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वार्षिक प्रतिवेदन
Annual Report
2019-20

हींग: भारत में पहली पहल
Asafoetida: The First Initiative in India

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

संस्थान गान

हे हिमालय हम तेरे, हैं प्रबुद्ध अन्वेषी।

हे हिमालय हम तेरे, हैं प्रबुद्ध अन्वेषी।
जैव सम्पदा को तेरी, सुरक्षित करते जाएंगे।।

प्रौद्योगिकी से हम तेरी, वैभवता बढ़ाएंगे।
अनुसंधान से जग में, अर्थ विकास करायेंगे।
अर्थ विकास करायेंगे।।

हिम आचंल में तेरे, प्रगति कर दिखलायेंगे।
ज्ञान से अज्ञान तिमिर, हम मिटाते जाएंगे।
हम मिटाते जाएंगे।।

हो समर्पित हम सभी, जन उत्थान करायेंगे।
हे हिमालय हम तुझे, भव्य बनाते जाएंगे।।

भव्य बनाते जाएंगे
भव्य बनाते जाएंगे
भव्य बनाते जाएंगे

संस्थान गान हेतु क्यूआर कोड को स्कैन करें

क्यूआर रीडर ऐप डाउनलोड करें

Scan QR Code for Institute's song

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https://www.youtube.com/watch?v=ZOh-_oXN3T0

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Annual Report 2019-20

With Best Compliments from :
Dr. Sanjay Kumar
Director

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

Published by: Dr. Sanjay Kumar
CSIR- Institute of Himalayan Bioresource Technology
Palampur (HP)-176061, India.
Phone: +91-1894-230411, Fax: +91-1894-230433
Email: director@ihbt.res.in; Web: http://ihbt.res.in

Editorial Committee: Dr. Amita Bhattacharya, Dr. Vipin Hallan,
Dr. Sanjay K. Uniyal, Dr. Gireesh Nadda,
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Mr. Sanjay Kumar, Mr. Mukhtiar Singh

Technical Support: Mr. Saurabh Sharma
Photograph and cover design: Mr. Pabitra Gain

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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 District Kangra was still a part of the State of Punjab, the state Government considered to set up the National Biological Research Institute (NBRI) at Palampur, as a constituent establishment of the Council of Scientific and Industrial Research (CSIR), an autonomous society under the Ministry of Science and Technology, Govt. of India.

In January 1966, a notification was issued by the Medical and Health Department of the Govt. of Punjab to initiate the process of acquiring land measuring about 12396 karnals for the purpose from the Holta Tea Estate at Palampur. The process of land transfer took some more time and with a turn of events followed with reorganization of the state of Punjab in September 1966 that led to merger of District Kangra with state of HP, and the issue of setting up of NBRI at Palampur lost priority, at least for some more time to come. With the passage of time, the HP Govt. allocated part of the total land earmark for creation of NBRI, to other establishments. Consequently, a smaller piece of land was left at Banuri and Holta, for the purpose for which it was acquired initially.

By 1970s, CSIR marked its presence in the state of HP when Regional Research Laboratory (RRL) Jammu set up its Extension Centre in a rented building at the Bundla Tea Estate at Palampur. The idea of setting up of an independent CSIR laboratory at Palampur picked up momentum once again. On 26 August 1978, 186.2 acres of land lying vacant that figured in the name of NBRI, was put in possession of RRL, Jammu, for the purpose of establishing the proposed research institute at Palampur.

Finally, the foundation stone of CSIR Complex Palampur was laid on July 2, 1983 by the Vice-President of CSIR and Minister of Science and Technology, Govt. of India, Prof. Nural Hasan, in the presence of the then Chief Minister of HP, DG CSIR, Dr. G.S. Sidhu and other dignitaries.

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, (HP) on October 2011.

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

Secretary DSIR & Director General, CSIR

Research Council → **Director** ← **Management Council**

R&D Areas

- Agrotechnology
- Biotechnology
- Chemical Technology
- Dietetics and Nutrition Technology
- Environmental Technology

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

Dr. Anil Kush, Chairman
Chief Executive Officer
Vittal Mallya Scientific Research Foundation,
#23, 5th Main, J.C. Industrial Layout,
Kanakapura Road,
Bangaluru - 560062

MEMBERS

Sh. Anand Chordia
Director (Technical)
Pravin Masalewale, 44,
Hadapsar Industrial Estate,
Hadapsar, Pune-411013
Maharashtra (India)

Dr. Anup Karwa
Director
Life Sciences Krishidhan
Seeds Pvt Ltd, Jalna-
431203, Maharashtra

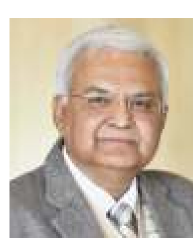
Prof. Alok Bhattacharya
Professor
School of Life Sciences,
Jawaharlal Nehru
University,
New Delhi-110067

Dr. (Mrs) Meenakshi Singh
Chief Scientist, RPPBDD
Council of Scientific &
Industrial Research
New Delhi - 110001

Dr. Ramesh V Sonti
Director
National Institute of Plant
Genome Research,
Aruna Asaf Ali Marg,
P.O. Box No. 10531, New
Delhi-110067

Dr. Saroj K Barik
Director
CSIR-National Botanical
Research Institute,
Rana Pratap Marg,
Post Box No. 436,
Lucknow - 226001

Dr. Amarinder Singh Bawa
Former Director, DFRL 103,
Begonia,
Hadapsar Industrial Estate,
Pune - 411013,
Maharashtra (India)

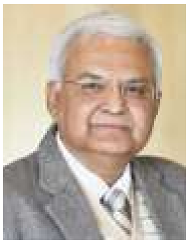


Dr. Sanjay Kumar
Director
CSIR-Institute of
Himalayan Bioresource
Technology,
Post Box 6,
Palampur-176061

58th Research Council Meeting was held at CSIR-IHBT Palampur on September 10-11, 2019

59th Research Council Meeting was held at CSIR-IHBT Palampur on March 12-13, 2020

MANAGEMENT COUNCIL



Dr. Sanjay Kumar, Chairman
Director
CSIR-Institute of Himalayan Bioresource Technology,
Palampur-176061 (H.P.)

MEMBERS

Dr. Sanjeev Khosla
Director
CSIR - Institute of Microbial Technology,
Chandigarh- 160036

Dr. Vipin Hallan
Senior Principal Scientist
CSIR-Institute of Himalayan Bioresource Technology,
Palampur – 176 061 (H.P.)

Dr. Rakesh Kumar
Senior Principal Scientist
CSIR-Institute of Himalayan Bioresource Technology,
Palampur – 176 061 (H.P.)

Dr. Sushil Kumar Maurya
Principal Scientist
CSIR-Institute of Himalayan Bioresource Technology,
Palampur – 176 061 (H.P.)

Dr. Damanpreet Singh
Senior Scientist
CSIR-Institute of Himalayan Bioresource Technology,
Palampur – 176 061 (H.P.)

Dr. Sukhjinder Singh
Senior Scientist
CSIR-Institute of Himalayan Bioresource Technology,
Palampur – 176 061 (H.P.)

Dr. Robin Joshi
Sr. Technical Officer (3)
CSIR-Institute of Himalayan Bioresource Technology,
Palampur – 176 061 (H.P.)

Sh. Satya Narayan Gulia
Finance & Accounts Officer
CSIR-Institute of Himalayan Bioresource Technology,
Palampur – 176 061 (H.P.)

Sh. Alok Sharma
Member Secretary
Administration Officer
CSIR-Institute of Himalayan Bioresource Technology,
Palampur – 176 061 (H.P.)

IMPRESSIONS

02 July 2019

Sh. Akhilesh Kumar Tyagi, Department of molecular biology, University of Delhi: “It is pleasure to visit IHBT, after some time, on foundation day. The Institute has always taken new initiatives and took them to fruitful stage. Looking at the work in basic areas of research and generation of new products of relevance to society is encouraging. IHBT has a very specific niche and is moving in the direction of broader ramifications of great scientific value. I can foresee the possibility of walking together in the area of genomics in near future. The clarity of vision and infectious enthusiasm have greatly impressed and looking forward for rewarding contribution and with best wishes.

03 July 2019

Mr. Fong-Rong Cheng, National Research Institute of Chinese Medicine, Taiwan: “It is great visit to IHBT”. We appreciate from bottom of our hearts. We do believe we will have fruitful cooperation in the near future.

Wonderful place! Wonderful people!

04 July 2019

Dr. P.K. Agrawal, Vice Chancellor, Odisha University of Agriculture and Technology, Bhubneshwar: “Staying in the sabbatical guest house is a wonderful experience”. The guest house is well planned and very carefully maintained. The staff is very caring. I visited IHBT after almost 18 years. A great change, with more laurels and beautiful campus. I congratulate the Director and Staff of IHBT. All the best to the institute, much more to add in future.

04 July 2019

Dr. K.V. Prasad, Director, ICAR-Directorate of Floricultural Research, CoA, Pune: “Delighted to see the state of the art research facilities”. Had a productive discussion with floriculture, food and nutraceutical, group members besides those working on natural pigments. Look forward for mutually rewarding projects with ICAR-DFR. Amazed to test a wide array of nutri food developed using the best technologies. Oxy rich environment of the campus, entering surrounding snow-capped mountains certainty detox individuals and I am not exception. Three kudos of to team-IHBT for the spectacular work under the able and dynamic leadership of Director Dr. Sanjay Kumar.

05 July 2019

Dr. Purnima Sharma, Managing Director, Biotech Cooperation India Limited: “I had a very enriching experience both at professional and personal levels”. I am highly impressed with the high quality technological leads developed by the various departments as well as the state of art infrastructure. I congratulate the excellent scientist and very able Director Dr. Sanjay Kumar for the proactive initiatives in technology transfer and communications and look forward to close and fruitful association in strengthening technology transfer initiatives.

07 July 2019

Prof. B C Goswami, Vice Chancellor, Cotton University, Guwahati: “Impressed with the works of dedicated scientists staff & research scholar and well maintained infrastructure. A portion of bioresources has been transformed into value added products through R&D pilot projects most of them have been taken up by entrepreneurs & the products are well accepted by the consumers. I congratulate the present Director and best wishes for the present & future endeavours.

11 September 2019

Dr. Anil Khush, Bangalore: “One of the best research institute with facilities, zeal and ambience to deliver”. Congratulations to the director, leadership team and all members of IHBT family. Sky is not the limit!

11 September 2019

Mr. Naveen Sharma, Bangalore Life Science Cluster, NCBS, Bangalore: “This was my first visit to the institute and got to know wide areas of scientific research being done here”. Liked the spirit of young scientist who are thinking about science beyond laboratories. Would definitely keep an eye on the progress of the projects.

11 September 2019

Dr. Ramesh Sonti, NIPGER, New Delhi: “IHBT is doing excellent work on characterizing and utilizing bioresources in the Himalayan region”. The team work in the institute is to be commanded greatly. The ambience for science is excellent. The faculty are knowledgeable, students are enthusiastic and are ably led by the Director. I wish IHBT all the very best as its strives to achieve greater glory to itself and to CSIR.

17 September 2019

Prof. T. P. Singh, AIIMS New Delhi: “This was my first visit to IHBT and second to Palampur”. I have gone around to see the facilities and interacted with scientists. I was so impressed to learn about some very exiting research result, several very valuable products and original and novel plant breeds. The approach here present are complete scientific programme from raw material to final products. The work on enzyme and phytochemical is of very high standard. Director Dr. Sanjay Kumar leading this lab most admirably. I Consider his contribution of the highest standard in the country.

21 September 2019

Dr. Ch Mohan Rao, CSIR-Distinguished Scientist, Former Director, CCMB, Hyderabad: “Beautiful environment with highly motivated and outstanding scientific community make this place an ideal place for intellectual development”. The facilities and the quality of research has improved significantly over the years. Planning and implementation of many programme, specially during last few year, have make IHBT a most visit able laboratory. I am impressed with the high quality science with the high quality science with sensitivity for socioeconomic need of our country. I wish the laboratory and the Director Dr. Sanjay Kumar, very best their future endeavour.

21 September 2019

Prof. S. P. Gautam, Former Chairman, CPCB: “Wonderful ambiance, very comprehensive integrated approach adopted to achieve the science for societal cause”. Leadership is very distinct.

25 September 2019

Dr. P.G. Raw, Former Director, CSIR-NEIST, and Currently DS, CSIR: "The director of the institute and his team needs appreciation for creating and maintaining of facility for creativity for the benefit of intellectual output, which is helping our nation, in particular rural areas with scientific approach. The scientific output and team work is excellent. The infrastructure is excellent. The guest house, an important item of the institute is managed excellently. Overall the approach and work culture of the people here in commendable. I wish all success to team IHBT under the leadership of Dr. Sanjay Kumar, Director.

26 September 2019

Mr. V. Prakash, FRSC, Former Director of CFTRI and Distinguished Scientist of CSIR, Founder & Hon. Chair. of IFRIFANS, Mysore and Vice President of International Union of Nutritional Sciences: "This is the great day to visit IHBT being CSIR foundation day and matters me more proud to delivered the address on this day of IHBT. CSIR-IHBT is anonymous with Himalayans. In expressing a sense of gratitude to the founders of the institute, the present director Dr. Sanjay Kumar has transformed the institute into a scientific citadel of learning placed was informality, excellent scientists and their projects and the other engaged youngster. The institution has huge potential and is going to be one of the Kohinoor of CSIR chain and the necklace of activity. The scientific culture is very high and the guest house is indeed immaculately maintained into its eco merging with nature. I wish all the best to the institute and love to be back here sooner.

21 November 2019

Dr. Girish Sahni, Former Director General, CSIR: "This excellent institute has grand plane for both fundamental and traditional research. It is delivering real value! Best Wishes!

21 December 2019

Mr. Henry Ho-Hsien Chen: "IHBT is of a research excellence, I have never seen super scientist, staff that make IHBT great institute. A beautiful campus nice and friendly people I met. A very good service and hospitality of the guest house that provided to us. I appreciate the leadership by the Director, Dr. Sanjay Kumar Ji. I have seen the hardworking of these elites. I salute you!

21 December 2019

Mr. Aaron Fang-Rong Chang: "I am very happy to visit again! One of the best place in the world for not only research but also wonderful people and nature"! Thank you very much IHBT!

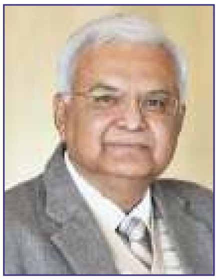
29 February 2020

Dr. Shrinivas V Kaveri, CNRS, French Embassy: "A memorable experience. A hidden treasure in the Himalayas". I am extremely overwhelmed with the quality of scientific work that is being carried out in IHBT. The institute offers remarkable facilities with the state of art infrastructure in several domains of research ranging for improved biotechnological approaches, nanotechnology, natural product chemistry to explore the medicinal value of plants in the Himalayan region to the most sophisticated technologies including protein chemistry, vascular biology, remote sensing for biodiversity and others. The young and dynamic team of scientist are highly motivated by able leadership of the director Dr. Sanjay Kumar. All the best!

14 March 2020

Dr. Pradeep Kumar Singh, Director, CSIR-Central Institute of Mining and Fuel Research, Dhanbad: “This is my first visit to the IHBT Palampur”. I congratulate Dr. Sanjay Kumar and his team to make the IHBT a leading a institution of the country. The leadership is in the place and has created beautiful ambience, modern infrastructure and focused translational research. All the best to this great institute.

FROM THE DIRECTOR'S DESK



I am delighted to present a report for the year 2019-20, and to share that the institute holds 9th position among 38 institutes of CSIR according to SCImago institutional ranking. It is now 37 years since establishment of CSIR-IHBT, and the year marks a significant increase in the number of scientists to 54 by March, 2020, from 41 till August, 2019. During the report year,130 research papers were published in peer reviewed journals with highest impact factor touching 8.649, 45 patents were filed, 13 technologies were transferred to entrepreneurs, incubation of 14 start-ups took place and 100 MoUs/MTAs were signed by our institute. Internationally, CSIR-IHBT signed MoU with the National Research Institute of Chinese Medicine (NRICM, Taiwan) to work in the area of traditional system of medicine of the two countries.

In context to COVID-19 pandemic, the institute started to realign for COVID-19 testing, and strengthened its ready-to-eat food technology that served the entrapped migrant labourers and corona warriors with nutritious food. Also, technologies for hand sanitizer and the SDS-SLS free soap were transferred to several entrepreneurs for its large scale production.

The year also witnessed extension of agrotechnologies related to aroma and spice industries in the newly developed Union Territory of Ladakh.

During the year, CSIR-IHBT became a member of the "Indian Himalayan Central Universities Consortium" as approved by The National Institution for Transforming India (NITI Aayog). Our responsibility would be to offer relevant technologies to these universities to solve the societal issues using scientific interventions and create an environment of entrepreneurship development.

CSIR-IHBT has been identified as a “Bioresource Information Centre for floral resources of Western Himalaya” under the Indian Bioresource Information Network initiative of the Department of Biotechnology, GoI. During the year, 300 wild edible plants of western Himalaya were studied for their taxonomical, ecological and utility functions.

Also, under “National Mission on Himalayan Studies”–an initiative of the Ministry of Environment, Forest and Climate Change we have been entrusted upon the responsibility to co-ordinate a project on reviving threatened tree species in the Himalayan region. With CSIR-IHBT in the lead role, four Institutes are involved in the project-The HP Forest

Department, Himalayan Forest Research Institute, and Dr. YS Parmar University of Horticulture and Forestry, Solan (HP).

In recent past, we had taken up to address three societal issues (i) vegan source of vitamin D (ii) degradation of night soil under cold environment and (iii) absence of value chain for floriculturist. I am happy to share thata unique initiative have been undertaken in collaboration with Ministry of Micro, Small & Medium Enterprises (MoMSME) under the Scheme of Fund for Regeneration of Traditional Industries (SFURTI) to generate sustainable livelihood forthe rural population by assisting them with advanced technologies and requisite equipments. Technologies to address the above three issues were selected by MoMSME to establish clusters (co-operative societies) in rural areas.

With CSIR-IHBT as a Technical Agency, and Khadi and Village Industries Commission (KVIC) & Foundation of MSME Clusters (FMC) as nodal agencies, these activities are now in the hands of >1500 persons grouped in 7 cluster across the state of Himachal Pradesh and North Eastern states. These activities have a support of Rs. 14.75 crores from MoMSME. Extension of our technologies in the North Eastwas also sought by "North Eastern Region Community Resource Management Project (NERCOMP)"for which a MoU agreement was signed on 1st September, 2018. Realising the successful performance of low chilling verities of apple in Mizoram, these were also introduced in the states of Manipur and Meghalaya during the current years.

National gap analysis carried out recently suggested that the country imports about (i) 1100 tonnes of asafoetida (*Heeng*) and (ii) 90 tonnes of saffron per year. Working to address the issue, the institute procured quality planting material and developed agrotechnologies for production of asafoetida, and the rate limiting bulb production technology for saffron. The State Govt. also appreciated our work on bamboo and funded the institute for bamboo research and development, including skill-development and development of a high tech nursery for mass propagation of bamboos. I am happy to share that State Government sanctioned to the institute Rs. 10.13 crores for the purpose.

Himachal Pradesh is now the highest producer of wild marigold oil in the country with 6.49 tonnes of oil produced by local farmers; a step towards self reliant India (आत्मनिर्भरभारत). This could be possible due to Aroma Mission of CSIR that was launched in the year 2017 under which our institute played a significant role by providing improved varieties of Tagetesto the farmers, imparting training for production and processing for generating quality produce, and finally linking the farmers with the market. During the year, the area under wild marigold, damask rose, Indian valerian and lemongrass was extended to 538 ha in ten states and two union territories in the country. Fifty distillation units were set up in the farmers' fields for extraction of essential oils in Himachal Pradesh, Mizoram, Sikkim, Uttarakhand, Odisha, Punjab, Haryana, Uttar Pradesh, Chhattisgarh and union territories of Jammu & Kashmir and Ladakh.

During the current year, 5 varieties of aromatic crops *viz*., *Him Basant* (damask rose), *Him Surbhit* (Indian valerian), *Him Sugandh* (white dragonhead), *Him Devsugandh* (sea wormwood) and *Him Swarnima* (wild marigold), having higher biomass/flower yield and essential oil content were releasedby the Hon'ble Governor of HP, Shri Bandaru Dattatreya on 3rd March, 2020. On this occasion, five new varieties of chrysanthemum (*Him Aditya*, *Him Pushkar*, *Him Shikhar*, *Him Ujjwala* and *Him Shringar*) having novel flower colours and shapes were also released.

Under the social responsibility, ~55 tonnes of ready-to-eat canned foods, and energy &protein bars were supplied for the distribution to the victims of FANI cyclone-hit areas of Odisha.

Like previous years, research scholars of the institute organised 3rd Student Seminar Series on 5th September 2019 on the theme "Science for society: targeting the unmet demands of the nation"**.** The event celebrated with great fervour included scientific presentations, a photography competition and popular science writing contest. Presence of Dr. Shekhar C. Mande, Hon'ble DG, CSIR and Secretary, DSIR duringthe function motivated students and the staff for further advancement in the coming year.

Various other activities were also organized at CSIR-IHBT under the JIGYASA -the student scientist connect programme, under which about 2075 school students and their teachers participated. Besides, scientists of the institute visited different schools and delivered popular scientific talks to motivate students towards science and technology under the outreach programme. In addition to this, 1200 college/ university students and teachers from different states of the country visited CSIR-IHBT.

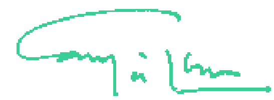
Skill development programs in the areas of apiculture, plant tissue culture, hydroponics & aeroponics, essential oil distillation, floriculture & landscaping, and plant nursery management, trained 1213 trainees under CSIR Integrated Skill Initiative, DBT sponsored "Advance Diploma in Plant Tissue Culture", and state sponsored Skill Vigyan Programmes. About 159 UG/PG/Ph.D. students from different educational and research institutes across the country visited CSIR-IHBT, and were provided laboratory training.

Technology development as been CSIR mandate. In consultation with Research Council of the institute, departments were organised as Agrotechnology, Biotechnology, Chemical Technology, Dietetics and Nutrition Technology, and Environmental Technology to help prioritizing the focus and alignment of the institute with CSIR goal.

The year witnessed a fresh focus on upgrading/ improving the general facilities within the institute. Encompassing this, new activities were initiated that included construction of bridge and concrete road network, improvement in entrance gate of the institute, installation of roof top solar power plant, steel bridge and covered paths connecting (i) scholar hostel and (ii) canteen area with the main building, a multipurpose hall, and new construction of type-V, IV and III staff quarters (16 numbers). Also foundation stones of a 120-room scholar hostel and Enzyme Bioprocessing Unit were laid by the Hon'ble Governor HP and Hon'ble DG, CSIR and secretary DSIR, respectively. Also, the existing buildings of the institute were renamed to honour the four former directors of CSIR-IHBT.

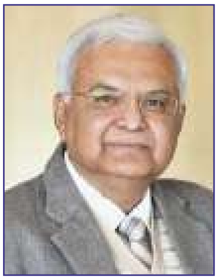
The Research Council played a vital and positive role in guiding the R&D programme of the institute. Excellent support of CSIR-headquarters, Management Council, and various funding agencies continued to motivate us for achieving scientific excellence, developing newer technologies and entrepreneurships, and discharging social/national responsibilities. We pledge to rededicate ourselves to meet the challenges of industry, society and the environment.

Jai Hind!



