituents and resulted into the isolation of four compounds namely 5-hydroxy-1, 4- naphthoquinones (1), 3-methoxy-5-hydroxy-1,4-naphthoquinone (2), 5-hydroxy-3-pentyl,1,4- naphthoquinone (3) and dihydrophaseic acid (4).



Structures of the compounds isolated from *J. regia*

Left to Right: Ankita Choudhary, Shinde Bhagatsing Devidas, Pamita Bhandari and Nitisha Sendri

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NMR, Metabolomics and Natural Product Chemistry

From the primitive age, plants, animals, minerals and marines have been used to cure serious complications of life, health and are still very significant. Their derived products are used either as such or template in the discovery of valuable products. Several biologically active secondary metabolites have been used for their therapeutic and important values. Therefore, to understand the chemistry, metabolite composition and alterations in plant, marines and biofluids, along with quality assessment and control, is the need of current time. In this regard, the present focus is on metabolomics, development of chemical signatures, isolation and characterization of natural molecules, identification and isolation chemical markers and quality control for medicinally important resources of western Himalaya using NMR, UPLC-MS/MS and HPTLC techniques. Moreover, laboratory is also working to find out mechanistic role of medicinal plants and their derived products *(*Lower to trans Himalaya) using modern analytical techniques based metabolomics approach for toxicity, safety and action in health disorders. Process, formulation and value added product development from natural resources based on the traditional and current knowledge is also one of the important focused area.

Chemical characterization and antipsoriatic activity of *Vernonia anthelmintica* Willd

Vernonia anthelmintica has been utilized traditionally in Ayurveda and Uighur medicine for management of skin disorders, and scientific reports have also justified its use in treating vitiligo, dermatosis and leucoderma. Hence, present study was focused to chemically profile and evaluate the antipsoriatic potential of *V. anthelmintica* fruit extracts and fractions. Chemical characterization of extract showed the presence of fatty acids while the lead fraction revealed that essential fatty acids (i.e., linoleic acid, palmitic acid, oleic acid and stearic acid) formed the bulk of bioactive fraction. The dichloromethane extract (5%, w/w) showed statistically significant (* $p < 0.05$) antipsoriatic potential with respect to control and equivalent to that of the standard drug, retino-A 0.05%, in terms of degree of orthokeratosis, whereas, methanol extract (5%, w/w) showed significant (* $p < 0.05$) differentiation in comparison to the control group. Among the all fractions, F-6 showed statistically significant (* $p < 0.05$) antipsoriatic activity with respect to control and equivalent to that of the standard. F-6 (15.6-1000 µg/ml) also showed dose-dependent inhibition of HaCaT cell lines proliferation and suggests keratinocyte modulating activity. Ameliorative effect of *V. anthelmintica* in psoriasis might be attributed to the presence of essential fatty acids. There by corroborating its traditional claim in the treatment of skin problems.

Metabolomics of *Ophiocordyceps sinensis*

Ophiocordyceps sinensis, internationally known as 'Himalayan Viagra' and commonly known as kida jaddi, is one of the highly valuable natural resource with wide spectrum of medicinal values. It is distributed in 3000–5500 m amsl confined to Tibetan Plateau, South-western China, certain parts of Nepal, Bhutan and Northern India. Due to the high demand in the trade market, the authenticity and quality of the material is major concern. Therefore, a fast reproducible UHPLC-IMS method was developed and validated for concurrent determination of eight nucleosides (adenine, adenosine, cordycepin, guanosine, inosine, thymidine, thymine and uracil) in natural *O. sinensis*. The presence of cordycepin, an important marker compound was identified for the first time using ion mobility mass spectrometry (IMMS) technique (Fig. 1). Metabolomics approach was also used which resulted in 18, 12 and 9 metabolites in three different samples using METLIN database. This study created new avenues to identify and explore more novel biomarkers in Ophiocordyceps. Therefore, IMS based methods may be applied to verify/certification of Ophiocordyceps containing marker nucleosides for their dietary intake.

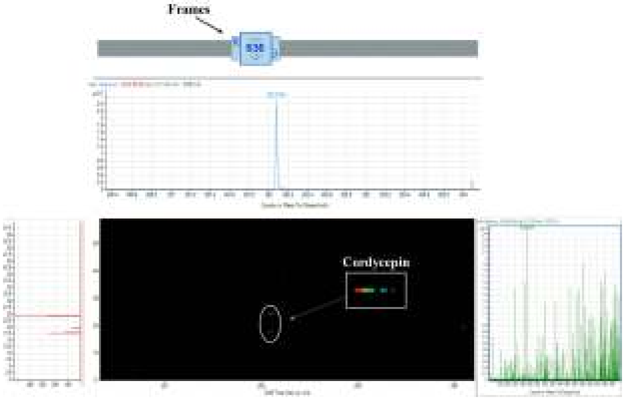

Fig. 1 Identification of Cordycepin using IMS

UPLC-DAD-MS based quality control method and discrimination analysis of different parts of *Crataegus rhipidophylla*

Crataegus rhipidophylla is utilized throughout for medicinal, cosmeceutical, nutritional purposes. Thus, fast analytical method for quality control is required and a UPLC-DAD-MS based quality control method has been developed for the determination of targeted twelve polyphenols (protocatechuic acid, chlorogenic acid, caffeic acid, epicatechin, epigallocatechin gallate, *p*-coumaric acid, hyperoside, quercetin 3-glycoside, epicatechin gallate, luteolin, quercetin dihydrate and kaempferol) within nine minutes. The method was validated as per ICH guidelines. The same method was applied for the assessment of polyphenols in different parts such as stem, leaves, flowers, fruits, and seeds. A significant alterations of metabolites in different parts were noticed and also observed that hyperoside, quercetin, quercetin 3-glycoside, kaempferol, chlorogenic acid, were present in all parts while epicatechin and epicatechin gallate were only present in stems. Moreover, the protocatechuic acid is also present in all aerial parts except seeds. Thus the method is benficial to understand the accumulation and discrimination pattern of metabolites among the different biometrics.

Chemical exploration of *Polygonatum verticillatum*

Polygonatum verticillatum (L.) ALL. is an astavarga plant of Ayurveda. Rhizomes of this plant are sweet and used as part of food by ethnic people in various part of the World. Plant is also known as rasayana in Ayurveda and attributed to be effective against senility, pain, pyrexia, weakness, burning sensation, phthisis, and pulmonary affections. Critically endangered status and adulteration are the current hot issue for astavarga plants. Confusion in vernacular names, non-availability of drug, and lack of chemical markers are main reasons for adulteration of astavarga drugs. Therefore, group focuses on isolation and characterization of chemical markers for and screening for biological potential. In the present study, one new and two known homoisoflavonoids were isolated and found potential for antimicrobial activity (Fig. 2).

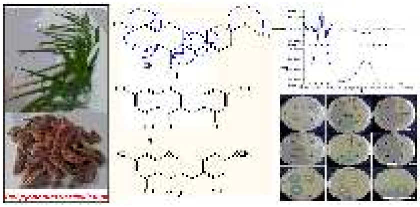

Fig. 2 Homoisoflavonoids and antimicrobial potential of *P. verticillatum*

Publications

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Joshi R, Sharma A, Thakur K, Kumar D and Nadda G (2018) Metabolite analysis and nucleoside determination using reproducible UHPLC-Q-ToF-IMS in *Ophiocordyceps sinensis.* Journal of Liquid Chromatography & Related Technologies, DOI:10.1080/10826076.2018.1541804.

Sharma A, Sharma R, Kumar D and Padwad YS (2018) *Berberis lycium* Royle fruit extract mitigates oxi-inflammatory stress by suppressing NF-κB/MAPK signalling cascade in activated macrophages and Treg proliferation in splenic lymphocytes. Inflammopharmacology. DOI:10.1007/s10787-018-0548-z.

Sharma S, Patial V, Singh D, Sharma U, Kumar D (2018) Antimicrobial homoiso-flavanoids from the rhizomes of *Polygonatum verticillatum.* Chemistry & Biodiversity, DOI.org/10.1002/cbdv.201800430.

Left to Right: Anil Kumar, Anchal Sharma, Vandana Kumari, Bindu Rawat, Ranaja Sharma, Mrs. Vijaylata Pathania, Mr. Shiv Kumar, Dr. Dinesh Kumar, Pradeep Bhatia, Mr. Ramesh Kumar, Shruti Sharma, Manish Kumar, Jigyasa Malhotra

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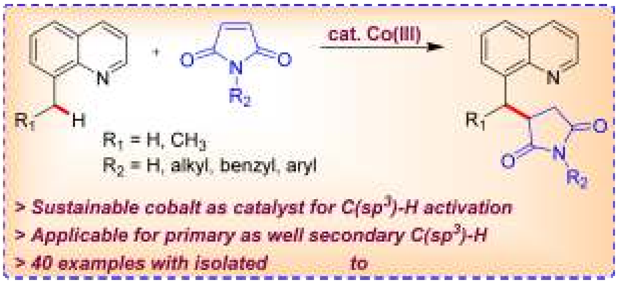
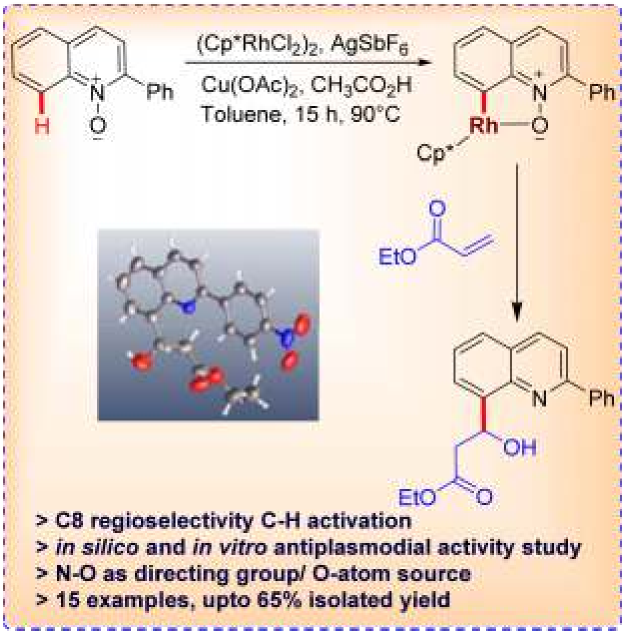
Catalysis for C-H Activation/functionalization, Natural Product Chemistry and Medicinal Chemistry

C-H activation and functionalization: efficient bioactive molecule synthesis: Our group's main focus is the synthesis of new quinoline derivatives *via* C-H activation. This year we have developed four innovative catalytic methods for the synthesis of >200 new quinolines derivatives. Most of these synthesized molecules were evaluated for their antiplasmodial potential.

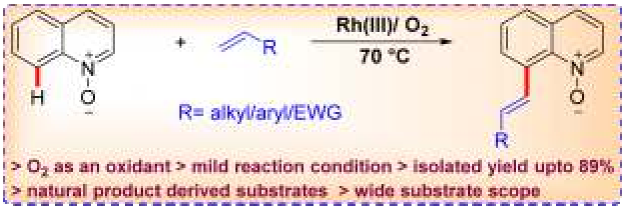
Cp*Co^{III}-Catalyzed $C(sp^3)$-H Bond Activation: The Cobalt (III)-catalyzed $C(sp^3)$-H bond activation and subsequent alkylation of 8-methyl quinoline with maleimides is developed. This method used the catalytic amount of acid and applicable for the secondary $C(sp^3)$-H alkylation. Atom-economy, high regioselective with good to excellent yields of the alkylated products under mild reaction conditions are important features of this method.



Simultaneous C-C and C-O Bond Formation *via* C-H activation: Synthesis of 3-hydroxyquinoline 8-yl propanoates *via* Rh(III)-catalyzed C(8)-H activation of 2-substituted quinolines has been developed. The reaction proceeds *via* C(8)-H activation, functionalization with acrylates followed by intramolecular migration of the oxygen atom from quinoline *N*-oxides to the acrylate moiety. In this approach, *N*-oxide is playing dual role of a traceless directing group as well as a source of oxygen atom for hydroxylation. Catalytically competent five-membered rhodacycle has been characterized, thus revealing a key intermediate in the catalytic cycle. *In vitro* evaluation of selected compounds against CQ sensitive *pf*3D7 and CQ resistant *pf*INDO strains reveled IC_{50} 9.5 μM against *Plasmodium falciparum*. One of the compound was found to be most potent on the basis of both *in vitro* antiplasmodial activity (IC_{50} 9.5 μM (*P f* 3D7) and 11.9 μM (*P f* INDO), Resistance Index 1.25) and *in silico* studies.

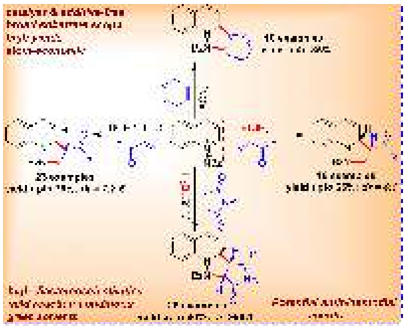


O_2 as Green Oxidant in C-H Activation: Molecular oxygen was explored as economic and clean oxidant, alternative to inorganic oxidants. Wide substrate scope with respect to quinoline *N*-oxides and olefins (activated: acrylates, styrenes, and un-activated: aliphatic olefins) demonstrates the robustness of the developed cata-lytic method. Interestingly, 2-substituted quinoline N-oxides also afforded good yields of the corresponding C8-olefinated products. Kinetic isotope studies and deuterium labeling experiments have been performed to understand the preliminary mechanistic pathway. The applicability of the developed method is demonstrated by utilizing natural product derived substrates and by converting the C8-olefinated quinoline N-oxides into various other useful molecules.



Fused *N,N´*-Heterocycles with Promising Activity against Drug Resistant Malaria Parasite

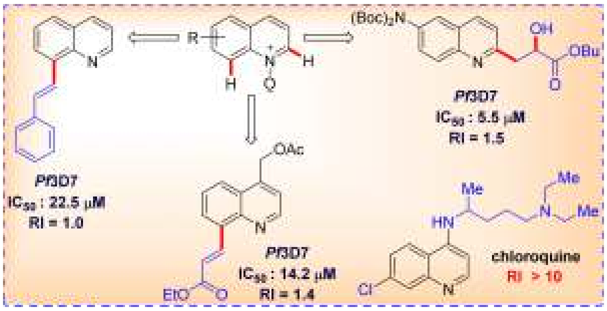
Various fused *N*-heterocyclic compounds through the catalyst and additive-free 1,3 dipolar cycloadditions of quinolinium imides with olefins, maleimides and benzynes in excellent yields and diastereoselectivities was developed. Cycloaddition reaction between quinolinium imides and olefins provided *cis*-isomers at low temperature and *trans*-isomers at high temperature. A reaction between quinolinium imides with substituted maleimides gave four-ring-fused *N*-heterocyclic compounds in high yields as a single diastereomer. The aryne precursors also provided four-ring-fused *N,N´*-heterocyclic compounds in high yields. *In silico* study of the synthesized compounds revealed that these compounds could be explored as potential PI3 kinases and Falcipain 2 inhibitors.



Evaluation of Antiplasmodial Potential of Modified Quinolines

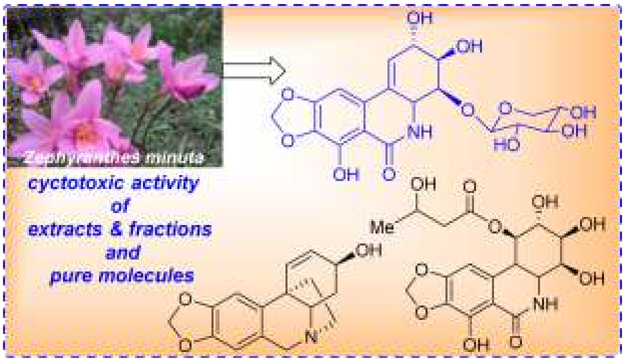
The antiplasmodial potency of C-2 and C-8 modified quinoline analogs obtained *via* C-H bond functionalization approach has been carried out. *P. falciparum* culture using SYBR Green microtiter plate based screening revealed good activity of quinoline-8-acrylate (IC_{50} 14.2 μM), 2-quinoline-α-hydroxypropionates (IC_{50} 5.5 μM), against chloroquine sensitive *pf 3D7* strain. Top fourteen molecules were screened also against chloroquine resistant *Pf INDO* strain and the observed resistant indices were found to lie between 1 and 7.58. Computational molecular docking studies indicated a unique mode of binding of theses quinolines to Falcipain 2 and heme moiety, indicating their probable targets of antiplasmodial action.

Phytochemical Investigation of Medicinal Plants: Chemical Profiling and Characterization of Bioactive Secondary Metabolites



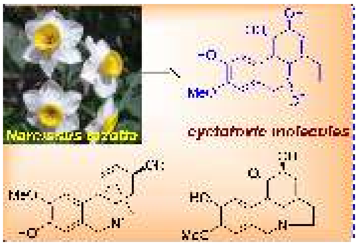
Natural product based novel and bioactive molecules will impute the therapeutic application in modern science. The scientific validation of Ayurveda plants provides scientific basis for their use leading towards high social impact. This year phytochemical investigations of *Zanthoxylum armatum, Zephyranthes grandiflora, Narcissus tazetta* and *Zephyranthes minuta* were carried out. During this study two novel alkaloids along with twenty-two known compounds belonging to alkaloid flavonoids and lignin were isolated and characterized.

A New Narciclasine glycoside from *Zephyranthes grandiflora:* A new narciclasine glycoside, narciclasine-4-*O*-*β*-D-xylopyranoside was characterised along with four known alkaloids. Their structures were established on the basis of spectroscopic data analysis. The *in vitro* cytotoxic study of extract, fractions and isolated compounds against two human cancer cell lines (KB and SiHa) indicated the potential activity of extract and *n*-butanol fraction due to presence of active alkaloids pancratistatin, 1-*O*-(3-hydroxybutyryl) pancratistatin, lycorine and haemanthamine.

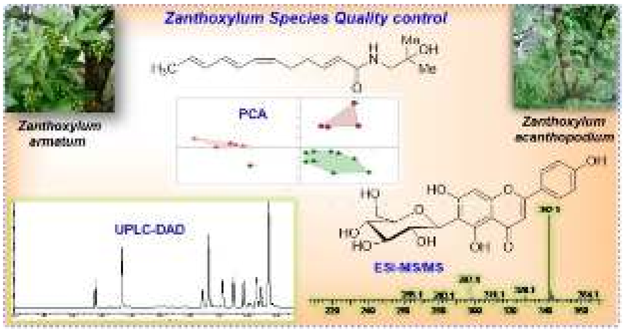


A New *N*-Oxide from *Narcissus tazetta*

A new *N*-oxide, Pseudolycorine *N*-oxide was characterised along with eleven known alkaloids. Their structures were established on the basis of spectroscopic data analysis. The extract, fractions and isolated compounds were screened for *in vitro* cytotoxicity against two human cancer cell lines, human cervical cancer (SiHa) and human epidermoid carcinoma (KB) cells. The study demonstrated the cytotoxic potential of extract and its chloroform and *n*-butanol fractions. Further the results revealed the bioactive potential of narciclasine, pseudolycorine and homolycorine alkaloids.



Chemical Profiling of *Zanthoxylum armatum* and *Zanthoxylum acanthopodium*: A UPLC-DAD-MS/MS method has been developed for the determination of the biologically important compounds in the different parts (leaves, bark, flowers and fruits). The results revealed that lignans and flavonoids are the principal components in leaves samples while aporphine alkaloids, lignans and amides are the major constituents in bark samples of *Z. armatum*. None of the analyzed compounds were detected in bark and leaves of *Z. acanthopodium* except catechin. In contrast, the fruit pericarp was characterized by the sanshool analogues, especially hydroxy-*a*-sanshool. In addition, the method was also applied for identification of twenty-seven metabolites in the different parts of *Z. armatum* and *Z. acanthopodium*.



Exploration of Himalayan Plants for Novel Antimalarial Agents: Characterization of potential molecules

Active fraction/extracts have been identified for *Cissampleos parrera* on the basis of *in vitro* anti-plasmodial activity assay. Three alkaloids have been isolated from active fractions/extracts of *Cissampleos parrera* and characterization under progress.

Cissampleos parrera is identified as source of antimalarial agents. Study being carried out on identification of secondary metabolites responsible for the antimalarial activity. Knowledge generated under this project can be applied for the development of herbal formulation.

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Left to Right: Vinod Bhatt, Diksha Parmar, Shivani Puri, Ritika Sharma, Surekha Kumari, Divya Rana, Shiv Patil Prasad, Prateek Bohra, Upendra Sharma, Shiv Shankar Gupta, Devesh Chandra, Munish Kumar, Rakesh Kumar, Rohit Kumar, Arvind Sharma, Prithavi Pal Thakur, Ankit Kumar Dhiman

Planning, Project Monitoring and Evaluation

Rakesh Kumar Sud, Senior Principal Scientist & Head
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Agrotechnology, Advisory and Extension, Planning, Project Monitoring and Evaluation

Performed the duties of nodal scientist of CSIR-Aroma mission of the institute upto November 28, 2018 and played a significant role in bringing 256 ha area under aromatic crop cultivation and setting up of 12 essential oil distillation units. In addition, R&D activities under Tea Board of India sponsored projects on mechanization of tea cultural operations and tea improvements were continued. Advisory and extension services to tea growers and other farmers were provided and demonstration of young tea using improved tea cultivars were set up at 4 locations and about 5000 nursery plants of large cardamom were supplied to the farmers for additional income generation. From October 2018 took over the charge of PPME division of the Institute.

Mechanized tea harvesting under different levels of fertilizer application

Farm mechanization has become the essential component of the tea industry to cut down labour cost and improve the growers' income.

A trial to assess the four plucking methods i.e. one man plucking machine, two men plucking machine, hand shear and hand plucking for tea harvesting in association with three fertilizer levels of nitrogen, phosphorus and potash ($N:P_2O_5:K_2O$) i.e. F1 (90:90:90 kg/ha), F2 (120:90:120 kg/ha) and F3 (180:90:180 kg/ha), laid out previous year in China hybrid tea was continued. The aim was to study the effect on green leaf yield and fineness of the harvest. The experiment was laid out in RBD with 3 replications keeping 100 bushes/plot.

One man plucking machine

Two men plucking machine

Shear plucking

Hand plucking

Results showed that across the different fertilizers, the mechanical methods of plucking had significantly higher yield than hand plucking. Across different methods of plucking, the fertilizer level 120:90:120 showed higher yield than other combinations. Leaf grade or fineness of leaf was noticeably reduced with all mechanical methods. However, the reduction was relatively less with hand shears. It was also observed that by increasing the fertilizer level, the fineness of leaf decreased gradually. Fertilizer level 90:90:90 showed higher value of leaf grade than other combinations.

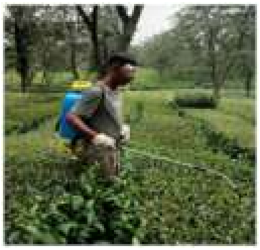
All mechanical plucking methods resulted in extension plucking interval to 10-12 days as compared to 6-7 days in Hand plucking, consequently reduced number of total plucking rounds during the entire season and thereby man-days requirement. Overall man-days requirement reduced one-sixth to one-seventh with one man plucking machine and to one-ninth to one eleventh with two men plucking machine in pruned and unpruned tea. Even shear plucking also reduced the labour requirement to half.