(Sanjay Kumar)

निदेशकीय प्रतिवेदन



मुझे संस्थान के 2019–20 के वार्षिक प्रतिवेदन को प्रस्तुत करते हुए तथा यह सूचित करते हुए अत्यंत हर्ष हो रहा है कि शिमेगो संस्थागत रैंकिंग में हमारे संस्थान को सीएसआईआर के 38 संस्थानों में से 9वां स्थान प्राप्त हुआ है। सीएसआईआर–आईएचबीटी को स्थापित हुए अब 37 वर्ष हो गए हैं। इस अवधि के दौरान जहां अगस्त 2019 में संस्थान में 41 वैज्ञानिक कार्यरत थे, अब उनकी संख्या मार्च, 2020 में बढ़कर 54 हो गई है। वर्ष के दौरान, अधिकतम 8.649 इम्पैक्ट फैक्टर सहित प्रतिष्ठित उच्च प्रभाव वाली अन्तर्राष्ट्रीय पत्रिकाओं में 130 शोध पत्र प्रकाशित हुए, 45 पेटेंट दर्ज किए गए, 13 प्रौद्योगिकियॉं उद्यमियों को हस्तांतरित की गईं, 14 स्टार्ट–अप को इन्क्यूबेट किया और 100 समझौता ज्ञापन/ सामग्री हस्तांतरण करार (एमटीए) पर हस्ताक्षर किए गए। अंतर्राष्ट्रीय स्तर पर सीएसआईआर–आईएचबीटी ने पारंपरिक चिकित्सा पद्धति के क्षेत्र में नेशनल रिसर्च इंस्टीट्यूट ऑफ चाइनीज मेडिसिन (एनआरआईसीएम, ताइवान) के साथ समझौता ज्ञापन किया।

कोविड–19 महामारी के संदर्भ में, संस्थान ने परीक्षण शुरू कर दिए हैं और अपने रेडी टू ईट खाद्य प्रौद्योगिकी को सुदृढ़ करते हुए पोषक तत्वों से भरपूर भोजन प्रवासी मजदूरों और कोरोना योद्धाओं को उपलब्ध कराया। इसके अतिरिक्त, हैंड सैनिटाइजर और एसडीएस–एसएलएस रहित हर्बल साबुन निर्माण की प्रौद्योगिकियों का बड़े पैमाने पर उत्पादन करने के लिए कई उद्यमियों को हस्तांतरित भी किया गया।

इस वर्ष भी नव गठित केंद्र शासित प्रदेश लद्दाख में सुगंध और मसाला उद्योगों से संबंधित कृषि प्रौद्योगिकी का विस्तार किया गया।

वर्ष के दौरान, सीएसआईआर–आईएचबीटी नीति आयोग (नेशनल इंस्टीट्यूशन फॉर ट्रांसफॉर्मिंग इंडिया) द्वारा अनुमोदित 'भारतीय हिमालयन सेंट्रल यूनिवर्सिटीज कंसोर्टियम' का सदस्य बन गया। एक सदस्य के रूप में संस्थान का दायित्व इन विश्वविद्यालयों को वैज्ञानिक पहल के माध्यम से सामाजिक मुद्दों को हल करने हेतु प्रासंगिक प्रौद्योगिकियॉं उपलब्ध कराना और उद्यमिता विकास का वातावरण तैयार करने का होगा।

जैव प्रौद्योगिकी विभाग, भारत सरकार की भारतीय जैवसंपदा सूचना नेटवर्क पहल के अन्तर्गत सीएसआईआर–आईएचबीटी को पश्चिमी हिमालय की पुष्पीय संपदा के लिए जैवसंपदा सूचना केन्द्र के रूप में चुना गया है। इस वर्ष के दौरान, पश्चिमी हिमालय के 300 जंगली खाद्य पौधों का उनके वर्गीकरण, पारिस्थितिकी और उपयोगिता के लिए अध्ययन किया गया।

इसके अतिरिक्त, पर्यावरण, वन और जलवायु परिवर्तन मंत्रालय की एक पहल 'नेशनल मिशन ऑन

हिमालयन स्टडीज' के अंतर्गत संस्थान को हिमालयी क्षेत्र में संकटापन्न प्रजातियों के संरक्षण हेतु एक परियोजना के समन्वय का दायित्व प्राप्त हुआ है। इस परियोजना में सीएसआईआर–आईएचबीटी प्रमुख भूमिका में है तथा हिमाचल प्रदेश का वन विभाग, हिमालयन वन अनुसंधान संस्थान, शिमला, डा. वाई एस परमार औद्यानिकी एवं वानिकी विश्वविद्यालय, सोलन (हि.प्र.) भी इसमें शामिल हैं।

पिछले कुछ समय से, हमने तीन सामाजिक मुद्दों (i) विटामिन डी के शाकाहारी स्रोत (ii) शीत वातावरण में नाईट सॉयल के क्षरण और (iii) पुष्प उत्पादकों हेतु उचित विपणन व्यवस्था पर कार्य को प्रारम्भ किया है। मुझे यह बताते हुए हर्ष हो रहा है कि संस्थान ने पारंपरिक उद्योग संपोषण कोष योजना (स्फूर्ति) के अन्तर्गत सूक्ष्म, लघु और मध्यम उद्यम मंत्रालय (एमओएमएसएमई) के सहयोग से उन्नत प्रौद्योगिकियों और अत्यावश्यक उपकरणों को उपलब्ध कराकर ग्रामीण जनसमुदाय की सतत आजीविका के लिए एक अनूठी पहल की है। सूक्ष्म, लघु और मध्यम उद्यम मंत्रालय (एमओएमएसएमई) द्वारा उपरोक्त तीन मुद्दों के हल करने के लिए ग्रामीण क्षेत्रों में समूहों (सहकारी समितियों) की स्थापना करने के लिए उपयुक्त प्रौद्योगिकियों का चयन कर लिया गया है।

एक तकनीकी एजेंसी के रूप में सीएसआईआर–आईएचबीटी तथा नोडल एजेंसियों के रूप में खादी और ग्रामोद्योग आयोग (केवीआईसी) एवं एमएसएमई फाउंडेशन कलस्टर (एफएमसी) की इन गतिविधियों के साथ अब हिमाचल प्रदेश और उत्तर पूर्वी राज्यों के 7 क्लस्टर में 1500 से अधिक व्यक्ति समूहों से जुड़े हैं। सूक्ष्म, लघु और मध्यम उद्यम मंत्रालय (एमओएमएसएमई) से इसके लिए 14.75 करोड़ रुपये की धनराशि का सहयोग मिला है। 'उत्तर पूर्वी क्षेत्र सामुदायिक संसाधन प्रबंधन परियोजना (NERCOMP)' ने संस्थान द्वारा विकसित प्रौद्योगिकियों का उत्तर पूर्वी क्षेत्र में विस्तार करने लिए सहयोग चाहा है, जिसके लिए 1 सितंबर, 2018 को एक समझौता ज्ञापन पर हस्ताक्षर किए गए हैं। मिजोरम में सेब की लो–चिलिंग किस्म की सफलता को देखते हुए, इस वर्ष के दौरान मणिपुर और मेघालय राज्यों में भी इस फसल को लगाने की पहल की गई।

हाल ही में किए गए राष्ट्रीय विश्लेषण से पता चला कि हमारा देश प्रति वर्ष लगभग 1100 टन (हींग) और 90 टन केसर का आयात करता है। इन मुद्दे को हल करने के लिए, संस्थान ने गुणवत्ता रोपण सामग्री की खरीद करके हींग के उत्पादन के लिए कृषि प्रौद्योगिकी और केसर के लिए बल्ब उत्पादन तकनीक को विकसित किया है। राज्य सरकार ने बांस पर हमारे कार्य को सराहा और बांस अनुसंधान और विकास के लिए संस्थान को वित्त पोषित भी किया, जिसमें बांस के बड़े पैमाने पर प्रसार के लिए एक उच्च स्तरीय पौधशाला निर्माण एवं कौशल–विकास कार्यक्रम शामिल हैं। मुझे यह बताते हुए अत्यन्त हर्ष हो रहा है कि राज्य सरकार ने संस्थान को उक्त प्रयोजनों के लिए 10.13 करोड़ स्वीकृत किए हैं।

स्थानीय किसानों द्वारा 6.49 टन जंगली गेंदे के तेल उत्पादन के साथ हिमाचल प्रदेश अब भारत का सर्वाधिक सगंध तेल उत्पादक राज्य बन गया है। यह

'आत्मनिर्भर भारत' की दिशा में एक सार्थक कदम है और यह वर्ष 2017 में प्रारंभ किए गए 'अरोमा मिशन' के कारण ही संभव हो सका, जिसके अन्तर्गत हमारे संस्थान ने किसानों को टैजेटिस (जंगली गेंदे) की उन्नत किस्मों की रोपण सामग्री, गुणवत्तायुक्त फसल प्राप्ति, उत्पादन एवं प्रसंस्करण तकनीक का प्रशिक्षण प्रदान करके और किसानों को फसल/उत्पाद के विपणन के लिए बाजार से जोड़ने में महत्वपूर्ण भूमिका निभाई है। वर्ष के दौरान, जंगली गेंदा, दमस्क गुलाब, भारतीय वेलेरियन और लेमनग्रास जैसी सुगंधित फसलों का दस राज्यों और दो केंद्र शासित प्रदेशों के 538 हेक्टेयर क्षेत्र में विस्तार किया गया। हिमाचल प्रदेश, मिजोरम, सिक्किम, उत्तराखंड, ओडिशा, पंजाब, हरियाणा, उत्तर प्रदेश, छत्तीसगढ़ और दो केंद्र शासित प्रदेशों जम्मू–कश्मीर और लद्दाख में सगंध तेलों के निष्कर्षण के लिए पचास आसवन इकाइयां स्थापित की गईं।

इस वर्ष के दौरान उच्च बायोमास/फूलों की उपज एवं तेल सामग्री युक्त विकसित सगंध फसलों की पांच किस्मों, हिम बसंत (दमस्क गुलाब), हिम सुरभित (भारतीय वेलेरियन), हिम सुगंध (व्हाइट ड्रैगनहेड), हिम देवसुगंध (सी वर्मवुड) और हिम स्वर्णिमा (जंगली गेंदा) को हिमाचल प्रदेश के माननीय राज्यपाल श्री बंडारू दत्तात्रेय ने 3 मार्च, 2020 को विमोचित किया। इस अवसर पर नवीन पुष्प रंगों और आकृतियों युक्त पांच प्रकार के गुलदाउदी किस्मों (हिम आदित्य, हिम पुष्कर, हिम शिखर, हिम उज्जवला और हिम श्रृंगार) को भी विमोचित किया।

सामाजिक दायित्व के अंतर्गत संस्थान द्वारा ओड़िशा के फानी चक्रवात प्रभावित क्षेत्रों के पीड़ितों को वितरण के लिए 55 टन रेडी–टू–ईट डिब्बा बंद खाद्य पदार्थ सामग्री और एनर्जी एवं प्रोटीन बार की आपूर्ति की गई।

पिछले वर्षों की भांति, संस्थान के शोधार्थियों ने 5 सितंबर 2019 को 'समाज के लिए विज्ञानः राष्ट्र की अधूरी अपेक्षाओं की लक्ष्य साधना' विषय पर तीसरी छात्र संगोष्ठी श्रृंखला का आयोजन किया। हर्षोल्लास के साथ आयोजित इस समारोह में वैज्ञानिक प्रस्तुतियां, एक फोटोग्राफी प्रतियोगिता और लोकप्रिय विज्ञान लेखन प्रतियोगिता का आयोजन किया गया। समारोह में डॉ. शेखर सी. मांडे, माननीय महानिदेशक, सीएसआईआर और सचिव, डीएसआईआर की गरिमामयी उपस्थिति ने छात्रों और स्टाफ को आने वाले वर्षों में इन आयोजनों में ओर अधिक उत्कृष्टता लाने के लिए प्रेरित किया।

सीएसआईआर–आइर्चबीटी में छात्र वैज्ञानिक संपर्क 'जिज्ञासा कार्यक्रम' के अन्तर्गत विभिन्न गतिविधियों का भी आयोजन किया गया, जिसमें 2075 स्कूली छात्रों और उनके शिक्षकों ने प्रतिभागिता की। इसके अतिरिक्त आउटरीच कार्यक्रम के अंतर्गत संस्थान के वैज्ञानिकों ने विभिन्न स्कूलों में जाकर विज्ञान और प्रौद्योगिकी के प्रति छात्रों को प्रेरित करने के लिए लोकप्रिय वैज्ञानिक वार्ताओं का प्रस्तुतिकरण किया। इसके साथ ही देश के विभिन्न राज्यों के कॉलेजों/विश्वविद्यालयों के 1200 छात्रों और शिक्षकों ने सीएसआईआर–आईएचबीटी का शैक्षणिक भ्रमण भी किया।

सीएसआईआर एकीकृत कौशल पहल, जैवप्रौद्योगिकी विभाग, भारत सरकार द्वारा प्रायोजित 'पादप उत्तक संवर्धन में उच्च स्तरीय डिप्लोमा और राज्य सरकार

द्वारा प्रायोजित कौशल विज्ञान कार्यक्रम के अन्तर्गत मधुमक्खी पालन, पादप उत्तक संवर्धन, हाइड्रोपोनिक्स एवं एरोपोनिक्स, सगंध तेल आसवन, पुष्पखेती एवं भू–दृश्य तथा पौधशाला प्रबन्धन के क्षेत्रों में कौशल विकास कार्यक्रमों के माध्यम से 1213 प्रशिक्षणार्थियों को प्रशिक्षित किया गया। देश भर के विभिन्न शैक्षणिक और अनुसंधान संस्थानों के लगभग 159 स्नातक / स्नातकोत्तर / पीएचडी छात्रों को सीएसआईआर–आईएचबीटी में प्रयोगशाला प्रशिक्षण प्रदान किया गया।

प्रौद्योगिकी विकास सीएसआईआर का ध्येय रहा है। संस्थान की अनुसंधान परिषद के परामर्श से अपनी शोध गतिविधियों को सीएसआईआर के लक्ष्यों के साथ समन्वित करने के लिए विभागों को कृषि प्रौद्योगिकी, जैव प्रौद्योगिकी, रासायनिक प्रौद्योगिकी, आहारिकी और पोषण प्रौद्योगिकी और पर्यावरण प्रौद्योगिकी के रूप में वर्गीकृत / पुनर्गठित किया गया।

इस वर्ष संस्थान में सामान्य सुविधाओं के उन्नयन / सुधार पर ध्यान केंद्रित किया गया। नई गतिविधियाँ शुरू की गईं जिनमें पुल और कंक्रीट मार्ग का निर्माण, संस्थान के प्रवेश द्वार में सुधार, रूफ टॉप सोलर पावर प्लांट की स्थापना, मुख्य भवन के साथ जुड़ने वाले (1) स्कॉलर हॉस्टल और (2) कैंटीन एरिया के छतयुक्त रास्ते एवं लोहे का पुल, एक बहुउद्देशीय सभाकक्ष, और टाइप–5, टाइप–4 और टाइप–3 के 16 मकानों का निर्माण शामिल हैं। माननीय राज्यपाल हिमाचल प्रदेश और माननीय महानिदेशक, सीएसआईआर एवं सचिव डीएसआईआर द्वारा क्रमशः एक 120 कमरे वाले छात्रावास और एंजाइम बायोप्रोसेसिंग यूनिट की आधारशिला रखी गई। साथ ही, संस्थान के विद्यमान भवनों का नामकरण सीएसआईआर–आइर्चबीटी के चार पूर्व निदेशकों के सम्मान में किया गया।

अनुसंधान परिषद ने संस्थान के अनुसंधान एवं विकास कार्यक्रमों को अपना मार्गदर्शन देने में एक महत्वपूर्ण और सकारात्मक / निर्णायक भूमिका निभाई है। सीएसआईआर–मुख्यालय, प्रबंध परिषद और विभिन्न वित्त पोषित एजेंसियों का बहुमूल्य सहयोग हमें वैज्ञानिक उत्कृष्टता प्राप्त करने, नई प्रौद्योगिकियों एवं उद्यमशीलता को विकसित करने तथा सामाजिक / राष्ट्रीय उत्तरदायित्वों का निर्वहन करने के लिए प्रेरित करता रहा है। हम उद्योग, समाज और पर्यावरण की चुनौतियों का सामना करने के लिए अपने आप को पुनसर्मपित करने का संकल्प भी लेते हैं।

जय हिन्द!

(संजय कुमार)

Technologies Available/ Rolled Out

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) 6,950 USD Million in 2017 expected to reach 9,500 USD Million
2.	Variant of Super Oxide Dismutase (SOD)	World Enzyme Demand (Industrial and Speciality) 6,950 USD Million in 2017 expected to reach 9,500 USD Million
3.	Phospholipase	World Enzyme Demand (Industrial and Speciality) 6,950 USD Million in 2017 expected to reach 9,500 USD 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 are of medicinal and pharmaceutical important. In India, annual medicinal plant based raw material trade is 1,28,000 tons with a value of USD 555.44 Million 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 *Arnbia euchroma*	Global Herbal Medicine Market Size is expected to reach a valuation of more than USD 129 Billion by 2023, according to the latest research report from Market Research Future (MRFR). The market is expected to exhibit a strong 5.88% CAGR over the forecast period from 2018 to 2023, according to the report.
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 USD 38.37 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.

S. No.	Title of Product/Process/Design/Equipment Developed	Market Size
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%.
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 USD 3.44 Billion 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 Mn by 2026, from more than USD 700 Mn 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™	Geographic Analysis of Distillation Systems Market. The distillation systems market is estimated to be valued at USD 6.17 Billion in 2018 and is projected to reach USD 7.91 Billion by 2023, at a CAGR of nearly 5.1% from 2018

S. No.	Title of Product/Process/Design/Equipment Developed	Market Size
17.	Mini Laminar Flow Unit - Steriflow™	The food sterilization equipment market is estimated at USD 678.8 Million in 2018 and is projected to reach USD 922.7 Million by 2023, growing at a CAGR of 6.3% during the forecast period
18.	Gel Processing and Transfer Device (GEPROTED)™	The global gel market, in terms of value, is projected to reach USD 1.96 Billion by 2026, at a CAGR of 6.9%, from 2016 to 2026
19.	iRIS™ ......an easy solution to RNA isolation	Get in-depth analysis of the COVID-19 impact on the Nucleic Acid Isolation and Purification Market. The global nucleic acid isolation and purification market is projected to reach USD 4.8 Billion by 2025 from USD 3.2 Billion in 2020, at a CAGR of 8.9% during the forecast period.
20.	Culture vessel for rooting of micro shoots	The global Cell Culture Vessels market size is expected to gain market growth in the forecast period of 2020 to 2025, with a CAGR of 5.9% in the forecast period of 2020 to 2025 and will expected to reach USD 564.2 Million by 2025, from USD 448 Million
21.	Tea Withering Machine	Asia Pacific dominated the global market in 2018 owing to presence of majority of tea producing as well as consuming markets. China, Japan, India, Indonesia, Vietnam, and Sri Lanka are major markets, besides Middle East & Africa which is also a prominent tea producing region with prominent markets including Turkey, Iran, and Kenya
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	Global Herbal Tea Market is expected to register a CAGR of 4.94% to reach USD 4,226.9 Million by 2025. Herbal teas or tisanes are caffeine-free and do not use the leaves of the *Camellia sinensis* plant. Tisanes are made using a mixture of dried leaves,

S. No.	Title of Product/Process/Design/Equipment Developed	Market Size
		seeds, grasses, nuts, barks, fruits, flowers, or other botanical elements that provide taste and various health benefits.
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)	The home care settings segment is likely to expand at the maximum CAGR between 2017 and 2025, due to rising demand for self-diagnostic test kits for virus detection
29.	Formulation of herbal incense Cones from herbs and flowers	Growing at a CAGR of 15%, it is expected to grow exponentially reaching USD 1586.98 Million 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	According to the India Brand Equity Foundation (IBEF), Government of India, the construction industry of India is anticipated to grow at a CAGR of 10.5% and is expected to reach over USD 215 Billion by 2020. The Building and Construction Authority (BCA) of Singapore, in 2018, announced the growth of USD 23.48 Million by the end of 2019. Owing to these factors, the cyclohexane market is expected to propel during the forecast period
32.	Process Development for 4-alkyl resorcinols production from 4-alkyl cyclohexane-1,3-diones	The Global Resorcinol Market is poised to grow at a CAGR of around 8.8% over the next decade to reach approximately USD 585.25 Million by 2025. Some of the prominent trends that the market is witnessing include growing adoption in wood-bonding adhesives, increasing applications in automotive industry, and rising demand from emerging countries

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 USD 1.22 Billion during 2017 and is projected to witness robust growth at a CAGR of 14.08% during 2018-23, thereby reaching USD 2.76 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 (USD 529 – USD1060 per kg) and huge market (1-10 metric tonnes per 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	The cephalosporin drugs market size is expected to witness a remarkable growth in the forecast period, owing to increasing approvals of new cephalosporin drugs. For instance, in March 2018, Allergan plc.

		announced that the U.S. Food and Drug Administration (FDA) has approved its supplemental New Drug Application (sNDA) to expand the approved use of AVYCAZ (ceftazidime and avibactam) for the treatment of hospital-acquired bacterial pneumonia.
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
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	

52. Development of New Plant

S. No.	Title of Product/Process/Design/Equipment Developed	Market Size
60.	Herbal Soap	The liquid segment is expected to register the highest CAGR of 8.4% in the organic soaps market from 2019 to 2025. The Global Organic Soap market is projected to register a CAGR of 7.2% over the forecast period (2020-2025).
61.	Hand Sanitizer	The global hand sanitizer market size valued at USD 2.7 Billion in 2019 and is expected to grow at a compound annual growth rate (CAGR) of 22.6% from 2020 to 2027. The 77.0 % population in the favor of using hand sanitizer is comprised of 37.5% male users and 62.5% of female users.
62.	Tea Vinegar	According to a new report by EMR titled, 'Global Vinegar Market Report and Forecast 2020-2025', the global vinegar market reached USD 1.30 Billion in 2019. It is further expected to grow in the forecast period of 2020-2025 at a CAGR of 1.8% to attain USD 1.45 Billion in 2025.
63.	Compost Booster	The global compost market is expected to reach an estimated USD 9.2 Billion by 2024 with a CAGR of 6.8% from 2019 to 2024. The major drivers for this market are increasing demand for organic products and growing awareness regarding disadvantages of chemical fertilizer and pesticides

TRANSFER OF TECHNOLOGIES FIVE YEARS DETAILS

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

Sixteen incubates are being facilitated to undertake the 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 207 number of agreements/MoUs were signed during last five years (2015-16 to 2019-20). These agreements/MoUs include technology transfer agreements, agreements for consultancy services, material transfer agreements, and other miscellaneous agreements/ MoUs and agreements/ MoUs signed with incubatees. Details of agreements/ MoUs signed during last five years are as below:

Year	Transfer of Technology	Consultancy	Material transfers	Misc.	Incubatees	Total
2015-16	-	1	2	-	-	**3**
2016-17	2	2	2	1	-	**7**
2017-18	4	4	8	4	9	**29**
2018-19	5	-	31	26	6	**68**
2019-20	13	2	25	46	14	**100**
Total	**24**	**9**	**68**	**77**	**29**	**207**
Average	4.80	1.80	13.60	15.40	5.80	41.40

i) **Transfer of technology during different years:** A total of 24 Agreements/ MoUs for transfer of technology were signed during the last five years. The detail is given below:

- 2016-2017: Signed agreements for transfer of 2 technologies (Ready to eat Kangri dham and Crispy fruits). In addition, MoU was signed with The Lisavenko Research Institute of Horticulture for Siberia for technical cooperation in Hippophae research.
- 2017-2018: Signed agreements for transfer of 4 technologies (Tea catechins, Nutri bar, Ready-to-eat preservative free khichdi and Extraction of steviol glycosides).
- 2018-2019: Signed agreements for transfer of 5 technologies (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 D_2 enrichment (2 Nos.).
- 2019-2020: Signed thirteen agreements for transfer of technology i.e. (i) Large scale production of Shiitake mushroom with Mr. Satish Kumar Gill, Nadaun, Hamirpur (H.P.) (ii) Commercial production of Ready to Eat (RTE) foods free from additive and

preservatives with M/s A Qube Inc., Ludhiana, Punjab (iii) Technology for commercial production of Tea Wines & RTD Tea with M/s Camelia Beverages Pvt. Ltd., New Delhi, (iv) Commercial production of Natural Soap with Mr. Sandeep Kumar and Company, Nadaun, Hamirpur (H.P.), (v) Manufacturing/ processing of Spirulina based PRODUCTS with M/s Yujo Agriculture & Aquaculture Farm Society, Meerut (U.P.), (vi) Manufacturing/ production of Tissue culture plants (gerbera, potato, *Bambusa balcoa* sp.) with M/s Pratyaksha Agrotech Private Limited, Assam, (vii) Making herbal incense cones from temple waste flowers at Mata Bala Sundari Temple Trilokpur with Deputy Commissioner-cum- Commissioner Trilokpur Temple Trust, Sirmour (H.P.), (viii) Manufacturing/ processing of Multigrain Protien powder with The Unati cooperative Marketing- cum Processing Society Ltd., Talwara, Punjab, (ix) Manufacture Granola bars - (millet and cereals based) products with M/s Sirimiri Nutrition Food Products Pvt. Ltd., Bangalore, (x) Production of natural colours and herbal lipsticks from different natural sources with M/s Nano Tech Chemical Brothers Pvt. Ltd., Village Mangarh, Ludhiana, (xi) Making Herbal incense Cones and Herbal Soap with M/s A B Scientific Solutions, Palampur (H.P.), (xii) Technology for commercial production of hand sanitizer transferred to M/s AB Scientific Pvt. Ltd., Palampur (H.P.) and (xiii) M/s Sandeep & Company, Nadaun (H.P.).

ii) Agreements for Consultancy signed: A total of 9 agreements were signed, 8 on stevia cultivation and one on mass multiplication of bamboo species, for consultancy during the last five years.

iii) Material transfers: A total of 68 material transfer agreements were signed during the last five years, as per following detail:

- 2015-2016: Virus free apple rootstock (2 No.)
- 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 No.)
- 2018-2019: Wild Marigold (3 No.), Rosemary (3 No.), Stevia (4 No.), Palmarosa crop (1 No.), Gerbera Culture (2 No.) Bamboo culture (1 No.), Damask rose Varieties "Jwala" and "HimRoz" (16 No.), RET MAPs (01 No.)
- 2019-2020: Wild Marigold (2 No.), Rosemary (5 No.), Lavender (3 No.), Lavandin (1 No.), Marjorum (1 No.), Origano (1 No.), *Ginkgo biloba* (2 No.), Stevia (7 No.), Gerbera Culture (1 No.) Damask rose (1 No.), Matricaria (01 No.), *Valeriana jatamansi* (02 No.), *Dendrocalamus asper* (02 No.), *Bambusa balcoa* (04 No.), *bambusa nutans* (01 No.), *Dendrocalamus hamiltonii* (01 No.), Kuth (01 No.), Apple scion and rootstocks (02 No.), Saffron (01 No.), Heeng (01 No.), banfsa (01 No.), chia (01 No.), hawthorn (01 No.), thyme (01 No.), Rose geranium (02 No.), Lemon grass (01 No.), Marigold (01 No.),

iv) **Miscellaneous Agreements/ MoUs**: 77 No. (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 No. (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 No. (MoUs with farmers societies for installation of distillation Unit (9 No.), MoU's with Industries for utilizing facility of CSIR IHBT for essential oil (3 No.), MoU's with societies for cultivation and rural development in Uttarakhand, Northeast States, Lahaul & Spiti and upper area of District Shimla (4 No.), agreements for production of floriculture plants using CSIR-IHBT facility (2 No.), agreement for utilizing Retort facility (1 No.) and agreements for processing of stevia leaves and conversion into stevia liquid using CSIR IHBT facility (4 No.), 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.).
- 2019-2020: Different farmer societies (33 No.), Academic and R&D collaborations with government institutes/universities (SCVB Palampur, CIAB, Mohali, RPGMC, Tanda and CSKHPKV, Palampur) (4 No.), Need based agreements for R&D sponsored by companies (M/s Baijnath Pharmaceutical Pvt. Ltd., Paprola, H.P. and SS Sujalam Suphalam Foundation, Gurgaon) (2 No.), MoU with All Mizoram Farmers Unions for livelihood promotion in Mizoram state (1 No.), MoA with KVIC to release funds under MSME SFURTI scheme (1 No.), MoU with M/s Anodyne Bio Spargyric for formulation of Electro homeopathic Medicine and monk fruit cultivation and processing technology (1 No.), MoU with National Research Institute of Chinese Medicine (NRICM) - Taiwan, to improve understanding between their respective academic institutions and to establish mutually beneficial collaborations among their academicians, scientists and students (1 No.), Agreement for 3rd party production with M/s. Mother India Organics and Naturals Pvt Ltd. for manufacturing of dehydrated Fruit bars (1 No.), Agreement extended for facility use for production of stevia liquid drops (1 No.), MoA with M/s IoTechWorld Aviation Pvt. Ltd. to collaborate and leverage on each other's expertise and knowledge base sharing to DRONE based agriculture application in India (1 No.).

v) **Agreements/ MoUs signed with Incubatees:** 29 No. (agreements/ MoUs) were signed during the last five years. Year wise detail is as below:

- 2017-2018: A total number of 9 agreements were signed.
- 2018-2019: A total number of 6 agreements were signed.
- 2019-2020: A total number of 14 agreements were signed

CSIR-IHBT TECHNOLOGIES ROLLED OUT

Sr.	Title of agreement/ MoU/ MTA	Name of company with whom agreement/MoU were signed and technology transferred	Date of signing
1.	Extension of agreement to use CSIR-IHBT facility to produce stevia liquid drops for another 1.5 Years	Mr. Udhey Singh Director, M/s Himalayan Natural and Herbal products Pvt. Ltd., VPO Bundla, Near Neugal Café, Palampur (H.P.)	07/04/2019
2.	Lab scale technology on cultivation of *Shiitake* mushroom to its implementation at large scale as per technical know-how of CSIR-IHBT	Mr. Satish Kumar Gill, V.P.O Putrial, Tehsil Nadaun, District Hamirpur (H.P.)	09/04/2019
3.	Commercial production of Ready to Eat (RTE) foods free from additive and preservatives at Ludhiana (Punjab)	M/s A Qube Inc., 29, NRI Block, Carlton Woods, South City, Ludhiana	10/04/2019
4.	Seeds of Stevia and Matricaria	Dr. Sinam Yoirentomba Meetei, Project Coordinator, , MSME-Technology Centre (FFDC Kannauj), Food Park, Nilakuthi, Imphal East, Manipur	24/04/2019
5.	Incubation facility to make Green Coffee Extract with Stevia.	Mr. Udhey Singh S/o Sh Kuldeep Singh House No. 41, V.P.O Dehan Khas, Tehsil Palampur, District Kangra, (H.P.)	25/04/2019
6.	Stevia Seeds (500 gm seeds)	Mr. Munesh Kumar, Village Etah, P.O. Salempur, District Firozabad, (U.P.)	01/05/2019
7.	MoU to join hands for strategic partnership as well as implementation partnership based on principles of mutual strengths and benefits for the purpose of livelihood promotion and rural development in Mizoram state	All Mizoram Farmers' Union (AMFU), General Headquarter Office, Treasury Square, Aizawl, Mizoram.	03/05/2019
8.	Stevia seeds and one Him stevia culture	Dr. S.S. Goraya, Manmohan Farm, Village Shahdoura, Kichha, District Udham Singh Nagar, Uttarakhand	06/05/2019
9.	Agreement with Third Party for manufacturing of dehydrated Fruit bars with the added special ingredients (Nutritional Herbal Powder) provided by CSIR - IHBT as per requirement of CSIR - IHBT	Mr. R. Durairaj, Chief Executive Officer, M/s. Mother India Organics and Naturals Pvt Ltd, 801, 8th Floor, Brigade Rubix, No. 20, Watch Factory Main Road, Peenya, Bangalore 560013	10/05/2019
10.	Incubation facility to produce natural dyed pine needles products.	Mrs. Sudershna Kumari, V.P.O Rait, Tehsil Shahpur, District Kangra (H.P.)	21/05/2019

Sr.	Title of agreement/ MoU/ MTA	Name of company with whom agreement/MoU were signed and technology transferred	Date of signing
11.	Plants of each Rosemary, Lavander, Lavandin, 10 seedlings of Marjorum and Origano each, 60 plants of Ginkgo	Dr. Meenu Sood, Professor & Head, Department of Forest Products, COF-UHF, Nauni, District Solan (H.P.)	04/06/2019
12.	To establish stevia cultivation in 5 acres at Hasanpur Farm,Village Chachar, Tehsil Kichha, Dist. Udham Singh Nagar, Uttarakhand	Mr. Kabir Singh, Hasanpur Farm,Village Chachar, Tehsil Kichha, Dist. Udham Singh Nagar, Uttarakhand	07/06/2019
13.	Installation of Distillation Unit under CSIR Aroma Mission in Orissa	Social Action for People, Sanyashipali, P.O. Kolabira, Dist.-Jharsuguda Odisha	10/06/2019
14.	Utilize facility (lab scale technology on cultivation of *Shiitake* mushroom) available at CSIR-IHBT for making/ producing *Shiitake* mushroom	M/s Innotech AgroPostikum Pvt. Ltd., Biotech Park, IIT Guwahati, Guwahati, Assam	14/06/2019
15.	Installation of Distillation Unit under CSIR Aroma Mission in Pathankot	Progressive Aroma Crop Farmers Welfare Association, Chohan, P.O. Gharota, Tehsil and District Pathankot, Punjab	20/06/2019
16.	Installation of distillation unit under CSIR Aroma Mission in Shimla	Shiv Aushdhiya Paudh Utpadan Society, Rajgardh (Gumna), Gram Panchayat Todsa, Tehsil Chirgaon, District. Shimla (H.P.)	21/06/2019
17.	Installation of distillation unit under CSIR Aroma Mission in Shimla	Satohar Kalyan Samiti, Tur, V.P.O. Darbhala Sub-Tehsil Darbhala, District Chamba	21/06/2019
18.	Formulation of Electrohomeopathic Medicine and monk fruit cultivation and processing technology	Rehanul Huda, Director, Anodyne Bio Spagyric, Delhi Darwaza, Sambhal, (U.P)	24/06/2019
19.	To take up 100 gm Stevia seeds	Ms. Jyoti Chhimwal D/o Shree H.C. Chhimwal, Vipin Vihar, Kotdwar Road, Ramnagar (Nainital)	28/06/2019
20.	Installation of distillation unit under CSIR Aroma Mission	Chamunda Kisan Samiti Village Kathiyari, Gram Panchyat Dharoon, Tehsil Sihunta Distt. Chamba (H.P.)	28/06/2019
21.	To take up 100 gm Stevia seeds	Mr. Papa Rao Vaikuntapu, School of Life Sciences, Department of Plant Sciences, University of Hyderabad, Gachibowl, Hyderabad	03/07/2019

Sr.	Title of agreement/ MoU/ MTA	Name of company with whom agreement/MoU were signed and technology transferred	Date of signing
22.	Installation of distillation unit under CSIR Aroma Mission	Sugandhit Krishi Vikas Samooh, Village Kaamla. Gram Panchyat Kaamla, Tehsil Sihunta, District Chamba (H.P.)	03/07/2019
23.	Installation of distillation unit under CSIR Aroma Mission	The Shivdass Ramdass Medicinal & Aromatic Plant Growers Cooperative Marketing Society Ltd. VPO Udaipur, Tehsil Keylong, Distt. Lahul & Spiti (H.P.)	04/07/2019
24.	To take up 3 kg seeds of Wild marigold under CSIR Aroma Mission	Sh. Nitish Gupta Village & Post Office Uchagaon Tehsil Jalesar Distt. Etah. (U.P.)	10/07/2019
25.	To take up 3 kg seeds of Wild marigold under CSIR Aroma Mission	Sh. Sandeep Kumar Gupta Village & Post Office Uchagaon Saraineen, Tehsil Jalesar Distt. Etah. (U.P.)	10/07/2019
26.	Commercial production of Tea Wines & RTD Tea	Ms. Payal Mittal Director M/s Camelia Beverages Pvt. Ltd., K-8, Ground Floor, Jangpura Extension, New Delhi	26/07/2019
27.	To take up 6,000 Plants of *Valeriana jatamansi* under CSIR Phytopharma and CSIR Aroma Mission	Sh. Amar Chand, S/o Sh. Karam Chand, Village Chhoyal, P.O. Khokhan Tehsil Bhunter, District Kullu (H.P.)	12/08/2019
28.	Installation of distillation unit under CSIR Aroma Mission	Green Himalaya Herb Process Committee, Village and P.O. Sarahan Pargna-Sahoo Tehsil and District Chamba (H.P.)	13/08/2019
29.	Installation of distillation unit under CSIR Aroma Mission	Gandhinagar Dist. Co-op. Society for Flower Production and Selling, Krishi Vigyan Kendra, Village Randheja Tehsil & Distt. Gandhinagar	19/08/2019
30.	Installation of distillation unit under CSIR Aroma Mission	Shakti Ajibika NRLM Gram Sangthan Vill. Jhudgaon Tulla, Block Okhalkanda Distt. Nainital (U.K.)	22/08/2019
31.	Incubation facility to make/provide Papaya (burfi & peda) and Amla (burfi) products/formulations.	Mrs. Reena Chandel, Village Gagal P.O. Bharmoti, Tehsil Nadaun Distt.Hamirpur (H.P.)	26/08/2019

Sr.	Title of agreement/ MoU/ MTA	Name of company with whom agreement/MoU were signed and technology transferred	Date of signing
32.	Incubation facility to make/ provide the herbal products.	Dr. Ankita Rana, V.P.O Ghati Bilwan Tehsil Kotla Jaswan Distt. Kangra (H.P.)	26/08/2019
33.	Incubation facility to make/ provide ready to drink products with herbs.	Mr. Vipan Kumar Village Magroo Suryala P.O. Aloh, Tehsil Rakkar Distt. Kangra (H.P.)	26/08/2019
34.	Installation of distillation unit under CSIR Aroma Mission	Manav Jiwan Sudhar Evam Kshamata Nirman Samiti, Daragaon, Soreng, West Sikkim	27/08/2019
35.	Installation of distillation unit under CSIR Aroma Mission	Association for Peoples Advancement and Action Research (APAAR) 7/12/Ramashram, Tekana Road, Pithoragarh (Uttrakhand)	28/08/2019
36.	Incubation facility to healthy food for post-partum women.	Mrs. Mona Singh, V.P.O Bharmat, Palampur (H.P.)	28/08/2019
37.	Installation of distillation unit under CSIR Aroma Mission	Jai Bhawani Krishi Vikas Sangh Chala Dochi, Village Chala Dochi, P.O. Sanora, Sub-Tehsil Pajhota at Nohri, Distt. Sirmour (H.P.)	04/09/2019
38.	Installation of distillation unit under CSIR Aroma Mission	Kartik Krishak Society Guwad, Village Tipri, P.O. Sarahan, Tehsil & Distt. Chamba (H.P.)	04/09/2019
39.	To take up 10 Nos. flask bunch of shoot culture and 05 Nos. *Dendrocalamus asper* and *Bambusa balcoa* flasks	Ana Bioenergy, 255/9, Krishna Colony, Ladwa-Kurukshetra	06/09/2019
40.	To take up 30000 Nos. plants of Valeriana and 850 plants of Kuth (*Saussurea lappa*)	Shiv Aushdhiya Paudh Utpadan Society, Rajgardh (Gumna), Gram Panchayat Todsa, Tehsil Chirgaon, District. Shimla (H.P.)	06/09/2019
41.	Installation of distillation unit under CSIR Aroma Mission	Ladakh Farmer's & Products Cooperative Ltd., Post Box No. 240, Leh Ladakh	16/09/2019
42.	Installation of distillation unit under CSIR Aroma Mission	Nagsen Kissan Club Trust, Galhar Tehsil Nagsen Distt. Kishtwar J&K	19/09/2019
43.	Installation of distillation unit under CSIR Aroma Mission	Krishi & Van Sudhar Sabha Khani-Gareema Village Khani, Tehsil Bharmour Distt. Chamba (H.P.)	25/09/2019
44.	Academic and R & D Collaboration between CIAB, NABI and CSIR-IHBT	CIAB, NABI, Mohali	30/09/2019

Sr.	Title of agreement/ MoU/ MTA	Name of company with whom agreement/MoU were signed and technology transferred	Date of signing
45.	Incubation facility Improved methods of beekeeping, honey extraction and value addition of honey.	Mr. Satish Kumar S/O Sh. Kishori Lal VPO Ghurkari Khash Tehsil & Distt. Kangra (H.P.)	07/10/2019
46.	Installation of distillation unit under CSIR Aroma Mission	Lemon Grass Farmer Produce Committee, Village Ghagwal, Tehsil Mukerian, District Hoshiarpur, Punjab	09/10/2019
47.	Installation of distillation unit under CSIR Aroma Mission	Bhuja Rishi Kisan Vikas Committee Shilhibagi, VPO Shilhibagi, Tehsil Thunag Distt. Mandi (H.P.)	10/10/2019
48.	Installation of distillation unit under CSIR Aroma Mission	Danpur Himalayan Rural and Agriculture Society, Dani Bhavan, Mukhani Choraha, Haldwani, Nainital (UK)	10/10/2019
49.	Installation of distillation unit under CSIR Aroma Mission	The Eco Friendly society of Farmers (Regd.) Rureke Kalan, Barnala Punjab	18/10/2019
50.	Scheme of Fund for Regeneration of Traditional Industries (SFURTI)	Khadi & Village Industries Commission, Gramodaya, 3, Irla Road, Vile Parle (West), Mumbai	18/10/2019
51.	Cultured flasks of *Bambusa Balcoa, Dendrocalamus asper, Bambusa nutans Dendrocalamus hamiltonii* (Four Each)	M/s Sashanka Agro Tech. Pvt., Ranchi (Jharkhand)	22/10/2019
52.	Cultured flasks of apple scion (4 varieties) and rootstocks (1 variety)	M/s Sashanka Agro Tech. Pvt., Ranchi (Jharkhand)	22/10/2019
53.	Installation of distillation unit under CSIR Aroma Mission	The Energy & Resources Institute, 6 C Darbari Seth Block India Habitat Centre Complex, Lodhi road, New Delhi	31/10/2019
54.	Installation of distillation unit under CSIR Aroma Mission	Aromatic Medicinal and Herbal Farmers Society, Jalauli, Tehil Panchkula Haryana	31/10/2019
55.	Need based R & D project (sponsorship by the PARTY) for co-development (new products) and value addition (JB BAL-VITA)	M/s Baijnath Pharmaceuticals Pvt. Ltd., VPO Paprola, Tehsil Baijnath Distt. Kangra (H.P.)	01/11/2019
56.	To take up planting material to cultivate saffron and Heeng in high altitude of Himalaya	SS Sujalam Sukhalam Foundation and Affiliates, Y C Co working Space, 3rd Floor, plot No. 94 Sector 13 Dwarka, Delhi	05/11/2019

Sr.	Title of agreement/ MoU/ MTA	Name of company with whom agreement/MoU were signed and technology transferred	Date of signing
57.	R & D project for Co-development of product / process / technology for the purpose of debittering of Orange Juice in India	SS Sujalam Sukhalam Foundation and Affiliates, Y C Co working Space, 3rd Floor, plot No. 94 Sector 13 Dwarka, Delhi	05/11/2019
58.	Producing floriculture plants at Bandla Farm of CSIR-IHBT	Dev Bhoomi Flower Nursery, House No. 123, House Board Colony, Bindravan , Tehsil Kangra (H.P.)	11/11/2019
59.	Incubation facility to make Sea buckthorn based products; Concentrates and powder and Meal replacement (With benefits of barley)	Amshu C.R, Thapasu Centre, Marhi Near ICAR Research Farm, Naggar Kullu (H.P.)	18/11/2019
60.	Collaborative research and Academic activities of Mutual Interest	SCVB Government College, Palampur	21/11/2019
61.	Collaborative research and Academic activities of Mutual Interest	Rajendra Prasad Govt. Medical College and Hospital (RPGMCH), Tanda, Kangra (H.P.)	27/11/2019
62.	Commercial production of Herbal Soaps	Mr. Sandeep Kumar and Company, VPO Nadaun, Jwalaji Road, Tehsil Nadaun District Hamirpur	03/12/2019
63.	Installation of distillation unit under CSIR Aroma Mission	Mizoram Rural and Development Society, Zotlang, Aizawl Mizoram	06/12/2019
64.	To take up planting material of *Bambusa balcooa* and apple scion and rootstocks raised through plant tissue culture in flasks/bottles.	M/s Beej Sheetal Research Private Limited Jalna, Maharashtra	09/12/2019
65.	To take up 2,000 stem cuttings of rosemary under CSIR Aroma Mission	Mr. Jaiveer Singh, V.P.O Sidhpur Sarkari, Tehsil Palampur, District Kangra (H.P.)	12/12/2019
66.	MTA to take rooted plants of lavender (25,000 rooted plants) and CSIR-IHBT will be providing 12,500 rooted plants on Free of Cost (FOC)	Association for Peoples Advancement and Action Research (APAAR) C/o VSMD Enterprises, 1-97, Basement, Lajpat Nagar 1, New Delhi	13/12/2019
67.	To take up 500 gm stevia seeds for cultivation at selected areas of district Mathura.	Mr. Sanjay Kumar Village and Post office Ranhera, Tehsil Chhata, District Mathura, Uttar Pradesh	17/12/2019
68.	Installation of distillation unit under CSIR Aroma Mission	Helping Hands Welfare Society, 339 Bagh, Khinni Mahal, Taj Nagari Phase 2, Fatehabad Road, Taj Ganj Agra, Uttar Pradesh	19/12/2019

Sr.	Title of agreement/ MoU/ MTA	Name of company with whom agreement/MoU were signed and technology transferred	Date of signing
69.	Improve understanding between their respective academic institutions and to establish mutually beneficial collaborations among their academicians, scientists and students	National Research Institute of Chinese Medicine (NRICM), Taiwan, 155-1, Section 2, Linong Street, 11221 Taipei, Taiwan	21/12/2019
70.	Installation of distillation unit under CSIR Aroma Mission	SAMPDA (Samagra Adivasi Medicinal Plants Development Association),in front of Telephone exchange, Post Office Kondagaon, DNK Colony Tehsil Kondagaon, Chhattisgarh	23/12/2019
71.	Installation of distillation unit under CSIR Aroma Mission	Himalayan Phytochemical & Growers Association, Baggi Tehsil Sadar District Mandi (H.P.)	24/12/2019
72.	Consultancy for establishing stevia plantation	Aman Van Vatika Pvt. Ltd, Maidalpur Distt. Nabrangpur (Odisha)	31/12/2019
73.	Installation of distillation unit under CSIR Aroma Mission	Om Shanti Vishav Jagriti Mission, 761/7 Gali No. 7, Govind Puri, Kalka Ji, Delhi	09/01/2020
74.	Installation of distillation unit under CSIR Aroma Mission	Neel Kanth India, VPO Lag Baliana Tehsil Dehra District Kangra (H.P.)	14/01/2020
75.	Cultivation of *Ginkgo biloba*, banfsa, chia, rosemary, hawthorn, lavender, and thyme	Mr. Anoop Sharma S/o Rishi Dev Sharma, Village Patruma, Post Office Tikroo, Tehsil Salooni, District Chamba (H.P.)	17/01/2020
76.	To take up damask rose cuttings	The Eco Friendly Society of Farmers (Regd.), Village & P.O. Rure Ke Kalan, Tehsil, Tapa, District Barnala, Punjab	21/01/2020
77.	Incubation facility for development of vedic, traditional and holistic based products from cow urine, dung and medicinal plants found in Himachal Pradesh	Mr. Sandeep Bhatia C/o Sh. Surender Pal V.P.O Nadaun, Ward no. 6, Tehsil Nadaun, District Hamirpur (H.P.)	21/01/2020
78.	Manufacturing/ processing of Spirulina based PRODUCTS	M/s Yujo Agriculture & Aquaculture Farm Society, 354 (S), Green Heights, A 2 Z Colony, Pallavapuram, Meerut (U.P.)	28/01/2020