Efficiency of high volume sprayers

A comparative study on the working efficiency of automatic spray pump (Model ASPEE 20 BEPK), battery operated spray pump (Model V-DYUT DELUX VBD09) and manual pump (Model ASPEE Napsak) for spraying agrochemicals was carried out at Tea Experimental Farm of the Institute. The area selected for the study was 1 ha each for each type of sprayer. It was observed that mechanical methods of spraying were more economical that manual method of spraying. Unit cost of spraying including depreciation charges and wage rate (@ Rs. 279.84/day) was recorded to be Rs. 311, Rs. 222 and Rs. 350 per hectare for high volume power sprayer, battery operated sprayer and manual sprayer, respectively.

High volume power sprayer

Manual sprayer



Battery operated sprayer

Mechanized pit making for tea planting

Objective of the study was to assess the operational efficiency of earth auger in comparison with manual method of pit making. Three methods of pit making viz; one man operated earth auger (Model STIHL BT 131) with 10 cm bit diameter, twomen operated earth auger (Model STHIL BT 360) with 30 cm bit diameter and manual method of pit making were employed for this purpose. The results showed that one man operated earth auger was more cost effective, time saving and reduced the drudgery involved in the work in comparison to other methods of pit making. Unit cost of pit making with one man operated earth auger was one tenth to that of manual method. Two men operated earth auger was not found user friendly and cost effective.

One man earth auger method

Two men earth auger

Manual

Setting up of demonstration plots on tea

Demonstration plots on new tea plantations were set up at the grower's field using 'Him Sphurti' clonal variety at 4 locations, 3 in Kangra district viz., Thandole, Saloh and Paprola, and one at Chauntra in Mandi district. At each location 600 plants were planted using mechanized augers.

Demonstrations plots on new plantation set up at the grower's field

Aparna Maitra Pati, Sr. Principal Scientist
aparna@ihbt.res.in
R & D Management

PGPR

The PGPR attributes namely phosphate solubilization, siderophore production, IAA production and ACC deaminase production of selected soil microbes were assessed. The culture media and growth parameters were standardized for selected microbes in shake flask and further, the process was upscaled in 10L bioreactor. The assessment of growth promoting potential of the selected microbe is underway in Stevia in pots under greenhouse condition. Efforts were made to multiply Arbuscular Mycorhhizal Fungi in host plants like maize and grass.

CSIR Integrated Skill Initiative

CSIR Integrated Skill Initiative

Different skills development programmes were conducted under CSIR Integrated Skill Initiative in the area of floriculture and analytical chemistry (Table 1)

Table 1 Skills development programmes/ trainings conducted under CSIR Integrated Skill Initiative

Sr. No.	Industry/Govt Agency name	Skill/training programme name	Duration		No. of candidates trained
			From	To	
1	Periyar Maniammai Institute of Science & Technology, Thanjavur, TN	Hands-on Laboratory Experiment and Analytical Exposure	22/11/2018	01/12/2018	01
2	HIMCOSTE Shimla , HP	Flower Farming Cultivation	24/05/2018	24/05/2018	84
3	Dept of Horticulture Dharmshala , Kangra HP	Flower Farming Cultivation	18/12/2018	20/12/2018	27
4	Dept of Horticulture Panchrukhi , Kangra HP	Flower Farming Cultivation	11/02/2019	15/02/2019	18
5	Dept of Horticulture Bhawarna , Kangra HP	Flower Farming Cultivation	11/02/2019	15/02/2019	25

Incubation Centre at CSIR-IHBT

Incubation Centre at CSIR-IHBT

CSIR-IHBT has been recognised as one of the incubation centres by Department of Scientific and Industrial Research (DSIR) and Micro Small and Medium Enterprises (MSME), Govt. of India. Department of Industry, Himachal Pradesh signed an MoU on 23rd February, 2017 for implementation of H.P. state Chief Minister start-up incubation scheme at CSIR-IHBT, Palampur. Under this scheme, incubatees shown interest to establish new start-up/enterprise in the state after training at CSIR-IHBT, Palampur. The institute encourages strong linkages with MSMEs. Active interactions are being pursued to encourage individual entrepreneurs (start-ups/ stand-ups), micro and small scale industries to utilize the facilities of the incubation centre. Opportunities are being explored to tie up with various government agencies, private companies and multiple industries.

In order to promote industrial enterprises for youth of the nation and employment generation, incubation centre was developed in the institute. Technical competency and facilities exist within the institute to guide the start-ups for networking, infrastructure development, awareness and up-scaling in the area of food processing, nutraceuticals, enzymes and mass propagation of plants.

Major processing facilities at CSIR-IHBT campus are available for usage by the MSMES are:

- Canning unit for ready-to-eat food products
- Crispy fruit making pilot scale unit
- Distillation of essential oils from medicinal and aromatic crops
- Extraction of steviosides from stevia
- Extraction of dietry fibers from apple pomace, pomegranate, amla and other fruits.
- Bamboo candies and other value added products from bamboo
- Tea based beverages: Tea concentrates for preparation of soft drinks, tea wines, black and green herbal teas
- Extraction of catechins from tea leaves
- Raising of tissue culture plants for RET MAPs, ornamentals, apple, bamboo, potato, rose, etc
- Soil testing
- Animal testing and preclinical trials
- Pac Bio analysis
- Pesticide residue analysis

Initially five incubatees (Mr. Sahil Dutta, Mr. Paritosh Bhardwaj, Mr Rakesh Kumar, Mr. Aman Patial and Mr Akash Patial) registered their idea under start-up scheme in CSIR-IHBT. After that additional nine incubatees (Mr Chandan Sood, Mr Sandeep Kumar, Mrs Samita Gupta, Mr Shivanshu Mehta, Mr Paritosh Sharma, Mr Sunil Kumar, Mrs Swati Sharma, Mr Vipin Kumar and Mr Sandeep Kumar) joined in between February 2018 to March 2019. First five incubatees have been completed their tenure and also launched their products in start-up yatra and department of industry event. Currently nine incubatees are actively working in the area of process development, food processing, tea, floriculture, aroma and e-marketing under the State CM Startup Scheme.

CSIR-IHBT has also demonstrated the incubation facilities in various events organised at state and national level for encouraging young potential incubators for new start-ups.

Currently fourteen incubatees are implementing their progressive ideas at CSIR-IHBT Incubation Centre which includes:

Sr. No.	Name of Incubatees	Idea of Start-up and Start date
1	**Mr. Sahil Dutta** Pine Villa, Below HIMUDA Colony, Sector – 6, Kangra Dharamshala. Contact No. 7831012202	Mango Panna Juice, Apple Juice and Amla honey juice formulations **25th September, 2017**
2	**Mr. Paritosh Bhardwaj** VPO, Kand Gwal Tikker, Tehsil Palampur, Distt. Kangra, Contact No. 9459252890	Ready to serve healthy beverages such as medicated and ice Kangra tea **25th September, 2017**
3	**Mr. Rakesh Kumar** Village Dhanyater, P.O. Chauntra, Tehsil Joginder Nagar, Distt. Mandi Contact No. 9857999888	Herbal green tea, black tea and blends of different tea products **25th September, 2017**
4	**Mr. Aman Patial** #60/4, Bhojpur Sundernagar (HP) Contact No. 9816484577	Honey vinegar from waste honey **25th September, 2017**
5	**Mr. AkashPatial** #60/4, Bhojpur Sundernagar (HP) Contact No. 9816860577	Fruit Burfi from different seasonal fruits such as guava, mango, apple and amla etc. **25th September, 2017**
6	**Mr Chandan Sood** Phase – 7, Mohali Contact No. 7045018453	Agro-technology e-market platform **13th February, 2018**
7	**Mr Sandeep Kumar** VPO Trilokpur, Teh. Jawali, Distt – Kangra Contact No. 9805620466	Potato seed production through Plant Tissue Culture and aeroponic facility **13th February, 2018**
8	**Mrs Samita Gupta** Kashmir Avenue, Amritsar – Punjab Contact No. 7589208889	Kinnow Juice processing and packaging. **13th February, 2018**
9	**Mr Shivanshu Mehta** Palampur (HP) Contact No. 9418010613	Floriculture establishment **6th April , 2018**

Sr. No.	Name of Incubatees	Idea of Start-up and Start date
10	**Mr Paritosh Sharma** Bundla, Palampur, Contact No. 9816623345	Turmeric based essential oil and other products **6th April , 2018**
11	**Sunil Kumar** Vill. Bhadrin P.O Galore Tehsil Galore Distt. Hamirpur (HP) Contact No. 7009454779	Aloe vera processing, retail, marketing services along with farming services in Hamirpur, Himachal Pradesh. **21st February 2019**
12	**Swati Sharma** M-150, Jal Vayu Vihar, Sector 25, Noida 201301, Contact No. 9560035488	A complete detox drink which rejuvenates from within and nourishes you. Essential nutrients and provide immunity against several diseases. **21st February 2019**
13	**Vipin Kumar** Vill. Bharmat PO Banuri Teh. Palampur Distt. Kangra (HP) 176061 Contact No. 9816949833	Tea is a major produce of palampur which never got the respect in market that it should so tea vinegar is a product which can turn the tables for kangra tea. **5th March 2019**
14	**Sandeep Kumar** Palampur, Contact No. 8580753926	Development of package for pollution awaited plants for different location like house, hospital offices etc. **5th March 2019**

AcSIR- IHBT

AcSIR- IHBT

Under the banner of Academy of Scientific and Innovative Research (AcSIR), CSIR- IHBT has initiated Ph.D programme since January 2011. There are 48 courses (9 compulsory courses, 39 optional courses) that are being taught under Biological Sciences & 14 courses (all compulsory) that are being taught under Chemical Sciences under AcSIR in the Institute. Following are the AcSIR activities that are being performed at CSIR- IHBT:

- Liaison between AcSIR HQ and students enrolled and/or registered for Ph.D under AcSIR at CSIR- IHBT.
- Maintenance and updation of the records of Ph.D students.
- Handling various administrative, financial, academic matters and other duties and responsibilities related to functioning of AcSIR- IHBT.
- Establishing and maintaining the communication link between the AcSIR and CSIR- IHBT through electronic mode.
- Addressing day to day queries of the students/ scientists related to AcSIR.
- Ensuring that the timelines as defined by AcSIR are followed by the students for the timely completion of Ph.D degree.
- Liaison between AcSIR- IHBT and external examiners regarding various activities like thesis evaluation, viva voce examinations, guest lectures and comprehensive examination of the students.

A total of 188 students were enrolled for Ph.D at CSIR-IHBT in Biological Sciences and Chemical Sciences till date (Fig. 1) and 57 students had successfully defended their research work during the viva voce examinations.

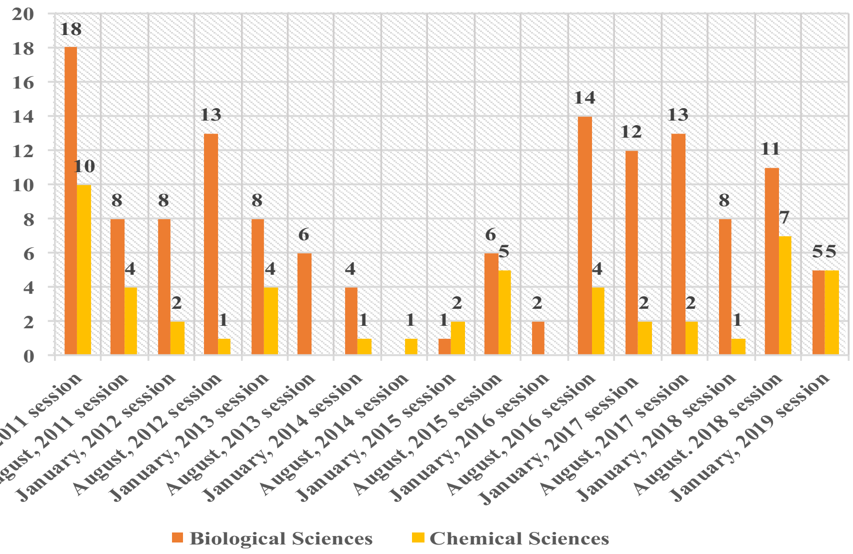


Fig. 1 Semester wise enrolment in Ph.D programme of AcSIR at CSIR- IHBT

During 2018-19, twelve students defended their thesis during the Viva Voce Examination and were awarded Ph.D. The details of these students are as under:

Sr. No.	Name of the Student (Registration #)	Faculty	Supervisor
1.	Aditya Kulshreshtha (10BB12J33008)	Biological Sciences	Dr. Vipin Hallan
2.	Ajay Kumar (10BB12A33005)	Biological Sciences	Dr. Ravi Shankar
3.	Indu Gangwar (10BB12J33003)	Biological Sciences	Dr. Ravi Shankar
4.	Madhu Kumari (10BB12A33002)	Biological Sciences	Dr. Mahesh Gupta
5.	Maheshwar Singh Thakur (10CC14J33007)	Chemical Sciences	Dr. S. K. Maurya
6.	Munish Kaundal (10BB13J33007)	Biological Sciences	Dr. Rakesh Kumar
7.	Pritu Pratibha (10BB11J33008)	Biological Sciences	Dr. Y. Sreenivasulu
8.	Rimpy Diman (10BB11J33007)	Biological Sciences	Dr. Y. Sreenivasulu
9.	Rubbel Singla (10BB13A33003)	Biological Sciences	Dr. Amitabha Acharya
10.	Saurabh Sharma (10CC13J33012)	Chemical Sciences	Dr. Pralay Das
11.	Sourabh Soni (10BB14J33004)	Biological Sciences	Dr. Y. S. Padwad
12.	Vandna Thakur (10CC13A33007)	Chemical Sciences	Dr. Pralay Das

Important Events

Important Events

Shri Giriraj Singh, Hon'ble Minister of State for Micro Small Medium Entrepreneurs (MSME), Govt. of India visited the Institute during 30 April to 1 May 2018.

Shri Giriraj Singh addressing scientists and staff of the Institute

Shri Giriraj Singh visited various facilities, labs and experimental fields

Shri Giriraj Singh visited flowers exhibition

Shri Giriraj Singh planted a plant in the Institute

Shri Giriraj Singh interacted with the Director and Scientists of the Institute regarding lab products and technologies developed

Shri Jai Ram Thakur, Hon'ble Chief Minister, Himachal Pradesh visited the Institute on 6 May 2018.

Shri Jai Ram Thakur inaugurated the Sabbatical Home in presence of Shri Shanta Kumar, Member of Parliament and Dr. Sanjay Kumar, Director and Staff of the Institute

Shri Jai Ram Thakur and Shri Shanta Kumar, Member of Parliament interacted with Dr. Sanjay Kumar, Director on technologies and products exhibited

Shri Jai Ram Thakur addressing the scientists, scholars and staff of the Institute

National Technology Day


Celebrated National Technology Day on May 11, 2018. Dr. Tej Partap, Vice Chancellor AP Goyal University, Shimla delivered the National Technology Day lecture on "Organic Agriculture: Perspective and Future Strategies". Dr. Naresh Kumar, Former Head, RDPD, CSIR HQ was the Guest of Honour and Prof. Anupam Varma, Adjunct Professor Advanced Center for Plant Virology, IARI, New Delhi was the Chief Guest of the function.

CSIR-IHBT Foundation Day


Celebrated Foundation Day on July 02, 2018. Dr. Lok Man S. Palni, Vice Chancellor, Graphic Era University, Dehradun and former Director, GBPIHED Almora delivered the Foundation Day Lecture on "Biodiversity is Life: Biodiversity is our Life". Released a book on "Plants of CSIR-IHBT Campus" and technical brochures on Institute Profile and Energy Fruits.

CSIR Foundation Day


Celebrated CSIR Foundation Day on October 01, 2018. Prof. Arun Tiwari, Secretary Care Foundation delivered the Foundation Day lecture on "Plant Based Medicine: Paradigm Shift". Prof. V.L. Chopra, Former Member, Planning Commission, Govt. of India was the Chief Guest on the occasion.

National Science Day


Celebrated the National Science Day on February 28, 2019. The keynote lecture was delivered by Prof. Surinder Singh (CSIRO Agriculture and Food, Canberra, Australia) on "Designer plant oils through metabolic engineering". Prof. Gurmeet Singh (TDU, Bengaluru) also delivered a lecture on "Imperative for Investing in Integrative Health Sciences". Prof. Vinod Yadava Director NIT, Hamirpur (H.P.) was the Chief Guest of the function.

JIGYASA program

CSIR-Institute of Himalayan Bioresource Technology organized various activities under the Jigyasa programme. During 2018-19, a total of 2102school students and their teachers participated in this programme (Table 1). They were exposed to various R&D activities of the Institute through demonstrations, exhibitions, lectures, hands on training and visits to inculcate scientific temperament in them. They were exposed to different state-of-art facilities in the area of biotechnology, bioinformatics, agrotechnologies of commercially important crops, floriculture, natural product chemistry, synthetic chemistry, internationally recognised Herbarium, remote sensing and mapping facilities, regulatory research facility, pilot plant for nutraceuticals, essential oil and herbals. Under the outreach programme, scientists of CSIR-IHBT visited different schools and delivered popular scientific talks to motivate students towards science and technology.

Prof. Anupam Verma
(National Technology Day)

Dr. Lok Man S. Palni
(IHBT Foundation day)

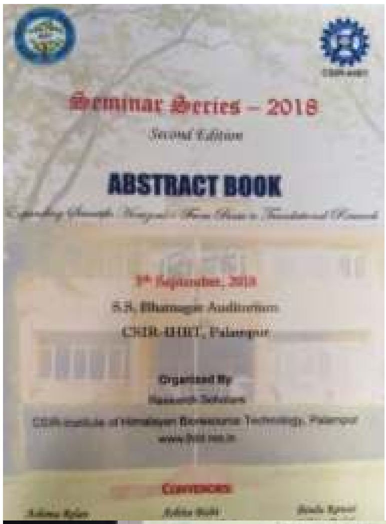
Prof. Arun Tiwari
(CSIR-Foundation D

Table 1. Details of the students and teachers participated in Jigyasa Progrmme

S. No.	Program Name	Days	Training/Exposure on	Students Grade	No. of Teachers	No. of Students
1.	National Technology Day	1	Laboratory visits and Lecture by:- **Prof. Anupam Verma**	08th -12th	22	117
2.	36th IHBT Foundation Day	1	Laboratory visits and Lecture by:- **Dr. Lok Man S. Palni**	10th	05	68
3.	India International Science Festival (IISF)	1	Lecture by:- **Dr. O.P. Sharma** and organised Science exhibition	09th-12th	14	360
4.	76th CSIR Foundation Day	2	Lecture by: **Prof. Arun Tiwari**	10th-11th	36	446
5.	General Visit (KVs)	11	Lab and field visit to apprise R&D activities of CSIR-IHBT	08th -12th	40	419
6.	Japan International Cooperation Agency (JICA)	1	Lab and field visit to apprise R&D activities of CSIR-IHBT	06th-10th	04	40
7.	General Visit (State Govt. Schools)	04	Lab and field visit to apprise R&D activities of CSIR-IHBT	08th-12th	15	130
8.	General Visit (Other schools)	06	Lab and field visit to apprise R&D activities of CSIR-IHBT	08th-12th	20	320
9.	Outreach Programme	01	Lecture on Floriculture at KV Palampur	12th	02	44
Grand Total					158	1944

Student Seminar Series

In continuation to preceding year wherein the student seminar series was initiated, the 2nd student seminar series was held on 5th September 2018. The seminar theme for this year was "Expanding Scientific Horizon: from Basic to Translation Research". A total of 28 entries were received for the same. In addition, tagline, photography, and quiz contests were also held. Ms. Srijana Mukhia (1st Prize), Mr. Gopal Singh (2nd Prize), and Mrs. Bharati Barsain (3rd Prize) were adjudged the best presenters while entries by Ms. Shruti Sinai Borker (1st Prize), Ms. Bipasha Bhattacharjee (2nd Prize), and Ms. Ashita Bisht (3rd Prize) were awarded for photography. Ms. Jyoti Chhimwal was the winner of the tagline contest. The noteworthy point of this year seminar was the sponsorship. Thanks to sponsors for coming forward and nurturing this initiative.



Seminar Series – 2018

Second Edition

ABSTRACT BOOK

5th September, 2018

S.S. Bhatnagar Auditorium

CSIR-IHBT, Palampur

Organized By

Research Scholars

CSIR-Institute of Himalayan Bioresource Technology, Palampur

www.ihbt.res.in

CONVENORS

Business Development & Marketing Unit (BDMU)

Business Development and Marketing Unit (BDMU)

BDMU is making all efforts to convert high end R&D technologies into the business. It is involved in economic and social impact analysis, organizing scientific and industrial meets, promoting technologies, responding to the queries of farmers and entrepreneurs regarding different technologies, facilitating technology transfers through agreements, Material Transfer Agreements (MTAs), incubation facilities under "Chief Minister's Start up Scheme", need based incubation,MoU with farmer societies for installation of essential oil units,processing and disseminating technologies and products to the society.

During 2018-19, BDMU assisted in signing five technology transfers, 31 material transfer agreements (MTAs), 26 miscellaneous MoUs, including nine MoUs signed with different farmer societies. Six MoUs signed for different innovation projects under "Chief Minister's Start up Scheme". BDMU was also intensively involved in showcasing institute's technologies and products in various business meets, trade fairs and exhibitions at regional and national levels.

BDMU also undertake other activities including evaluation of techno-economic feasibilities of technologies developed at CSIR-IHBT, drafting agreements for transfer of technology, material transfer agreements, agreements with incubatees and MoUs with government institutes, responding queries of clients, raising expression of interest (EOI) for different technologies, raising FVC for timely payment of GST related to CSIR-IHBT, socio-economic impact analysis of technologies/ services from third parties and providing inputs for drafting technology specific documents.

Transfer of Technologies

During 2018-19, CSIR-IHBT has signed five agreements for transfer of technology i.e. (i) (manufacturing / processing of multigrain high protein beverage and soup mixes products with M/s Access India Impex Centre Pvt. Ltd., New Delhi (ii) large scale production of biofertilizers (NFB, PSB, KMB) with M/s Vandeep Green Globe Organic Venture Pvt. Ltd., Sikkim; (iii) vertical gardening and indoor air pollution abatement, making herbal cones from temple waste flowers with Dr. Gaurav Aggarwal, Kangra; and (iv)& (v) cultivation of Shiitake mushroom (Lentinula edodes) in synthetic logs for vitamin D2 enrichment with M/s Innotech Agro Postikum Pvt. Ltd., Guwahati and M/s Pravin Masalewale, Pune.