Sr.	Title of agreement/ MoU/ MTA	Name of company with whom agreement/MoU were signed and technology transferred	Date of signing
79.	To take up planting material of *Bambusa balcoa* and improved varieties of gerbera raised through plant tissue culture in flasks/bottles.	M/s Pratyaksha Agrotech Private Limited, Pratyaksha House Bagbahar Part- II, P.O. Bagbahar District Cachar Assam	31/01/2020
80.	Technology for manufacturing/ production of Tissue culture plants (gerbera, potato, *Bambusa balcoa* sp.).	M/s Pratyaksha Agrotech Private Limited, Pratyaksha House Bagbahar Part- II, P.O. Bagbahar District Cachar Assam	31/01/2020
81.	Making herbal incense cones from temple waste flowers	Deputy Commissioner-cum-Commissioner Trilokpur Temple Trust, Nahan, District Sirmour (H.P.)	01/02/2020
82.	To take up 1,000 rooted plants of rosemary and 100 rooted plants of Rose geranium	Resham Ayurvedic Nursery, Kartarpur, District Jalandhar, Punjab	03/02/2020
83.	Drone based agriculture application in India strictly abiding by rules of Govt. of India	M/s IoTechWorld Avigation Pvt. Ltd., Plot 1643, Sector 52, Gurgaon (Haryana)	03/02/2020
84.	Incubation facility for nursery raising of aromatic crops	Mr. Subodh Thakur, Village & Post office Saloh, Tehsil Palampur, District Kangra (H.P.)	13/02/2020
85.	Incubation facility to make bio fertilizer	Mr. Jaiveeer Singh, Village Jandera, P.O. Rajpur, Tehsil Palampur (H.P.)	13/02/2020
86.	To take up 40,000 lemongrass slips under CSIR Aroma Mission	Rural Development Farming Society, Village Kaltri, P.O. Kothuwan, Tehsil Sandhol, District Mandi (H.P.)	14/02/2020
87.	10 gm seeds of Marigold (CSIR-IHBT selection) from CSIR-IHBT	Mr. Anil Kumar, V.P.O Puthar, Tehsil Israna, District Panipat, Haryana	18/02/2020
88.	Installation of distillation unit under CSIR Aroma Mission	Suhavi Producer Company Ltd., Village Kangar, P.O. Basali, Nurpur Bedi, District Ropar (Rupnagar) Punjab	24/02/2020
89.	To take up 250 plants of rosemary, 500 plants scented geranium and lavender 250 plants packed in ploy sleeves	Medicinal plant Lab, IIT Mandi - EWOK, Kamand District Mandi (H.P.)	26/02/2020
90.	Installation of distillation unit under CSIR Aroma Mission	Shiva Kisan Samiti Kangra, Village Bhatera, P.O. Jol Lambri, Tehsil Sujanpur, District Hamirpur (H.P.)	26/02/2020

Sr.	Title of agreement/ MoU/ MTA	Name of company with whom agreement/MoU were signed and technology transferred	Date of signing
91.	Installation of distillation unit under CSIR Aroma Mission	Kisan Bagwan Samiti, Village Deol, Sub Tehsil, Holi, Tehsil Bhhwarna, Distt Chamba	26/02/2020
92.	Manufacturing/ processing of multigrain protein powder	The Unati cooperative Marketing-cum Processing Society Ltd., Talwara, Punjab	27/02/2020
93.	To take up stevia seeds	Mr. Rajiv Sharma, F-326, /1 Kamla Nagar, Agra	02/03/2020
94.	Manufacture Granola bars - (millet and cereals based) products	M/s Sirimiri Nutrition Food Products Pvt. Ltd. 134/A, 3rd Floor, , Yeshwanthpur, Bangalore	03/03/2020
95.	Production of natural colours and herbal lipsticks from different natural sources.	M/s Nano Tech Chemical Brothers Pvt. Ltd. Village Mangarh, Post Office Kohara, Chandigarh Road, Ludhiana	03/03/2020
96.	MoU for close cooperation in research and academic activities	Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vidyalaya (CSKHPKV), Palampur (H.P.)	03/03/2020
97.	Making herbal incense cones and herbal soap	M/s A B Scientific Solutions, Green Vally Lohna, Palampur District Kangra (H.P.)	03/03/2020
98.	Commercial production of hand sanitizer	M/s A B Scientific Solutions, Green Vally Lohna, Palampur District Kangra (H.P.)	16/03/2020
99.	Installation of distillation unit under CSIR Aroma Mission	Jan Shakti Committee, Gram Panchayat Mangli, Tehsil Churah, District Chamba (H.P.)	20/03/2020
100.	Commercial production of hand sanitizer	M/s Sandeep Kumar & Company, Nadaun (H.P.)	29/03/2020

Mission Mode Projects

AGRI NUTRI BIOTECH THEME

With a mission to boost farmers' income, CSIR has 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 the positive 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 approved. Out of these, CSIR-IHBT participated in 10 Fast Track Translational (FTT), 1 Fast Track Commercialization (FTC), 7 NCP and 5 FBR projects.

Salient achievements of the approved IHBT projects:

1. L-Asparaginase with no glutaminase activity for food processing and therapeutic applications (FTC): Development of a bioprocess for application of HimAsnaseTM, identified from Himalayan niches, in food industry.

2. Optimization of aeroponic and hydroponic conditions for increasing commercial crop productivity: In continuation to previous experiments with lilium, hydroponic cultivation reduced the flowering by 60 days. Cropping cycles at an interval of 15 days were planned to cultivate lilium in both hydroponic and field condition. The results revealed that plant height was significantly increased under hydroponic conditions within a lesser time duration as compared to open field condition.

Further, hydroponic cultivation of spice crops (Basil, Origano, Parsley and Rosemary) was also carried out. In basil, plant height (54 cm), number of branches and leaves/plant was significantly increased in nutrient media as compared to Hoagland media (49 cm). In case of parsley and oregano, plant height, no. of branches per plant and no. of leaves per plant was also significantly increased in hydroponic as compared open field conditions. However, in case of rosemary, no such advantage was seen.

3. Introduction of high value spice saffron (*Crocus sativus* L.) in unexplored areas (IHBT): Alternate sites for quality saffron production were identified through modelling. Flowering sized corms were produced in selected locations in Himachal Pradesh and Uttarakhand. Further, saffron was introduced for the first time in an area of 8000 m^2 at 25 different locations (508 m to 3600 m amsl) PAN India under the project. Entrepreneurship has been developed with farmers for saffron production in Bharmour in HP and villages Peekh, Harshil and Jhinjhi of district Bhageshwar, Uttarkashi and Chamoli in Uttarakhand (UK) in association with AAPAR NGO, Pithoragarh, UK. Quality of saffron was at par with the market sample bought from Kashmir. While samples from some of the locations *viz.*, Bharmour in H.P, Bageshwar in Uttarakhand showed better quality than market sample. Corm production technology has been commercialized and will be given to Himachal Pradesh government for large scale cultivation in HP.

4. Development of applications of laccase for diverse (food, health and cosmetic) industries (IMTECH, IHBT, CFTRI, IITR, IIP): Biotransformation of catechin and epicatechin to theaflavins was standardized. Further, process optimization for analysis of catechins and theaflavins using RP-HPLC was carried out. Process and reaction parameters were optimized for conversion of tea catechins into theaflavins (TFs) and thearubigens (TRs). This enzyme laccase has applications in preparing dark teas enriched with TFs and Trs.

5. Rapid and point care microfluidic kit for multiplex diagnosis of viral diseases in tomato and apple (IMMT, IHBT): Under this project, IHBT responsibility of raising antisera of the important apple and tomato viruses was completed. Antisera to Apple stem grooving virus, Apple chlorotic leaf spot virus, Apple mosaic virus, Cucumber mosaic virus, Groundnut bud necrosis virus and Chilli veinal mottle virus was developed and tested for suitability in testing by ELISA.

6. Indigenous enzymes for degumming of rice bran oil and other vegetable oils (IICT, IHBT): Bacteria were isolated from sites in Eastern and Western Himalaya and significant zone of clearance was observed in 20 bacteria out of the 209 bacteria using phospholipase screening media agar plates. Three potential bacteria with phospolipase activity are *Chyseobacterium polytricastri* ERMR1:04 , *Enterobacter hormaechei* SOS:03 and *Pantoea dispersa* POS:06.

7. Combating Iron and Zinc deficiency using microalgae based foods (IHBT): A cultivation process for enhancing iron and zinc content up to 2 folds in microalgae (*Spirulina platensis*) developed. Enhanced iron content promoted accumulation of carotenoids (beta-carotene) and phycobiliproteins in microalgae cells. Ready to eat food products have been developed incorporating iron and zinc enriched *Spirulina platensis* biomass. Single serving of product meets up to 20% of recommended dietary intake levels of iron and zinc. Spirulina incorporated products promoted recovery from iron deficient anaemia. Supplementation of Spirulina incorporated food products improved hemoglobin and serum albumin levels. Technology for commercial production of ready to eat food products such as Spirulina based energy bars, Spirulina based beverage mixes has been commercialized

8. Development of bamboo composite structural elements (AMPRI, CSIO, CBRI, IHBT) : The institute developed protocol of quality planting material for mass propagation with high multiplication rates with axillary buds in shorter duration of industrially and commercially important bamboo species viz. *D. hamiltonii, D. asper, D. giganteus, B. balcoa, B. nutans, D. membranaceus and B. tulda*. Bamboo splitting, slicing and agarbatti sticks (0.6 mm) making were also standardized as the Incense market norms. This industrially important bamboo species were supplied to CSIR-AMPRI Bhopal, CSIR-CSIO Chandigarh for study and development new products. CSIR-CBRI Roorkee studied the physico-mechanical properties of different species of bamboo fibres and polymers. CSIR-CSIO Chandigarh designed, fabricated 40 different joints and section with 3 D printer and comparative studied the features of traditional and existing joints for bamboo houses, bridges and trusses whereas CSIR AMPRI Bhopal had developed bamboo composites material size 1200 mm x 900 mm which could be converted to panels of desired thicknesses, widths and lengths which could be used as wall-panels, partitions, coverings, decoration laminates, floorings, thermal/ electrical insulations, doors, windows, table tops, false ceilings, roofs etc. Training was organized on "Bamboo-based Composites for Government Officials and Bamboo Entrepreneurs" at State Convention Centre, Shillong on 12/03/2020. A patent was filed on Bamboo based Composition Material and Process for Preparation Thereof.

9. Design and development of indigenized lyophiliser for preservation of Indian fruits and vegetables (CSIO, IHBT): The lyophilizer has been designed, developed, fabricated and tested for different fruits and vegetables. This is an indigenous lyophilizer with affordable cost and energy saving features as compared to the available make and models. Processing parameters for different fruits and vegetables for crispy drying and economic aspects were standardized.

10. Identification of improved clones of *Stevia rebaudiana* (Bertoni) (IHBT): High yielding clone of stevia (CSIR-IHBT-ST-1801) has been identified for the purpose of cultivation which has a yield potential of 5.0 tons per ha of dry leaf biomass.

11. 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): The prototype of self- propelled specialty harvester for stevia harvesting has been developed and tested in the farmer's field in Ludhiana, Punjab.

FBR/NCP projects of CSIR-IHBT approved by the Committee:

1. UAV based high resolution remote sensing for modernized and efficient cultivation practices of commercially important medicinal and aromatic crops (IHBT, CIMAP, NAL): Quad- Rotor-Multicopter autonomous navigation type drone system was designed and developed by CSIR-NAL for rapid, timely and on-demand real time image data acquisition. Hyperspectral image was recorded for various stages of Lilium (Nascent plantations, Young plantations, harvest stage, and flowering stage) on 06.02.2019 using terrestrial HySpex VIS-NIR 1800 (400–1000 nm) Hyperspectral Imaging Sensor. The reflectance spectra of these stages of Lilium were retrieved for the classification of image. An automated method was developed for counting of Lilium buds (cut flowers) and Tagetes (lose flowers) at the time of their harvesting using digital image processing techniques. The Digital Terrain Model (DTM) and Digital Surface Model (DSM) were prepared for *Rosa damascena* and *Stevia rebaudiana* fields using point cloud data of drone. Using these elevations, slope, and aspect maps were prepared for the above plot at 1.5 cm resolution. Canopy Height Model (CHM) was prepared using DTM and DSM to derive height of individual plant of *Stevia rebaudiana*. In April their height ranged from 7-10 cm and in July 24-41 cm, attaining 98% accuracy. Canopy temperature of *Stevia rebaudiana* was retrieved using LWIR band, attaining 98.54 % accuracy.

2. Molecular mechanism underlying Apple scar skin viroid-whitefly interaction: The replication of ASSVd in insect ovary cell lines (SF9, SF21 and High 5) and human tongue epithelial carcinoma cells (CAL 27) was achieved. Viroid interacting small heat shock (sHSP) from whitefly has been identified by Northwestern and MALDI-TOF analysis. Its silencing lead to limited transmission capability of the insect.

3. Development of process for conversion of cellulosic biomass into nanocellulose (IHBT): A lab scale process has been developed for the isolation of nanocellulose from Parthenium species and a patent filing is under process.

4. Creation of aroma bank by utilization of western Himalayan biodiversity (AROMA-BANK) : In order to create an aroma bank, essential oil from 28 plants (*Cinnamomum tamala*, *Murraya koenigii*, *Hedychium spicatum*, *Eucalyptus globulus*, *Mentha piperita*, *Erigeron annuus*, *Eucalyptus camaldulensis, Ageratina adenophora, Cedrus deodara, Zanthoxylum armatum*, *Artemisia dracunculus, Artemisia maritima, Curcuma aromatic* (fresh leaves, dried leaves & rhizomes), *Curcuma longa, Cymbopogon flexuosus, Dracocephalum heterophyllum, Hedychium spicatum* (dried leaves), *Juniperus communis L., Ocimum gratissimum, Pinus gerardiana, Pinus roxburghii, Pinus wallichiana, Rosmarinus officinalis, Skimmia laureola (DC), Tagetes minuta* and *Valeriana jatamansi*, were extracted, characterized and deposited in AROMA-BANK (~50 g each).

5. Microbiome of Indian Trans-Himalayan niches for functioning of ecosystems: With the aim of discovering novel microbes from Himalaya niches, *Glaciimonas sp.* PCH181, *Miniimonas sp.*, *Paenibacillus sp. Janthinobacterium sp.* Among others were identified. These were found to have novel and unique activities such as laccase, endogluconase, xylanase, and PHA synthase (phaC) for commercial applications.

Patent filed in PCT Countries: "Bioprocess for simultaneous production and extraction of polyhydroxybutyrate and violacein pigment from Himalayan bacterium Iodobacter sp. PCH 194".

6. Alternative *in vitro* system for production of naphthoquinone pigments from Arnebia species on sustainable basis: Callus culture lines were established from leaves and rhizome of *Arnebia euchroma*. Technology was developed for naphthoquinone pigments production using cell and organ culture. Protocol for cryopreservation of callus was also developed.

7. Development of high - through put genotyping platform for next generation plant breeding in tea (IHBT): 917122 single nucleotide variants (SNPs) were ascertained at the genome level. of these, 80,000 high quality SNPs also mapped with multiples transcriptomes key pathways [abiotic (drought, heat, salt), biotic (blister blight) and quality characteristics]. Further, ~40 trait specific SNP were tested for parental polymorphism and utilized for genotypes of trait specific mapping populations.

8. Characterization and development of agro- technology for low calorie natural sweetener: Monk fruit (*Siraitia grosvenorii*): The germination method and nursery raising technique have been standardized for the mass propagation. Vegetative propagation technology has also been developed.

The morphological and anatomical characterizations of leaf, stem and root have also been completed.

The phenology of female and male flowers and pollination behavior were documented.

Protocol for estimation of Mogroside-V has been developed.

Chemical characterization of monk fruit grown under Palampur conditions has been completed.

Demonstration plot has been set up for demonstration to the farmers and entrepreneurs.

9. Exploration of Himalayan plants for novel antimalarial agents; characterization of potential molecules (IHBT): *Cissampleos parrera* was identified as source of antimalarial agents on the basis of in vitro anti-plasmodial activity assay. UPLC-MS/MS based chemical profiling led to the characterization of 30 molecules. Out of which, one molecule was identified with antimalarial activity in nano molar concentration.

Patent: One patent is filed based on this complete study (Ref. No.: 0219NF2019).

10. Conservation and bioprospecting of selected high altitude bioresources at CSIR–Centre for High Altitude Biology (IHBT): The project is multicomponent and concise achievements of the various components are as follows:

(i) Species niche distribution maps were prepared and field genebanks were established for targeted RET species.

(ii) Ex-situ conservatories were also established for targeted RET medicinal plant species viz., *Dactylorhiza hatagirea* (in vitro repository), *Aconitum heterophyllum* (field nurseries), *Arnebia euchroma* (in vitro cultures) and *Nardostachys jatamansi* (*in vitro* shoot cultures).

(iii) Multi-location trials of *Ferula asafoetida* (Heeng) were undertaken at CSIR IHBT Palampur and CeHAB, Ribling (Lahaul & Spiti) evaluation of better accessions suited for the region and for developing agro-practices.

(iv) Cuttings of elite Russian varieties of Seabuckthorn were raised for propagation and Germplasm Resource Center of Sea buckthorn at CeHAB Lahaul & Spiti was enriched with these elite varieties which are being propagated for distribution to the farmers of the region.

(v) Distributed 16,100 tulip bulbs to 110 farmers of four farmer cooperative societies and 1500 bulbs have been planted at CeHAB as field trials.

(vi) Functional characterization and safety assessment of identified potential probiotics strains was undertaken from local fermented beverages. Out of 256 different morphotype isolates found, 121 selected as potential probiotic bacteria. Finally, 54 lactic acid bacteria were obtained that passed all the attributes for being pro-biotic.

(vii) Formulation of Buckwheat based products such as Puffed Bar, Noodles, and Puffed snacks has been done. Further, standardization of these products and formulation of restructured rice shaped buckwheat has been performed.

(viii) Screening of more than 600 pure bacterial isolates for cellulolytic activity. Broad pH and temperature operative endoglucanase from Himalayan bacteria was identified. Successfully cloned and in vitro expressed endoglucanase gene in the host E. coli.

11. Development of customized flow hive for quality honey harvesting and extraction (CSIO, IHBT): The institute alongwith CSIR-CSIO, Chandigarh developed improved bee hive and evaluated successfully in the field which had the following advantages:

- Extraction and harvesting of honey without disturbing the frames and honey bees.
- No mortality of honey bees during harvesting as compared to honey extractors.
- The harvested honey is hygiene and high quality which fetches good price in the market.
- The bee hive is cost effective, easy to operate and less human intervention.
- Yield of honey /hive/year is approximately 30-35 kilograms.

CSIR-AROMA MISSION

CSIR-Aroma Mission was launched in 2017 with an aim to provide end-to-end technology and value addition solutions for cultivation and processing of aromatic crops across the country and also to extend the cultivation of aromatic crops over 530 ha during the project duration. Under the aroma mission, the area under aromatic crops viz., wild marigold, damask rose, Indian valerian and lemongrass was extended to 538 ha in ten states and two union territories under aroma mission. Of this wild marigold (*Tagetes minuta*) covered about 401 ha area in Himachal Pradesh, Jammu & Kashmir and Uttarakhand. An area of about 18.4 ha was covered under damask rose in H.P., Punjab and Uttarakhand. Lemongrass was rejuvenated in 22 ha area in different warmer regions of H.P. and Punjab. In addition, aromatic crops like chamomile (21 ha), Indian valerian (30 ha) and palmarosa (30 ha) were cultivated by farmers in different parts of HP, Uttarakhand, Uttar Pradesh and Odisha. To empower the farmers for growing aromatic crops, 43 distillation units for extraction of essential oils were set up in the farmers' fields by CSIR-IHBT in different states (Himachal Pradesh, Mizoram, Sikkim, Uttarakhand, Odisha, Punjab, Haryana, Uttar Pradesh, Chhattisgarh and union territories of Jammu & Kashmir and Ladakh). About 6.49 tonnes of high grade Tagetes oil was produced under the mission. Himachal Pradesh became the highest producer of Tagetes oil in the country with revenue generation of Rs. 5.19 crores. With 43 farmer groups representing 861 farmer families benefitted through cultivation of aromatic crops. Capacity building of 1397 farmers/unemployed youth/entrepreneurs were covered in 50 training programs.

Generation of quality planting material

The planting material generated for the targeted aromatic crops presented in Table 1.

Table 1. Planting material generated

Crops	Planting material generated
Rosa damascena	62,000 cuttings
Tagetes minuta	1.14 tonne
Matricaria chamomilla	50 kg
Valeriana jatamansi	3,00,000 rooted slips
Artemisia maritima	30,000 rooted plants
Dracocephalum heterophyllum	25,000 rooted plants
Cymbopogon flexuosus	2,00,000 rooted slips
Cymbopogon martini	100 kg
Lavandula officinalis	12,500 rooted plants
Rosmarinus officinalis	12,000 rooted plants

Training and awareness programmes for skill development

Forty-one awareness cum training programmes on cultivation and process technologies of aromatic crops were conducted during April 2019 to March, 2020 and more than 763 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 farmers were inculcated for the cultivation and price determination of aromatic crops namely damask rose, wild marigold, chamomile, jatamansi, lavender and rosemary (Table 2).

Programme	Duration	Location	District	State	No. of Participants
Awareness cum training programme on cultivation, processing and marketing of lemongrass	5-04-2019	Kangra	Kangra	H.P	13
Awareness among tribal farmers on cultivation, processing and marketing of aromatic crops	7-4-2019	Manipur	Kangpokpi (Senapati)	Manipur	10
Awareness cum training programmes conducted to promote the cultivation of *Valeriana jatamansi*	10-4-2019	Garola	Chamba	H.P	28
Awareness cum training programmes conducted to promote the cultivation of *V. jatamansi*	11-04-2019	Dharwala	Chamba	H.P	5
Awareness cum training programmes conducted to promote the cultivation of *V. jatamansi*	12-04-2019	Khani	Chamba	H.P	4
Awareness cum training programmes conducted to promote the cultivation of *V. jatamansi*	13-04-2019	Brehi	Chamba	H.P	13
Awareness cum training program on the cultivation of aromatic plants.	22-04-2019	Pokhri	Champawat,	Uttarakhand	34
Skill development proogramme conducted on processing of damask rose	27 to 29-4-2019	Chamba, Mandi and Shimla	Chamba, Mandi and Shimla	H.P.	6
Awareness cum training programme on cultivation of aromatic crops	16-5-2019	IIT Mandi	Mandi	H.P.	35
Awareness cum training programme on cultivation, processing and marketing of aromatic crops.	23-5-2019	CSIR-IHBT Palampur,	Kangra	H.P.	10
Awareness cum training programme on cultivation and processing of *V. jatamansi*	24-5-2019	Bharwali	Chamba	H.P.	11
Awareness cum training programme on cultivation and processing of *V. jatamansi*	25-5-2019	Kuwarsi	Chamba	H.P.	11
Awareness cum training programme on cultivation and processing of *V. jatamansi*	27-5-2019	Garola	Chamba	H.P.	16
Awareness cum training programme on cultivation and processing of *V. jatamansi*	28-5-2019	Hiling	Chamba	H.P.	10

Awareness programme on cultivation of aromatic crops	2-7-2019	CSIR-IHBT Palampur,	Kangra	H.P.	4
Awareness programme on cultivation, of aromatic crops	9-7-2019	CSIR-IHBT Palampur,	Kangra,	H.P.	16
Awareness cum training programme on cultivation, processing and marketing of aromatic crops	12-7-2019	CSIR-IHBT Palampur, HP	Kangra,	H.P.	32
Awareness cum training programme on cultivation of *V.jatamansi*	17-7-2019	Bharmour	Chamba	H.P.	56
Awareness cum training programme on cultivation of *V.jatamansi*	18-7-2019	Salooni	Chamba	H.P.	15
Awareness cum training programme on cultivation of *V.jatamansi*.	19-7-2019	Salooni	Chamba	H.P.	25
Awareness cum training programme on cultivation of *V.jatamansi*	20-07-2019	BatankaSalooni	Chamba	H.P.	43
Awareness cum training programme					

Programme	Duration	Location	District	State	No. of Participants
Training cum seed distribution of *M. chamomilla*	17-12-2019	Ulangra Block- Dewal	Chamoli Ulangra village farmers	Uttarakhand	32
Training cum seed distribution of aromatic crops	18-12-2019	Village-Karmi Block- Kapkot	Bageshwar	Uttarakhand	10
Awareness cum training programme on rosemary cultivation	20-12-2019	Block-Pati	Champwat	Uttarakhand	10
Training cum awareness program on improved agro and process technologies of aromatic crops	13-02-2020	Sundargarh	Sundargarh	Odisha	50
Training cum awareness program of aromatic crops	24-02-2020	Farmers of Jhajjar at CSIR-IHBT	Kangra	H.P.	8
Awareness cum training program on improved agrotechnologies for cultivation of aromatic plants	28-02-2020	Farmers of Baramulla, J & K at CSIR-IHBT	Kangra	H.P.	25

New varieties/cultivars released (5 nos.)

Five new varieties/ cultivars of aromatic crops namely 'Him Swarnima' of wild marigold (*Tagetes minuta*), 'Him Sugandh' of White dragonhead (*Dracocephalum heterophyllum*), 'Him Surbhit' of Indian valerian (*Valeriana jatamansi*), 'Him Basant' of Damask rose (*Rosa damascena*), and 'Him Devsugandh' of sea wormwood (*Artemisia maritima*) were released by Hon'ble Governor of Himachal Pradesh Sh. Bandaru Dattatreya on 3 March, 2020 (Fig. 1).

Fig. 1 Hon'ble Governor of Himachal Pradesh releases ten new varieties/cultivars of aromatic crops

Brief outline of varieties/cultivars of aromatic crops

Him Swarnima (CSIR-IHBT-TM-09), a variety of wild marigold

Developers: Dr. Ashok Kumar and Dr. Sanatsujat Singh

Contributors: Dr. Probir Kumar Pal, Dr. Rakesh Kumar, Dr. Ram Kumar Sharma and Dr. Dinesh Kumar

The variety 'Him Swarnima' (CSIR-IHBT-TM-09) of *T. minuta* has been developed by CSIR-IHBT, Palampur through half-sib progeny selection approach. The variety has high biomass yield (18-23 tonnes/ha) and essential oil content of 0.30 to 0.34% and was selected from advanced breeding lines developed from germplasm core collections through half-sib family selection.

Him Basant (CSIR-IHBT-RD-04), a cultivar of damask rose

Developers: Dr. Sanatsujat Singh and Dr. Ashok Kumar

Contributors: Dr. Rakesh Kumar, Dr. Probir Kumar Pal, Dr. Ram Kumar Sharma and Dr. Dinesh Kumar

The cultivar 'Him Basant' (CSIR-IHBT-RD-04) of *R. damascena* has been developed through half-sib selection approach. The cultivar has high flower yield (3.3 - 4.1 tonnes/ha) and essential oil content of 0.025-0.031% and was selected from clonal breeding lines developed from breeding lines through half-sib family selection.

Him Surbhit (CSIR-IHBT-VJ-05), a variety of Indian valerian

Developers: Dr. Sanatsujat Singh, Dr. Ashok Kumar

Contributors: Dr. Probir Kumar Pal, Dr. Ram Kumar Sharma and Dr. Dinesh Kumar

Him Surbhit (CSIR-IHBT-VJ-05) of *V. jatamansi* has been developed through progeny selection approach. The variety has root biomass yield of 3.4-4.5 tonnes/ha and essential oil content of 0.29-0.31% after two years of growth. It was selected from breeding lines developed from germplasm collections through progeny selection.

Him Sugandh (CSIR-IHBT-DH-04), a variety of white dragonhead

Developers: Dr. Ashok Kumar and Dr. Sanatsujat Singh

Contributors: Dr. Probir Kumar Pal, Dr. Ram Kumar Sharma and Dr. Dinesh Kumar

Him Sugandh (CSIR-IHBT-DH-04) of *D. heterophyllum* has been developed through half-sib progeny selection approach. The variety yields biomass of 4.5-5.1 tonnes/ha and essential oil content ranges from 0.20-0.22%. It was selected from advanced breeding lines developed from germplasm collections through half-sib progeny selection.

Him Devsugandh (CSIR-IHBT-AM-02), a variety of sea wormwood

Developers: Dr. Ashok Kumar and Dr. Sanatsujat Singh

Contributors: Dr. Rakesh Kumar, Dr. Ram Kumar Sharma and Dr. Dinesh Kumar

Him Devsugandh (CSIR-IHBT-AM-02) of *A maritima* has been developed through half-sib progeny selection approach. The variety gives biomass yield of 2.8-3.4 tonnes/ha and essential oil content ranges from 0.22-0.23%. It was selected from breeding lines developed from germplasm collections through half-sib family selection.

Brief outline of chrysanthemum cultivars

Developers: Dr. Ashok Kumar and Dr. Sanatsujat Singh

Contributors: Dr. Bhavya Bhargav and Dr. Ram Kumar Sharma

Five new cultivars viz., Him Aditya, Him Pushkar, Him Shikhar, Him Ujjwala and Him Shringar developed by CSIR-IHBT through hybridization and selection programme. Using characterized parental lines, a controlled hybridization programme was carried out followed by selection of promising hybrid genotypes superior to the parents for morphological and floral attributes. The criteria for selections were unique of flower shapes and bright colors.

Performance of wild marigold in Chamba (H.P.)

Interaction of scientists with the farmers of wild marigold clusters at Ghoghar Dhar (Mandi) and Kamand (Sainj valley, Kullu) in H.P.

Damask rose and rosemary nursery at farmers field Bharmat, Palampur, District Kangra (H.P.)

Monitoring of *Valeriana jatamansi* at Deoki and Khani villages in Bharmour, District Chamba (H.P.)

Intercropping of lemongrass in a citrus orchard (Jawali, Kangra, H.P.)

Installation of distillation unit in the remote place, Chamba (H.P.)

Installation and commissioning of distillation unit at Village Puthar, Panipat (Haryana)

Installation of distillation unit at village Kamla Chamba (H.P.)

Installation and commissioning of distillation unit at village Thiksey, Leh & Ladakh

Installation and commissioning of distillation unit at Bageshwar (UK)

Installation and commissioning of distillation Unit (4 qtl. capacity) in Pathankot (Punjab)

Distribution of quality planting material to the farmers at Ulansa, District Chamba

Distribution of quality planting material to the farmers of Shimla region (H.P.)

Distribution of planting material to the farmers of Punjab and H.P.

Awareness cum training program on aromatic plants cultivation at village Pokhri, Champawat (UK)

Awareness among tribal farmers on aromatic crops Kangpokpi, District Senapati (Manipur)

Training programme on wild marigold at District Chamba

Awareness cum training programme on cultivation, processing and marketing of aromatic crops at CSIR-IHBT, Palampur.

Training cum awareness programme at CSIR-IHBT Palampur for farmers of Pulwama (J & K)

Training cum seed distribution for farmers of Nainital (UK)

Awareness cum training programme on aromatic crops at village Thicksey Leh

Awareness cum training programme on aromatic crops at village Jhinjhi (UK)

Awareness programme on aromatic plants at village Puthar, District Panipat (Haryana)

Awareness cum training programme on aromatic plants at village Kilor, Chamba

Fig. 2 Details of training and awareness programs conducted by CSIR-IHBT

CSIR MISSION ON NUTRACEUTICALS AND NUTRITIONALS

Nutraceuticals and Nutritionals Mission initiated during April 2018 by CSIR mainly focused on the development of novel health products for the management of overall human well-being. CSIR-IHBT is the nodal laboratory to coordinate the projects activities among ten different institutes (CSIR-IHBT (Nodal laboratory), CSIR-CDRI, CSIR-CFTRI, CSIR-CIMAP, CSIR-CSMCRI, CSIR-IGIB, CSIR-IIIM, CSIR-IITR, CSIR-NEIST and CSIR-NIIST) across India. The following are the objectives of the mission:

- Development of region-specific and pan Indian nutritious first meal of the day for children that meets the RDA requirement of essential nutrients
- Development of nutraceutical formulations/ products for bone health, cognition, immunity and sleep disorders
- Establishing proof of studies for developing nutraceuticals for NCDs and CNS indications

The mission had seven thematic areas, which includes Enhancing Nutrition, Bone and Cartilage Health, Non-Communicable Diseases (NCDs), Cognition and Brain Health, Immunity, Sleep Disorder and Central Nervous System (CNS). The mission had 12 work packages, with CSIR-IHBT participated in five thematic areas (Fig.1) to develop various health products.

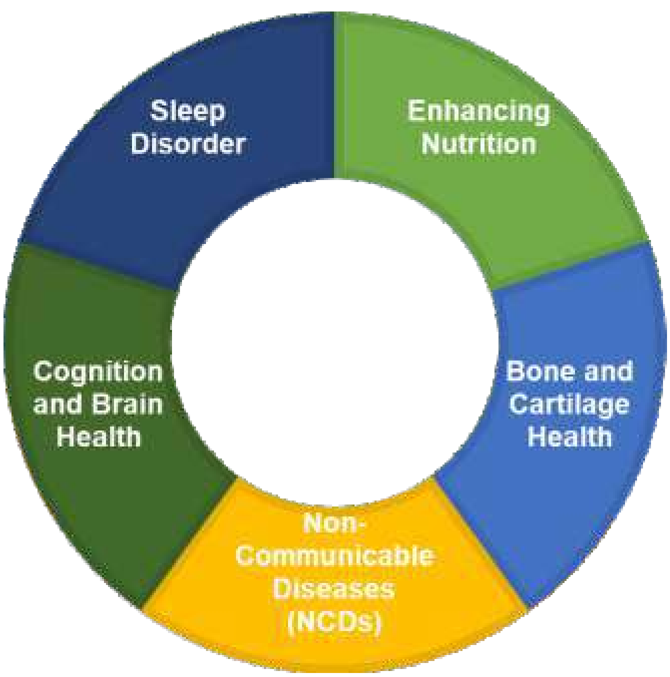


Fig. 1 Thematic areas of participation by CSIR-IHBT

The following Nutraceuticals and Nutritionals are developed under various themes by CSIR-IHBT under various work packages of the mission:

1. Development of vitamin D2 enriched formulation from *Lentinula edodes* (Shiitake)

Shiitake (*Lentinula edodes*) mushroom is a highly nutritious rich vegetarian source of vitamin D. More than 70 % of Indian population is Vitamin D deficient (2014). Presently, it is imported from Thailand, Korea and China, at Rs 1600.00 per kg dried shiitake (2016). The estimated shiitake market demand is projected to reach 4370 tons by 2023 compared to 2109 tons in 2017 @ 15.31% CAGR. In Himalayan states, shiitake is popular for its unique taste (Umami flavour). Its natural cultivation took around 12 months for fruiting with 3-8 years' of the production cycle. However, CSIR-IHBT has developed a technology with shorter cultivation cycle of about two months with approx. yield of 0.5-0.6 kg fresh mushroom using optimized substrate (Fig. 2).

Fig. 2 Captive cultivation of shiitake mushroom at CSIR-IHBT

The exact dosage and varied conditions were optimized to achieve maximum vitamin D2 concentration. Vitamin D2 estimation carried out by irradiating different portions of shiitake mushroom (caps, gills, stipes) and different UV dosage (10, 20, 30, and 40 KJ/m2) with wavelengths (UV-A, UV-B, UV-C). Shiitake was dried using an oven-tray dryer at 50 °C temperature. The proximate composition, including vitamin D_2 content (99.83 mcg) was given in Table 1. The quantification of vitamin D_2 using HPLC (standard and test samples) of dried shiitake was also done, and chromatogram is given in Fig. 3. The third-party analysis of shiitake mushroom was also performed at NABL certified Interstellar Testing centre that showed the presence of 112.1 vitamin D_2 (µg/g) in oven-dried samples.

Table 1. Nutritional composition of dried powder of shiitake mushroom

Parameters	Oven-dried samples
Moisture, % by wt.	7.14
Total Ash, % by wt.	6.65
Fat, % by wt	2.55
Crude fiber, % by wt	7.20
Protein, % by wt	28.01
Carbohydrate, % by wt.	48.45
Calorific value, K.cal/100g	328.79
Iron, mg/100g	2.47
Zinc, mg/100g	6.30
Vitamin A, µg/g	BDL*of 0.150

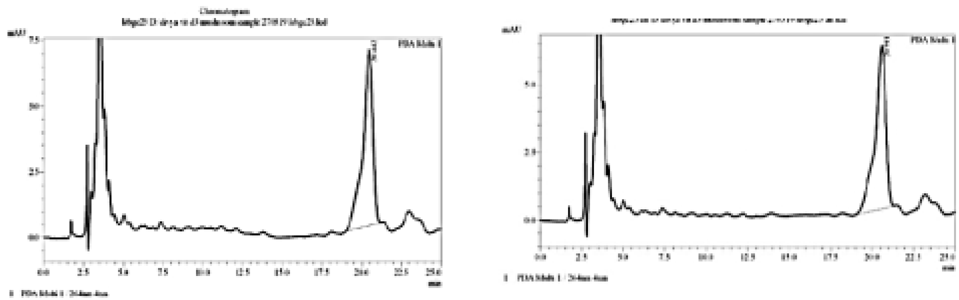


Fig. 3 HPLC chromatograms of vitamin D_2 a) standard and b) test sample

In addition, the elemental analysis and amino acid composition of shiitake powder were also done (Table 2). The elements like iron, magnesium, phosphorus, potassium are present in a reasonable amount, while five essential amino acids *viz*. Tryptophan, Lysine, Methionine, Threonine, Valine too quantified in the samples. The allergenicity evaluation of the mushroom has been done with the help of CSIR-IGIB, whereas the quantitative analysis of vitamin D2 performed by CSIR-CFTRI in the project.

Table 2. The elemental and amino acid composition of dried shiitake

Element	Fe	Mg	Mn	Cu	Ca	Na	P	K	Zn
Conc. (mg/g)	0.196	0.901	0.026	0.016	0.082	1.675	13.960	33.831	0.065

Amino acids	Ser	Arg	Asp	Glu	Thr	Ala	Pro	Lys	Tyr	Met	Val	Trp
Quantity (mg/g)	1.98	2.34	3.49	15.4	3.81	1.63	5.21	76.4	12.98	41.52	24.28	15.82

A number of vitamin D_2 enriched shiitake mushroom products were developed at CSIR-IHBT (Fig. 4).

Fig. 4 Vitamin D_2 enriched shiitake mushroom products

Significant achievements:

- Shorter production time: 2.5-3 months as opposed to 8-12 months, with high yield 0.5-0.6 kg/ 1 kg dry substrate
- 350 mg shiitake powder meets 100% RDA of Vitamin D2 (sachet or capsules)
- CSIR compendium of technologies (TRL≥6)
- Technology knowhow on cultivation and production of Vitamin D2 rich Shiitake mushroom in dried as well as powder form (Fig 1) was developed and transferred to 03 entrepreneurs/industries. The project work had a collaboration with CSIR-CFTRI & CSIR-IGIB. Three SFURTI clusters on *Shiitake* mushroom are sanctioned under MoMSME at **Sikkim** impacting **750** beneficiaries under the project with a total cost of Rs. 7.35 Crores.
- The developed technology is already 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

1. Developing nutrifoods for breakfast

In this project, PAN India first meal of the day (10 recipes of breakfast) was developed for combating malnutrition in school children. It is a multi-institutional project and involved CSIR-CFTRI, CSIR-CIMAP, CSIR-NEIST, CSIR-NIIST & CSIR-IITR laboratory across India. CSIR-IHBT has developed Ready To Eat & Ready to Reconstitute Khichdi and Ready to Cook Dhalia (Sweet & Savoury variants). Besides, multigrain protein mixes and multigrain protein and fiber-enriched cereal bars as snack product was also developed.

a) **Khichdi – Ready to Eat & Ready to Reconstitute**: Khichdi is a wholesome meal and National Cuisine) that has the perfect balance of nutrients is prepared by CSIR-IHBT (Fig. 5).

Fig. 5 Khichdi–Ready to Eat & Ready to Reconstitute

b) **Ready to Cook Dalia** (Sweet & Savoury variants): The production process involves 5 unit processes that are linear viz., roasting of grains, pulverizing or grinding, sifting, blending and packaging. Skimmed milk powder, vitamins and mineral premixes are added at the end of the process to the processed dalia mix according to the formulation.

Product 1 – Savoury variant

Ingredients: Dalia grits, Flattened rice, Sesame, Skimmed milk powder, Dehydrated vegetable (Carrot, Cabbage, Beans, Tomato, Onion, Coriander leaves, Curry leaves, Spice mix (Salt, Black pepper, Turmeric powder)

Product 2 – Sweet variant

Ingredients: Dalia grits, Skimmed milk powder, Rice flakes, Sesame seeds, Peanuts, Sugar, Peanuts, Jaggery, Dehydrated beetroot, Dehydrated carrot, Coconut powder, Cardamom powder

Table 3. Typical Nutritional value/50g of product – Ready to Cook Dalia

Component	Savoury variant		Sweet variant	
	Approx. per serving 50 g	% RDA* per serving	Approx. per serving 50g	% RDA* per serving
Energy Kcal	205.00	12.80	205.00	12.80
Proteins, g	8.33	18.51	6.66	13.33
Fat, g	5.00	16.66	5.00	16.66
Carbohydrates,g	30.00	25.00	33.33	25.00
Dietary Fiber, g	5.00	10.00	5.00	10.00
Calcium, mg	158.33	26.38	158.33	26.38
Iron, mg	3.33	18.50	3.33	18.50

*RDA-Recommended Dietary Allowance calculated for 1800 KCal diet for age group between 6 and 11 years

Fig. 6 Ready to Cook Dalia a) Sweet variant, and b) savoury variant) stored under accelerated conditions in CPP pouches.

Sensory evaluation of ready to cook dalia (savoury & sweet variants): The products were reconstituted with boiling water and cooking for less than 7 minutes to attain soft texture and sensory score. The savoury variant had a characteristic spicy aroma and taste, while sweet variant possessed a mild cardamom flavour and sweet milky taste. The study indicated that the product had overall acceptability ranging from like moderately towards like very much (Table 4). Addition of micronutrient pre-mix did not alter the sensory properties of the product.

Table 4. Sensory scores for Ready to Cook Dalia as per Hedonic scale

Parameter	Cooked Dalia (savoury)	Cooked Dalia (sweet)
Colour	7.10±0.85	7.3±0.80
After Taste	6.66±0.80	7.5±1.05
Flavour (Aroma & Taste)	6.66±0.95	7.2±0.77
Mouthfeel (Consistency)	6.77±0.73	6.9±0.85
Overall Acceptability	7.00±0.44	7.4±0.82

d) Multigrain protein mix: The production process involves 5 unit processes that are linear viz., roasting of grains, pulverizing or grinding, sifting, blending and packaging. Heat liable ingredients such as skimmed milk powder, vitamins and mineral premixes are added at the end of the process to the processed multigrain flour according to the formulation.

Ingredients: Parboiled Rice, Wheat, Finger millet (Ragi), Green gram dhal, Puffed Bengal gram, Jowar (Sorghum), Sesame seeds, Skimmed milk powder, Sweetener (Sugar + Jaggery), Vitamins and mineral mix

The nutritional profile (Table 5) reveals the developed product as a rich source of protein, dietary fiber and calcium.

Table 5. Nutritional composition of multigrain protein mix

Parameters	Approx. per 100g	Approx. per serving (50 g)
Energy (Kcal)	425.00	212.50
Proteins (g)	22.00	11.00
Fat (g)	6.00	3.00
Carbohydrates (g)	72.00	36.00
Dietary Fiber (g)	12.00	6.00
Calcium (mg)	190.00	95.00
Iron (mg)	2.00	1.00

Shelf-life studies: Shelf life studies were conducted for the multigrain mix under the following two conditions:

1) Room temperature (18-20°C, 60% - 65% RH)

2) Accelerated conditions – 75% RH and 40 °C

Accelerated storage study indicated that product, when stored in LDPE/CPP composite packaging material, did not undergo any significant physico-chemical changes such as moisture, texture and microbial growth suggesting that product retains its quality in the selected packing material and under accelerated storage conditions. The changes in physico-chemical properties are represented in the following graphs.

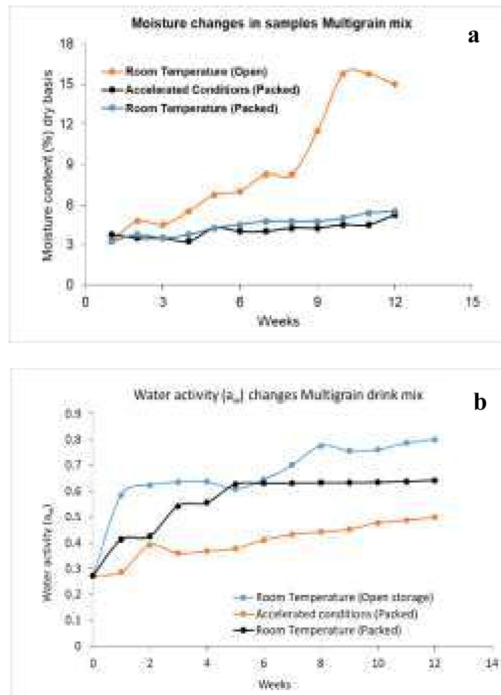


Fig. 7 Moisture changes and water activity in the multigrain mix under different storage conditions

Fig. 8 Multigrain mix kept under accelerated storage conditions

Sensory evaluation of multigrain mix

The sensory evaluation of the products was done using a hedonic scale for colour, aroma, aftertaste, flavour, texture or consistency and overall acceptability after reconstitution of the product by 30 untrained panellists (participants). The product was reconstituted with hot water above 85°C - 90°C for better texture and sensory score. The product had a mild, grainy and pleasant after taste and aroma upon reconstitution in hot water/milk. The acceptability was found higher in hot milk as compared to hot water. Reconstitution with milk resulted in a thicker consistency and better mouthfeel. The study indicated that the products have overall acceptability ranging from like moderately towards like very much (Table 6). Addition of micronutrient pre-mix did not alter the sensory properties of the product.

Table 6. Sensory evaluation of multigrain mix

Parameter	Multigrain mix Reconstituted in water	Multigraiin mix Reconstituted in milk
Colour	7.15±0.85	7.20±0.65
After Taste	7.05±0.91	7.15±0.82
Flavour (Aroma & Taste)	7.15±0.95	7.3±1.05
Mouthfeel (Consistency)	6.75±1.13	6.90±1.08
Overall Acceptability	7.20±1.02	7.40±1.13

Significant achievements:

- Ready to eat and reconstitute Kichdi developed
- Ready to cook Dalia (sweet and savoury)
- Multigrain protein beverage mix and traditional Sattu (sweet and savoury) variants
- Multigrain protein and fiber-enriched cereal bars and Iron enriched snack balls (nuts and seeds based) was developed as nutritious snacks
- Pilot-scale production at 500 kg per day developed and validated.
- A micronutrient premix containing Iron, Zinc, Vitamin A, Vitamin B12, Vitamin C and Folic acid developed in consultation with ICMR-National Institute of Nutrition.
- Shelf-life studies under accelerated conditions and sensory properties of micronutrient fortified nutri-breakfast products revealed average shelf life of breakfast products up to 6 months.
- Experimental animal studies in understanding the bio-efficacy of breakfast foods completed - IAEC No. (IAEC/IHBTP-9/May 2019).

Technology transfer

Instant khichdi and ready to eat khichdi

1. A Qube International, Ludhiana, Punjab
2. M/s. Singh Agritech, Kashipur, Uttarakhand

Multigrain protein beverage mixes

1. M/s. Access India Impex Centre Pvt. Ltd., New Delhi
2. M/s. Unati Co-Op, Marketing cum Processing Society, Talwara, Punjab
3. M/s. LokSeva Trust, Meerut, U.P

Multigrain protein and fiber enriched energy bars

1. M/s. Sirimiri Nutrition Food Products Pvt. Ltd., Bengaluru, Karnataka

1. Nutraceutical formulation for boosting bone and cartilage health: Over 15% of Indian population affected by osteoarthritis. The market for these products has reached USD 6.8 billion market in 2017 and expected to touch USD 10.1 billion by 2024 @ 8.1% CAGR. The marker bioactive identified from these plants are Negundoside, Isoorientin, Agnuside, Isovitexin, Resveratrol, Luteolin and Casticin. *In vitro* and *in vivo* studies showed cartilage health improvement in osteoarthritis animal model (patent submitted). Under the project, a UPLC-DAD method (15 min) was developed for the simultaneous quantification of marker compounds of Bergenin, Negundoside, Isoorientin, Agnuside, Vitexin, Isovitexin, Resveratrol, Luteolin, Kaempferol and Casticin) molecular markers in the plant extracts. The yield of specific metabolites was also quantified (Table 7). *Vitex negundo* plant leaves and *Cissus quadrangularis* stem were initially dried in the shade and powdered to coarse particle size. The sample was further analysed by UHPLC- PDA analysis which confirmed the presence of various marker compounds in the extracts.