Participation of BDMU team in exhibitions/ technology promotion programmes

Sr. No.	Programme	Duration
1	IISF-2018 at Indira Gandhi Pratishthan, Lucknow during 5-8 October, 2018 (U.P.)	5 to 8 October, 2018
2	10th Agrovision and Agri Summit held at Nagpur (Maharashtra)	23 to 26 November, 2018
3	106th Indian Science Congress (ISC) held at Lovely Professional University, Jalandhar (PUNJAB)	3 to 7 January 2019
4	Participated in "KUTUHAL" at Nagpur (Maharashtra)	9 to 11 February, 2019
5	Scientific exhibition in Shillong (Meghalaya)	28 February to 1 March, 2019

राजभाषा गतिविधियाँ

राजभाषा गतिविधियाँ

संसदीय राजभाषा समिति द्वारा राजभाषा संबन्धी निरीक्षण

संसदीय राजभाषा समिति की दूसरी उप–समिति ने दिनांक 12.05.2018 को धर्मशाला में संस्थान का राजभाषा संबन्धी निरीक्षण किया। समिति ने दिनांक 13.05.2018 को संस्थान का दौरा किया तथा शोध एवं विकास गतिविधियों का अवलोकन किया। इस समिति में निम्नलिखित सदस्य उपस्थित हुए।

डा. प्रसन्न कुमार पाटसाणी संसद सदस्य (लोकसभा)	संयोजक
डा. सुनील बलिराम गायकवाड़ संसद सदस्य (लोकसभा)	सदस्य
श्री लक्ष्मी नारायण यादव संसद सदस्य (लोकसभा)	सदस्य
श्री प्रतापराव गणपतराव जाधव संसद सदस्य (लोकसभा)	सदस्य

निदेशक डा. संजय कुमार निरीक्षण बैठक में संयोजक एवं सदस्यों का स्वागत करते हुए।

निरीक्षण बैठक

माननीय सदस्य हिंदी प्रकाशनों का अवलोकन करते हुए

माननीय सदस्य शोध गतिविधियों का अवलोकन करते हुए।

संसदीय राजभाषा समिति के माननीय सदस्य पौधारोपण करते हुए।

हिंदी सप्ताह समारोह 2018

संस्थान में हिंदी सप्ताह समारोह का मुख्य समारोह बड़े हर्षोल्लास के साथ मनाया गया। समारोह का शुभारंभ संस्थान गान के साथ हुआ।

समारोह के मुख्य अतिथि, प्रदेश के वरिष्ठ साहित्यकार एवं कांगड़ा लोककला साहित्य मंच के निदेशक डा. गौतम शर्मा 'व्यथित' ने ' लोक संस्कृति का संरक्षण' विषय पर संभाषण दिया। अपने संबोधन में डा. गौतम ने हमारी प्राचीन सांस्कृतिक धरोहर, लोक परम्पराओं, लोक गीतों, लोक कथाओं, लोक नाट्यों के महत्व के बाते में बताया। उन्होंने आगे बताया कि आधुनिकता की दोड़ में हम इन सांस्कृतिक परम्पराओं को भूलते जा रहे है। आवश्यकता इस बात की है कि हम अपनी इन संस्कृति को संरक्षित करें। ग्रामीण निष्पादन कला विकास केन्द्र तथा कांगड़ा लोकसाहित्य परिषद इस संस्कृति को बचाने, इसे संरक्षित करने तथा इसके प्रलेखन एवं फिल्मांकन की दिशा में कार्य कर रहा है। आने वाली पीढ़ी के लिए यह एक बहुमूल्य उपहार होगा। उन्होंने आह्वान किया कि हम सभी इस सांस्कृतिक धरोहर को संरक्षित करने में अपना योगदान दें।

अपने अध्यक्षीय संबोधन में संस्थान के निदेशक डा. संजय कुमार ने भाषा और संस्कृति के समन्वय के बारे में बताया। साथ ही संदेश दिया कि हिंदी एक सशक्त भाषा है जिसकी विश्व व्यापकता है। हिंदी में अभिव्यक्ति सहजता से की जा सकती है। उन्होंने संस्थान के परिवार से हिंदी का अधिकाधिक प्रयोग एवं इसमें कार्य करने का आह्वान किया।

संस्थान के प्रशासन अधिकारी श्री आलोक शर्मा ने हिंदी सप्ताह के दौरान आयोजित गतिविधियों की जानकारी दी तथा हिंदी प्रतियोगिताओं के विजेताओं की घोषणा भी की। जिसका विवरण इस प्रकार है:

1 हिन्दी टिप्पण लेखन प्रतियोगिता

प्रथम पुरस्कार – श्रीमती पूजा अवस्थी
द्वितीय पुरस्कार – श्री वेद प्रकाश
तृतीय पुरस्कार – श्री बलदेव

2 हिन्दी लोकप्रियविज्ञान लेखन प्रतियोगिता

प्रथम पुरस्कार – श्रीमती रिम्पी धीमान
द्वितीय पुरस्कार – डा. अशोक गहलोत
तृतीय पुरस्कार – श्री मोहित स्वर्णकार

3 हिन्दी टिप्पण प्रोत्साहन योजना

प्रथम पुरस्कार – श्रीमती संतोष कुमारी
प्रथम पुरस्कार – श्रीमती पूजा अवस्थी
द्वितीय पुरस्कार – श्री मनोज कुमार
द्वितीय पुरस्कार – श्री बलदेव
द्वितीय पुरस्कार – श्री अजय कुमार
तृतीय पुरस्कार – डा. शशी भूषण
तृतीय पुरस्कार – डा. अशोक गहलोत

मंच का संचालन संस्थान के हिंदी अधिकारी श्री संजय कुमार ने किया। प्रशासन अधिकारी ने मुख्य अतिथि डा. गौतम शर्मा, निदेशक डा. संजय कुमार विभिन्न प्रतियोगिताओं के प्रतिभागी एवं निर्णायक मंडल तथा समारोह में प्रत्यक्ष या परोक्ष रूप से सहयोग करने वाले सभी स्टाफ सदस्यों का धन्यावाद किया। राष्ट्रगान के बाद समारोह संपन्न हुआ।

दिनांक 14.09.2018 को प्रशासन अधिकारी श्री आलोक शर्मा ने ''राजभाषा नीति और हमारा दायित्व'' विषय पर कर्मचारियों को धारा 3(3) के अनुपालन राजभाषा संबन्धी आवश्यक दिशा निर्देशों एवं जांच बिन्दुओं की जानकारी दी।

प्रशिक्षण कार्यक्रम में प्रतिभागिता

केन्द्रीय अनुवाद ब्यूरो, राजभाषा विभाग, गृह मंत्रालय, भारत सरकार, नई दिल्ली द्वारा दिनांक 26—30 नवम्बर 2018 के दौरान आयोजित उच्चस्तरीय अनुवाद प्रशिक्षण कार्यक्रम में संस्थान के हिंदी अधिकारी श्री संजय कुमार ने प्रतिभागिता की।

वेबसाइट अद्यतनीकरण

संस्थान की वेबसाइट की सामग्री को समय—समय पर अद्यतन किया गया।

पुस्तकें, पत्रिकाएं एवं संदर्भ सामग्रियों को उपलब्ध कराना

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 करवाया। इसके अतिरिक्त विभिन्न प्रयोगशालाओं/संस्थानों द्वारा प्रकाशित पत्रिकाओं को भी संस्थान में उपलब्ध करवाया गया। इस वर्ष 74832/— रुपये की हिंदी पुस्तकों की खरीद की गई। हिंदी पुस्तकों की सूची संस्थान की वेबसाइट पर उपलब्ध है।

राजभाषा संबन्धी कार्यान्वय

नए कार्यभार ग्रहण करने वाले कर्मचारियों को राजभाषा नीति एवं संस्थान में राजभाषा अनुभाग के कार्यों के बारे में व्यक्तिगत रूप से अवगत करवाया गया। इसके अतिरिक्त प्रशासन में सदर्भ सामग्री भी हिंदी में उपलब्ध कराई गई।

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।

विभिन्न अनुभागों से प्राप्त कागजातों का हिंदी अनुवाद उपलब्ध करवाया गया। संस्थान द्वारा किये जा रहे शोध कार्यो को आम जनता तक पहुंचाने के उद्देश्य से ब्रोशर आदि के लिए सामग्री का अनुवाद एवं प्रकाशन।

विविध कार्य

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/समारोहों के आयोजनों, निमंत्रण पत्र, विज्ञापन, प्रेस नोट आदि को तैयार करके प्रैस—मीडिया को उपलब्ध कराया गया।

Support Services

Planning Project Monitoring and Evaluation

Institutional Research Planning

PPME has coordinated series of meetings and facilitated formulation of institutional document presented to performance appraisal board. The strategic planning document "MANTHAN" was further strengthened and action taken towards achievement of goals were regularly reported to the competent authority. For constant updating, institutional data on various domains (34) were uploaded to C-DIS portal during 2018-19 as per the specific formats. The cell recorded initiation of 46 new projects funded by various agencies (DBT, DST etc.) and 30 (FTT/NCP/Mission Mode/FBR etc.) projects funded CSIR HQs.

As a part of routine activity, the updation and maintenance of databases pertaining to project, staff, paper, patent, ECF, royalty, MoUs, resource management etc. was carried out. To facilitate decision-making, the monitoring of institutional performance with respect to publication, ECF, patent and technology transfer was done regularly.

56th & 57th Research Council meeting of the Institute was conducted on July 5-6, 2018 and February 18-19, 2019, respectively at Palampur and also supported in the follow-up actions.

Furnished information regarding 36 Parliament questions received from CSIR. In addition to the above, the following events were also organized:

Resource planning and monitoring: PPME cell facilitated the fund allocation and expenditure as per the need and mandate of the Institute. Also coordinated meetings to plan new infrastructures and equipment. Appropriate steps were taken to seek approvals and induct new manpower to cater the need of the Institute.

Right to Information

Furnished information on 55 queries under RTI Act and filed quarterly report to RTI portal www.rti.gov.in.

IT based activities

The updates were promptly posted on Facebook and Twitter time to time. Information were regularly updated and flashed in online editorial pro-forma, online pro-forma for submitting Project proposal and ESU maintenance log book portal was developed through in-house efforts.

Engineering Services Unit

(A) Construction of staff quarters

The construction of 16 staff quarters comprising of Type-V (4 No.), Type-IV (8 No.) and Type-III (4 No.) was started during year 2017-18 and work is likely to be completed by July 2019.

Construction of staff quarters

(B) Upgradation of Natural Product Chemistry Lab:

Due to the space constraint in Natural Product Chemistry laboratory, the roof terrace was covered with pre-coated sheet. The aluminium glazing on walls and ACP ceiling was also provided and the existing cut-out was also covered with R.C.C. slab.

(C) Upgradation of Canteen building:

Due to space constraint in existing dining hall in the Canteen building, the existing open terrace was covered with pre-coated sheet along with aluminium glazing on walls for creating additional dinning space.

(D) Upgradation of Botanical Garden

The construction of hi-tech green house of 12x9=108 sqm was started along with 5 feet wide pavered path from guest house to botanical garden gate (near Chadiar road) under the grant in aid project.

Footpath and Green house

(E) Institutional guide map

In the campus bi-lingual Institutional guide map has been fixed at two locations along with sign board indicating different locations.

(F) Extension of existing bamboo treatment plant

The work for creation of additional space (150 sqm) was started for installation of bamboo machine. The facilities consists of three rooms for placement of bamboo machine and a hall for drying of bamboo and a common toilet. The work is likely to be completed at the end of June 2019.

Bamboo treatment plant

(G) Parking in front of regulatory lab along-with path to pentagon corridor

The existing open parking in front of regulatory lab along-with path to pentagon corridor was covered with pre coated sheet.

Other minor construction/upgradation activities

- Covering of rear yard of Food Processing Unit.
- Provision of parking in Hostel building
- Shed for placement of UPS & emergency exit in NPP building.
- Furniture for fragrance room in Academy block.
- Sitting module for incubators in old lab.
- Porch for Sabbatical House.
- Mezzanine floor in workshop.
- Modification in building for creation of office space for Engineering Services Unit.
- Farm store in floriculture field.
- Sale counter at Bundla farm.
- Widening of biodiversity road from central store to culvert.
- Tissue culture lab.
- Modification of old canteen as chemistry lab.
- External painting work in bamboo museum.

Administration

The administration provides a variety of support services for research and development activities in the Institute. The division functions in a very smooth manner to realize the vision of CSIR-IHBT and facilitates the overall system to meet the set goals and targets. The division has significant roles to play in every phase of the career development of staff as well as providing continuous care right from their recruitments to superannuation, and even after superannuation. Administration connects all staff as a central unit and facilitates them in various vital needs like academic aspirations, career progression, housing and health care needs, in the following manner.

- Formulate and implement the policies concerning administrative procedure for smooth functioning of the Institute.
- Provide advice to the functional bodies (committees / functional groups) within the organization.
- Maintain liaison with CSIR Headquarters on matters related to administration.
- Provide healthy working conditions and conducive environment in the Institute by connecting interpretation as well as implementation of governing rules and regulation.
- Assist the authorities of the Institute, namely, the Director, the Head of Departments and Project Investigators on issues and decisions of administrative nature.

The division is headed by the Administrative Officer (AO), who is the over all In-charge of the activities. He is supported by Section Officers (SO) and a group of Assistant Section Officers(ASOs), Senior Secretariat Assistant (SSAs), Junior Secretariat Assistant (JSAs) and other supporting staff, security services and hindi cell. A number of security services for the various laboratory buildings and farms is provided by the security department which is headed by a security assistant. The Hindi cell is headed by a Hindi Officer.

Administration is moving ahead towards major transformation in terms of work culture and implementing paperless processes. An improved work culture and decentralized leadership at all levels has been introduced to bring the desired changes. A trend of faster service delivery system has been inculcated in the staff to match with the expectations of CSIR-IHBT in this new era of translational Research.

CSIR-IHBT is moving towards implementation of Integrated ERP system.

Left to Right, Row 1: Santosh Kumari, Amarjeet, Alok Sharma, SD Rishi, Baldev, Mukul Sharma, Pooja Awasthi, Left to Right, Row 1: Sandeep Kumar, Ishwar Das, Ved Prakash, Boni Kumar, , Kirti Raj, Avinash Chander Rana, Ajay Singh Kaundal, Thaman Bahadur

Finance & Accounts

Finance & Accounts division is contributing in managing the Institute finances, taking care of accounting, book keeping and simultaneously playing the role of auditing as well as budgeting. The division has a vital role in the Institute activities, particularity providing support to scientific, technical as well as other administrative staff. The division manages the activities of crucial financial planning, budgetary control and adopts remedial measures for optimum utilization of allocation according to the rules, regulation and guidelines of CSIR. In addition, it maintains accounts of the institute as per CSIR guidelines and also provides services for effective planning, utilization and post utilization of grants received grant in aid, sponsored consultancy, collaborative projects and technical services aid.

Broad activities of Finance and Account section are:

- Assisting and advising Director on financial, auditing and accounting related matters.
- Preparation and compilation of revised estimates and budget estimates of the Institute.
- Management of financial resources received from CSIR, GAP, Sponsored, CNP & CLP projects.
- Ensuring scrupulous 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.
- Coordinating 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 payment of pensionary benefits.
- Investment of resources from laboratory reserve funds.

Left to Right: Shweta, Aruna Kumari, Manoj Kumar, Darshan Singh, SN Gulia, Vipin Kumar, Swarup Chand, Om Prakash and Manoj Kumar

Store & Purchase

The Store & Purchase division is mainly responsible for the procurement of capital equipments from India and abroad like purchase of spares and consumables items, Annual Maintenance Contracts (AMCs) of equipments, Annual Rate Contracts (ARCs) for chemicals, etc. The division also maintains a minimum inventory of routine consumable items such as office stationary, cleaning items, hardware, plumbing, etc. Technical & Purchase Committees, Purchase Committees, Standing Disposal Committee etc. help the division to take suitable decisions as per the CSIR procedures. The division also co-ordinates activities between indenting, planning, accounts, administration, vendor and various agencies like bank, customs, insurance, transportation, clearing and forwarding agents etc.

The major procurements made during 2018-19

1. Protein Purification System
2. Mass/PDA Directed Auto Purification System
3. Projection System with accessories
4. Cell Homogenizer
5. Multipurpose Essential Oil Field Distillation Units
6. Multimode Microplate Reader
7. Refrigerated Centrifuge
8. Cryogenic Chest Freezer
9. Plant Growth Chamber

Left to Right: Harsh Pal, Vikash, Kamal Singh, Ranjeet Singh, Swaroop Chand, Ram Singh, Vishal Kumar, Suresh Pant, S. Gnanaprakasam, Karandeep Sood, Akhil, Rajeev Sood, Rajinder Singh, Lalita Bhatt and Anupama Saini

Computer Section

This section takes care of managing existing IT resources in the institute which has a fleet of servers from HP, IBM, Supermicraused for hosting website, DNS, centralized antivirus solution, intranet website etc.

Institute is one of the nodal points of NKN (National Knowledge Network) connectivity as a part of CSIR programme under the premise of Govt. of India's National Programme, in which a dedicated 1GBps WAN link is provided to the institute on optical fiber backbone through which wired (LAN) and wireless Internet facility were provided in the campus including hostel and faculty residences. It has40 managed switches and 68 indoor and outdoor wireless access points.

All the internet users are managed centrally with the help of authenticator and policies for IPS,IDS are deployed centrally. Based on client-server architecture centralized antivirus has been deployed to protect computers, laptops from various external/internal threats from the internet.

Network security hardware used for LAN and WAN comprises of almost 40 high speed managed switches, unified threat management System (UTM/Firewall), web application firewall, wireless Authenticator, wireless controller on high availability and its policies were deployed to protect IHBT resources centrally. 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 and coordinates AMC for computer and peripherals.

Library: IHBT-Knowledge Resource Centre (IHBT-KRC)

Library continuously contributed to achieve scientific goal of the Institute through quality knowledge resources. The library procured and managed a range of knowledge resources including e-journals, databases and print materials such as books, subject encyclopaedias, research reports, online and CDs databases, theses in the field of science and technology. Various services were provided by the library including reference and consultation, circulation, document delivery, reprographic, resource sharing, information alert, user awareness using ICTs for web based library management and services to users. In this way, library contributed in generating new knowledge by the researchers of the institute.

Relevant information on impact factor of journals, publishers' guidelines to authors, publishing policy of journals for selecting quality journals for publication of their research articles as well as online submission of research articles were provided. During the year, 37 books of research value, 286 hindi books covering scientific and societal issues and 8 thesis were added to the library collection. In KOHA software, database of books, journals and other documents was updated with new additions. This database was made accessible on http://library.ihbt.res.in.

Online Public Access Catalogue (OPAC): OPAC of the library is accessible on internet. It has facility for view on-line checkout status, reservation of books, and online recommendations by users for new books, journals and other resources besides indicating the status of a particular document. The user can check self status of the issued books through KOHA software. Database can be searched by keywords, author, title, publisher, accession number, subject, ISBN, etc. at http://14.139.59.218/ in addition to a link in library website.

National Knowledge Resource Centre (NKRC): Library tried to meet the users need at some extent by participating NKRC in its limited budgetary resources and increasing cost of knowledge resources with an aim to provide a wide range of quality knowledge resources. The library has been the founder member of this consortium. The researchers of the institute were provided access to more than 2500+ e-journals of all major publishers, patents, citation and bibliographic databases through this consortium.

Citations: The library continued to provide inputs on citations and supply of citation report to researchers. The reports were prepared by consulting the international database resources of Web of Science, SciFinder and Google scholar.

User orientation: In this year, 170 new users registered and provided training on access of library resources, the arrangement of books and journals, OPAC and services provided by the library.

E-Mail Alert: The users of the library were provided alerts on the information of their interest through Email Alert Service and alerts for overdue books.

Plagiarism (Similarity Check): Research articles, thesis/dissertation, project proposal and project reports were checked for similarity with the ithenticate database. In this year, more than 600 similarity reports were provided to the researchers for the mentioned documents.

Grammar Checker: Library procured grammarly database and provided to scientists and staff. It is add-in for Microsoft office and allows detection of error and provide suggestions

Reference Service: Library staff attended more than 1148 queries related to books, journals & research articles and specific research topics.

Photocopy, Scanning and printing service: Print pages(fivelakh fifty thousand) of training manuals, project proposals, project reports, research papers, advertising materials, office document, technical brochures and folders were provided to scientists, scholars and staff of the institute.Library was prepared binding and scanning of 348 documents during the year.

Newspapers clipping service: Library subscribed sixteen daily newspapers of Hindi and English languages. All newspapers were screened and marked relevant news items and provided clips to the researchers and staff of the Institute. News related to activities of the institute and scientific items were kept for future reference and also uploaded on blog at-http://ihbtinnews.blogspot.in/.

During the year, the library was visited by 3875users including scientists, students, research scholars and faculty members from several academic and R&D institutions to consult library resources.

Saurabh Sharma, Mukhtiar Singh, Sarwan Kumar, Jasveer Kaur and Rujala Devi

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 thesis 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. This unit also covers activities of official functions, trainings, workshops, conferences and symposia organised 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 alongwith interviews with farmers and entrepreneures those are provided with the technologies from the Institute. Regular assistance rendered to design cover page of annual reports, brochures of technologies, banners and certificates to the participants in trainings, workshops, conferences, symposia, invitation and greeting cards, posters of research activities and labels for lab products.

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Shukla AK, Sharma C, Abidi SMS and Acharya A (2018) "Spectroscopy and microscopy of eco-friendly polymer composites". In Sustainable Polymer Composites and Nanocomposites, (Eds. Inamuddin), Springer: UK, 105-141.

Singla R, Sharma C, Shukla AK and Acharya A (2019) Toxicity concerns of therapeutic nanomaterials. Journal of Nanoscience and Nanotechnology, 19: 1889-1907.

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Warghat AR, Thakur K and Sood A (2018) Plant stem cells: what we know and what is anticipated. Molecular Biology Reports, 45:2897-2905.

Training manuals

Kumar R, Sharma M, Sharma C and Sood R (2018) Training manual on aromatic crops for socio economic development in rural areas of Himachal Pradesh. pp1-79.

Kumar R (2019) Training manual on cultivation of low chilling varieties of apple and their post-harvest management. pp 1-86.

Thesis/Dissertations/Report/Supervised

Ph.D

Anish Kaachra (2018) Studies on the effect of co-overexpression of selected genes of carbon and nitrogen metabolism in *Arabidopsis thaliana* (ecotype Col-0). Supervised by Dr. Sanjay Kumar.

Anita Kumari (2018)Transcriptome analysis and molecular response of *Sinopodophyllum hexandrum* (Royle) T.S. Ying to environmental cues. Supervised by Dr. Sanjay Kumar.

Ganesh Panzade (2019) High-throughput data handling, management and analysis in genomics studies. Supervised by Dr. Ravi Shankar.

Sewa Singh (2019)Heterologous Expression of *Polyphenol Oxidase* Gene of *Camellia sinensis* (L.) O. Kuntze and understanding its Possible Significance. Supervised by Dr. Sanjay Kumar.

Msc./BSc./BTech.

Ayushi Jain (2018) MSc Biotechnology, D.A.V College, Chandigarh, June 5-September 5.

Ayushi Sharma (2018)B. Tech Biotechnology, Banasthali Vidyapeeth, Rajasthan, June 4 to Nov 4.

Dewansh Mehta (2019) B. Tech Biotechnology from Amity University U.P, May 21- July 1.

Shivangi Thakur (2018) S.D. college Hoshiarpur, Punjab, June 5-July 20.

Training Imparted: Summer and Winter

Institute is providing trainings to Graduate/ Post Graduate/ Ph.D. students from different Institutes, Universities and affiliated colleges. This year 165 students were selected for training at CSIR-IHBT for different time durations *viz*. one month, three months, six months and one years. Out of which 136 students completed their training as mentioned in the table below.