Table 7. Bioactive constituent in selected plants

Compounds	*Vitex negundo*	*Cissus quadrangularis*	Powder
Negundoside	16.9	-	0.98
Isoorientin	21.7	-	0.88
Agnuside	198.8	0.06	19.5
Isovitexin	4.2	0.06	-
Resveratrol	-	0.3	-
Luteolin	0.06	-	-
Casticin	0.1	-	-

The *in vitro* studies of extracts and combination found to inhibits ROS production in IL-1 β - induced Chondrocytes and also suppresses inflammatory mediators. In addition, the *in vivo* efficacy of extracts in monosodium iodoacetate induced osteoarthritis revealed that *Vitex negundo* and *Cissus quadrangularis* in combined form attenuated the expression of inflammatory cytokines and mediators. The histopathology study was done to determine the severity of inflammation and cartilage damage using Haematoxylin and Eosin (H&E) staining and Toluidine staining. The treatment with syrup and powder formulations found to inhibit proteoglycan degradation and cartilage structure damage in joints (Fig. 9). Thus, it is concluded from the results that *Vitex negundo* and *Cissus quadrangularis* reduced the severity of pain in rats. The topical formulation was developed to improve cartilage health (Fig. 10).

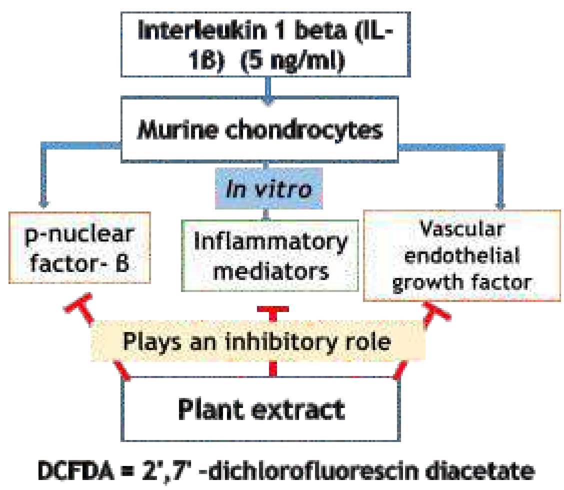


Fig. 9 Combination of selected plants reduced IL-1β induced damage in chondrocytes

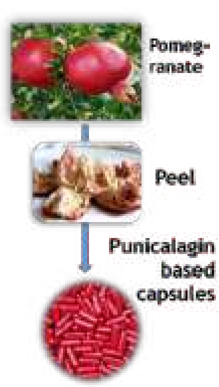
Fig. 10 Vee Cee formulation to improve the cartilage health

Significant achievements:

- The molecular markers having an effect on bone and cartilage health are characterized
- Efficacy evaluation of various combinations of extracts and their comparison with selected standard references on isolated primary cells (murine chondrocytes) showed better efficacy than individual extracts.
- Mono-iodoacetate-induced experimental osteoarthritis model was developed to check the efficacy of products as well as a combination of extract.
- The topical formulation in the form cream was prepared.

1. Development of *Punica granatum* based nutraceutical for cardio-protection:

Heart disease is a major public health problem leading to premature deaths and disease across India. About 54.5 million people were affected by the disease in 2016 compared to 25.7 million in 1990. Pomegranate is a source of very potent antioxidants that attenuates atherosclerosis development and its consequent cardiovascular events. In this project, pomegranate fruit parts were assessed for their cardioprotection properties. Pomegranate peel portion is divided into outer, middle and inner portion. The hydro-ethanolic extracts were analysed using UPLC that showed over 60 % presence of punicalagin in peel extract (Fig. 11). *Punica granatum* extract was studied on isoproterenol-induced cardiac damage zebrafish model with different concentrations (25-100 μg/mL). The extracts showed a significant increase in heart rate and ventricular stroke volume. In conclusion, pomegranate peel extract found to have cardioprotective activities in terms of blood glucose and triglycerides levels (Fig. 12).



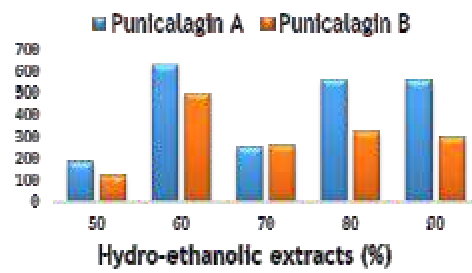


Fig. 11 Punicalagin content in pomegranate peel

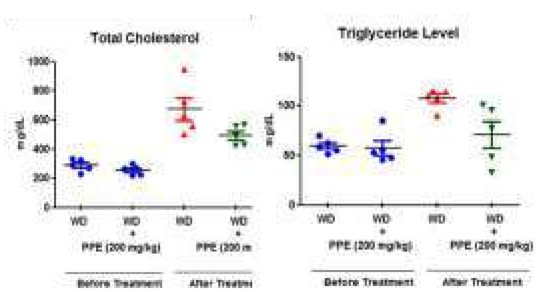


Fig. 12 Pomegranate peel extract fed mice showed lower plasma triglyceride

Significant achievements:

- A green process for the extraction of punicalagin from the peel
- Extracts showed a cardioprotective effect in cardiac damage induce zebrafish model
- Nutraceutical formulation as capsules and tablets developed
- Patent submitted
- Pilot-scale (100 Kg) process was developed

for pomegranate processing

1. Development of nutraceutical for neurodegeneration linked cognitive impairments in the elderly population:

Cognitive impairment characterized by trouble in remembering, learning new things, concentrating or making decisions. The prevalence of cognitive impairment is 22.2% in India. In general, the aged population (above 60 yrs and older) is the major target of age-linked neurodegeneration. In this project, extracts from different botanical parts of *Bacopa monnieri, Withania somnifera* and *Mucuna pruriens* were prepared and tested for neurodegeneration-linked cognitive impairments. Heavy metals, microbial testing, pesticides residue, aflatoxins content in extracts were found to be in permissible limits. Also, the chemical characterization of each extract was done for major bioactive metabolites (Table 8).

Table 8. Chemical characterization of plant extracts.

Extract	Compound	RT (min)	Content (%)
Equiv Withania (10mg/mL)	Withanoside IV	16.074	0.09
	Withanolide A	22.677	0.03
Equiv Bacopa (10mg/mL)	Bacoside A3	14.141	0.25
Equiv Mucuna (20mg/mL)	Luteolin	3.503	0.06
	L Dopa	7.555	3.62

The pharmacological activity of each extract and combination relevant to neurodegeneration and cognitive impairments was done in Zebrafish model (Table 9) and *Caenorhabditis elegans* models to select the most active ratio of extracts. The Extracts showed a cardioprotective effect in cardiac damage induce zebrafish model (Fig. 13). A syrup-based nutraceutical formulation was developed from the pharmacologically active *Bacopa monnieri, Withania somnifera* and *Mucuna pruriens* extracts. In addition, the efficacy testing of the formulation was done in a rat model of beta-amyloid-induced cognitive dysfunction linked with neurodegeneration that indicated it to be neuroprotective. Further, it improved cognitive functions in rats.

Table 9. Pharmacological testing in Zebrafish model

Animal model/activity carried out	Species	Clinical significance in relation to cognition/neurodegeneration
1mM Acrylamide-induced locomotor defects	5-*dpf* zebrafish larvae	Locomotor disability associated with cognitive deficit in neurodegeneration disorders
2.5 mM Acrylamide-induced neurotoxicity	-do-	Neuronal dysfunction and death
Scopolamine-induced learning impairment in T-maze	Adult Zebrafish	Impaired learning in neurodegenerative disorders
Scopolamine-induced memory impairment in T-maze	-do-	Memory dysfunctions in neurodegenerative diseases

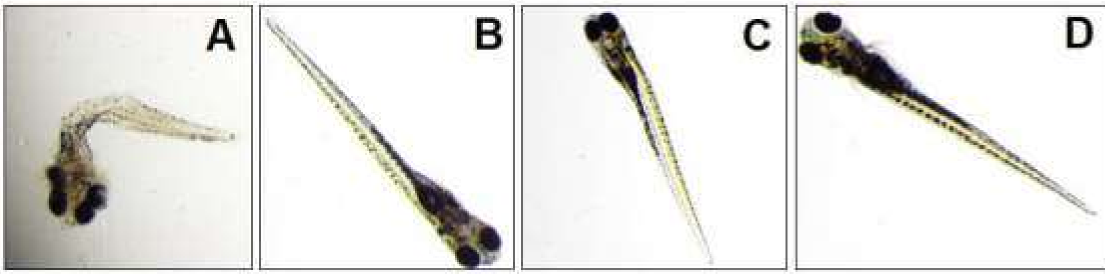


Fig. 13 Effect of *Mucuna pruriens* (B) *Withania somnifera* (C) and *Bacopa monnieri* (D) extracts on acrylamide-induced toxicity in comparison to vehicle control diseased (A)

Significant achievements:

- The extracts received from CSIR-CIMAP and combinations were tested in Zebrafish models of neurotoxicity, learning and memory.
- A syrup-based formulation was developed using the best active ratio of the extract. The stability studies were also carried out on developed formulation for up to 3 months. The formulation was tested rat model of β-amyloid induced neurotoxicity.
- Single-dose toxicity studies on the formulation were carried out as per OECD guidelines 423. Pharmacokinetics study was also carried out in rats after a single dose.
- Different tests on *C.elegans* were performed to study the neuroprotective effect of the extracts and combination. The major test carried out included Aldicarb assay, Amplex Red test, Nonanol repulsion assay, Chemotaxis index, Nile red assay, α-synuclein assay, Juglone assay, Paraquat assay and ROS (DCF-DA)-CL2006 assay. Further, specific gene expression studies were also carried out to ensure neuroprotection.

1. **Nutraceutical formulation based on plants for sleep disorders**: The purpose of sleep is one of the great mysteries of biology and has fascinated people for millennia. The International Classification of Sleep Disorders includes six symptom-based categories: hypersomnia, insomnia, parasomnias, sleep-related breathing disorders (SRBD), circadian rhythm sleep disorders and sleep-related movement disorders. As a therapeutic group, there is a great interest in nutraceuticals for these disorders. Preparation and chemical profiling of tea theanine enriched extract (Fig. 14) and aqueous extract of *Withania somnifera* leaves (Fig. 15) was done. It also include4s stability and safety studies of tea theanine and W. somnifera leaves extracts. Withania aqueous leaf extract was evaluated on mice model for safety and found safe up to 2000 mg/Kg. The extracts were evaluated for the potentiation of sleep in a well-established diazepam-induced sleep mouse model (Fig. 16). A minimum dose of diazepam that induced sleep, which retained for a measurable duration, was found to be 30 mg/kg; ip.

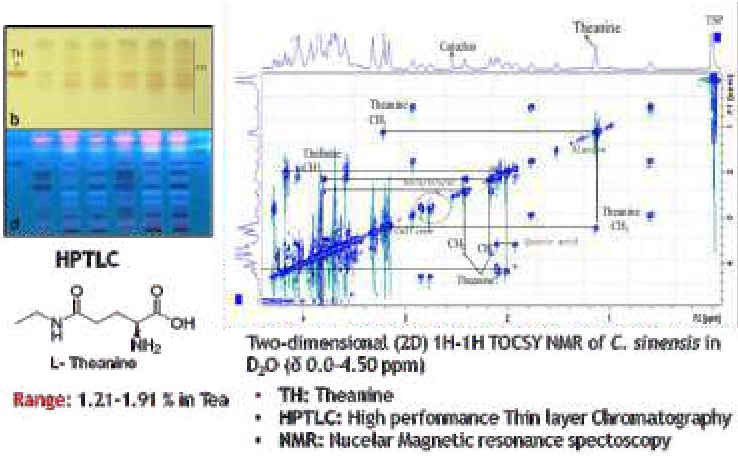


Fig. 14. Chemical characterization of theanine in tea

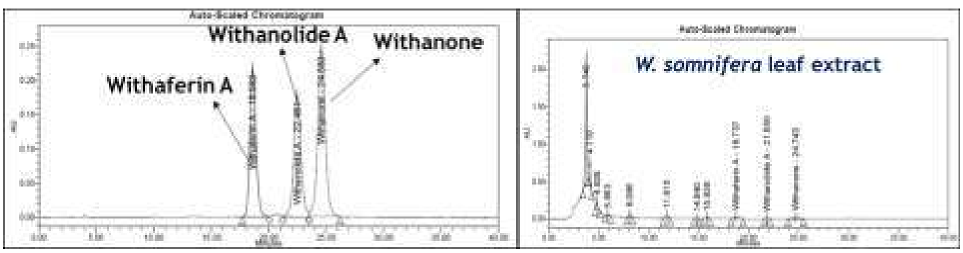


Fig. 15 Chemical profiling of *W. Somnifera* leaf extract

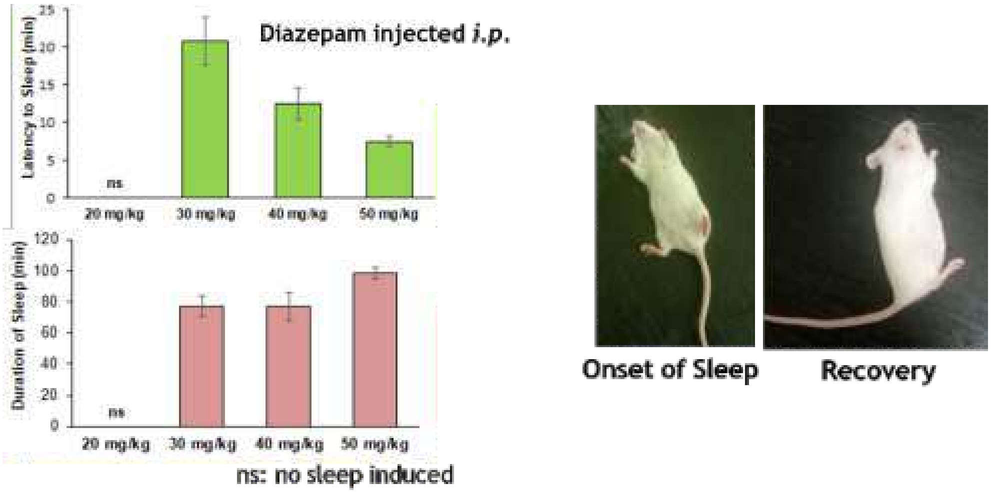


Fig. 16. Standardization of mouse model of benzodiazepine-induced sleep

The compatibility study was also done for individual, i.e. tea extract (T), and *W. somnifera* extract (W) and a mixture of both extract at the ratio of 1:1(T:W) and found stable (Fig. 17). The extracts not produced any changes in body weight as compared to control animals. The nutraceutical in the form of the tablet was developed as a binary mixture (1:3) of tea theanine, and *W. somnifera* leaves extract.

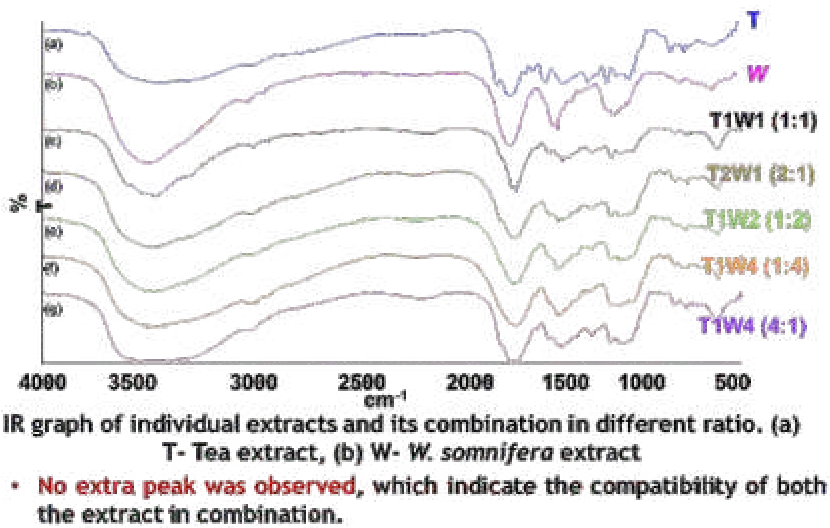


Fig. 17. Chemical compatibility (by infrared spectroscopy)

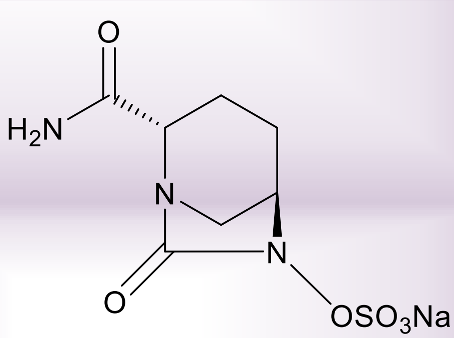
Significant achievements:

- *W. somnifera* extract, and tea L-Theanine enriched fraction potentiate the diazepam-induced sleep in mice model. Both extracts decreased the onset of the bout and increased sleep bouts in comparison to control.
- Withania leaves extract showed less onset bout, while tea theanine enriched extract showed more number of sleep bout. However, the combination of Withania leaf extract: L-theanine enriched extracts found most effective.
- Extracts were found physically and chemically compatible.

CSIR MISSION PROJECT
INNOVATIVE PROCESS AND TECHNOLOGIES FOR INDIAN PHARMACEUTICAL & AGROCHEMICAL INDUSTRIES (INPROTICS-PHARMA & AGRO) (HCP 011)

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

Pharmaceutical sector is a very important and integrated part of the Indian chemical industry which is a key constituent of the nation's economy accounting for about 1.38% of the GDP. 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 the various sectors catered by Indian chemical industry, mission INPROTICS-PHARMA & AGRO addresses the needs of two vital sectors, viz., Pharmaceutical and Agrochemical sectors.



Avibactam

Pharmaceutical industry is a very dynamic industry generally cater the need of human health. With discovery of new drugs, formulations and treatment methods being introduced at a steady pace to alleviate health related problems of people the pharmaceutical sector is consistently growing. Though India is lagging in new drug discovery, it is a world player in generic drugs. The Indian Generic drugs account for 20 per cent of global exports in terms of volume, making India the largest in terms of value. There is increased competition from other countries and to retain its position, India has to continuously upgrade its portfolio with drugs and pharmaceuticals that come out of patent protection. In this mission project CSIR worked on to develop non-infringing and free to operate processes for new drugs for different diseases such as Cancer: Nilotinib, Hepatitis C: Daclatasvir, Dolutegravir, Ledipasvir; and drugs for other diseases such as Infectious diseases (Avibactam), Cardiovascular diseases (Nicergolin) and Epilepsis (Pregabalin).

β-lactamase inhibitors have been demonstrated to restore the efficacy of antibiotics against resistant pathogens as growing resistance against current line of treatment became a global challenge. 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 has developed a new lab-scale process for the synthesis of Avibactam under this mission.

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 this area, the CSIR Mission Phytopharmaceuticals was launched wherein CSIR-IHBT is playing a vital role. Coordinated efforts are being made under this mission. **CSIR-IHBT** achievements in the last year vis-à-vis verticals is as follows:

Vertical A: Captive cultivation of selected medicinal plants

Medicinal plants are globally valuable sources of herbal products. Due to poverty and lack of access to medicine, over extraction of many of these plants has threatened its status in wild and these have been listed as endangered species. Under Phytopharmaceutical mission mass multiplication and captive cultivation of selected medicinal plants like *Valeriana jatamansi, Stevia rebaudiana, Saussurea lappa* and *Inula racemosa* have been done.

Key achievements

- Area covered: ~75 hectares
- Training & awareness programs conducted: 22 Nos
- MoUs signed: 2 nos.

Mass multiplication of quality planting material:

Stevia rebaudiana: About 2.0 crore quality planting materials have been generated for captive cultivation at different locations in India.

Valeriana jatamansi: About 2.0 lakh quality planting materials and 1kg quality seeds have been raised at farmer's field and Institutional land for captive cultivation of *Valeriana jatamansi*.

Saussurea lappa: 10 kg seeds and 50 thousand quality seedling have been generated to meet the target of this mission.

Inula racemosa: One lakh rooted plants and 10 kg seeds have been generated and distributed to the farmers for captive cultivation.

Area covered under captive cultivation:

Under this mission, four important medicinal plants i.e., *Stevia rebaudiana*, *Valeriana jatamansi*, *Saussurea lappa*, and *Inula racemosa* were brought under captive cultivation in PAN India basis. About 65 hectares of land has been covered under stevia cultivation throughout the India in collaboration with different private agencies viz. M/s. Agri Natural India, Ludhiana, M/s. MS, Ludhiana, M/s. KS, Udham Singh Nagar, Uttarakhand, M/s MDHP Ltd, Bastar, Chhattisgarh and progressive farmers from UP, Andhra Pradesh, Haryana, Punjab, UP and Gujrat (Fig. 1).

At Pathankot, Punjab

At Ludhiana, Punjab

At Palampur, H.P.

At Uttarakhand

At Agra, UP

Fig. 1 Field view of stevia plantation at different location in India

Further, 10 hectares of land has been covered under *Valeriana jatamansi*, *Saussurea lappa*, and *Inula racemosa* in different districts (Lahaul- Spiti, Shimla, Chamba and Mandi) of HP to conserve the plants and boost the economy of local farmers (Fig. 2).

Captive cultivation of *S. lappa*

Captive cultivation of *I. racemosa*

***V. jatamansi* at experimental filed**

***V. jatamansi* at underutilized land**

Fig. 2 Captive cultivation of *Valeriana jatamansi*, *Saussurea lappa*, and *Inula racemosa*

Table 1. Status of captive cultivation of medicinal plants

Plant	Area covered (ha): 2019-2020	Location/region/state
Stevia rebaudiana	65 hectares of land has been covered in farmer's field	UP, Andhra Pradesh, Haryana, Chhattisgarh, Punjab, HP, Gujrat and Uttarakhand
Valeriana jatamansi	8 hectares of land has been covered	HP and Uttarakhand
Saussurea lappa	1 hectares of land has been covered	HP
Inula racemosa	1.25 hectares of land has been covered	HP

Chromatographic finger print profiles were generated for *Valeriana jatamansi* and *Stevia rebaudiana*. Four markers from *Stevia rebaudiana* (Stevioside, Reb-A, Reb-B, Reb –C) three markers from *Valeriana jatamansi* (Valerenic acid, Acetoxy valerenic acid, hydroxy valerenic acid) have been identified.

Chemical characterization of 42 accession of Stevia in terms of steviol glycosides accumulation has been completed. Agrotechnology packages have been developed for *Valeriana jatamansi* and *Stevia rebaudiana.* Stevia-based intercropping system has also been developed under Palampur conditions. To understand the effect of planting methods and agroforestry systems on growth, yield and quality of *Valeriana jatamansi* on field experiment was conducted at CRIR-IHBT experimental farm. The major component of essential oil is Patchouli alcohol, and highest percentage was recorded with plants grown under Ginkgo agro-forestry system.

Botanical data for *Valeriana jatamansi* and *Stevia rebaudiana* have been developed (Fig.3) under this mission.

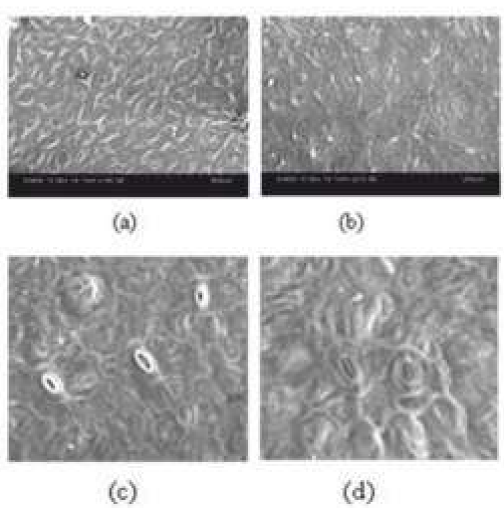


Fig. 3 Scanning electron microscopy (a) upper epidermis of leaf; (b) lower epidermis of leaf showing stomata (c); epidermis of leaf showing open stomata (d) epidermis of leaf showing closed stomata of *Valeriana jatamansi*

Vertical B: Revival status of high value rare, engendered and threatened (RET) medicinal plant species

Under the mission, 4 important RET species are being targeted at the institute to provide end to end solutions for achieving the non-RETs status of these species. Following key achievements were made during the year:

- Area covered: 6 acre
- Collection/ Characterization:(741 genotypes/ 50 populations)
- Gene bank creation: 4 species
- Genomic resource creation: (4/4 species)
- Phyto-chemical evaluation: (4/ 4 species)
- Micro/ Macro propagation: (4 species)
- Training and awareness programme: 10 Nos (H.P)

MoUs with line departments:

- Department of Ayurveda, Govt. of H.P.
- State Medicinal Plant Board, Govt. of H.P.
- Department of Forest, Govt. of H.P.
- Shiv Aushdhiya Paudh utpadan Society, Rajgarh

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

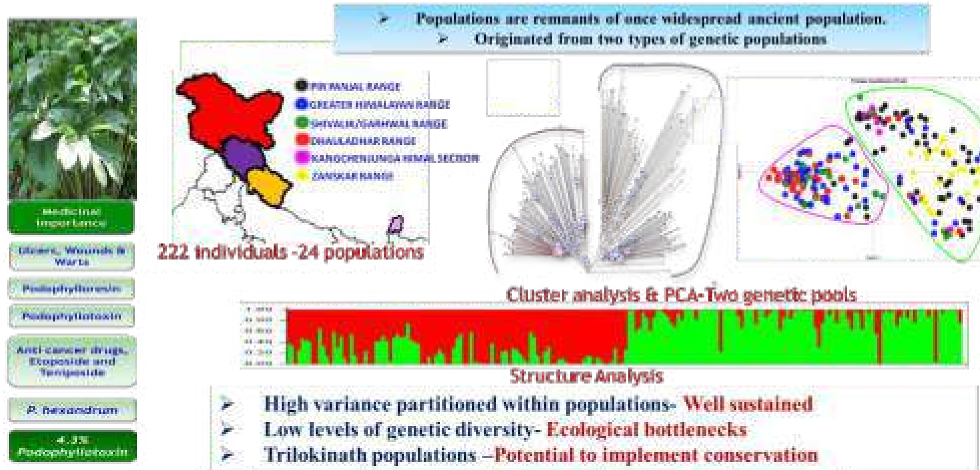
Table 2. CSIR-IHBT – Quantifiable achievements

Plant species	% progress vis-à-vis end point/final deliverable					Area to be covered (acre)
	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 %	2.5
Podophyllum hexandrum	250/24P 24/1P (50%)	50	Marker procured (10%)	100 % Achieved (Macro-P)	30 %	2.5
Trillium govanianum	250/11P 50/2P (40 %)	50	8 (3 new) compounds isolated (50 %)	20 % (TCP)	20 %	2.5
Fritillaria roylei	125/3P (20%)	25	2 compounds isolated (40 %)	70 % (TCP) 20 % (Ma_P)	15 %	2.5

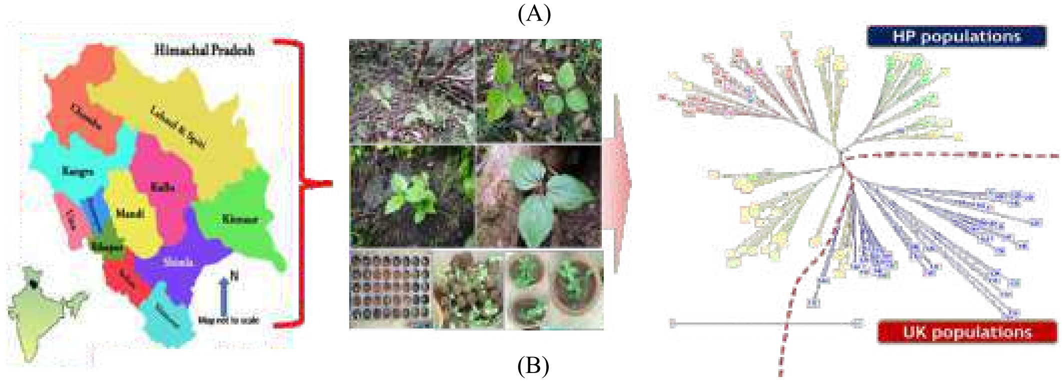
Ma_P: Micropropagation; P: Population; TCP: Tissue culture raised

Activity 1: Diversity collection and characterization

A total of 766 genotypes representing 52 populations of different geographical locations were collected from H.P, Uttarakhand, J&K and single population from north-eastern region of India. While collecting the plant materials all the GPS and environmental parameters were also collected. Genetic diversity assessment for identification of core population was carried out to expedite the conservation plan. Next-generation genomic resources have been created for three of four targeted species. 6000 microsatellite markers were identified and validated in selected random genotypes in case of three species (*Podophyllum hexandrum, Picrorhiza kurroa, Trillium Govanianum*). Diversity characterization using SSR makers were done in *Podophyllum hexandrum, Picrorhiza kurroa* and *Trillium govanianum* using 224, 152 and 150 genotypes, respectively (Fig. 4).



(A)



(B)

Fig. 4 Genetic diversity parameters of (A) ***Podophyllum hexandrum*** **; (B)** ***Trillium govanianum*****.**

Further, 25 additional genotypes representing two additional populations were added and 150 genotypes of *Fritillaria roylei* were collected and processed for tissue specific RNA sequencing. More than 1000 million reads representing 278.4 GB data was generated.

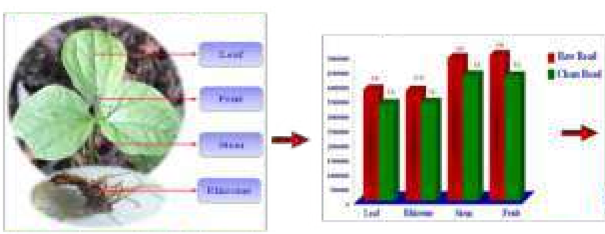
Creation of functionally relevant genomic resources

(i) *Podophyllum hexandrum*

Considering the industrial demand of PTOX, which relies on the highly endangered natural resources, multiple genotypes transcriptome sequencing was done to elucidate global molecular processes and identify key genes for enhancing PTOX biosynthesis by overexpressing the targeted candidates. Transcriptome of leaf, rhizome, and stalk was generated to analyse the spatial regulation of PTOX biosynthesis in genetically diverse genotypes. Overall, 198 million high-quality paired-end reads were assembled into 85,531 transcripts. In addition, 32,341 transcripts were assigned gene ontologies with 6570 hits in distinct pathways and 15,886 transcription factors representing 70 families.

(ii) *Trillium govanianum*

To facilitate the basic understanding of the key genes and regulatory mechanism of pharmaceutically important biosynthesis pathways, and also for creation of functionally relevant marker resource, first spatial transcriptome sequencing on Illumina platform of generated 151,622,376 (~11.5 Gb) high quality reads. Functional annotation with multiple public databases identified array of genes involved in steroidal saponin biosynthesis and other secondary metabolite pathways including brassinosteroid, carotenoid, diterpenoid, flavonoid, phenylpropanoid, steroid and terpenoid backbone biosynthesis, and important TF families (bHLH, MYB related, NAC, FAR1, bZIP, B3 and WRKY). Differentially expressed large number of transcripts, together with CYPs and UGTs suggests involvement of these candidates in tissue specific expression. Combined transcriptome and expression analysis revealed that leaf and fruit tissues are the main site of steroidal saponin biosynthesis. Additionally, 7514 SSRs were also ascertained to expedite to expedite conservation efforts in *T. govanianum* (Fig. 5).



Total number of sequences examined	69174
Total size of examined sequences (Mb)	27.74
Total number of identified SSRs	7514
SSR containing sequences	6340
Sequences with more than 1 SSR	901
Compound SSRs	698

- 7821 functionally relevant SSR markers identified
- 488 SSR markers were synthesized and validated

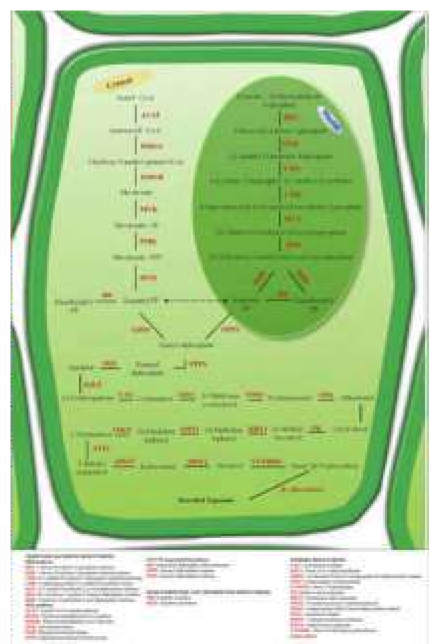
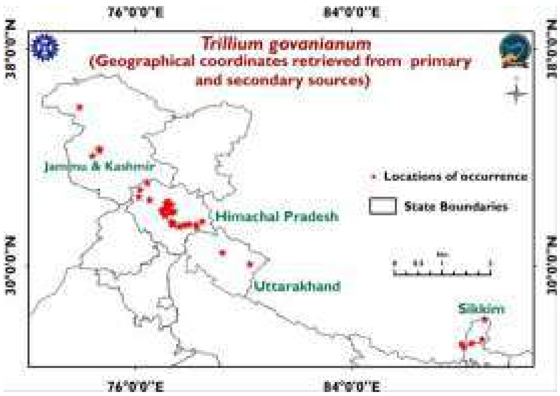


Fig. 5 NGS based genomic resource creation in *T. govanianum*

Ecological Niche Modelling (ENM) for in-situ conservation

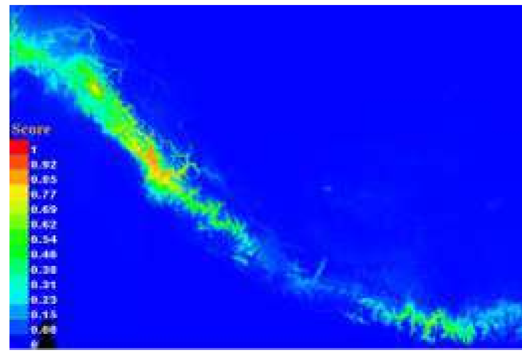
ENM were used for expedite the conservation and identification of suitable location for collection and in-situ conservation of targeted RETs. We had reported EN modelling in two important plant species (*Podophyllum hexandrum* and *Picrorhiza kurroa).* During the period, ENM was done to prioritize areas for *in-situ* conservation of *Trillium govanianum* (Fig. 6).

Occurrence data collection



- **52 geographical locations of occurrence of *T. gavanianum* in Indian Himalayan were used for modeling (primary= 14 & secondary= 38).**
- **Modeled output using MaxEnt software were further analyzed to derived final results.**

MaxEnt modeling



MaxEnt modeled probability area

- **80 environmental variables along with elevation were used for the modeling.**

Fig. 6 Ecological Niche Modelling (ENM) for in-situ conservation of *Trillium govanianum*

Activity 2: Gene bank creation

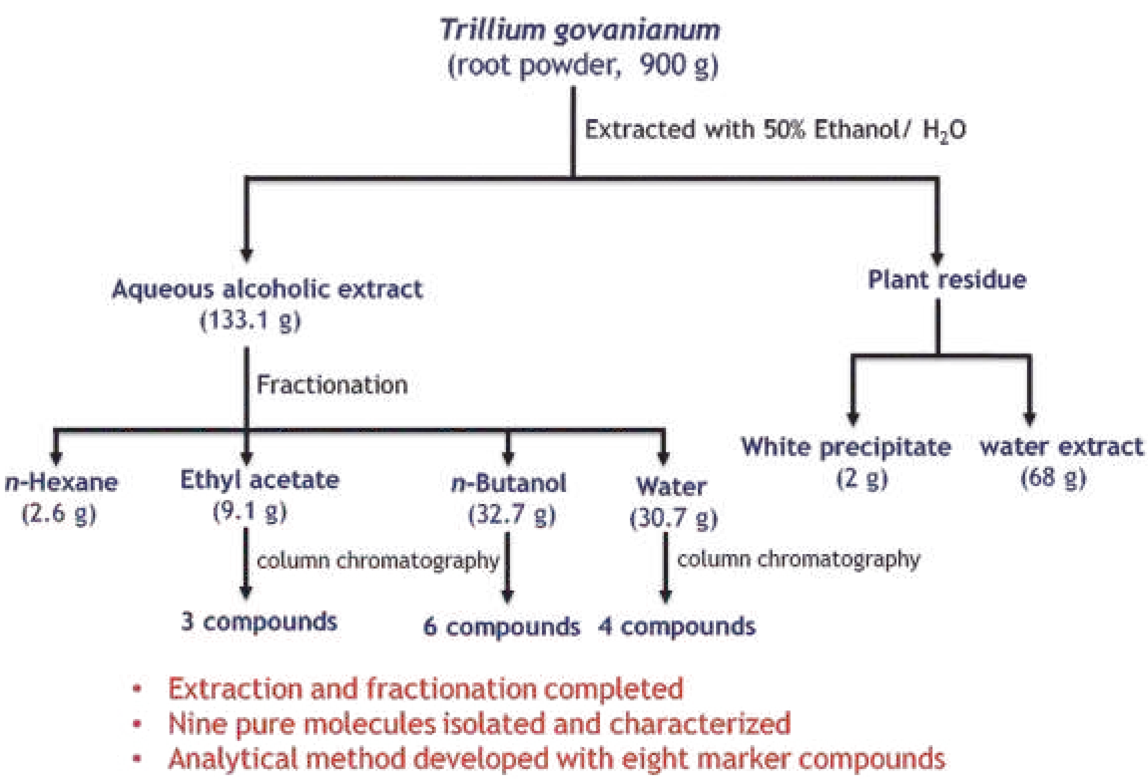
A total of 230 genotypes (60 each for *Podophyllum hexandrum, Picrorhiza kurroa* & *Trillium govanianum,* and 50 in case of *Fritillaria roylei*) with desirable phenotypic characters were collected and included in the gene bank at CeHAB. Breeding behaviour, phenotypic data collections, chemical and molecular characterization of newly added genotypes is in progress.

Activity 3: Phytochemical characterization

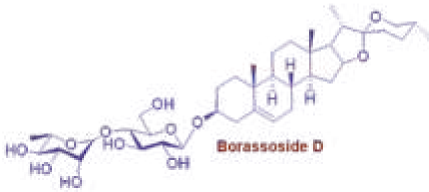
Of the four, marker compounds were known for two targeted RET plant species and hence, marker compounds were procured for *Picrorhiza kurroa* and *Podophyllum hexandrum.* So far, quality control method was developed for *Picrorhiza kurroa.* Further, extraction and fractionations completed both in *Trillium govanianum* and *Fritillaria roylei,* while nine pure molecules and quality control method was developed in case of *Trillium govanianum* during this period. Characterization of marker compounds is in progress (Table 3).

Table 3. Phytochemical Analysis status of targeted RETs

Targeted RETs Species	Marker Compounds	Work done
Picrorhiza kurroa	Known and procured	• Marker compounds Isolated and characterized. • Quality control method developed
Podophyllum hexandrum	Known	• Marker compounds procured. • Quality control method developed
Trillium govanianum	Not known	• Nine Marker compounds characterized • Quality control method developed
Fritillaria roylei	Not known	• Three marker compounds characterized • Quality control method developed with two marker compounds

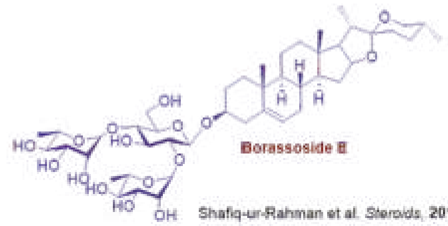


Pure Compounds from *Trillium govanianum*



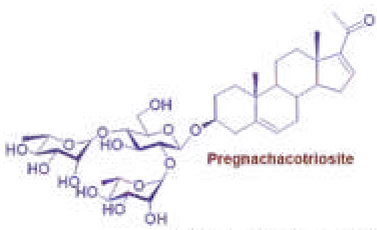
Borassoside D

M.Yoshikawa et.al. *Chem. Pharm. Bull.*, **2007**, *55*, 308-316



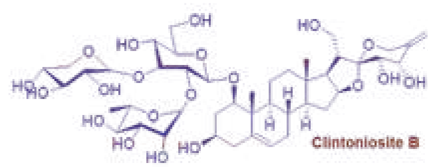
Borassoside E

Shafiq-ur-Rahman et al. *Steroids*, **2016**, *104*, 270-275



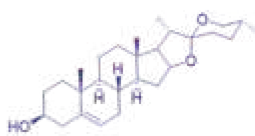
Pregnachacotriosite

Hu et. al. *J. Nat. Prod.* **1999**, *62*, 299-301

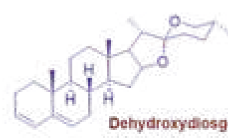


Clintonioside B

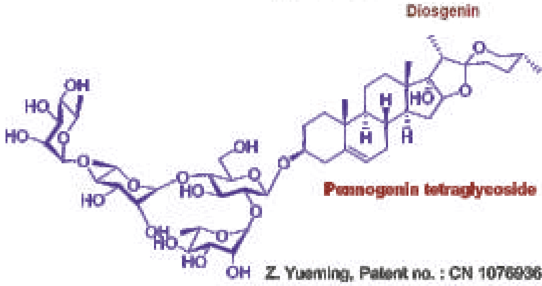
Y.Micami et.al. Helvetica Chimica Acta, **2008**, *91*, 2097-2106



Diosgenin

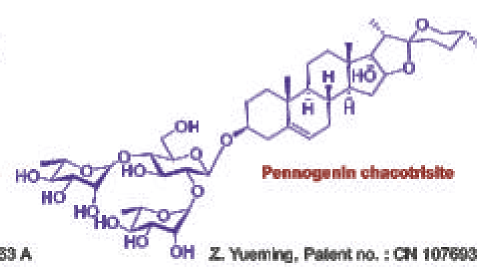


Dehydroxydiosgenin



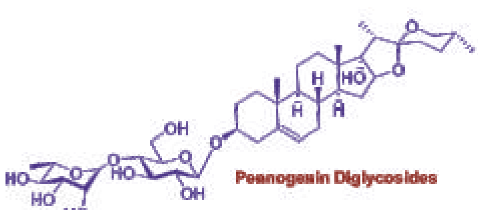
Pennogenin tetraglycoside

Z. Yueming, Patent no. : CN 107693663 A



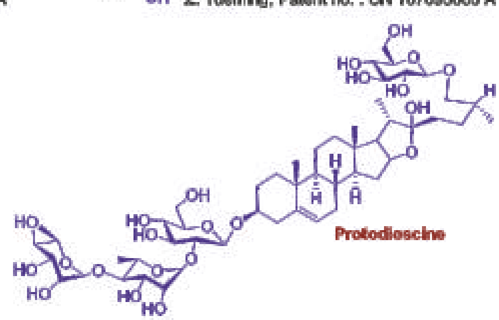
Pennogenin chacotrisite

Z. Yueming, Patent no. : CN 107693663 A



Pennogenin Diglycosides

Z. Yueming, Patent no. : CN 107693663 A



Protodioscine

Patricia Y. Hayes et. al. *Phytochemistry*, **2009**, *70*, 105

Activity 4: Micro and Macro-propagation

(A) Picrorhiza kurroa

Micropropagation

In continuation to the previous report, additional 6000 plants were generated through micropropagation. Of these, 4000 hardened plant were successfully transferred to the farmer's fields in Chamba region of Himachal Pradesh for captive cultivation in *Picrorhiza kurroa*.

Fig. 7 Leaf tissue derived direct organogenesis depicted hardened plantlets of *P. kurrooa* ready for field transfer

So far 11500 hardened plantlets were successfully transferred to the farmer's fields for captive cultivation (Fig.7).

(B) *Podophyllum hexandrum*

Micropropagation

- Micro-propgation efforts on multiple shoot regeneration and rooting are in progress

Macro-propagation:

In continuation to the previous report wherein 3500 plants were successfully regenerated and successfully transferred to the field at CeHAB, Keylong, (Fig. 8).

Fig. 8 *Podophyllum hexandrum* plantlets formation

(C) *Fritillaria roylei*

In-vitro regeneration system including successful transfer to the field conditions have been successfully standardized and root medium was successfully worked out. 1500 *in vitro* shoots produced and 150 hardened plantlets were transferred to natural habitat (Fig. 9).

Fig. 9 *In-vitro* regeneration system in *F. roylei*

(D) *Trillium govanianum*

In continuation to the previous experiments, 5 different media combination were tested for the shoot induction in *T. govanianum* and successfully standardized the protocol of micropropagation using medium with 5mg/L BAP and 1mg/L NAA (Fig. 10).

Fig. 10 Establishment of *T. govaniamum* shoot cultures:
a) Inoculated rhizome with apical shoot bud, b) Shot emergence,
c) Trifoliate leaf opening and stem elongation,
d) Multiple shoot formation

Area under captive cultivation: Restoration of RETs for sustainable utilization

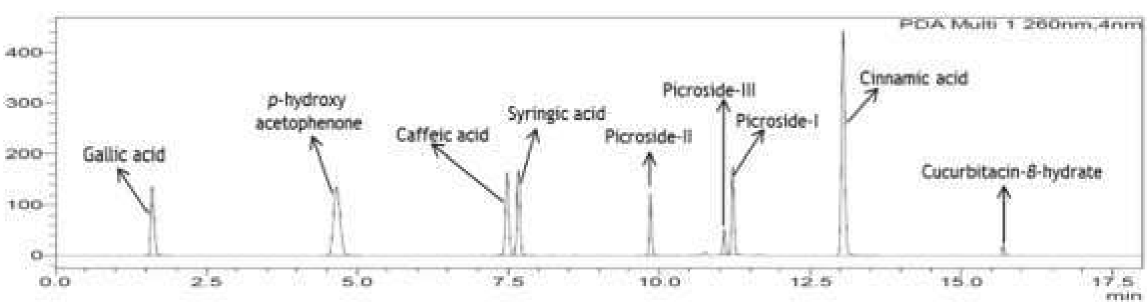
In continuation to ongoing efforts on generation of quality plant material of *Picrorhiza kurroa* and *Podophyllum hexandrum*, 30000 nursery raised plant lets were generated in *Picrorhiza kurroa* and their performance were evaluated at farmers' field. As suggested, *ex-situ* nurseries were maintained at CSIR IHBT and CeHAB (Fig. 11).

Fig. 11 Ex-situ conservation nursery for captive cultivation of *Picrorhiza kurroa*

Vertical C: Technology Packages for Production of GMP Grade Medicinal Plant extracts

UPLC-PDA based analytical method was developed for the quality control of both these plant. Complete CMC done for both these plant (Fig 12).

- Pilot scale process developed for *Picrorhiza kurroa* standardized extract enriched with picrosides
- Pilot scale process developed for *Ginkgo biloba* standardized extract enriched with ginkgolides and flavonoids



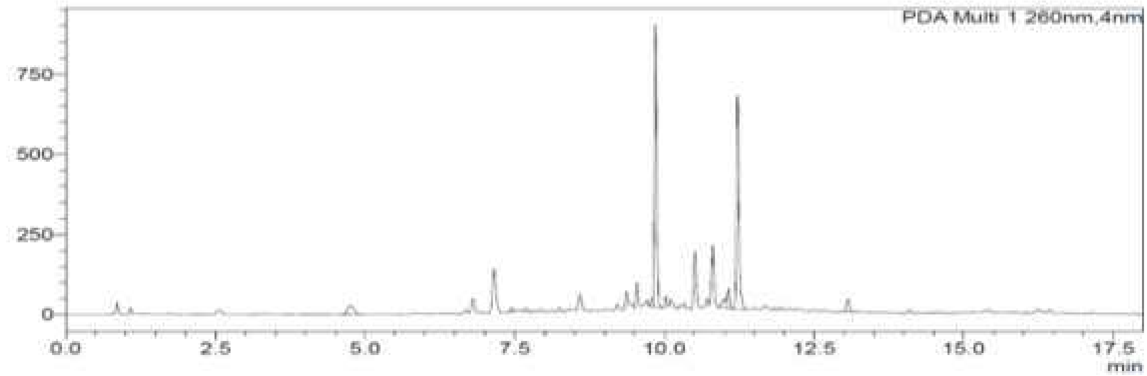


Fig. 12 UPLC chromatogram of standard and sample

Vertical D: Phytopharmaceutical development from important medicinal plants

Phytopharmaceutical development of *Cissampelos pareira* as per regulatory guidelines of AYUSH.

Chemical profiling of three parts including leaves, stem and root, five marker compounds isolated, characterized and also Analytical method developed and applied for the chemical standardization of extract (Fig. 13).