Details of trainings provided to Graduate/ Post Graduate/ Ph.D. students (April, 2018-March, 2019)

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
1.	Mr. Shivansh Ashish	Christ University, Bengaluru	B.Sc. Biotech	1	Er. Amit Kumar	Short-term internship on ecological surveys, leaf sample collections and biochemical lab analysis
2.	Ms. Arshi Gupta	Christ University, Bengaluru	B.Sc. Biotech	1	Dr. Amit Chawla	Study of photosynthesis and leaf properties in selected plants of Himalaya with wide distribution
3.	Mr. Steffin S. Mathew	Christ University, Bengaluru	B.Sc. Biotech	1	Dr. Amit Chawla	Understanding leaf structure and function in high altitude plants of Himalaya
4.	Mr. Akshay S	BITS, Pilani	M.Tech Biotech	2	Dr. Amita Bhattacharya	Techniques in plant biochemistry
5.	Ms. Anshika Dhiman	CU, Chandigarh	B.Sc. Biotech	1	Dr. Rakshak	Optimization of culture condition for lipase production
6.	Ms. Ambika Mehta	Chandigarh University	B.Sc. Biotech	1	Dr. Rakshak	Gram staining, enzyme assays and genomic DNA isolation of bacteria
7.	Mr. Kuldeep Sharma	Chandigarh University	B.Sc. Biotech	1	Dr. Amita Bhattacharya	Basic techniques in plant tissue culture
8.	Ms. Tanya Salotra	Chandigarh University	B.Sc. Biotech	1	Dr. Amita Bhattacharya	Basic techniques in plant tissue culture
9.	Mr. Jai Kumar	CU, Chandigarh	B.Sc. Biotech	1	Dr. Amitabha Acharya	Synthesis and characterization of nanoparticles and their biological efficacy evaluation
10.	Mr. Harniz kumar	Chandigarh University	M.Sc. Chemistry	1	Dr. Sushil Maurya	Basic chemical lab techniques and a multistep synthetic route to synthesis of azides
11.	Ms. Vivekeshu	Chandigarh University	M.Sc. Chemistry	1	Dr. Upendra Sharma	Analytical techniques used in phytochemical investigation
12.	Ms. Deepanki	Chandigarh University	M.Sc. Chemistry	1	Dr. Vijay K. Agnihotri	Chemical investigation of essential oil of *Pinus roxburghii* needles
13.	Ms. Anchal Bahman	NIT, Hamirpur	B.Tech. Chemical Engg.	1	Er. Mohit Sharma	Overview of different processing technologies for medicinal and aromatic plants
14.	Ms. Mariyum Mehndi Naqvi	SHUATS, Allahabad, UP	B.Sc. Biotech	1	Dr. Ashish Warghat	Basic techniques in plant tissue culture
15.	Ms. Ayushi Srivastava	SHUATS, Allahabad, UP	B.Sc. Biotech	1	Dr. Shashi Bhushan	Basic techniques in plant tissue culture
16.	Mr. Sandeep Kumar Yadav	SHUATS, Allahabad, UP	B.Sc. Biotech	1	Dr. Ashish Warghat	Basic techniques in plant tissue culture
17.	Ms. Shaina Bharti	SHUATS, Allahabad, UP	B.Sc. Biotech	1	Dr. Bhavya Bhargav	Study on micropropagation of *Chrysanthemum* & *Gerbera*
18.	Ms. Srishti Kandulna	SHUATS, Allahabad, UP	B.Sc. Biotech	1	Dr. Bhavya Bhargav	Study on micropropagation of *Chrysanthemum* & *Gerbera*

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
19.	Ms. Diksha Nirankari	Chandigarh University	M.Sc. Chemistry	1	Dr. Pamita Bhandari	Isolation of colour/dye from *Solanum lycopersicum*
20.	Ms. Jaya Singh	SHUATS, Allahabad, UP	B.Sc. Biotech	1	Dr. Vidyashankar	Studies on the growth profile of freshwater microalgae
21.	Ms. Nistha Srivastava	SHUATS, Allahabad, UP	B.Sc. Biotech	1	Dr. Vidyashankar	Studies on growth profile of industrially important cyanobacteria
22.	Ms. Pallavi	PG Govt. College, Chandigarh	B.Sc. Biotech	1	Dr. Ashu Gulati	Hands-on training on Biochemical analysis of Herbal samples
23.	Ms. Anjali Nisha	PG Govt. College, Chandigarh	B.Sc. Biotech	1	Dr. Ashu Gulati	Hands-on training on Biochemical analysis of Herbal samples
24.	Mr. Sahil Verma	PG Govt. College, Chandigarh	B.Sc. Biotech	1	Dr. Narendra Tripude	Sensitization training programme on molecular techniques and methodology involved in preclinical assessment
25.	Ms. Nikita Bhalla	PG Govt. College, Chandigarh	B.Sc. Biotech	1	Dr. Ashu Gulati	Isolation of theanine from *Camellia sinensis* and comparison in contents of different tea samples
26.	Ms. Anamika Kumari	PG Govt. College, Chandigarh	B.Sc. Biotech	1	Dr. Rajiv kumar	Hands-on training on molecular biology technology
27.	Ms. Niharika Rai	PG Govt. College, Chandigarh	B.Sc. Biotech	1	Dr. Rajiv kumar	Hands-on training on molecular biology technology
28.	Ms. Tejasvi Roy	LPU, Punjab	B.Tech Biotech	1	Dr. Ram Kumar Sharma	Basic techniques of molecular biology
29.	Ms. Pooja Poonia	Chandigarh University	B.Sc. Biotech	1.5	Dr. Ashish Warghat	Callus culture of commercially important medicinal herb *Picrorhiza kurroa*
30.	Ms. Meenakshi Sharma	Chandigarh University	B.Sc. Biotech	1.5	Dr. Ashish Warghat	*In-vitro* propagation of *Trillium govanianum* by using rhizome bud culture
31.	Mr. Dewansh Mehta	Amity University, Delhi	B.Tech Biotech	1.5	Dr. Vipin Hallan	Basic techniques associated with analysis of the model plant *Arbidopsis thalian*
32.	Mr. Garvit Arora	Amity University, Noida	B.Sc. Biotech	1	Dr. Bhavya Bhargav	Seed production of Calla lilies (*Zantedeschia sp.*) in low hills of Western Himalayas
33.	Ms. Simran Singh Rawat	SHUATS, Allahabad, UP	B.Sc. Microbio	1	Dr. E.Reddy	Multiplication evaluation of entomopathogenic fungi for the control of *Plutella xylostella*
34.	Ms. Anjali Dahiya	Amity University, Jaipur	B.Tech Bioteh	3	Dr. Vikram Patial	To study the pathology of methionine-choline deficient diet induced non-alcoholic fatty liver disease model in mice

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
35.	Ms. Sakshi Sood	Chandigarh University	M.Sc. Biotech	1	Dr. Ashish Warghat	Micropropagation of *Stevia rebaudiana* (Bertoni) using nodal explant
36.	Ms. Priti Lata Sinha	SHUATS, Allahabad, UP	M.Sc. Medic. Microbio	1	Dr. Rakshak	Basic techniques in microbiology: PCR amplification of bacterial DNA, prtease assay of bacteria and antibacterial activities against type strains
37.	Ms. Sweta Arora	MCM DAV College, Chandigarh	B.Sc. Microbio	1	Dr. Gireesh Nadda	Multiplication evaluation of entomopathogenic fungus strain (IHBF-16) for the control of *Plutella xylostella*
38.	Ms. Shagun Rana	LPU, Punjab	B.Tech F&ST	1	Dr. Vidyashankar	Studies on devlopment of process for prepration of Instant Dahi-Chiwda (Mix)
39.	Ms. Manmehar Kaur	Panjab University	B.Sc. Microbio	1	Dr. Dharam Singh	Short term internship on techniques in plant molecular biology
40.	Ms. Anika Sharma	CU Chandigarh	M.Sc. Chemistry	1.5	Dr. Dinesh Kumar	Chromatographic techniques involved in the purification of natural compounds from medicinal plants
41.	Ms Vaishali Arora	HMVC, Jalandhar	B.Sc. Bioinform.	1	Dr. Rituraj Purohit	In-silico molecular visualization using PyMOL
42.	Ms. Shanu Jamwal	HMVC, Jalandhar	B.Sc. Bioinform.	1	Dr. Rituraj Purohit	In-silico molecular visualization using PyMOL
43.	Ms. Radhika Rajput	HMVC, Jalandhar	B.Sc. Bioinform.	1	Dr. Vishal Acharya	In-silico molecular visualization using PyMOL
44.	Ms. Renuka	LPU, Punjab	B.Tech Biotech	1	Environmental Science	Studies on plant tissue culture of Chrysanthemum and Stevia
45.	Ms. Gagandeep Kaur	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Sanat Singh Sujat	Studies on micropropagation and characterization of genetic variability of Stevia
46.	Ms. Harpreet Kaur	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Ashish Warghat	Basic techniques in plant tissue culture
47.	Mr. Bhaskar Roy	Pondicherry University	M.Sc. Biotech	2	Dr. Dharam Singh	Molecular and biochemical assessment of microbes for enzymatic activities
48.	Mr. Vinayak S	IISER, Berhampur	B.Sc. -M.Sc. bioinform	1.5	Dr. Vishal Acharya	Whole genome sequencing of deadly apple-scab pathogen (*Venturia inaequalis*) and comparative analysis with relative phytopathogens
49.	Mr. Iwin K Joseph	IISER Berhampur	B.Sc.-M.Sc. Bioinform	1.5	Dr. Ravi Shankar	Transcriptome assembly and annotation of *Picrorhiza kurrooa* at two different temperatures

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
50.	Ms. Kriti Chakraborty	HIT, Kolkata	B.Tech Biotech	1	Dr. Sanat Singh Sujat	Studies on micropropagation and hardening of *Stevia* plant
51.	Ms. Priyanka Yadav	Amity University, HR	M.Sc. Biochemist.	2	Dr. Ashu Gulati	Optimisation of GGT activity: RSM approach
52.	Mr. Sarvpreet Singh	Chandigarh University	M.Sc. Chemistry	2	Dr. Pamita Bhandari	Phytochemical studies of *Rheum emodi*
53.	Ms. Kriti Sharma	UIET, KUK	B.Tech Biotech	1	Dr. Dharam Singh	Techniques in molecular biology
54.	Mr. Ashutosh Singh	Central. Univ of South Bihar	M.Sc. Biotech	2	Dr. Amitabha Acharya	Synthesis and characterization of nanocomposites of metallic oxides in sodium alginate matrix for their slow and sustained release
55.	Ms. Ankita Kumari	Central. Univ of South Bihar	M.Sc. Biotech	2	Dr. Yogendra Padwad	Animal cell culture and molecular techniques involved in proteomics study of head and neck squamous cell carcinoma (HNSCC)
56.	Ms. Sandeep Kaur Sonia	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Ashish Warghat	Basic techniques of plant cell, tissue and organ culture
57.	Ms. Navneet Kaur	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Narendra Tripude	Training on techniques involved in molecular biology, animal cell culture and laboratory animal facility
58.	Ms. Jaswinder Kaur	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Narendra Tripude	Training on techniques and methodology for *in-vitro* and *in-vivo* toxicological assessment
59.	Ms. Gagandeep Kaur	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Narendra Tripude	Sensitization training on methodologies of *in-vitro* studies, *in-vivo* experimentation and molecular biology techniques
60.	Ms. Jarmanjeet Kaur	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Narendra Tripude	Training on laboratory animal facility practices, procedures in molecular biology and techniques of animal cell culture
61.	Ms. Saima Firodus	Central. Univ of South Bihar	M.Sc. Biotech	2	Dr. Kunal Singh	Shelf life study of liquid based bioformulation of *Arthrobacter* sp.
62.	Ms. Nisha	Central. Univ of South Bihar	M.Sc. Biotech	2	Dr. Kunal Singh	Shelf life study of solid carrier based bioformulation of *Arthrobacter* sp.
63.	Ms. Parneet Kaur	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Damanpreet Singh	Basic techniques used in pharmacology and toxicology laboratory

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
64.	Ms. Palak Kashyap	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Vikram Patial	Training in different techniques used in pharmacology and toxicology laboratory
65.	Ms. Sulekha Rani	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Gireesh Nadda	Basic techniques in molecular biology
66.	Ms. Jasmine Kaur	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Ajay Rana	Basic techniques in microbiology: PCR amplification of bacterial DNA, SDS-PAGE electrophoresis of crude enzyme extracted from bacteria
67.	Ms. Shivani Sodhi	BBK DAV College, Amritsar	B.Sc. Biotech	1	Dr. Sanat Singh Sujat	Studies on micropropagation and hardening of Stevia plant
68.	Ms. Lipakshi Arora	KMV, Jalandhar	B.Sc. Biotech	1	Dr. Sanat Singh Sujat	Studies on micropropagation and hardening of Stevia
69.	Ms. Dilpreet Kaur	KMV, Jalandhar	B.Sc. Biotech	1	Dr. Ashok Yadav	Studies on micropropagation of Stevia
70.	Ms. Ramanpreet Kaur	KMV, Jalandhar	B.Sc. Biotech	1	Dr. Ashok Yadav	Studies on micropropagation of Stevia
71.	Ms . Ankita Sharma	KMV, Jalandhar	B.Sc. Biotech	1	Dr. Bhavya Bhargav	Studies on micropropagation of *Chrysanthemum, Orchid* and *Calla Lilly*
72.	Ms. Shivangi Thakur	S.D.College Hoshiarpur	B.Sc. Biotech	1.5	Dr. Vipin Hallan	Basic plant molecular techniques
73.	Ms. Trasvi Sharma	S.D.College Hoshiarpur	B.Sc. Biotech	1.5	Dr. Sanat Singh Sujat	Propagation of Stevia using plant tissue culture techniques
74.	Ms. Manisha Khewadia	S.D.College Hoshiarpur	B.Sc. Biotech	1.5	Dr. Ashok Yadav	Studies on micropropagation of *Chrysanthemum*
75.	Ms. Aashima Mahajan	Thapar Univ. Patiala	M.Sc. Chemistry	1.5	Dr. Pralay Dass	Transition metal nanoparticles catalyzed C-C cross coupling reactions
76.	Ms. Hardeep Kaur	Thapar Univ. Patiala	M.Sc. Biochemist	2	Dr. Amitabha Acharya	Nano-Curcumin: Spectroscopic and microscopic characterization and evaluation of their anti-bacterial activity
77.	Mr. Baneet Chawla	Thapar Univ. Patiala	M.Sc. Biotech	1.5	Dr. Ashu Gulati	Estimation and isolation of major phytochemicals from tea leaves *(Camellia sinensis*) growing in Kangra region
78.	Mr. Bimalpreet Singh	Thapar Univ. Patiala	M.Sc. Biotech	1.5	Dr. Ashu Gulati	Molecular biology techniques and its application
79.	Mr. Keshav Singh	RBSETC, Agra, UP	B.Tech Biotech	1.5	Dr. Shashi Bhushan	Plant tissue culture techniques

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
80.	Ms. Manushka Sondhi	Shiv Nadar University, UP	B.Sc. Biotech	1.5	Dr. Ram Kumar Sharma	Studies on utilization of basic molecular biology technologies for genetic diversity assessments
81.	Ms. Bhawana	Punjab University, Chandigarh	M.Sc. Microbio	2	Dr. Ram Kumar Sharma	Studies on basic molecular biology technology for development of DNA barcoding in plants
82.	Ms. Deepanjali Kapoor	Panjab University, Chandigarh	M.Sc. Microbio.	2	Dr. Gireesh Nadda	Isolation and molecular characterization of fungi
83.	Ms. Jyoti Prajapat	Shoolini University, Solan	M.Sc. Biotech	1	Dr. Ashish Warghat	Establishment and maintenance of callus culture of *Stevia rebaudiana* Bertoni using *in-vitro* leaf explant
84.	Mr. Vikrant Singh	Shoolini University, Solan	M.Sc. Chemistry	2.5	Dr. Upendra Sharma	Synthesis of quinoline N- oxides and maleimides
85.	Ms. Deepanki Awasthi	Central University, HP	M.Sc. Bioiform.	1	Dr. Rituraj Purohit	*In-silico* docking and molecular dynamics simulation to find potential inhibitors of enzyme glutaminyl cyclase
86.	Mr. Shivam Singh Dogra	Punjab University, Chandigarh	B.Sc. Biotech	1	Dr. Vishal Acharya	Genomic investigation into cold-adaptive traits of cold-loving *arthrobacter* species from there mesophilic counterparts
87.	Mr. Shubham Bhardwaj	Dr.A.P.J. Abdul Kalam Technical University, Lucknow).	B.Tech (ACSIR)	2	Dr. Rajiv kumar	Biochemical and proteomic analysis of tea leaves
88.	Mr. Anil Nandal	DAV, College, Chandigarh	M.Sc. Biotech	3	Dr. Amitabha Acharya	Synthesis, characterization and biological efficacy evaluation of the developed nanomaterials
89.	Ms. Nikita Saini	DAV, College, Chandigarh	M.Sc. Biotech	3	Dr. Mahesh Gupta	Utilization of sea buckthorn (*Hippophae rhamnoides*) berries for the development of food products
90.	Mr. Karan Kaul	DAV, College, Chandigarh	M.Sc. Biotech	3	Dr. Mahesh Gupta	Production of ready-to-eat instant crispy vegetables mix
91.	Mr. Akhil Agarwal	DAV, College, Chandigarh	M.Sc. Biotech	3	Dr. Yogendra Padwad	To study the effect of IHBT-RT on inflammatory stress by modulation of NF-κB and iNOS pathway in activated murine macrophages
92.	Mr. Pawan Vishwakarma	DAV, College, Chandigarh	M.Sc. Biotech	3	Dr. Vidhyashaknakr	Extraction and characterization phycocyanin from spirulina (*Spirulina plantesis*)
93.	Ms. Parul Dhankhar	DAV, College, Chandigarh	M.Sc. Biotech	3	Dr. Vidyashankar	Extraction, purification and characterization of proteins from *Sapium sebiferum* seed meal

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
94.	Ms. Kajal Chauhan	DAV, College, Chandigarh	M.Sc. Biotech	3	Dr. Rakshak	Standardization and validation of adjuvant induced osteoarthritis mice model
95.	Ms. Ayushi Jain	DAV, College, Chandigarh	M.Sc. Biotech	3	Dr. Vipin Hallan	Molecular cloning of Homeobox 27, transcription factor from *Arabidopsis thaliana*
96.	Ms. Sandhya Sharma	DAV, College, Chandigarh	M.Sc. Biotech	3	Dr. Vidyashankar	Extraction and characterization of rice bran protein
97.	Ekansh Kumar	SITM, Noida	B.Tech. Chemical Engg.	3	Er. Mohit Sharma	Study of various unit operations for processing of medicinal and aromatic plants
98.	Ms. Madhu Sharma	CU, Chandigarh	M.Sc. Biotech	1	Dr. Ashu Gulati	Biochemical analysis of *Camellia sinensis*
99.	Mr. Akshay Chauhan	SITM, Noida	B.Tech. Chemical Engg.	3	Dr. Ajay Rana	Extraction, isolation and identification of compunds using analytical techniques
100	Ms. Heta Trivedi	SITM, Noida	B.Tech. Chemical Engg.	3	Dr. Pamita Bhandari	Chemo-profiling of *Rheum emodi*
101	Ms. Gurvinder Kaur	Punjab Unviersity, Chandigarh	M.Pharma	3	Dr. Damanpreet Singh	Basic techniques in pharmacology
102	Ms. Antra Sood	DAV, Unviersity, Jalandhar	M.Sc. Microbio	1	Dr. Gireesh Nadda	Basic techniques in microbiology
103	Ms. Aditi Sharma	JUIT, Solan	B.Tech Biotech	1	Dr. Rajiv Kumar	Hands-on training on molecular biology techniques
104	Ms. Sunidhi Bhatt	GNDU, Amritsar	M.Sc. Microbio	3	Dr. Dharam Singh	Molecular and biochemical assessment of microbes for enzymatic activities
105	Mr. Ajay Kumar Thakur	DAV Jalandhar	M.Sc. Botany	3	Dr. Ashu Gulati	Isolation and characterization of essential oils
106	Dr. Shalika Rana	CSKHPKV, Palampur	Post-Doct	6	Dr. Yogendra Padwad	Antidiabetic potential if Apple leaf phenolics in ameliorating insulin resistance in373-L1 adipocytes
107	Ms. Poonam Kumari	GNDU, Amritsar	M.Sc. Microbio	3	Dr. Dharam Singh	Study of bacterial growth for bioplastic production and phenol degradation
108	Ms. Rachana Saini	BVU, Rajasthan	B.Tech Biotech	5	Dr. Ashish Warghat	*In vitro* propagation of *Picrorhiza kurroa* Royle ex Benth using seeds as explant and synergetic effect of methyl jasmonate (MJ) and yeast Extract (YE) on morphological performance of *Valeriana jatamans*i cultivated under aeroponic condition

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
109.	Ms. Tanya Jain	BVU, Rajasthan	B.Tech Biotech	5	Dr. Shashi Bhushan	Establishment of in vitro shoot cultures of *Arnebia benthamii*
110.	Ms. Ayushi Sharma	BVU, Rajasthan	B.Tech Biotech	5	Dr. Vipin Hallan	Interaction analysis of 2b protein of Cucumber mosaic virus with host HB27 transcription factor
111.	Ms. Akhileshwari Singh	BVU, Rajasthan	B.Tech Biotech	5	Dr. Ram Kumar Sharma	Studies on evaluation of polymorphic potential of SSR markers in Buckwheat
112.	Ms. Sakshi	GNDU, Amritsar	M.Sc. Completed	3	Dr. Vikram Patial	Training in histopathological and molecular techniques
113.	Mr. Bhavdeep Sharma	Thapar Univ. Patiala	B.Tech Biotech	5	Dr. Rakshak Kumar	Optimization, purification and characterization of cold active hydrolytic enzymes from *Chryseobacterium polytrichastri* HAM:01
114.	Mr. Arshwinder Singh	Thapar Univ. Patiala	B.Tech Biotech	5	Dr. Kunal Singh	Isolation and identification of plant growth promoting rhizobacteria from Kandi region, District Kangra
115.	Ms. Gitika	Shoolini University, Solan	M.Sc. Zoology	6	Dr. Narendra Tripude	IHBT-HE ameliorates DSS-induced colitis in mice via NF-KB signalling
116.	Ms. Priti	SGGWU, Fatehgarh	M.Sc. Biotech	3	Dr. Amita Bhattacharya	Basic techniques in plant tissue culture
117.	Ms. Ankita Choudhary	Sri Sai University, Palampur	M.Sc. Chemistry	6	Dr. Pamita Bhandari	Isolation of *Indigofera heterantha*
118.	Mr. Manoj Kumar	MCPS, Karnataka	B.Pharma	1	Dr. Damanpreet Singh	Neurotoxicity testing in zebrafish
119.	Ms. Ruchika Thakur	HPU, Shimla	M.Sc. Microbio	1	Dr. Dharam Singh	Techniques in molecular biology
120.	Ms. Alisha Thakur	KMV, Jalandhar	B.Sc. Biotech	1	Dr. Ashish Warghat	Basic techniques in plant tissue culture
121.	Ms. Nikunj Aggarwal	KMV, Jalandhar	B.Sc. Biotech	1	Dr. Ashish Warghat	Basic techniques in plant tissue culture
122.	Mr. Vikrant Singh	Shoolini University, Solan	M.Sc. Chemistry	1	Dr. Upendra Sharma	Synthesis of templates and Quinoline *N*-Oxides
123.	Ms. Aprajita Sood	CU, HP	M.Sc. Bioinfo	3	Dr. Ravi Shankar	Fundamentals in high throughput data analysis and visualization
124.	Mr. Mukesh Paswan	LMCS&T, Jodhpur, RJ	M.Sc. Biotech	1	Dr. Ashish Warghat	*In vitro* seeds germination of *Picrorhiza kurroa*: An important medicinal herb of North-Western Himalayas

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
125.	Ms. Tanu Bansal	LPU, Jalandhar	Ph.D Chemistry	3	Dr. Dinesh Kumar	Isolation and characterisation of extract of plants *Callistemon macropunctatus*
126.	Mr. Shubham Choudhary	BCET, Gurdaspur	B.Tech Biotech	6	Dr. Yogendra Padwad	Antidiabetic potential of IHBT-PKE in ameliorating insulin resistance *in-vitro*
127.	Ms. Neha Kumari	Bhara University, HP	M.Sc. Biochemistry	3	Dr. Amit Chawla	Estimation of biochemical and anatomical parameters in plant species
128.	Mr. Jai Prakash	LNMU, Darbhanga, Bihar	M.Sc. Biotech	3	Dr. Ashish Warghat	Plant tissue culture based interventions towards conservation of medicinal herbs of North-Western Himalaya
129.	Mr.Varun Mehta	BFIT, Dehradun	M.Sc. Food Tech	3	Dr. Mahesh Gupta	Determination of antioxidant activity, total Phenolic and flavonoid content in various solvent extracts from Black rice, quinoa seed and Chia seed
130.	Ms. Partiksha Sharma	JECRC University, Jaipur	B.Sc. Biotech	6	Dr. Vishal Acharya	Gene expression analysis of insect pathogen *(Nilaparvata lugens)* in rice
131.	Mr. Rajat Tyagi	BFIT, Dehradun	M.Sc. Food Tech	3	Dr. Vidyashankar	Utilization of *Sapium sebiferum* seed meal in animal feed
132.	Ms. Kritika Verma	Abhilashi University, Mandi	M. Pharmacy	6	Dr. Pamita Bhandari	Semi-Synthesis of indole derivatives from *Bacopa monnieri*
133.	Ms. Ankita Kumari	Bhara University, HP	M.Sc. Biochemistry	3	Dr. Dinesh Kumar	Theanine from *Camellia sinensis* growing in Kangra region (H.P.)
134.	Ms. Kajal Thakur	Bhara University, HP	M.Sc. Biochemistry	3	Dr. Dinesh Kumar	Catechin from *Camellia sinensis* growing in Kangra region (H.P.)
135.	Ms. Priya Sharma	JECRC, University	B.Sc. Microbiology	5	Dr. S.G.E. Reddy	Isolation, multiplication and evaluation of entomopathogenic fungi
136.	Mr. Lokesh Kumar	SRM, University	B.Tech Bioinformatics	6	Dr. Ravi Shankar	Development of visualization modules for interaction between micro RNA and RBP using high-throughput data
137.	Ms. Tehseen Fatima	Baba Ghulam Shah Badsha University, Rajouri		1	Dr. Damanpreet Singh	Investigating the effect of AC-IHBT01 in experimental animal model of obesity
138.	Ms. Rafia Tabassum	Baba Ghulam Shah Badsha University, Rajouri		1	Dr. Damanpreet Singh	Investigating the cardioprotective effect of PG-IHBT01 in zebrafish model

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
139.	Mr. Kunal Sahni	SUSCET, Tangori, Mohali		1	Dr. Damanpreet Singh	Investigating the anticonvulsant effect of FH-01 and FN-01 in zebrafish model of pentylenetetrazol induced convulsion
140.	Ms. Parneet Kaur	BBK, DAV College for Women, Amritsar		1	Dr. Damanpreet Singh	Basic techniques used in pharmacology and toxicology laboratory
141.	Mr. Manoj R.V.	Manipal College of Pharmaceutical Sciences, Manipal		1	Dr. Damanpreet Singh	Neurotoxicity testing in zebrafish
142.	Shagun Sharma	Baba Farid Institute of Technology, Dehradun		1	Dr. Vikram Patial	Study on the effect of IHBTK-01 in non-alcoholic fatty liver disease model of zebrafish
143.	Pooja	Chandigarh University		1	Dr. Vikram Patial	To study the pathology of diabetes induced nephropathy

Conference/ Training/ Workshop/Symposium presentations

Gupta M (2018) Invited lecture on "Value Addition and Processing of Agri produce and Bioresources" at The National Academy of Sciences, India (NASI) - UK Chapter and UCOST, Dehradun jointly organizes two days workshop on Awareness Building and Sensitization of Science and Technology for the Tribal population of Uttarakhand, June 27-28.

Kumar M, Debnath P, Devi R and Kumar R (2018) *Ex-situ* conservation of medicinal plant species under CSIR- Phytopharmaceutical mission. Poster presented in Third Himachal Pradesh Science Congress held at IIT Mandi, Himachal Pradesh, Organized by "HIMCOSTE", October 22-23.

Rathore S, Sharma S, Sud RK and Kumar R(2018) Doubling farmers income through cultivation of aromatic crops. Poster presented in Third Himachal Pradesh Science Congress held in IIT Mandi, Himachal Pradesh, Organized by "HIMCOSTE", October 22-23.

Sharma A and Uniyal SK (2018) Forest based agricultural tools and implements: their use and importance to *Bhangalis* in the Chhota Bhangal region of western Himalaya. 3rd Himachal Pradesh Science Congress, Mandi, October 22- 23.

Sharma C, Sharma M and Kumar R(2018) Introduction of aromatic crops for socio-economic development in Himachal Pradesh. Poster presented in Third Himachal Pradesh Science Congress held at IIT Mandi, Himachal Pradesh Organized by "HIMCOSTE", October 22-23.

Thakur M, Saini K, Sud RK and Kumar R (2018) Promoting aromatic crops as a means of diversification for doubling farmers' income. Extended summary presented in National symposium on 'Doubling farmers' income through agronomic intervention under changing scenario' at Maharana Pratap University of Agriculture and Technology Udaipur Rajasthan, October 24-26.

Mazumder AG, Patial V and Singh D (2018) Exploring the role of mycophenolate mofetil on neurohistopathological changes and gene expression in rat model of lithium pilocarpine induced spontaneous recurrent seizures. 48th Annual Meeting of the Society for Neuroscience. San Diego, United States, November 3-7.

Rana AK, Sharma S and Singh D (2018) Glycogen synthase kinase-3β inhibition a potential target in the management of post menopause neurobehavioral impairments. XLII All India Cell Biology Conference and 2nd International Conference on Trends in cell and Molecular Biology. Department of Biological Science, BITS Pilani, K.K. Birla Goa Campus, Goa December 21-23.

Uniyal SK (2019) Brainstorming Session on Declining Life support Multipurpose Tree species, New Delhi, January 16.

Sharma P, Kumari S and Singh D (2019) Investigating the role of major dietary flavonoids in zebrafish model of pentylenetetrazol-induced convulsions. 8th Annual Meeting of Indian Academy of Biomedical Sciences and Conference on Deliberation on Translation of Basic Scientific Insights into Affordable Healthcare Products. CSIR-NIIST, Thiruvananthapuram, Kerala, February 25-27.

Kumari S, Mazumder AG and Singh D (2019) Investigating the anticonvulsant effect of α-linolenic acid in zebrafish model of pentylenetetrazol-induced convulsions. 8th Annual Meeting of Indian Academy of Biomedical Sciences and Conference on Deliberation on Translation of Basic Scientific Insights into Affordable Healthcare Products. CSIR-NIIST, Thiruvananthapuram, Kerala, February 25-27.

Conference/ Training/ Workshop/Meeting attended

Hallan V (2018) Attended one workshop on "Biotechnology Start-up Ecosystem in India" at Indian National Science Academy (INSA), New Delhi, March 18.

Uniyal SK (2018) National Mission on Himalayan Studies, Dehradun, on April 25-27.

Sharma RK (2018) Attended and delivered invited talk during in State Conclave on "Perspective Planning for Resurgent Agriculture & Allied Sectors in Arunachal Pradesh" at Itanagar, Arunachal Pradesh, May 18.

Agnihotri VK (2018) Attended training program on fragrance & flavor creation and its application at FFDC, Kannauj. Sponsored by CSIR-IHBT, Palampur and organized by FFDC Kannauj, May 29 to June 2.

Kumar R (2018) Attended National Workshop and stakeholders meet on Himalayan medicinal and aromatic plants with focus on agro-technology and marketing on 15-16 June 2018 at GB Pant National Institute of Himalayan Environment and Sustainable Development, Mohal Kullu and delivered a lecture on the topic entitled "High value medicinal and aromatic plants for enhancing the income of hilly farmers" on June 16.

Sharma RK (2018) Attended and delivered invited talk during International Conference on Next Gen Crops for Sustainable Agriculture" meeting in Chandigarh, India, July 19-20.

Kumar R (2018) Attended 6th Group Monitoring workshop and 7 Project Advisory Committee meeting of DST at NIT, Raipur, CG on August 02-03.

Agnihotri VK (2018) Attended International Congress & Expo 2018 "Navigating Future of Essential Oils". Sheraton grand Bengaluru Whitefield, Hotel & Convention Center organized by "Essential Oil Association of India".August 03-05.

Sud RK. (2018) Navigating Future of Essential Oils - International Congress and Expo 2018, organised by Essential Oil Association of India in Bangaluru. August 03-05.

Kumar R (2018) Attended International Congress & Expo on "Navigating Future of Essential Oils. Sheraton Grand Hotel, Whitefield, Bengaluru, India, August 04-05.

Sud RK. (2018) Attended Meeting of Advisory Board of Innovation and Entrepreneurship Development Centre (IEDC) of National Institute of Technology (NIT), Hamirpur, August 24.

Sharma RK (2018) Attended and delivered invited talk in CAFT- Training programme "Next-Generation Sequencing and its application in Crop Sciences" at ICAR- National Research Centre on Plant Biotechnology, New Delhi, September 01.

Sud RK. (2018) Attended Research Advisory Group meeting of Himalayan Forest Research Institute (HFRI), Shimla. October 09.

Kumar R (2018) Attended Taiwan-India Symposium on Traditional Medicine" organized by Dept. of Chinese Medicine and Pharmacy, Ministry of Health and Welfare, Taiwan. Taipei City, Taiwan and delivered lecture on the topic entitled "The management and development of traditional medicine in India", October05-06.

Kumar R (2018) Attended one-day seminar entitled "Aroma Crops for Boosting Rural economy of North east India. Tezpur University, Assam on CSIR-Aroma Mission and delivered lecture on CSIR-IHBT technologies for North East, October 15.

Rathore S, Sharma S, Sud RK and Kumar R (2018) Doubling farmers income through cultivation of aromatic crops. Poster presented in Third Himachal Pradesh Science Congress held in IIT

Mandi, Himachal Pradesh,Organized by "HIMCOSTE", October 22-23.

Kumar R (2018) Attended XXI Biennial National Symposium of Indian Society of Agronomyon "Doubling Farmers' Income Through Agronomic Interventions Under Changing Scenario". Rajasthan College of Agriculture, MPUAT, Udaipur, Rajasthan, October 24-26.

Bhushan S (2018) Attended 19th IUFoST World Congress of Food Science and Technology - "25 Billion Meals a Day by 2025 with Healthy, Nutritious, Safe and Diverse Foods"., Mumbai, October 23-27.

Singh D (2018) Attended International Conference-cum-Workshop on Informatics Tools in Drug Discovery and Delivery". Punjabi University, Patiala, November 1-4.

Kumar R (2018) Attended the meeting along with Yes bank officials as team leader to present the case of Yes bank for Study to Access the Demand & Supply of Medicinal Plants in India at National Medicinal Plants Board (NMPB), at AYUSH Bhawan, New Delhi, November 13.

Uniyal SK (2018) State Biodiversity Board Meet, Shimla, November 21.

Hallan V (2018) Cucumber mosaic virus movement and suppressor proteins associate with the host rubisco small subunit to facilitate movement, in the international plant physiology congress, Lucknow, Uttar Pradesh, December 2-5.

Sharma RK (2018) Attended and delivered invited talk in National Conference on Recent Development in Plant Stress Biology: Translating Laboratory Research for Human Welfare (RDPSB-2018) organized by Department of Botany, Central University of Jammu, India, December 7-8.

Bhushan S (2018) Attended "Industry-Academia Meet (IMTechCon 2.0) in frontier areas of biotherapeutics and biochemical engineering" in CSIR-IMTECH, Chandigarh, December 10.

Kumar R (2018) Attended First Monitoring Committee meeting of CSIR-Aroma Mission project at CSIR Headquarter New Delhi, December20.

Kumar R (2019) Attended Agri- Based Biofuels Stakeholders' Consultive National Workshop. Mohali and delivered a lecture entitled "Feed Stock of Himalayan Region for Biofuel Production", January 15.

Singh A (2019) Attended 5 days Blended Capacity Building Programme "Climate Smart Governance" organized by IIPA New Delhi, Sponsored by DST SEED New Delhi on January 28- 01 February.

Agnihotri VK (2019) Attended International Scientific Symposium "The Panorma of Phytology in Electrohomeopathy". Gandhi Peace Foundation 221/223, Deen Dayal Upadhyay Marg, Near ITO Metro Station, Delhi, on February 9-10.

Patial V (2019) Attended 8th Annual Conference of Indian Academy of Biomedical sciences organized by CSIR-NIIST, Trivandrum, February 25-27.

Patial V, Padwad YS and Tripude NV (2019) Attended 8th Annual Conference of Indian Academy of Biomedical sciences organized by CSIR-NIIST, Trivandrum, February 25-27.

Agnihotri VK (2019) Attended National Seminar on "Creating Awareness on Standardization & Regulation among Fragrance & Essential Oil Industry". India Habitat Centre, New Delhi, organized by BIS and CSIR-IIIM Jammu, March 07.

Singh A (2019) Attended 3 days Training of Trainers (ToT) Programme on the topic "Biodiversity Governance" organized by NIRDPR Hyderabad, HP State Institute of Rural Development Shimla, venue at HIPA Shimla, on

March 11-13.

Mitali M, Anuradha and Pal PK (2018) Plant densities and levels of nitrogen influenced growth, yield and secondary metabolites of *Stevia rebaudiana*. In: XXI Biennial National Symposium of Indian Society of Agronomy organized by Indian Society of Agronomy, IARI, New Delhi.

Conference/Training/Workshop/Meeting organized

Sharma M (2018) Imparted one-day training cum demonstration of essential oil distillation to 42 local farmers by distilling rose flowers April 21.

Sharma M (2018) Imparted one-day training of essential oil distillation to 10 farmers and 3 faculty members of IIT, Mandi, May 18.

Sharma M (2018) Five days training imparted on 'Fragrance and Flavour creation' at FFDC, Kannauj was done by the group of Scientist, Technical Staff and Scholars of CSIR-IHBT, Palampur, May 29 to June 2.

Sharma M (2018) Imparted one-day essential oil distillation training cum demonstration to 26 farmers by distilling 2 batches of lemon grass (brought by the farmers) in direct fired 500kg/ batch distillation unit, Una, June 20.

Sharma M (2018) One-day demonstration cum training on cultivation and process technologies of lemon grass (*Cymbopogan* spp.) was imparted to around 40 farmers of Masrear, Sehor, Garni, Amb-doli, Hasor, Naloh Kharoh, Lag Baliana, Lahashan, Lohana Dhulash, Saloi, But under Mission Aroma at CSIR-IHBT, June 20.

Singh A (2018) Delivered lecture talk related to HIMCOSTE Shimla sponsored project related to commercial cultivation of RET plants for income generation. Mohani Panchayat Banjar block Kullu and 24 farmers attended the program, (RPs: Dr. Ashok Singh, Ms. Kanika Kiran, Mr. Anuj Kaushal, Mr. Mohit Kashyap, on July 14.

Singh A (2018) Delivered lecture related on the topic establishment and functioning of CeHAB Centre. Nominated farmers from Horticulture, Agriculture departments and progressive of Lahaul valley were present and 20 farmers attended the program and officials of the Keylang, Lahaul Block, on August 29.

Sharma M (2018) Training cum demonstration of essential oil distillation to local farmer and society member of society named 'Late Shree Aminchand Memorial Self Help Group' distilling of Lemon grass on distillation unit of capacity 2500L installed under Mission aroma, village Jounta, August 30 to September 7.

Sharma M (2018) Training cum demonstration of essential oil distillation to around 40 local farmer and society member at society named 'The Amb Aroma Crops Processing Cum Marketing Society, distilling Lemon grass on distillation unit of capacity 2500L installed under Mission Aroma, village Saloi (Amb), September 19-24.

Uniyal SK (2018) Interactive meet of the State Biodiversity Board on Biodiversity Act and Access and benefit sharing, Palampur, September 28.

Sharma M (2018) One-day training cum demonstration was given to around 50 farmers of Sihunta on essential oil distillation in newly installed essential oil distillation unit at their site, October 23.

Sharma M (2018) Training cum demonstration of essential oil distillation to around 20 local farmer and society member at society named 'The Aroma Kisan bagwan Sugandh avm Aushdhiya podhn Utpadan, Vidhayan avm Vipanan Bahudeshiya Sahkari Sabha, distilling Lemon grass in distillation unit of capacity 2500L installed under Mission Aroma, Chokath, Distt. Kangra, HP, October 23-25.

Sharma M (2018) Training cum demonstration of essential oil distillation to around 35 local farmer and society member of society named 'Pragati Kisan Kalian Samiti, Chirandi, distilling *Tagetes minuta* in distillation unit of capacity 2500L installed under Mission Aroma, Sihunta Distt. Chamba, HP, October29.

Sharma M (2018) Training cum demonstration of essential oil distillation to around 40 local farmer and society member at society named 'Pragati Kisan Kalian Samiti, distilling *Tagetes minuta* in distillation unit of capacity 2500L installed under Mission Aroma, Talla, Distt. Chamba, HP, October 30.

Sharma M (2018) Training cum demonstration of essential oil distillation to around 30 local farmer and society member at society named 'Chamunda Krishik Society Chakoli, distilling *Tagetes minuta* in distillation unit of capacity 2500L installed under Mission Aroma, Salooni, Distt. Chamba, HP, November1.

Hallan V (2018) Cucumber mosaic virus 2b protein interacts with Glycine Rich protein, in the international conference entitled “Global viral epidemics: A challenging threat” during at PGI, Chandigarh, on November 12-14.

Sharma M (2018) Training cum demonstration of essential oil distillation to local farmer and society member at society named 'Kishan Sahayata Samuh Siyun Ghoghardhar, by distilling *Tagetes minuta* in distillation unit of capacity 2500L installed under Mission aroma, Mandi, HP, November 14-15.

Sharma M (2018) Training cum demonstration of essential oil distillation to local farmer and society member at society named 'The Seraj Aromatics & Herbs Co-operative Marketing Society Ltd., Banjar, by distilling *Tagetes minuta* in distillation unit of capacity 2500L installed under Mission Aroma, November 16-18.

Kumar R(2018) Organized capacity Building programmes for NERCORMP Communities on cultivation and post-harvest management of low chilling varieties of apple. 30 farmers of Manipur and officials of NERCORMP, CSIR-IHBT, Palampur, December 3-8.

Kumar R (2018) Organized awareness cum training programme on agro and process technologies of aromatic crops. 8 Farmers of Arunachal Pradesh, CSIR-IHBT, Palampur, December 24-25.

Sud RK and Singh S (2019) One-day integrative workshop on Biotechnology for Rural Development through Livelihood Opportunities in Rural Areas, February 25, and Two days' awareness workshop for farmers on Prospects of Aromatic Plants Cultivation in HP at CSIR-IHBT, Palampur, sponsored by Department of Environment, Science & Technology, Govt. of HP, Shimla, February 25-26.

Kumar R (2019) Organized capacity building programmes for NERCORMP Communities on cultivation and post-harvest management of low chilling varieties of apple. 13 farmers of Meghalaya and officials of NERCORMP, CSIR-IHBT, Palampur, February 25- March 02.

Acharya V (2019) Organized two days' workshop as organizer on "Advances in Functional & Structural Genomics" at CSIR-IHBT, Palampur, March 25-26.

Sud RK. (2019) One-day workshop to CORD's associated program beneficiaries and team members on Improved Agro and Process Technologies of Damask Rose and other Aromatic Crops, CSIR- IHBT, Palampur, April 21.

Singh A (2018) Delivered talk related to the HIMCOSTE Shimla sponsored project related to commercial cultivation of RET plants for income generation. Mohani Panchayat Banjar lock Kullu and 18 farmers.

Lecture delivered

Dr Pralay Das (2018) attended Indo-German workshop on "Waste to Wealth" CSIR-AMPRI, Bhopal, February 25-26.

Dr Sanjay Kumar Uniyal (2018) Surveying and documentation Himalayan Bioresources at the Wildlife Institute of India, Dehradun during 8as part of collaborative programme with Princeton University on April 9-10.

Dr Vijai Kant Agnihotri (2018) Delivered a lecture on "Quality of rose volatile and its evaluation on "Improved agro and process technologies of damask rose (Rosa damascene Mill.) under CSIR-Aroma Mission (HCP0007)". CSIR-IHBT, Palampur, HP, April 21, 23.

Dr Rakesh Kumar Sud (2018) Uniqueness of Kangra tea: Ways to improve Kangra tea quality, Buyer-seller meet, organised by Technical Officer (Tea), State Agriculture Department, Palampur, May 2.

Dr Pralay Das (2018)Attended "2nd National Symposium on Shaping the Energy Future: Challenges and Opportunities (SEFCO-2018)", IIP, Dehradun, May 11-12.

Dr RK Sharma (2018) Sustainable management of bamboo resources in Arunachal Pradesh. Invited lecture delivered at State Conclave on "Perspective Planning for Resurgent Agriculture & Allied Sectors in Arunachal Pradesh" at Itanagar, Arunachal Pradesh, on May 18.

Dr Sanjay Kumar Uniyal (2018) Survey, mapping and database development to the IFS Probationers, June 12.

Dr Ashok Singh (2018) Delivered lecture on " Lahaul evum Spiti jila me Mojud Durlav Aushdiye Padap va Aneye upyogi Vanaspatiyon ka Sanrakshan, Sambardhan va Krishikarn-ek Prayas" during National Workshop and Stakeholders meeting at GBPNIHESD, Mohal-Kullu HP Regional Centre. Participants 80, June 15-16.

Dr Rakesh Kumar (2018) "High value medicinal and aromatic plants for enhancing the income of hilly farmers" on 16th June 2018 in National Workshop and stakeholders meet on Himalayan medicinal and aromatic plants with focus on agrotechnology and marketing. GB Pant National Institute of Himalayan Environment and Sustainable Development, Mohal Kullu, June 15-16.

Dr Rakesh Kumar Sud (2018) Kangra Tea GI – Its importance and use for marketing. Workshop on Importance of Geographical Indicators, organised by, Himachal Pradesh Council for Science, Technology & Environment, Shimla, June 19.

Dr Vijai Kant Agnihotri (2018) Delivered a lecture on topic "Quality evaluation of essential oils (Lemon grass)" in "Training programme on cultivation and process technologies of lemon grass (*Cymbopogon* spp) under CSIR-AROMA Mission (HCP 0007). CSIR-IHBT, Palampur (HP), June 20.

Dr Ashok Singh (2018) Delivered lecture on "Lahaul evum Spiti jila me Mojud Padap Jaev-vividata, Upyogi Aushdiye Padap Vanaspatiyon ka Upyog, Sanrakshan, Sambardhan va Krishikarn" during workshop program on "Biological Diversity Act 2002 & Rule 2004" at Gymnasium Hall-Keylang Lahaul-Spiti (HP), Organized by HIMCOSTE Shimla (Chief guest Sh. Sonam Member Tribal Development Council, Ms. Shashi Kiran Vice-President Jila Parishad Lahaul-Spiti, Sh. Kunal Satyarthi Joint Member Secretary HIMCOSTE Shimla, Participants 100, June 26.

Dr RK Sharma (2018) Next Generation Genomics of non-model plants: Effort for genetic improvement of commercially important bioresources. Invited lecture delivered at International Conference on Next Gen Crops for

Sustainable Agriculture" meeting in Chandigarh, India, July 20.

Dr Upendra Sharma (2018) "Herbal Material: Basic Research and Issue of Contamination". two Week Intensive Course on "Recent Trends and Challenges in Regulation and Standardization of Herbal Drugs and Formulations" organised by NIPER-SAS Nagar, August 06-16.

Dr RK Sharma (2018) Next Generation Genomics of orphan crops. Invited lecture delivered at CAFT- Training programme "Next-Generation Sequencing and its application in Crop Sciences" at ICAR- National Research Centre on Plant Biotechnology, New Delhi, India, September 1.

Dr Rakesh Kumar Sud (2018) New opportunities in Himalayan agriculture through crop diversification and value addition. Workshop on Youth in Agriculture, organised by CORD, Dharamshala, September 29.

Dr Rakesh Kumar (2018) "The management and development of traditional medicine in India" in Taiwan-India Symposium on Traditional Medicine" held in Taipei city, Taiwan, October 5-6.

Dr Bhavya Bhargava (2018) Potential floriculture crops for Himachal Pradesh – their cultivation and marketing. Lecture delivered to the batch of the students of 'Diploma in Agricultural Extension Services for Input Dealers (DAESI)' of Kangra district, Palampur, October 7.

Dr Rakesh Kumar Sud (2018) Cultivation of targeted medicinal, aromatic and industrial crops in Himachal Pradesh. Lecture delivered to the batch of the students of 'Diploma in Agricultural Extension Services for Input Dealers (DAESI)' of Kangra district, Palampur, October 7.

Dr Ashok Singh (2018) Delivered lecture on "Lahaul evum Spiti jila me Mojud Padap Jaev-vividata, Upyogi Aushdiye Padap Vanaspatiyon ka Upyog, Sanrakshan, Sambardhan va Krishikarn" during training program related to the subject "Capacity Building program to the TGT Teachers of the Lahaul-Spiti District, Himachal Pradesh", organized by DIET office Tandi Lahaul-Spiti (HP), 90 Participants, October 15.

Dr Ashok Singh (2018) Delivered lecture on "Lahaul evum Spiti jila me Mojud Padap Jaev-vividata, Upyogi Aushdiye Padap Vanaspatiyon ka Upyog, Sanrakshan, Sambardhan va Krishikarn" during training to farmers of Lahaul-Spiti at KVK-Kukumseri Lahaul-Spiti (HP). Participants 40, October 19.

Dr Sanjay Kumar (2018) Chaired the Session: Health Through Spices, Herbs, Condiments and Nutraceuticals in IUFoST 2018 at Mumbai, October 23-27.

Dr Pamita Bhandari (2018) Delivered a talk (oral presentation) on Bioactive Molecules from Indian Medicinal Plants in a conference, ٦thBiennialInternationalConferenceonNewDevelopmentinDrugDiscoveryfromNaturalProducts &TraditionalMedicine organized by National Institute of Pharmaceutical Education and Research (NIPER) Mohali, 15-17 November.

Dr Rakesh Kumar (2018) "Impact of climate change on mountain vegetation and mitigation measures" in popular lecture series on climate change and sustainable development at CSKHPKV, Palampur. Organized by Centre for Environment education, November 24.

Dr Sanjay Kumar (2018) Chaired the Session: Young Scientist Award Session in 4th International Plant Physiology Congress (IPPC-2018) at Lucknow, December 2-5.

Dr Ashok Singh (2018) Delivered lecture on "Jalvayu Parivartan Dwara Lahaul-Spiti Bhag Jeev Mandal Bhandar me Mojud Padap Jaev Vividtata va upyogi Aushidiye Padap Vanaspatiyon par Durgami Anumanit Prabhav" during seminar related to the subject "Climate Change & its Adverse Impact on the every-day life in the Great Himalayan Cold Desert of the Tribal Region Falling in Himachal Pradesh" organized by Tribal Today Magazine group, venue at Dev Sadan Bhawan Kullu (HP), Participants 150, December 5.

Dr Sanjay Kumar (2018) Valedictory Address on "Trek and Learn the Biologist Way: How Plants Adapt at High Altitude!" in National Conference On Recent Development in Plant Stress Biology: Translating Laboratory Research for Human Welfare (RDPSB- 2018) at Central University of Jammu, December 7-8.

Dr RK Sharma (2018) Next Generation Genomics to expedite the sustainable utilization and conservation of non-model plants. Invited lecture delivered at National Conference on Recent Development in Plant Stress Biology: Translating Laboratory Research for Human Welfare (RDPSB-2018) organised by Department of Botany, Central University of Jammu, India, December 8.

Dr Upendra Sharma (2018) "Quinoline Functionalization *via* C-H Bond Activation: Synthesis of Anti-malarial Quinolines". International conference on organometallics and Catalysis (ICOC 2018) at Holiday Inn Resort, Goa, December 13-16.

Dr. Amit Chawla (2019) Adding 'functional' dimension to species diversity: a synthesis of patterns from high altitude vegetation of western Himalaya. National Conference on Environment: Current Scenario and Future Perspectives (NCE-2019), at W.R.S. Govt. College, Dehri, Distt. Kangra, H.P., March 9, 2019.

Dr Sanjay Kumar Uniyal (2019) Himalayan Biodiversity: Gaps and Issues. Presentation at a Brainstorming held at CSIR-National Environmental Engineering Research Institute, Nagpur, February 4.

Dr Vijai Kant Agnihotri (2019) A lecture delivered on "Electrohomeopathy, A Spagyric Herbal Extraction Process: Quality Control and Scope" at Gandhi Peace Foundation 221/223, Deen Dayal Upadhyay Marg, Near ITO Metro Station, Delhi, February 9-10.

Dr Sanjay Kumar (2019) Keynote Address: Molecular approaches to decipher pathways for secondary metabolite synthesis in plants from Himalayas 9th Annual Conference of the American Council for Medicinally Active Plants, International Conference on Medicinal, Aromatic and Nutraceutical Plants from Mountainous Areas, Dehradun, February 14-16.

Dr Upendra Sharma (2019) "Innovative Approaches for the Synthesis of Antimalarial Quinolines". Natural Product Based Therapeutics in Drug Development, NIPER-Raebareli, Lucknow, February 14-15.

Dr Sanjay Kumar (2019) Chaired the Session: Molecular Approaches to Elucidate the Biosynthesis of Bioactive Natural Products in Plants 9th Annual Conference of the American Council for Medicinally Active Plants, International Conference on Medicinal, Aromatic and Nutraceutical Plants from Mountainous Areas, Dehradun, February 14-16.

Dr Pralay Das (2019) attended "8th National Symposium on Advances in Chemical Sciences" organized by department of chemistry, UGC center of advanced study, Gurunanak Dev University, Amritsar-143005 (Punjab), India, February 15-16.

Dr Vishal Acharya (2019) Invited speaker & Chairperson for the "International Conference on Bioinformatics" held at Hans Raj Mahavidalaya (HMV), Jalandhar, February 22-23.

Dr Shashi Bhushan (2019) Workshop for Biotech Professionals and Farmers of Himachal Pradesh on aromatic plants cultivation, February 25-26.

Dr Vishal Acharya (2019)As a resource person for Workshop on "Bioinformatics Tools & Its application in Agriculture" Organised by CSK Himachal Agriculture University, Palampur, February 28 - March 1.

Dr Sanjay Kumar (2019) Invited talk on the session "Technology and Innovation in Himalayas: Scope and Opportunity" in CPRG India Shimla Conclave, Hotel Peterhoff, Shimla, Himachal Pradesh, March 2-3.

Dr Sanjay Kumar Uniyal (2019) Biodiversity: Key Issues and approaches, at Himachal Institute of Public Administration, Shimla, March 11.

Dr Rakesh Kumar (2019) "Medicinal Plants of Himalayas and Their Therapeutics Uses". Attended "Asian Conference on Tropical Traditional Medicine: engaging in transcultural dialogues in the age of holistic health". Organized by National Research Institute of Chinese Medicines (NRICM), Taipei, Taiwan, March 22.

Dr Sanjay Kumar (2019) Chief Guest of the inaugural ceremony, NIMBUS, Technical Festival of NIT, Hamirpur, March 28.

Invited lectures

Dr Anil Koul (2018) Delivered a lecture on "Discovery and Development of novel medicines - Harnessing value of innovation". CSIR-IMTECH, Chandigarh, July 11.

Dr O.P. Sharma (2018) Delivered a talk on "Cultivation of Passion for Science and Innovation" during India International Science Festival (IISF), In charge IVRI extension centre at Palampur, September 26.

Shri Gurmit Singh (2018) Delivered a lecture on "Transforming of Logistics Support for Armed Forces through Innovation & Technology". Palampur, December 7.

Visits abroad

Dr. Mahesh Gupta (2018) Visited Operon, Korea for inspection of commercial scale lyophilizer as per our ordered during, July 22-27.

Dr Rakesh Kumar (2018) Visited Taiwan to attend Taiwan-India Symposium on Traditional Medicine" in Taiwan, on October 5-6.

Dr Ram Kumar Sharma (2019) Visited collaborative Institutes Tea Research Institute and University of Kelaniya, Sri Lanka to have interactions with the PIs under ongoing Indo- Sri Lanka Joint Research Project on tea during February 6-13.

Dr Rakesh Kumar (2019) Visited Taiwan to attend "Asian Conference on Tropical Traditional Medicine: engaging in transcultural dialogues in the age of holistic health". Organized by National Research Institute of Chinese Medicines (NRICM), Taipei, Taiwan, on March 22-24.

Distinguished visitors

Shri Giriraj Singh, Hon'ble Minister of State (Independent charge) Micro, Small & Medium Enterprises and visited the Institute on April 30, 2018.

Shri Jai Ram Thakur, Hon'ble Chief Minister of Himachal Pradesh visited the Institute on May 6, 2018.

Dr. Prasanna Kumar Patasani, Chairmen and other members of Rajbhasha Samiti visited the Instituted on May 13, 2018.

Shri Deepak Vohra, Ambassador Co-ordinated visit of the Institute, June 14, 2018.

Sh. Kunal Satyarthi Joint Member Secretary HIMCOSTE Shimla at our Centre CeHAB Ribling, Lahaul-Spiti HPon 26 June, 2018.

ICMR New Delhi, IGMC Shimla and Kendriya Vidyalya team visited at our Centre CeHAB Ribling, Lahaul-Spiti HP on 11,18 July 2018.

Dr(s) Mrs. RN Attanayake, MAB Ranatunga, Mr JD Kottawa-Arachchi from University of Kelaniya and Tea Research Institute, Talawakelle, Sri Lanka visited our Institute under to have one to one interactions with Dr R.K. Sharma 'group under ongoing Indo- Sri Lanka Joint Research Project on tea during March 26-30, 2019.

Advisory Visits to Different Tea Gardens

Sud RK and Dhadwal, VS (2018) Demonstration of plucking machine. Khilpat, Sulah, Saloh, Sungau and Thandol, April 4.

Sud RK and Dhadwal, VS (2018) Training and demonstration of plucking machines. Khalate, Raipur, Sulah, Sungal, Bhadal and Thandol, June 12.

Sud RK and Dhadwal, VS (2018) Advisory and demonstration of garden management practices during winter season. Saloh and Thandol, October 11.

Sud RK and Dhadwal, VS (2018) Demonstration of garden management practices during winter season. Maserna area, October 31.

Sud RK and Dhadwal, VS (2018) Demonstration of mechanized pruning and skiffing operations. Sungal and Thandol, November 19.

Sud RK and Dhadwal, VS (2018) Pruning and skiffing programmes for tea gardens. Chambi, Bahli, Gopalpur, Pathiar, December 19.

Dhadwal, VS (2019) Field operations in tea gardens during winter season. Chauntra, Dehluhar, Baijnath, Langoo & Sakri area, January 2.

Dhadwal, VS (2019) Advisory visit. Chambi, Gopalpur, Chakvan and Dharamshala, January 3.

Dhadwal, VS (2019) Field operations in tea plantations during winter season. Khalate, Raipur, Sulah, Bhadal Devi and Thandol, January 4.

Guleria S, Kumar A and Sud RK (2019) Demonstration of mechanized pit making for new plantation. Sulah, Saloh, Thandol, Paprola, Langoo & Sakri area, January 17.

Guleria S, Kumar A and Sud RK (2019) Mechanized tea skiffing. Sullah area, January 31.

Guleria S, Kumar A and Sud RK (2019) Mechanized tea skiffing. Langu & Sakri area, February 12.

Guleria S, Kumar A and Sud RK (2019) Mechanized tea skiffing. Labol, Trehal and Baijnath area, February 21.

Radio talk

Dr Rakesh Kumar (2018) “Aushdhiye paudhon ki vaigyanik vidhiyon se khetibari” on All India Radio Dharamshala, May 25.

Dr Rakesh Kumar (2019) “Sugandhit faslon ki kheti” on All India Radio Dharamshala, January 4.

Poster presented

Shaifali, Ram S and Das P (2018) Polystyrene stabilized nano-catalyst for CO/CO_2 fixation reactions using oxalic acid as C1 source. 2nd National Symposium on Shaping the Energy Future: Challenges and Opportunities (SEFCO-2018), CSIR-Indian Institute of Petroleum (IIP), Dehradun, May 11-12.

Maurya AK, Chand G and Agnihotri VK (2018) Essential oils composition of cultivated clones of *Juniperus communis.* International Congress & Expo 2018 “Navigating Future of Essential Oils”. Sheraton grand Bengaluru Whitefield, Hotel & Convention Center organized by “Essential Oil Association of India”, August 03-05.

Chander R and Agnihotri VK (2018) Isolation and characterization of essential oil major components from *Tagetes minuta* L. from western Himalayan region. International Congress & Expo 2018 “Navigating Future of Essential Oils”. Sheraton grand Bengaluru Whitefield, Hotel &

Convention Center organized by "Essential Oil Association of India", August 03-05.

Kumar K and Agnihotri VK (2018) Development of natural perfume blends using western Himalayan bioresources. International Congress & Expo 2018 "Navigating Future of Essential Oils". Sheraton grand Bengaluru Whitefield, Hotel & Convention Center organized by "Essential Oil Association of India, August 03-05.

Rani D and Agnihotri VK (2018) Bithiophenes from Aerial part of *Tagetes minuta* growing in western Himalayas. International Congress & Expo 2018 "Navigating Future of Essential Oils". Sheraton grand Bengaluru Whitefield, Hotel & Convention Center organized by "Essential Oil Association of India", August 03-05.

Kumar N and Acharya V (2018) Development if virtual screening pipeline by ensemble of biological- and chemical-space based specific target 17th International conference on Bioinformatics at JNU, New Delhi, September 26-28.

Ram S and Das P (2018) Supported palladium nanoparticles catalyzed carbonylative cyclization reaction of 2-aminobenzamide and aryl halides using oxalic acid as CO source for quinazolinones synthesis, "International conferences on synthetic potent molecules and its application (ICSPMIA-2018)", Sikkim manipal institute of technology Majhitar, Sikkim, October 30-31.

Sendri N, Shinde BS and BhandariP (2018) Characterization of Potential Natural Colors by Liquid Chromatography Mass-Spectrometry. 7th Biennial International Conference on New Development in Drug Discovery from Natural Products & Traditional Medicine, National Institute of Pharmaceutical Education and Research (NIPER) Mohali, November 15-17.

Uniyal SK (2018) "Folk knowledge for warmth: the tribe, the tools, and the weave" during 2nd Himalayan Researchers consortium, Sikkim, November 26- 27.

Kumar A, Chauhan SA and Das P (2018) Utilization of agro-waste feedstock for the synthesis of 5-hydroxymethylfurfural: A key intermediate for bio-polymer and bio-fuel production, Indo-German Workshop on Waste to Wealth, CSIR-AMPRI, Bhopal, February 25-26.

Dadwal V, Joshi R and Gupta M (2019) Extraction optimization of soluble polyphenols and their anti-cancer potential from *C. reticulate* (Kinnow) peel (8th Annual Meeting of Indian Academy of Biomedical Sciences).

Uniyal SK (2019) "Himalayan Research Fellowships", at GBPNIHESD HQs, Almora, Uttarakhand, on February 4-7.

Abidi SMS and Acharya A (2019) Isolation and characterization of polymeric biomaterials from Himalayan bioresources for improved biomedical applications. In International Conference on Functional Nanomaterials, IIT BHU, 22-25 February.

Shukla AK and Acharya A (2019) Exploring carbon nanomaterials from Himalayan embrace. In International Conference on Functional Nanomaterials, IIT BHU, 22-25 February.

Patial V, Sharma S, Chhimwal J and SK UH (2019) Inhibition of hepatocellular carcinoma by dendrimer conjugated podophyllotoxin through modulation of inflammatory and fibrogenic factors in mice. 8th Annual Conference of Indian Academy of Biomedical sciences. CSIR-NIIST, February 25-27.

Dadwal V, Joshi R and Gupta M (2019) Extraction optimization of soluble polyphenols and their anti-cancer potential from *C. reticulate* (Kinnow) peel (8th Annual Meeting of Indian Academy of Biomedical Science.

Participation in exhibition

Dr. Mahesh Gupta (2018) Participated in CSIR Industry Meet, North East Region, Guwahati, Assam, June 28-29.

Dr. Ashok Singh, Dr. Amit Chawla, Dr. Kiran Saini, Mr. Mohit Kashayp, Mr. Anuj Kaushal (2018) Organized the Exhibition stall in the Tribal fair Keylong Lahaul-Spiti Chief Guest Honorable Dr. R.L. Markanda agriculture minister HP, August 14-16.

Dr. Mahesh Gupta (2018) Participated in Annual Tribal Fair. Keylong, Lahaul & Spiti, August 14-16.

Dr. Vijai Kant Agnihotri participated in International Congress & Expo 2018 “Navigating Future of Essential Oils”. Sheraton grand Bengaluru Whitefield, Hotel & Convention Center organized by “Essential Oil Association of India”, August 03-05.

Dr. Mahesh Gupta (2018) Participated in 5th India International Science Festival (IISF) IISF, Lucknow (U.P.), October 05-07.

Dr. Mahesh Gupta (2018) Participated in International Union of Food Science and Technology (IUFoST), Mumbai, October 23-27.

Dr. Mahesh Gupta (2018) Participated in FSSAI-Eat Right Mela, Delhi, December, 14-16.

Dr. Mahesh Gupta (2019) Participated in North east Innovators Meet and Technology Innovation entrepreneurship (TIE) Expo, at Shillong (Meghalaya), February 28 to March, 1.

Prizes/awards/recognitions

Dr. Sanjay Kumar received R.D. Asana Endowment Award Lecture awarded by Indian Agricultural Research Institute, New Delhi, 20 November 2018.

Dr. Sanjay Kumar received Special Contribution Award (Essential Oil Association of India for contribution in Essential Oil Indstry-2018, 3 August 2018.

Dr. Sanjay Kumar received Ultra International Team Award (Ultra International Limited, UP) for the Innovative and Impactful Efforts towards promotion of Cultivation and Processing of Aromatic Crops for Improving the Production of Essential oils in India, 3 August, 2018.

Dr. Ravi Shankar new grant received against DBT call for projects on Big Data (Rs. 66.156 Lakh). "Exploration of RBP-RNA interactions to reveal the post-transcriptional regulatory impact and development of related tools and resource server [BT/PR16331/ BID/7 /589 /2016]".

Dr. Sanjay Kumar Uniyal nominated as a Member of the Project Approval and Evaluation Committee, Himachal Pradesh Council for Science and Technology.

Dr. Sanjay Kumar Uniyal, Expert committee member of Botany, Uttarakhand Council for Science and Technology.

Dr. Rakesh Kumar Sud (2018) Chaired a session on Natural Farming - Present Status and Future Strategies of the conference on Doubling Farmers' Income: Challenges and Strategies, organized by AGRIVISION – Himachal Pradesh, CSK Himachal Pradesh Agricultural University, Palampur, April 24.

Dr. Rakesh Kumar Sud (2018) Nominated Member of Research Advisory Group (RAG) of Himalayan Forest Research Institute (HFRI), Shimla by Indian Council of Forestry Research and Education, Dehradun.

Dr. Sanjay Kumar Uniyal panel Member during the 1st Himalayan Researchers Consortium, National Mission on Himalayan Studies, Dehradun, 25-27 April, 2018.

Dr. Vijay Kant Agnihotri received Rapporteur saward by International Congress & Expo 2018 “Navigating Future of Essential Oils” 2018, at Sheraton grand Bengaluru Whitefield, Hotel & Convention Center organized by “Essential Oil Association of India”, August 03-05.

Antim Kumar Maurya, AK Chand and Vijay Kant Agnihotri essential oils composition of cultivated clones of *Juniperus communis* received the best poster award, 3rd prize in International Congress & Expo 2018 "Navigating Future of Essential Oils" at Sheraton grand Bengaluru Whitefield, Hotel & Convention Center organized by "Essential Oil Association of India", 3-5August.

Dr. Vikram Patial received best poster presentation award in 8th Annual Conference of Indian Academy of Biomedical sciences. CSIR-NIIST, February 25-27.

Dr. Rakesh Kumar Sud (2019) Member of Editorial Board, Himachal Journal of Agricultural Research, Published by CSK HP Agricultural University.

Dr. Damanpreet Singh (2018) Served as a Chairperson for the Poster Presentation session at IT-DDD dissertation viva-voce of one M. Tech. (Food Technology) student at I.K. Gujral Punjab Technical University, Kapurthala, Punjab, November 12.

Dr. Damanpreet Singh (2018) Served as an external examiner for thesis evaluation and conduct 2018 an "International Conference-cum-Workshop on Informatics Tools in Drug Discovery and Delivery" organized by Punjabi University, Patiala, November 1-4.

Dr. Damanpreet Singh (2018) Served as an external examiner for thesis evaluation and conduct dissertation viva-voce of one M. Pharm. (Pharmacology) student at G.H.G. Khalsa College of Pharmacy, Gurusar Sadhar, Ludhiana, Punjab, November 16.

International Student Under CSIR-TWAS Fellowship

Mrs. Adenike Evelyn ADENIYI, University of Ibadan, Nigeria completed six-month TWAS-CSIR fellowship research on thesis entitled "Suitability of seed oil of *Hildegardia barteri* (Mast. Kosterm) for production of selected bio-products", January-July, 2018.

Membership of professional bodies/ organizations

Agnihotri VK, Member of Bureau of Indian Standard Committee (PCD 18).

Agnihotri VK, Member of Course Coordination Committee AcSIR-IHBT Chemical Sciences.

Agnihotri VK, Member of organizing committee of one-day national seminar on "Creating Awareness on Standardization & Regulation among Fragrance & Essential Oil Industry" at India Habitat Centre, New Delhi. Organized by Bureau of Indian Standards and CSIR-IIIM Jammu, on March 7, 2019.

Reddy SGE, Life member for association for advancement of pest management in horticulture ecosystems. ICAR- Indian Institute of Horticulture Research, Hesaraghatta, Bangaluru, Karnatak.

Uniyal SK, Member of the Society of Herbarium Curators, 4 December 2018.

Staff

Staff

DIRECTOR

Dr. Sanjay Kumar

Head, HRDG (Additional Charge) (22.03.2018 to 02.11.2018)

Sr. Principal Scientist

Dr. R.K. Sud

Er. K.K. Singh

Dr. Aparna Maitra Pati

Dr. Amita Bhattacharya

Principal Scientist

Dr. Vipin Hallan

Dr. Sanjay Kumar Uniyal

Dr. Ram Kumar Sharma

Er. Amit Kumar

Dr. Sanatsujat Singh

Dr. Rakesh Kumar

Dr. Shashi Bhushan

Senior Scientist

Dr. Pralay Das

Dr. Girish Nadda

Dr. Vijay Kant Agnihotri

Dr. Ravi Shankar

Dr. Probir Kumar Pal

Dr. Mahesh Gupta

Dr. Rituraj Purohit

Dr. Sushil Kumar Maurya

Dr. Ashok Kumar

Er. Mohit Sharma

Dr. Amit Chawla

Dr. S.G.E. Reddy

Dr. Y.S. Padwad

Dr. Dharam Singh

Dr. Pamita Bhandari

Scientist

Dr. Dinesh Kumar

Dr. Amitabha Acharya

Dr. VikramPatial

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

Dr. Rajiv Kumar

Dr. Narender Vijay Tirpude

Dr. Rakshak Kumar

Dr. S. Vidyashankar

Principal Technical Officer

Sh. Mukhtiar Singh

Sh. Om Prakash

Senior Technical Officer (3)

Sh. Sukhjinder Singh

Senior Technical Officer (2)

Dr. Robin Joshi

Dr. Kiran Devi

Sh. Vikrant Gautam

Dr. Avnesh Kumari

Sh. Ramdeen Prasad

Sh. Jitender Bisht

Sh. Jai Prakash Dwivedi

Dr. Kiran Singh Saini

Senior Technical Officer (1)

Sh. Rakesh Verma

Sh. Anil Kumar

Sh. Shiv Kumar

Dr. Rajneesh

Dr. Kulurkar Pankaj Markand

Sh. Ramjee Lal Meena

Sh. Vivesh Sood

Sh. Mahesh S.

Sh. Bijan Bihari Garnayak

Sh. Mohit Kumar Swarankar

Sh. Jasbeer Singh

Sh. Mukesh Gautam

Sh. Om Prakash

Sh. Ashok Gehlot

Sh. Kunjan Saxena

Technical Officer

Smt. Vijaylata Pathania

Sh. Pabitra Gain

Sh. Aman Kumar

Smt. Meenakshi

Sh. Anil Chaudhary

Sh. Dharmesh Kumar

Technical Assistant

Sh. Arvind Kumar Verma

Sh. Pawan Kumar

Smt. RimpyDhiman

Sh. ViratAbhishek

Sh. Saurabh Sharma

Senior Technician (2)

Sh. Karandeep Sood

Sh. Dharuv Kumar

Senior Technician (1)

Sh. Ramesh Kumar

Sh. Kuldip Singh

Sh. Parveen Kumar

Technician (2)

Sh. Sanjay Kumar

Sh. Avinash Chander Rana

Sh. Sandeep Sood

Sh. Ranjeet Singh

Sh. Ajay Kumar

Sh. Surjeet Singh

Sh. Arvind Kant

Smt. Jasveer Kaur

Sh. Vikas Kumar

Technician (1)

Sh. Sanjeev Kumar

Sh. Sanjeet Kumar

Sh. Monu Kumar

Sh. Parvinder Kumar

Sh. Ishwar Dass

Lab. Attendant (2)

Mrs. Anupama Saini

Sh. Shamsher Singh

Sh. Girjanand

Sh. Baldev Singh

Sh. Kuldeep Singh

Sh. Balwant Raj

Sh. Deepak Sood

Lab. Attendant (1)

Sh. Rakesh Chand

Sh. Balak Ram

Sh. Uttam Chand

Administration Officer

Sh. Alok Sharma

Finance & Accounts Officer

Sh. S.N. Gulia, joined on 04.09.2018

Controller of Store and Purchase

Sh. Suresh Pant

Section Officer (Gen.)

Sh. S.D. Rishi

Sh. Amar Jeet

Section Officer (F&A)

Sh. Darshan Singh

Section Officer (S&P)

Sh. Ram Singh, joined on 11.03.2019

Hindi Officer

Sh. Sanjay Kumar

Sr. Steno (MACP)

Sh. Didar Singh Patial

Assistant Section Officer

Sh. Raj Kumar

Sh. Parveen Singh

Sh. Ved Prakash

Sh. Keerti Raj

Smt. Santosh Kumari

Sh. Baldev

Assistant Section Officer (F&A)

Sh. Manoj Kumar

Sh. Vipan Kumar

Smt. Aruna Kumari

Assistant Section Officer (S&P)

Sh. Rajeev Sood

Senior Secretariat Assistant

Sh. Kiran Kumar

Smt. Pooja Awasthi

Junior Secretariat Assistant (S&P)

Sh. Rajinder Singh

Junior Secretariat Assistant

Sh. Praveen Kumar

Sh. Sandeep Kumar

Sh. Mukul Sharma

Sh. Ajay Singh Kaundal

Junior Stenographer

Sh. Boni Kumar

Security Assistant

Sh. Trilok Nath

Coupon Clerk

Sh. Anand Sharma

Cook

Sh. Oman Singh

Sh. Karan Singh

Driver

Sh. Partap Chand

Sh. Braham Dass

Sh. Lakhvinder Singh

Sh. Nitesh Bhardwaj

Waiter

Sh. Bipan Kumar

Gr. "C" (Non- Technical)

Sh. Thaman Bahadur

Chowkidar

Sh. Baleshwar Prasad

Sh. Devender Kumar

Tea Maker

Sh. Bipan Gurang

Frash

Smt. Rujala Devi

Staff Joined CSIR-IHBT between 01.04.2018-31.03.2019

Sr.	Name	Designation	Date of Joining
1.	Sh. Anish Kachra	STO (2)	28.02.2019

Staff Superannuated

Dr. S.K. Vats
Sr. Principal Scientist
30.04.2018

Sh. Shankar
Wash Boy
30.04.2018

Sh. Amar Singh
Lab Assistant
31.05.2018

Dr. Brij Lal
Sr. Principal Scientist
31.07.2018

Sh. Ajay Parmar
Senior Technician (2)
31.07.2018

Dr. Ashu Gulati
Sr. Principal Scientist
28.02.2019

Smt. Rajani Devi Chetri
Lab Attendant (2)
28.02.2019

EMERITUS SCIENTISTS/SCIENTIST FELLOW/RESEARCH SCHOLARS

Emeritus Scientists

Dr. Bikram Singh
Dr. Surender Kumar Vats

Project Scientist

Dr. Ajay Rana

TWAS Fellow

Mr. Tony KipkoechMaritim

Inspire Faculty

Dr. Rohit Sharma
Dr. Yogita Maheshwari
Dr. Nishma Daga

NPDF/SERB/WOMEN SCIENTIST

Mr. Archit Sood
Ms. Prakriti Kashyap
Dr. Pankaj Kumar
Ms. Ritu Sharma
Ms. Ranjana Sharma
Ms. Usha Kumari Rattan

Research Associate

Dr. Dipika Rana
Dr. Umesh Pankaj
Dr. Vinod Bhatt
Mr. Ashwani Kumar
Dr. Vaneet Kumar
Dr. Virender Kumar
Dr. Praveen Dhyani
Dr. Kashish Walia
Dr. Vijay Kumar
Dr. S Vijay Anand Raj
Dr. Ankita
Dr. Tanya Mohindroo
Dr. Vishal Priya
Dr. KumariSita
Dr. Rahul Jain
Dr. Shalika Rana
Dr. Rajni Devi
Dr. Shruti Choudhary
Mr. Antim Kumar Maurya
Dr. Vikrant Sharma

ISWP (Govt. Emp.)

Mr. Upendra Pradhan
Mr. Prakash Kumar
Ms. Gowsalyadevi A

SRF

Ms. Ambika
Mr. Rakesh Kumar
Mr. Gopal Singh
Ms. Shaifali
Ms. Namo Dubey
Mr. Shiv Rattan
Ms. Kajal Sinha
Mr. Neeraj Kumar

JRF

Mr. Anil Kumar Rana
Mr. Prince Anand
Ms. Arti Sharma
Ms. Bipasha Bhattacharjee
Ms. Aishwarya Rajlaxmi
Mr. Devesh Chandra
Mr. Ajay Kumar Sharma
Mr. Arvind Singh Chauhan
Ms. Mohini Verma
Mr. Syed Murtuza Sayeed Abidi
Ms. Ashrita
Mr. Anil Kumar
Ms. Kamini Kapoor

Mr. Lakhbeer Singh
Ms. Kanchan Yadav
Ms. Shruti Sinai Borker
Ms. Manglesh Kumari
Ms. Sheetal
Mr. Bittu Ram
Ms. Pooja
Ms. Diksha Parmar
Ms. Priyanka Dhaka

Research Fellow

Mr. Sourav Kumar

Project Fellow

Ms. Medhavi Srivastava
Ms. Neha Chilwal

Project Associate

Mr. Chirag Sharma
Ms. Kanika Kiran
Mr. Anil Kumar

Project Assistant II

Mr. Nitesh Kumar Sharma
Ms. Shruti Sharma
Mr. Aqib Iqbal Dar
Ms. Shriya Bhatt
Ms. Aakriti Sharma
Mr. Parveen Kumar
Ms. Mamta
Mr. Akshay Rana
Mr. Manish Kumar Sharma
Ms. Payal Kotvi
Ms. Surbhi Sharma
Ms. Shalika Rathore
Ms. Swati Walia
Ms. Ashita Bisht
Ms. Shivani
Ms. Nitika
Ms. Sonali Bhardwaj
Ms. Priya Kapoor
Ms. Mamta Masand
Mr. Rahul Dev Gautam
Mr. Sultan Singh
Ms. Deeksha Rani
Mr. Rajeev Kumar
Ms. Yamini
Ms. Amna Devi
Mr. Harish Kumar
Mr. Yog Raj
Mr. Ajay Kumar
Mr. Kushal Kumar
Mr. Deepak Kothari
Mr. Deepak Kothari
Mr. Shinde Bhagatsing Devidas
Ms. Meenakshi Thakur
Ms. Isha Sharma
Mr. Manish Kumar
Ms. Nilofer
Mr. Babit Kumar Thakur
Ms. Kanika
Ms. Sarika Verma
Mr. Balraj Sharma
Ms. Bindu Rawat
Mr. Ravi Kumar
Mr. Manish Kumar
Mr. Pradeep Bhatia
Ms. Swati Katoch
Mr. Rohit Kumar
Mr. Aman Kumar
Ms. Anuradha
Ms. Mamta Devi
Mr. Prithvi Pal Singh
Ms. Ekjot Kaur
Mr. Raman Kumar
Mr. Prateek Singh Bora

Ms. Neelam Kumari
Ms. Nitisha Sendri
Mr. Shashi Kumar
Ms. Savita Kumari
Ms. Shambhvi
Mr. Kishor Chandra Kandpal
Ms. Avantika Bhardwaj
Mr. Subhanshu Kapoor
Ms. Monika Kumari
Ms. Anchal
Mr. Aman Thakur
Ms. Pooja Sharma
Ms. Aditi Sharma
Ms. Vandana Kumari
Ms. Shivani Puri
Ms. Sampa Das
Mr. Shiv Shankar Gupta
Mr. Ashish Sharma
Ms. Anju Singh
Ms. Anika
Mr. Ajay Kumar Thakur
Ms. Priyanka Parmar
Mr. SauravAnand Gurung
Ms. KamleshVerma
Mr. Vinesh Sharma
Mr. Ravi Kumar
Mr. Abhisehk Khatri
Ms. Neha Baliyan
Mr. Swami Pragya Prashant
Ms. Anu Kumari
Mr. Amit Kumar
Mr. Sourbh Kumar
Mr. Jayaram C. S.
Ms. TamannaAwasthi
Mr. Priyanka Thakur
Ms. Suman
Ms. Ankita Choudhary
Mr. Sahil Sharma
Ms. Anjali Chandel
Ms. Pooja
Ms. Anchal Sharma
Ms. Deepika Verma
Ms. Poonam Kumari
Mr. Jatin Sharma
Ms. Diksha Patiyal
Mr. Sahil Salaria
Ms. Shivani
Ms. Swati Bhuria
Ms. Savita Chaudhary
Ms. Neha Chaudhary
Mr. Sarthak Sharma
Ms. Nidhi
Ms. Rashim Kumari
Mr. Anupam Bhatt
Ms. Mansi Awasthi
Mr. Aditya Singh Ranout
Ms. Neha Bhardwaj
Ms. Mehak Sharma
Ms. Ruhika Sharma
Mr. Aman Pathania
Mr. Ankush Chauhan
Mr. Suresh Kumar
Mr. Subham Anchal
Mr. Kartik Sharma
Ms. Sonam Bahuguna
Mr. Gaurav Aggarwal
Mr. Vikas Yadav
Mr. Anil Kumar
Ms. Shreya
Ms. Garima Dadhich
Ms. Naina Singh
Ms. Damini
Mr. Umesh Kumar Thakur

Ms. ShivantiNegi
Ms. Priya
Mr. Deepak Dabur
Mr. Mallikarjun CP
Mr. Deepak Singh
Ms. Jigyasa Malhotra
Ms. Sabina Rana
Ms. Pooja Sharma
Dr. Naresh Thakur
Mr. Rashmi Ranjan Sahoo
Ms. Diksha Sharma
Ms. Pooja Thakur
Ms. Snehlata Dalal
Ms. Manjeet Singh Dhrek
Mr. Kale Rohan Arjun
Ms. Preshika
Mr. Shivanshu Garg
Ms. Shivani Rana
Ms. Anchal Jamwal
Mr. Vijay Negi
Ms. Riya Maitra

Project Assistant I

Ms. Anjali Rakwal
Mr. Vinit Rana
Ms. Shikha Sharma
Mr. Akhil Kumar
Ms. Aakriti Sood
Ms. Neha Kumari
Ms. Pooja Kumari
Ms. Seema Chauhan
Mr. Rahul Kumar
Mr. Rajat Gupta
Mr. Akshay Kumar
Ms. Preksha Sharma
Mr. Anuj Kaushal
Ms. Renu Devi
Mr. Pritam Debnath
Ms. Nandita Chauhan
Mr. Ajeet Kumar
Mr. Ankush
Ms. Neha Kapoor
Mr. Ankush Kumar
Mr. Ishu
Mr. Sandeep Kumar
Ms. Gaytri
Ms. Shikha Rana
Mr. Arvind Sharma
Ms. Shilpa Bhardwaj
Mr. Gaurav Katoch
Ms. Diksha Patial
Ms. Pallavi
Mr. Sahil Sharma
Mr. Raj Veer
Mr. Deepak Guleria
Ms. Diksha Kumari
Mr. Sachin Vashisath
Ms. Priti
Mr. Priyabrata Sethy
Ms. Anjali Dhiman
Ms. Aprajita Sood
Mr. Rajesh Kumar
Ms. Kanika Devi
Ms. Shivani Chauhan
Mr. Narender Kumar
Mr. Neeraj Kumar Arya
Ms. Bharti Shukla
Mr. Nandan Gautam
Mr. Sourabh Kumar
Ms. Bharti Mongra
Ms. Anjali Mehta
Ms. Saizal Jamwal

Project Assistant

Ms. Shweta Thakur
Ms. Nandita Mehta

News Clippings of CSIR-IHBT

News Clippings of CSIR-IHBT

जानकारी प्रदर्शनी से विद्यार्थियों ने जाना अनुसंधान कार्यों का महत्व

लक्ष्य हासिल करने के लिए करें मेहनत

गुणवत्ता युक्त हींग प्राप्त करने के लिए कृषि तकनीक जल्द विकसित करेंगे : संजय कुमार

पालमपुर, (आपका फैसला)। सी.एस.आई.आर.-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान, पालमपुर में हर वर्ष की भांति 28 फरवरी को राष्ट्रीय विज्ञान दिवस मनाया गया। डा. चन्द्रशेखर वैंकटरमन द्वारा 28 फरवरी 1928 को 'रमन प्रभाव' की खोज के लिए उन्हें 1930 में भौतिकी के लिए नोबल पुरस्कार प्रदान किया गया था।
लिए प्रत्येक वर्ष 28 फरवरी को राष्ट्रीय विज्ञान
निदेशक डा. संजय कुमार ने सभी अतिथियों
सामाजिक, औद्योगिक और पर्यावरण के क्षेत्र
माध्यम से जैव आर्थिकी के विकास के लिए प्र
अग्रसर है। हमारे शोध की स्थानीय प्रासंगिकता
आगे बताया कि संस्थान ने गुणवत्तायुक्त हींग प्राप्त
शुरु कर दी है। इसकी सफलता से न केवल युव
आय में भी वृद्धि होगी। इसी प्रकार संस्थान

सीएसआईआर पालमपुर ने गिनाईं उपलब्धियां

पालमपुर (कांगड़ा)। सीएसआईआर का स्थापना दिवस समारोह आईएचबीटी पालमपुर में मनाया गया। निदेशक डॉ. संजय कुमार ने सीएसआईआर की प्रमुख प्रयोगशालाओं एवं संस्थान के 2017-18 के वार्षिक प्रतिवेदन को प्रस्तुत किया। समारोह में प्रो अरुण तिवारी, सचिव केयर फाउंडेशन ने पादप आधारित औषधियां विषय पर संभाषण दिया। मुख्य अतिथि प्रो. वीएल चोपड़ा ने वार्षिक प्रतिवेदन का विमोचन किया। संस्थान की प्रौद्योगिकी को अपनाने के लिए विनोद कुमार को सम्मानित किया गया।

अरुणाचल के किसानों को समृद्ध बनाएगा अरोमा मिशन

Minister lauds IHBT for developing stevia technology

Green coffee from Himachal

पत्रकार वार्ता

भूकंप के छोटे झटके टाल रहे बड़ी आपदा : डॉ. पालनी

जैव विविधता संरक्षण के लिए करने होंगे प्रयास

फूलों से हो सकती है आय दोगुनी : संजय

पालमपुर (कांगड़ा)। सीएसआईआर-हिमालय जैव संपदा प्रौद्योगिकी संस्थान पालमपुर एवं राज्य विज्ञान प्रौद्योगिकी एवं पर्यावरण परिषद शिमला के सौजन्य से राख पंचायत में किसानों के लिए प्रशिक्षण कार्यक्रम का आयोजन किया। कार्यक्रम में किसानों को फूलों की व्यावसायिक खेती से होने वाले लाभ के बारे में बताया। कार्यक्रम में करीब 90 किसानों ने भाग लिया। कार्यक्रम के संयोजक डॉ. भव्य भार्गव ने बरसात के बाद लगने वाली गैंदे की फसल की जानकारी दी। ब्यूरो

'जिज्ञासा' से दी विज्ञान तकनीक की जानकारी

सीएसआईआर में प्रो. अरुण तिवारी ने छात्रों से साझा किए अनुभव

मणिपुर में आईएचबीटी पालमपुर उगाएगा ऑफ सीजन सेब

अब मिजोरम-मणिपुर भी उगा सकते हैं सेब

सीएसआइआर ने किया कंपनी से करार

वैज्ञानिकों ने ग्लेशियर के बैक्टीरिया से खोजा कैंसर प्रतिरोधक एंजाइम

सीएसआईआर-आईएचबीटी संस्थान पालमपुर के शोध में मिलीं कई खूबियां

गिरिराज सिंह ने ली तकनीकों की जानकारी

आईएचबीटी में टीबीआई सेंटर

सीएसआईआर में छात्रों ने जाने रिसर्च

हिमालय जैव संपदा प्रौद्योगिकी संस्थान पालमपुर में हुआ जिज्ञासा कार्य

आइएचबीटी की अरोमा टीम अल्ट्रा इंटरनेशनल पुरस्कार से सम्मानित

सगंध फसलों पर बेहतर काम के लिए बेंगलुरु में मिला इनाम

सीएसआईआर और एचयू का बांस की पौध को करार

पालमपुर (कांगड़ा)। सीएसआईआर आईएचबीटी पालमपुर ने महाराष्ट्र की एचयू गुगले एग्रोबायोटेक कंपनी के साथ ऊतक संवर्द्धन तकनीक से तैयार बेंबुसा बाल्कोआ, डेंडरोकैलेमस एस्पर और डेंड्रोकैलेमस हेमिलटोनाई जैसी बांस की प्रजातियों के शूट कल्चर विधि की सामग्री के लिए करार किया है। व्यावसायिक रूप से महत्वपूर्ण मानी जाने वाले इन प्रजातियों का उपयोग कागज, फर्नीचर, खाद्य और कपड़ा उद्योगों में व्यापक स्तर पर होता है। इन पौधों को शूट कल्चर विधि से मूल पौधों से तैयार किए जाता है। संस्थान के निदेशक डा. संजय कुमार व वरिष्ठ वैज्ञानिक डा. आरके सूद ने कहा कि सीएसआईआर-आईएचबीटी बांस के प्रसार

अब पौधे रखेंगे आपकी सेहत का ख्याल

पहाड़ी प्रदेश की बंजर जमीन भी उगलेगी सोना

किसानों को दी फूल उगाने की जानकारी

खुंब के कैप्सूल से मिलेगी विटामिन डी

कैंसर के कणों से बचाएगा घर में लगा पौधा

वैज्ञानिकों ने खोजा कैंसर के इलाज में कारगर एंजाइम

चंबा में हजारों वर्ष पहले लुप्त हो चुकी 50 जड़ी-बूटियां मिलीं

लुंगड़ू मतलब बीमारियों के लिए रामबाण औषधि

की प्रजातियों पर हस्तांतरण करार

Wed, 31 October 2018

फूलों की किस्में बदलेंगी किसानों की तकदीर

हिमालय जैवसंपदा प्रौद्योगिकी संस्थान कल मनाएगा स्थापना दिवस

पालमपुर : सीएसआइआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान में दो जुलाई को स्थापना दिवस मनाया जाएगा। इस मौके पर डॉ. गिरीश साहनी महानिदेशक सीएसआइआर और सचिव डीएसआइआर मुख्य अतिथि होंगे। प्रमुख जैव प्रौद्योगिकी वैज्ञानिक लोकमान एस पालनी मुख्य वक्ता होंगे। इस मौके पर आसपास के क्षेत्रों के विभिन्न विद्यालयों के विद्यार्थी भी संस्थान का दौरा करेंगे। संस्थान की ओर से विकसित किए गए उत्पादों की प्रदर्शनी भी लगाई जाएगी। संस्थान के प्रधान वैज्ञानिक डॉ. आरके सूद ने बताया कि संस्थान ने विभिन्न उपलब्धियां पुष्प उत्पादन और अन्य क्षेत्रों में हासिल की हैं। इनके बारे में भी प्रदर्शनी के माध्यम से बताया जाएगा। जागरण संवाददाता

जानकारी प्रदेश में पाई जाती हैं 800 औषधीय गुणों की जड़ी-बूटियां, सीएसआइआर कर रहा संरक्षण का प्रयास

लापरवाही चूस गई पुष्पी पौधों का रस

उत्तराखड का फूला का खता सिखाएगा सीएसआइआर

संवाद सहयोगी, पालमपुर : सीएसआइआर-आइएचबीटी पालमपुर उत्तराखंड के लोगों को फूलों की खेती सिखाएगा। उत्तराखंड में लोगों की आजीविका के सुधार के तहत औषधीय और सुगंधित फसलों की खेती को बढ़ावा देने के लिए शुक्रवार को पीपुल्स एडवांसमेंट एंड एक्शन रिसर्च एसोसिएशन (एपीएआर) नई दिल्ली के साथ समझौता ज्ञापन पर हस्ताक्षर किए। सीएसआइआर-आइएचबीटी गुणवत्तायुक्त रोपण सामग्री के लिए नर्सरी की स्थापना, किसानों को प्रशिक्षण और फसलों से तेल निकालने के लिए इकाइयों की स्थापना में तकनीकी सहायता प्रदान करेगा।

किसानों के साथ संपर्क पीपुल्स एडवांसमेंट एंड एक्शन रिसर्च

हिमालयी कृषि फसलों में मौसम के विचलन और जलवायु परिवर्तन, जंगली जानवरों से खतरे और फसलों के उचित मूल्य न मिलने से इस खेती से किसान दूर होते जा रहे हैं, लेकिन हिमालय के राज्य में उच्च मूल्य की औषधीय और सुगंधित फसलों की खेती के लिए अपार संभावनाएं एवं अवसर उपलब्ध हैं। यह खेती न केवल उत्पादों की राष्ट्रीय और अंतरराष्ट्रीय मांगों को पूरा करती है बल्कि किसानों की आजीविका को भी बढ़ावा देती है।

इन फसलों में किसानों की आय को दो से तीन गुना बढ़ाने की क्षमता है। एपीएआर के प्रतिनिधि दक्ष गुप्ता ने आशा व्यक्त की कि सीएसआइआर-आइएचबीटी के साथ हाथ मिलाकर उन्हें उत्तराखंड राज्य में उच्च मूल्य वाली

खेती के लिए अपनाएं नई तकनीकें

ग्रामीण आजीविका मिशन के तहत सीएसआइआर-आइएचबीटी में कार्यक्रम आयोजित

किसानों को गेंदा फूल के बीज वितरित किए

राख में फूलों की खेती के लिए प्रेरित किए किसान

आइएचबीटी की ओर से आयोजित पुष्प खेती कार्यक्रम में उपस्थित प्रतिभागी ● जागरण

वाद सहयोगी, पालमपुर :
एसआइआर के हिमालय जैव संपदा
द्योगिकी संस्थान (आइएचबीटी) एवं
ज्य विज्ञान प्रौद्योगिकी एवं पर्यावरण
रिषद शिमला के सौजन्य से पंचायत
ख में शुक्रवार को पुष्प खेती पर
कदिवसीय प्रशिक्षण शिविर आयोजित
या गया। इस अवसर पर किसानों को
लों की व्यावसायिक खेती के लाभ
ताए गए। शिविर में लगभग 90 किसानों
भाग लिया। कार्यक्रम के संयोजक डॉ.
व्य भार्गव ने वर्षा ऋतु के उपरांत लगने
ली गेंदे की फसल की जानकारी दी।
होंने बताया कि इससे किसान दिवाली
समय अपनी उपज ले सकते हैं तथा
00 वर्ग मीटर से चार महीने में पचास
जार रुपये शुद्ध लाभ प्राप्त कर सकते
। प्रशिक्षण में खुले स्थान में उगाए जाने
ले विभिन्न फूलों की किस्मों के बारे

लगाने के तरीकों एवं मार्केटिंग की जानकारी दी गई। किसान कर्तित फूल जैसे कैला, लिली व ग्लैडियोलस उगाकर गेहूं, धान व सब्जियों से भी अधिक आय अर्जित कर सकते हैं। उन्होंने लघु किसानों को संगठित होकर व्यावसायिक खेती का सुझाव दिया। शिविर में संस्थान की ओर से किसानों को ग्लैडियोलस के पौधे भी उपलब्ध करवाए गए। पंचायत प्रधान रुकमणी एवं अन्य सदस्यों का इसमें सहयोग रहा।

आइएचबीटी के निदेशक डॉ. संजय कुमार ने कहा कि फूलों की खेती उच्च आय पैदा करने वाली गतिविधियों में से एक है। इससे पारंपरिक फसलों की तुलना में तीन से चार गुना अधिक लाभ प्राप्त किया जा सकता है। संस्थान ने कर्तित पुष्पों की उत्तम किस्मों को भी विकसित किया है ताकि किसानों को

किसानों के लिए भी तकनीकें विकसित करें वैज्ञानिक : राणा

IHBT signs pact to extract catechins from tea leaves

OUR CORRESPONDENT

अब दुर्लभ नहीं रहेगी नाग छतरी

जैविक कृषि में सहायक होगा सूचना प्रौद्योगिकी का उपयोग

CSIR students hailed for scientific temperament

जानकारी | सीएसआईआर-आईएचबीटी के स्थापना दिवस पर बोले प्रो. अरुण तिवारी

तकनीकों का ग्लोबलाइजेशन जरूरी

लाहुल-स्पीति और पालमपुर में उगेगा हींग

Ultra International Team Award for CSIR-IHBT

सीएसआईआर को मिलेगा बाजार

केसर से बनी दवा से होगा मिर्गी दौरे का उपचार

सुगंधित गुलाब की अंतरराष्ट्रीय बाजार में मांग

पालमपुर में कार्यशाला के दौरान किसानों को बांटी जानकारी

22 शोध छात्रों ने पेश किए रिसर्च वर्क

बंजर को स्वर्ण भूमि बना रहा जंगली गेंदा

सीएसआईआर-आईएचबीटी शोधार्थियों ने आयोजित किया सेमिनार

सीएसआईआर में 450 छात्रों ने निहारी प्रदर्शनी

गेंदा उगाओ...और मुनाफा कमाओ

अरोमा मिशन के अंतर्गत प्रशिक्षण कार्यक्रम में बांटा ज्ञान

पत्तों से बनाया जाएगा ईंधन

पालमपुर में सजी कार्यशाला

परंपरागत पौधे औषधीय गुणों की खान

पालमपुर – हिमालय जैवसंपदा प्रौद्योगिकी संस्थान में सीएसआईआर स्थापना दिवस पर कार्यक्रम का आयोजन किया गया। इस समारोह में प्रो. अरुण तिवारी, सचिव, केयर फाउंडेशन ने 'पादप आधारित औषधियां' विषय पर संभाषण में विभिन्न पौधों के उपयोग तथा

पर प्रकाश डाला। प्रो. तिवारी ने कहा कि औषधीय गुणों के ज्ञान को भूलते जा रहे हैं। उद्यमी अपने उत्पादों का प्रसार कर रहे जाता है, लेकिन अन्य रोग पैदा हो जाते की है कि आधुनिक उपायों के साथ-साथ अपनाएं तथा इस ज्ञान को संरक्षित करने

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अब नए वर्षा वाले क्षेत्रों में भी उगेगी चाय

प्रौद्योगिकी हस्तांतरण पर एमओयू

स्टार्टअप सीएसआईआर आविष्कार पर कार्यशाला

अरुणाचल के किसानों ने जानी फूलों की खेती

पालमपुर में दो दिन मिला वैज्ञानिकों से प्रशिक्षण

हिमाचल दस्तक। पालमपुर

सीएसआईआर हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर ने अरोमा मिशन के अंतर्गत अरुणाचल प्रदेश के जनजातीय क्षेत्र के किसानों के लिए दो दिवसीय जागरूकता एवं प्रशिक्षण

सुगंधित गुलाब, लैवेंडर, रोजमेरी, जंगली गेंदा, लैमन ग्रास आदि की खेती उत्पादन एवं मूल्यवर्धन के बारे में जानकारी दी गई। प्रधान वैज्ञानिक एवं प्रशिक्षण कार्यक्रम के आयोजक डॉ. राकेश कुमार ने किसानों को खेती की तैयारी, नर्सरी प्रबंधन, पोषक तत्व प्रबंधन, खरपतवार

उद्योग से आर्थिक लाभ मिल सके। सीएसआईआर-आईएचबीटी के निदेशक डॉ. संजय कुमार ने किसानों को सुगंधित फसलों की क्षमता और इत्र, स्वाद और खाद्य उद्योग में इसकी बढ़ती मांग के बारे में बताया। डॉ. संजय कुमार ने कहा कि हिमाचल प्रदेश और अरुणाचल प्रदेश की कृषि, जलवायु परिस्थितियां समान हैं और किसान सीएसआईआर-आईएचबीटी पालमपुर द्वारा विकसित कृषि, प्रक्रिया प्रौद्योगिकियों का उपयोग करके सुगंधित फसलों की खेती के माध्यम से लाभ प्राप्त कर सकते हैं। उन्होंने भविष्य में सुगंधित पौधों की खेती में आने वाली कठिनाइयों

प्रगतिशील किसानों को दिया सगंध फसलों संबंधी प्रशिक्षण

पालमपुर में स्थापित होगा एलबीटी

स्टार्टअप सेंसिटाइजेशन पर कार्यशाला आयोजित

पालमपुर। सीएसआईआर आईएचबीटी पालमपुर ने हिमाचल प्रदेश सरकार के उद्योग विभाग के सहयोग से अपने परिसर में स्टार्टअप सेंसिटाइजेशन एंड आइडियाशन पर एक कार्यशाला का आयोजन किया। सीएम स्टार्टअप योजना के माध्यम से स्टार्टअप संस्कृति को बढ़ावा देने के लिए राज्य सरकार द्वारा दिए गए प्रोत्साहनों पर युवा नवप्रवर्तनकों और उद्यमियों को संवेदनशील बनाने के उद्देश्य से इस कार्यक्रम का आयोजन किया गया था। इस आयोजन में कृषि विश्वविद्यालय, श्री साई विश्वविद्यालय और सीएसआईआर आईएचबीटी के छात्रों, विद्वानों और संकाय ने भाग लिया था। कार्यक्रम का शुभारंभ करते हुए डॉ. संजय कुमार निदेशक सीएसआईआर

बांस को लेकर आई.एच.बी.टी. व गुजरात प्रतिष्ठान के मध्य समझौता

सेब उत्पादन में अब उत्तर-पूर्वी राज्यों ने आरंभ की कदमताल

सुगंधित फसलों की खेती

गुणवत्तायुक्त हींग की कृषि तकनीक विकसित करने की तैयारी में आईएचबीटी

राष्ट्रीय विज्ञान दिवस पर निदेशक डॉ. संजय ने दी जानकारी

प्राकृतिक तेल की विश्व में भारी मांग : डॉ. सुरिंद

आर्गेनिक एग्रीकल्चर के बारे में बताया

पालमपुर। शुक्रवार को हिमालय जैव संपदा प्रौद्योगिकी संस्थान पालमपुर ने, राष्ट्रीय प्रौद्योगिकी दिवस मनाया। समारोह में कैंब्रिज इंटरनेशनल स्कूल पालमपुर के विद्यार्थियों ने अपनी उपस्थिति दर्ज करवाई। स्कूल के प्रधानाचार्य ने बताया कि प्रश्नोत्तरी सत्र के अंतर्गत हमारे विद्यालय के छात्रों ने बढ़-चढ़कर भाग लिया। मुख्यातिथि डॉ. अनुपम वर्मा ने बच्चों के द्वारा पूछे गए प्रश्नों के उत्तर दिए तथा उनके प्रश्नों के लिए उन्हें सराहा। उन्होंने बताया कि कार्यक्रम में एपीजी यूनिवर्सिटी के कुलपति डॉ. तेज प्रताप ने आर्गेनिक एग्रीकल्चर के बारे में रोचक जानकारी दी। उन्होंने बताया कि छात्रों ने संस्थान के बारे में भी जानकारी प्राप्त की।

मेघालय के बागवानों ने सीखी सेब प्रबंधन की तकनीक

किसानों को सुगंधित पौधों की खेती की संभावनाएं बताईं

हिम प्योर ग्रीन कॉफी अब बाजार में

पालमपुर, 10 अप्रैल (ब्यूरो)। हिमालय नैचुरल एंड हर्बल प्रोडक्टस ने सी.एस.आई.आर. हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर के सहयोग से हिम प्योर ग्रीन कॉफी तैयार की। इस हिम प्योर ग्रीन कॉफी का लोकार्पण मंगलवार को किया गया। यह कॉफी ताजी ऑर्गेनिक

बंजर भूमि को स्वर्ण भूमि बना सकते हैं किसान

सीएसआईआर-आईएचबीटी पालमपुर की नई तकनीक काम आई

अब धूप बन सुगंध देंगे मंदिरों में चढ़ाए फूल

आईएचबीटी एवं मैसर्ज एचयू गुगले एग्रो बायोटेक कंपनी में करार

हिमाचल दस्तक। पालमपुर

सीएसआईआर-आईएचबीटी, पालमपुर ने मैसर्ज एचयू गुगले एग्रोबायोटेक कंपनी जामखेड जिला अहमदनगर, महाराष्ट्र के साथ ऊतक संवर्धन तकनीक से तैयार बैंबू साबाल्कोआ, डेंडरो कैलेमस एस्पर और डेंड्रो केलेमसहेमिल्टोनाई जैसी बांस की प्रजातियों के शूट कल्चर के लिए सामग्री हस्तांतरण करार (एमटीए) पर हस्ताक्षर किए। व्यावसायिक रूप से इनका उपयोग कागज, फर्नीचर, खाद्य और कपड़ा उद्योगों में व्यापक स्तर पर होता है। इन पौधों को शूट कल्चर विधि द्वारा मूल पौधों से तैयार किए जाता है। इन ऊतक संवर्धन तकनीक से तैयार शूट मूल पौधे के एक समान होते हैं और इन्हें 3-4 सप्ताह की लघु अवधि

✔ बांस की प्रजातियों के शूट कल्चर पर होगा शोध

हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर में जिज्ञासा कार्यक्रम आयोजित

छात्रों ने शोधार्थियों से सीखे विज्ञान के गुर

सीएसआईआर के पूर्व निदेशक से की भेंट

पालमपुर – भारत सरकार के अति प्रतिष्ठित संस्थान हिमालय जैव संपदा सीएसआईआर के पूर्व निदेशक डा. अनिल सूद के साथ पालमपुर के पूर्व विधायक एवं समाजसेवा में समर्पित इसवाक संस्था के अध्यक्ष एवं संरक्षक प्रवीण कुमार ने उनके आवास पर मुलाकात की। इस शिष्टाचार भेंट में पूर्व विधायक ने संस्था की गतिविधियों एवं प्रस्तावित कार्यक्रमों के बारे में डा. अनिल सूद से विस्तृत चर्चा की। पूर्व विधायक ने बताया कि डा. सूद ने प्रस्तावित योजनाओं से प्रभावित होकर संस्था के निदेशक मंडल में शामिल होने के आग्रह को कबूल किया। इस मौके पर संस्था के प्रपत्र को भरते एवं प्रतिनिधि के रूप में सदस्यता ग्रहण करते हुए।

दिव्य हिमाचल Thu, 02 August 2018 epaper.divyahimachal.co

सुगंधित पौधों की खेती के लिए किसानों को किया प्रोत्साहित

सीएसआईआर-आईएचबीटी ने अरोमा मिशन के तहत लगाई कार्यशाला

किसानों को फूलों की खेती पर दिए टिप्स

पालमपुर – सीएसआईआर हिमालय जैव संपदा प्रौद्योगिकी संस्थान पालमपुर एवं राज्य विज्ञान प्रौद्योगिकी एवं पर्यावरण परिषद शिमला के सौजन्य से पंचायत राख, ब्लॉक भवारना, पालमपुर व कांगड़ा में प्रशिक्षण कार्यक्रम का आयोजन किया। कार्यक्रम में किसानों को फूलों की व्यावसायिक खेती से होने वाले लाभ के बारे में बताया। इस एकदिवसीय कार्यक्रम में लगभग 90 किसानों ने भाग लिया, जिनमें मुख्यता महिलाओं की प्रतिभागिता रही। कार्यक्रम के संयोजक डा. भव्य भार्गव ने वर्षा ऋतु के उपरांत लगने वाली गेंदे की फसल पर जानकारी दी, जिससे किसान दिवाली के समय अच्छी उपज ले सकते हैं तथा 1000 वर्ग मीटर से चार महीने में पचास हजार रुपए शुद्ध लाभ प्राप्त कर सकते हैं। प्रशिक्षण में खुले स्थान में उगाए जाने वाले विभिन्न फूलों की किस्मों के बारे में तकनीकी ज्ञान, उत्पादन, रखरखाव, लगाने के तरीकों एवं मार्केटिंग की जानकारी प्रदान की गई।

दिव्य हिमाचल Sat, 26 May 2018 epaper.divyahimachal.com

हिंदी में श्रेष्ठ काम करने वालों को सम्मान

सीएसआईआर-आईएचबीटी में समारोह में मुख्यातिथि ने बढ़ाया हौसला

सीएसआईआर में अंतरराष्ट्रीय विज्ञान समारोह

पहाड़ी नस्ल की गऊओं पर शोध को केंद्रित करे वैज्ञानिक : गिरिराज

देश में पहली बार होगी हींग की पैदावार

हिमाचल की पहाड़ियों में मिला कैंसर की दवा का एंजाइम

ाष्ट्रीय उद्यमशीलता पुरस्कार पर कार्यशाला आयोजित

युवा उद्यमी बनने के लिए आगे आएं

पालमपुर: सी.एम. स्टार्टअप योजना के अंतर्गत आयोजित
में भाग लेते छात्र।

पालमपुर, 12 सितम्बर (भृगु): आई.एच.बी.टी. पालमपुर ने
प्रदेश सरकार के उद्योग विभाग के सहयोग से अपने परिसर में
सैंसिटाइजेशन एंड आइडियाशन पर कार्यशाला का आयोजन
सी.एम. स्टार्टअप योजना के माध्यम से स्टार्टअप संस्कृति कं
देने के लिए राज्य सरकार द्वारा दिए गए प्रोत्साहनों पर युवा नव
और उद्यमियों को संवेदनशील बनाने के उद्देश्य से इस कार्य
आयोजन किया गया था। कार्यक्रम का उद्घाटन करते हुए सी.एस.अ
आई.एच.बी.टी. के निदेशक डा. संजय कुमार ने कहा कि

बच्चों को बताए शोध कार्

आई.एच.बी.टी. में जिज्ञासा कार्यक्रम का आयोजन

पालमपुर, 4 अक्तूबर (भृगु): सी.एस.आई.आर. हिमालय जैव
संपदा प्रौद्योगिकी संस्थान पालमपुर में जिज्ञासा कार्यक्रम का आयोजन
किया गया। इस कार्यक्रम में केंद्रीय विद्यालय मंडी के अलावा 9
राजकीय वरिष्ठ माध्यमिक विद्यालय पालमपुर कन्या, अवैरी, कंडबाड़ी,
बिंद्रावन, राजपुर, खलेट, बंदला, चंदपुर तथा बनूरी के 450 छात्रों तथा
शिक्षकों ने भाग लिया। इस उपलक्ष्य पर आए हुए छात्रों और शिक्षकं
ने सी.एस.आई.आर. आई.एच.बी.टी. की विभिन्न प्रयोगशालाओं क
भ्रमण किया तथा वैज्ञानिकों और शोधार्थियों से विज्ञान संबंधित वार्तालाप
किया। इस अवसर पर मिसाइल वैज्ञानिक व वर्तमान में सचिव, केय
फाउंडेशन, हैदराबाद के प्रो.अरुण तिवारी ने छात्रों व उनके शिक्षकं
के साथ वार्तालाप किया और जीवन के लक्ष्यों को हासिल करने वे
स अवसर पर संस्थान के निदेशव
कों को संबोधित करते हुए का
रित करके उसको हासिल करं

उत्तराखंड में औषधीय व सुगंधित फसलों की कृषि को बढ़ावा देगा आई.एच.बी.टी.

पालमपुर, 26 अक्तूबर (भृगु): सी.एस.आई.आर. आई.एच.बी.टी. पालमपुर ने उत्तराखंड राज्य में लोगों की आजीविका के लिए

पालमपुर : औषधीय और सुगंधित फसलों की खेती को बढ़ावा देने के लिए आई.एच.बी.टी. व ए.बी.ए.ए.आर. के प्रतिनिधि एम.ओ.यू. का आदान-प्रदान करते हुए।

आई.एच.बी.टी. में स्थापित होगा टैक्नोलॉजी बिजीनैस इंक्यूबेटर

सगंध फसलों को व्यावसायिक स्तर पर उगाएं किसान

पालमपुर, 2 नवम्बर (भृगु): सी.एस.आई.आर. हिमालय जैव संपदा प्रौद्योगिकी संस्थान पालमपुर ने 31 अक्तूबर से 1 नवम्बर को सी.एस.आई.आर. अरोमा मिशन के अंतर्गत हिमाचल प्रदेश एवं जम्मू-कश्मीर के प्रगतिशील किसानों के लिए 2 दिवसीय जागरूकता शिविर का आयोजन किया। इन जागरूकता शिविरों में मंडी जिला एवं जम्मू-कश्मीर के रेयासी जिला के लगभग 60 किसानों ने भाग लिया। संस्थान के निदेशक डा. संजय कुमार ने किसानों से आह्वान किया कि वे सगंध

Event on cultivation of apple variety

Palampur: A capacity-buildir
programme on the cultivat
of low-chilling varieties of a
and their post-harvest mar
agement, organised by the
CSIR-Institute of Himalayar
Bioresource Technology,
Palampur, for Northeastern
Region Community Resour
Management Project (NER
CORMP) Communities, cor
ay.
g farmers
RCORMP
nt. Partici
onstrated
of low-chi

जंगली गेंदे की फसल की सफलतापूर्वक खेती करने के लिए 16 किसानों का समूह सम्मानित

ट्रांसलेशनल रिसर्च विषय पर लगाया सैमीनार

प्राकृतिक संसाधनों के अत्यधिक दोहन से उभरीं अनेक समस्याए

आई.एच.बी.टी. का स्थापना समारोह आयोजित

ौद्योगिकी संस्थान में आयोजित स्थापना दिवस समारो

Farmers trained to cultivate aromatic crops

OUR CORRESPONDENT

PALAMPUR, DECEMBER 28
Tribal farmers from West Kameng, West Siang and Tawang districts of Arunachal Pradesh visited CSIR-IHBT, Palampur, for a two-day awareness-cum-training programme on the process and technologies to cultivate aromatic crops under CSIR's Aroma Mission.

The farmers were imparted training on the process to cultivate various vari-
ies, including damask
se, wild marigold, rose-
ary, Valeriana jatamansi
d Matricaria chamomilla.
Rakesh Kumar, principal
ientist-cum-training pro-
amme organiser, said the
rmers were imparted
actical exposure on field
eparation and manage-
ent of nursery, nutrients,
ed, insect, pest and dis-
se and post harvest man-
ement of aromatic crops.
e crops have a huge
tential in the world mar-
t as the essential oils
tained from these are
ed in perfumes, fra-

New technology to increase shelf-life of fruits, veggies

'Lifelisation' technology retains nutritional value of fruits

CM visits CSIR at Palampur

सी.एस.आई.आर-आई.एच.बी.टी. में हिंदी सप्ताह समारोह संपन्न

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

CSIR-IHBT
1983

परिकल्पनाः जैवार्थिकी के उन्नयन हेतु प्रौद्योगिकीय उद्भवता एवं विकास में हिमालयी जैवसंपदा के संपोषणीय उपयोग द्वारा विश्व स्तर पर अग्रणी होना

Vision: To be a global leader on technologies for boosting bioeconomy through sustainable utilization of Himalayan bioresources

उद्देश्यः सर्वोत्कृष्ट विज्ञान एवं प्रौद्योगिकी द्वारा हिमालयी जैवसंपदा से प्रक्रमों और उत्पादों की खोज, विकास एवं व्यवसायीकरण

Mision: To discover, develop and commercialize processes and products from Himalayan bioresources using cutting edge science and technology

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