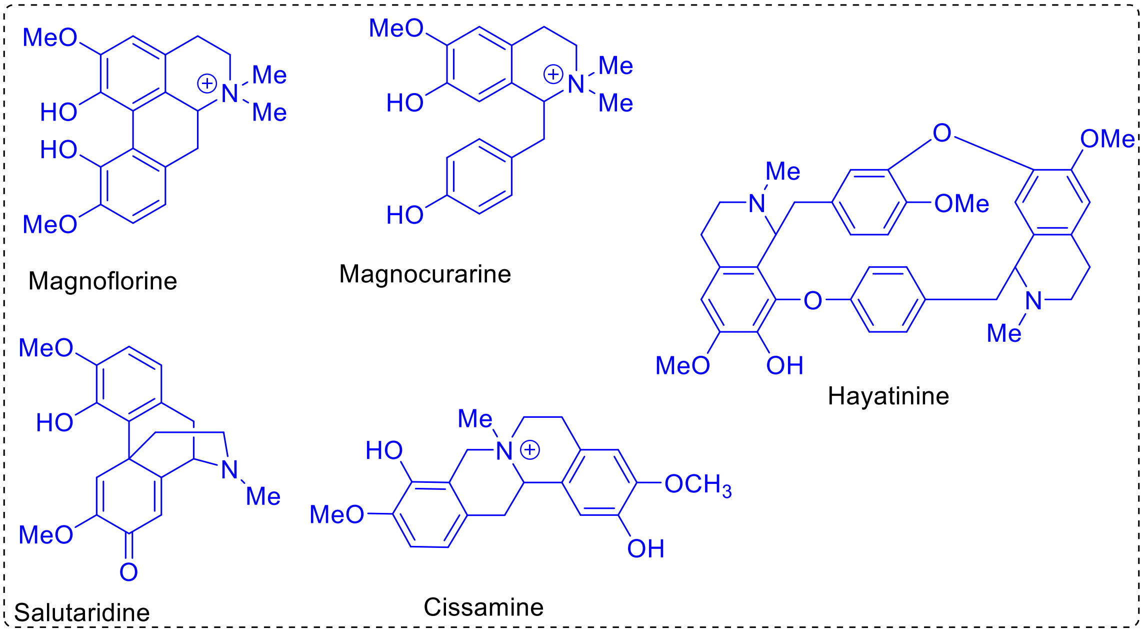


Fig. 13 Marker compounds isolated and characterized

The extracts and fractions of different botanical parts of *Cissampelos pareira* showed inhibition of venom protease, phospholipase A2, acetylcholinesterase and L-amino acid oxidase. The effect of root extract and the butanol fraction was found to be better as compared to other parts and fractions (Fig. 14).

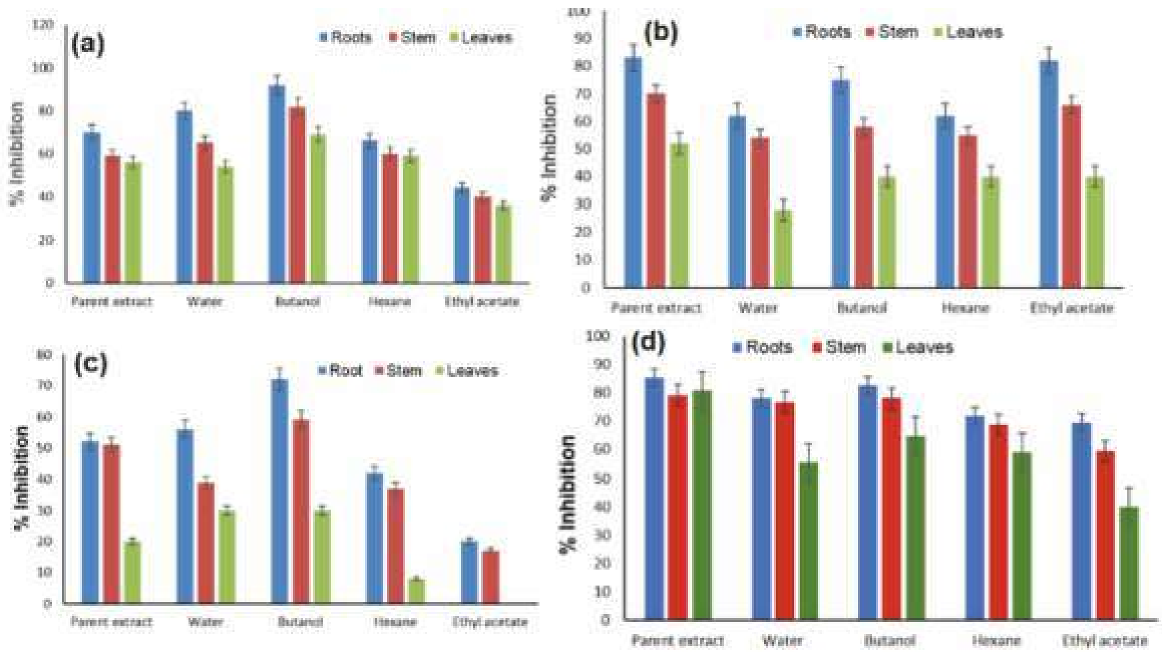
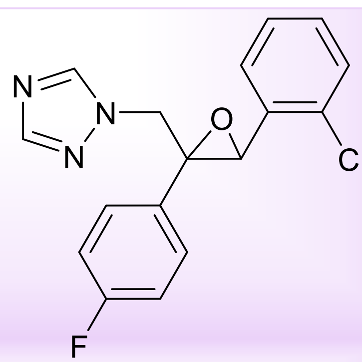


Fig. 14 Effect of extracts/fractions of different botanical parts of *C. pareira* extract on Indian cobra (Naja naja) venom enzymes inhibition assays (a) Protease activity, (b) Acetylcholinesterase activity, (c) L-amino acid oxidase activity, (d) Phospholipase A2 activity

CSIR MISSION PROJECT
CROP PROTECTION CHEMICALS (CPC)

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

Agrochemical Industry: Agrochemicals are crucial for ensuring food and nutrition security of the nation. Worldwide an average of 3 kg per ha of crop protection chemicals are being used whereas Indian consumption of products for crop protection is much lower at 0.6 kg per hectares (ha) and offers immense opportunities for future growth. Agrochemical sector is opening opportunities for generics, contract manufacturing & research as there are several new products going off-patent globally and huge demand. Agrochemical sector is important due to business as well as social responsibility point of view. 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: As per a knowledge paper prepared by Tata Strategic Management Group, Indian agrochemical industry is estimated to be worth US$ 4.4 Billion in FY15 is expected to grow at 7.5 per cent per annum to reach US$ 6.3 billion by FY20. With estimated 355 million metric tons per annum (MMTPA) food grain requirement in 2030 from current 253 MMTPA, efficient usage of crop protection products and solutions for Indian agriculture are highly required. 15-25% of food produced by the farmers in India eat away by pests and diseases every year and is a huge loss to the farmers. Demand for food grains is increasing at a faster pace when compared to its production due to the decreasing arable land and rising population. 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 and are very essential to ensure food and nutritional security.

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

ACTIVITIES IN NORTH EAST

Introduction of low chilling varieties of apple and their chemical analysis

CSIR-IHBT started introduction of low chilling varieties of apple in North eastern states during 2016 and in continuation to this activity apple was introduced in Manipur and Meghalaya during 2019-2020 in association with NERCORMP. The apple plants which were introduced 2016-2018 have started bearing fruits and they were compared for quality analysis during 2019-2020. The fruit from three different low chilling apple cultivars were harvested at commercial maturity from two geographically distinct Himalayan regions and analyzed for their phenotypic properties, proximate nutritional composition. Fructose (355.50±0.48 to 530.49±0.40 mg/g) was the most dominant sugar in all the apple cultivars at both locations followed by sucrose (187.72±0.68 to 309.58±0.41 mg/g) and glucose (76.85±0.70 to 117.41±0.35 mg/g). The result showed that all the attributes are comparable with the commercial apple and thus suggested that these low chilling apple cultivars might be the promising for the eastern Himalayas where the cultivation of apple is not reported yet.

Table 2. Effect of location and cultivars on sugar content (mg/g) in apple fruits

Locations	Cultivars	Sugar content (mg/g)			
		Glucose	Fructose	Sucrose	Rhamnose
West Himalaya	Dorsett Golden	76.85±0.70	355.50±0.48	207.55±0.78	24.48±0.08
	Fuji	103.26±0.80	399.72±0.66	187.72±0.68	48.19±0.01
	Anna	91.57±0.75	439.68±0.75	203.49±0.60	27.64±0.01
	Mean	90.56±0.75	398.3±0.63	199.59±0.69	33.44±0.03
East Himalaya	Dorsett Golden	79.57±0.51	397.94±0.55	191.84±0.80	29.90±0.22
	Fuji	117.41±0.35	530.49±0.40	192.49±0.68	21.83±0.04
	Anna	110.71±0.75	402.06±0.29	309.58±0.41	21.18±0.01
	Mean	102.56±0.54	443.49±0.41	231.30±0.63	24.30±0.09
Market sample	Control	111.65±0.62	362.27±1.11	237.81±0.16	18.84±0.53

Results as mean ± SEM (Standard Error of Measurement) of triplicate measurements.

CSIR-IHBT scientist imparting training on apple cultivation to the farmers of Champhai, Mizoram

Rural entrepreneurship development at Northeast India

CSIR-IHBT has contributed for the development of rural entrepreneurship in the Northeast region by disseminating the technologies developed at institute in partnership with Ministry of Micro, Small & Medium Enterprises (*MoMSME*) under Scheme of Fund for Regeneration of Traditional Industries (SFURTI). Under this unique initiative sustainable livelihood generation among the rural population is targeted by assisting them with advanced technologies and equipments. Two technologies of the institute have been chosen by MoMSME to establish clusters (co-operative societies) in rural areas of the Northeast India. So far, with CSIR-IHBT as a Technical Agency and Khadi and Village Industries Commission (KVIC) as nodal agency (NA), *MoMSME* has sanctioned setting up of three clusters on *Shiitake* mushroom and other food processing cluster at Sikkim and three more *Shiitake* clusters at Nagaland, Manipur and Meghalaya are proposed (Table 1). The sanctioned three clusters at Sikkim will be functional by November 2020 and it will impact 750 farmers with projected additional income of Rs 50,000/- per year per farmers, by selling fresh and dried *shiitake* and other products made using the *shiitake* powders. Under the clusters, a common facility centre (CFC) will be established in collaboration with a non-profit making organization. Another technology of the institute on efficient bacterial formulations for enriched compost in cold hilly region has also led to formation of one "Enriched Composting/ Vermicomposting Cluster" at West Sikkim in collaboration with Foundation of MSME clusters (FMC) as NA (Table 1). The cluster will impact 200 farmers and it is projected that each farmer can earn additional Rs 30,000/- per year by selling enriched compost.

Table 1. Clusters sanctioned in with CSIR-IHBT as Technical agencies in collaboration with Nodal agencies (KVIC and FMC) in the Northeast regions

Sl. No.	Name of the proposed cluster/ State	Implementing Agency	No. of targeted beneficiaries	Total Project Cost	Status
		Nodal Agency: KVIC			
1	**Sumbuk** *Shiitake* **mushroom and other food processing cluster. South Sikkim**	Glen Leu Women's Service Co-operative Society (NGO)	250	244.90	Sanctioned
2	Norbo Choeling *Shiitake* **mushroom and other food processing cluster. South SIkkim**	Lamaten Tingmoo Organic Growers Cooperative Society Limited (FPO)	250	244.90	Sanctioned
3	West Sikkim *Shiitake Mushroom and Other Food Processing cluster.* West Sikkim	Manav Jiwan Sudhaar Evam Kshamata Nirman Samiti (NGO)	250	244.90	Sanctioned
4	**Seithekema** *Shiitake* **mushroo m and other food processing cluster/ Nagaland**	Sustainable Development Research Centre (NGO)	250	To be decided	Proposed
5	*Hungpung Shiitake Mushroom and Other Food Processing Cluster/* **Manipu***r*	Ukhrul District Community Resource Management Project (NGO)	250	To be decided	Proposed
6	*Ri-Bhoi Shiitake Mushroom and Other Food Processing Cluster/* **Meghalaya**	Eastern Ri-Bhoi Organic Farmer Producer Company Ltd. (FPC)	250	To be decided	Proposed
		Nodal Agency: FMC			
7	Moonew Tareybhir Enriched Composting/ Vermicomposting Cluster	Sikkim Kishan Society (NGO)	200	205.08	Sanctioned

Agrotechnology

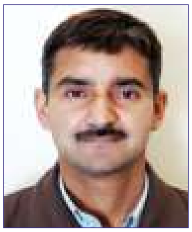
Krishan Kumar Singh, Sr. Principal Scientist
kksingh@ihbt.res.in
Farm Mechanization

My group is working on development and evaluation of farm machinery for tea, medicinal, aromatic and other commercially important crops/plants.

A protocol for improved reproducibility of micro propagation systems for economically valuable bamboo species viz. *Dendrocalamus hamiltonii, D. asper, Phyllostachys pubescens* spp, *Bambusa balcoa, B. nutans, D. membranaceus* and *B. tulda* using nodal segments were developed. Direct organogenesis from nodal segments was accomplished by culturing on different inoculation media. Shoot multiplication was subjected by sub culturing in the shoot proliferation media after a number of repeated transfer of mother explants or sub culturing on fresh medium. Further, rooting medium was used for successful root formation under *in vitro* conditions. The rooted plantlets were planted in the specialized and standardized medium (GM1) and hardened in the greenhouse till establishment. Completely acclimatized plantlets exhibited good survivability. The present propagation techniques are used for the commercial propagation of valuable bamboo germplasms.

CSIR-IHBT forward towards the enhancement of rural economy and social upliftment. Bamboo machines were established tor cutting, striping, slicing and agarbatti stick making for small scale/cottage industries to make quality agarbatti sticks from bamboos by village groups. Agarbatti sticks were successfully made with *Dendrocalamus hamiltonii and B. tulda.*

Bamboo charcoal powder was standardized and used successfully for the growth of anaerobic bacteria for digestion of waste in cold desert region of Himachal Pradesh. In addition, standard diameter bamboo charcoal particles were pulverized and used for the growth of PGPR successfully on different crops and skill development. Bamboo charcoal (7000 kg) of was prepared for studies on activated bamboo charcoal.



Sanatsujat Singh, Principal Scientist & Head
sanatsujat@ihbt.res.in
Plant Breeding

My research work is focused on breeding of floricultural, aromatic and medicinal plants for development of varieties for superior yield/quality/performance.

Evaluation of breeding lines of stevia in multi-location trials

The clonal lines of stevia (*Stevia rebaudiana*) were evaluated for dry leaf biomass along with check (Him Stevia). Experiments were laid out in RBD with 50 plants/accession/plot and replicated thrice in four locations (Palampur, Ludhiana, Hoshiarpur and Kichha). Results showed that, significant variations in dry leaf biomass clonal lines were observed in different locations (Table 1). Among them, clonal line (CSIR-IHBT-ST-1801) is significantly superior and recorded an average of 4.76 kg dry leaf biomass/plot (5.0 tons/ha) at four locations as compared to check (Him Stevia) and other stevia lines. The steviol glycoside content of CSIR-IHBT-ST-1801 was comparable to check.

Table 1. Mean variations for dry leaf biomass in stevia clonal lines over different locations

S. No.	Clonal line No.	Dry leaf biomass (kg/plot)			
		Palampur	Ludhiana	Hoshiarpur	Kichha
1.	CSIR-IHBT-ST-G1	3.765	3.727	3.687	3.899
2.	CSIR-IHBT-ST-G12	4.394	4.208	4.228	4.168
3.	CSIR-IHBT-ST-1801	4.783*	4.831*	4.728*	4.711*
4.	CSIR-IHBT-ST-G27	3.076	3.127	3.214	3.310
5.	CSIR-IHBT-ST-G142	3.132	3.114	3.353	3.229
6.	CSIR-IHBT-ST-G290	3.379	3.381	3.447	3.256
7.	CSIR-IHBT-ST-27	3.793	3.713	3.691	3.900
8.	Him Stevia	3.950	4.148	4.154	4.127
9.	CSIR-IHBT-ST-41	3.660	3.549	3.667	3.565
	S. E. (d)	0.093	0.089	0.119	0.108
	C.D.	0.200	0.191	0.254	0.230

*Significant at P=0.05

Gerbera breeding

To develop unique flower types in gerbera, 21 F_1 hybrids were developed through controlled crossing program and multiplied clonally under *in vitro* conditions. Of these, eight gerbera selections were characterized for morphological and floral traits under protected cultivation (Table 2 & Fig.1) and evaluated for field performance in RBD for four years (2016 to 2019) along with check (Him Gaurav) with three replications at CSIR-IHBT floriculture farm, Palampur. Data recorded in ten plants per replication for flower diameter (cm), stalk length (cm) and number of flowers per plant. Results indicated that Gr-RP-02 and Gr-RD-09 were significantly superior for flower head diameter, Gr-M-08 was significantly superior for stalk diameter and Gr-Y-20 and Gr-RD-09 were significantly superior for number of flowers per plant as compared to the check 'Him Gaurav' (Table 3).

Table 2. Details of floral features of new gerbera F_1 selections

S. No.	Selection No.	Flower colour	Flower shape	Disc colour	Flower type
1.	Gr-LR-3	Light Red	Double	Green	Mini
2.	Gr-RP-2	Red Purple	Single	Dark	Standard
3.	Gr-YO-6	Yellow orange	Double	Green	Mini
4.	Gr-M-8	Maroon	Single	Green	Standard
5.	Gr-Y-20	Yellow	Single	Green	Standard
6.	Gr-RD-9	Red	Single	Dark	Standard
7.	Gr-RP-3	Red Purple	Semi-double	Green	Standard
8.	Gr-W-13	White	Semi-double	Green	Standard

Gr-Y-20 Gr-RD-09 Gr-RP-03 Gr-W-13

Fig. 1 Flower colors and shapes of potential gerbera F_1 selections

Table 3. Field performance of new gerbera F_1 selections

Traits	Selection No.	Year				Mean
		2016	2017	2018	2019	
Flower size (diameter in cm)	Gr-LR-03	9.27	8.66	9.12	8.09	8.79
	Gr-RP-02	11.19*	11.41*	11.58*	11.16*	11.34
	Gr-YO-06	9.23	8.68	9.36	9.28	9.14
	Gr-M-08	10.50	10.15	10.02	10.45	10.28
	Gr-Y-20	10.18	10.34	10.06	10.44	10.26
	Gr-RD-09	11.50*	11.11*	11.92*	11.87*	11.60
	Gr-RP-03	9.70	9.77	9.50	9.47	9.61
	Gr-W-13	10.04	10.16	10.83	10.36	10.35
	Him Gaurav	10.5	10.27	10.15	10.25	10.29
	S.E. (d)	0.261	0.312	0.325	0.366	0.306
Stalk length (cm)	Gr-LR-03	42.06	41.35	41.60	42.30	41.82
	Gr-RP-02	43.55	43.60	44.00	43.60	43.68
	Gr-YO-06	32.60	34.64	29.47	30.69	31.85
	Gr-M-08	47.53	48.09*	46.57*	45.06	46.81*
	Gr-Y-20	41.50	43.20	42.75	40.55	42
	Gr-RD-09	46.43	43.51	46.17*	45.68*	45.44
	Gr-RP-03	31.25	32.14	30.56	32.41	31.59
	Gr-W-13	37.15	36.48	38.77	39.85	38.06
	Him Gaurav	46.50	43.60	44.00	43.60	44.42
	S.E. (d)	2.01	1.72	2.12	1.80	1.88
Number of flowers per plant	Gr-LR-03	16.5	17.4	15.6	15.3	16.2
	Gr-RP-02	23.2	22.4	20.5	22.7	22.2
	Gr-YO-06	20.70	21.10	21.9	20.8	21.12
	Gr-M-08	21.3	20.1	22.7	20.9	21.25
	Gr-Y-20	24.0	23.1*	28.7*	25.3*	25.27*
	Gr-RD-09	24.60	25.8*	25.1*	23.7*	24.8*
	Gr-RP-03	20.5	21.0	21.2	22.7	21.35
	Gr-W-13	23.5	24.3*	22.2	21.7	22.92
	Him Gaurav	24.40	21.85	21.55	21.75	22.38
	S.E. (d)	0.87	0.81	1.17	0.92	0.87

*Significant at P=0.05

REGISTRATION OF GERMPLASMS

- Registered two calla lily genotypes "CSIR-IHBT-CL-W-1" (Him Shweta) IC0630597, **INGR19094** and "CSIR-IHBT-CL-Y-1" (Him Sumukh) IC0630596, **INGR19093** as Germplasm at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research on 21st October, 2019.
- Registered two gerbera genotypes "CSIR-IHBT-Gr-24-6 (Him Aabha) IC0623708, **INGR19096** and "CSIR-IHBT-Gr-13-1 (Him Gaurav) IC0623707, **INGR19095** as Germplasm at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research on 21st October, 2019.

Rakesh Kumar, Principal Scientist
rakeshkumar@ihbt.res.in
Development of agrotechnologies

Our group is developing agro technologies for *Rosa damascena, Tagetes minuta, Crocus sativus, Picrorhiza kurrooa, Trillium govanianum* and *Hypericum perforatum.* We are also involved in studying the growth and phenology of Himalayan spp. under elevated carbon dioxide and temperature conditions.

Effect of growth regulators on damask rose (*Rosa damascena* Mill.)

R. damascena is an important industrial crop commercially grown for its high-value essential oil. The yield and quality of damask rose were affected by a number of factors. A field experiment was conducted to study the effect of growth regulators on growth, yield and essential oil composition of damask rose under the western Himalaya during 2019-2020. Results showed that diphenyl urea @ 20 ppm significantly enhanced the number of flowers (29.1%) and fresh flower weight/plant (26.2%) as compared to control (Fig. 1).

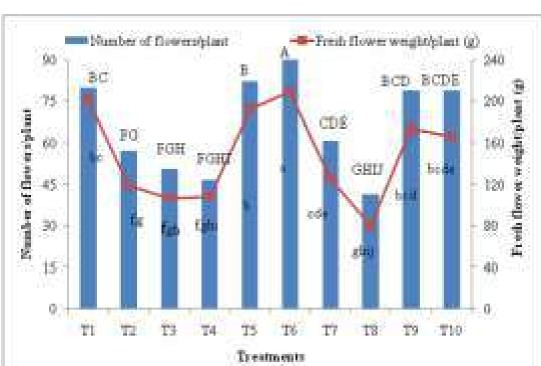


Fig. 1 Effect of growth regulators on number of flowers and fresh flower weight/plant in damask rose

Effect of phosphorus and bio stimulants on Chamomile (*Matricaria chamomilla* L.)

A field experiment was conducted to study the effect of phosphorus and bio stimulants on growth, yield and essential oil composition of *M. chamomilla* in western Himalaya (Fig. 2 and 3). Application of phosphorus @ 90 kg/ha showed 28.6% and 40.8% higher dry flower biomass and essential oil over control. Similarly, application of humic acid (10 mL/L) and amino acid (5 mL/L) recorded 4.1 and 2.1% higher dry flower biomass, respectively as compared to control .

Fig. 2 Field view of chamomile experiment

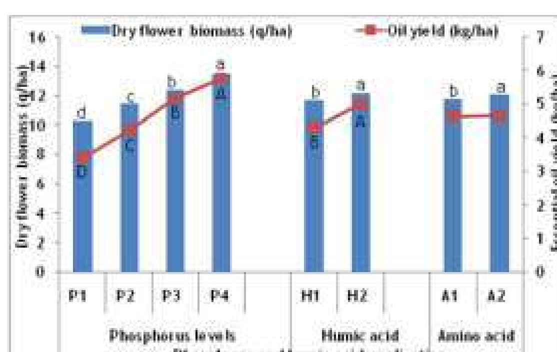


Fig. 3 Effect of phosphorus and bio stimulants on dry flower biomass and essential oil yield

Effect of nitrogen and sulphur on growth and yield of wild marigold (*Tagetes minuta*)

Application of nitrogen @ 120 kg/ha and sulphur @ 60 kg/ha recorded high bio-mass (4.5 and 16.8%), oil yield (4.5 and 16.8%), essential oil content (0.67 and 0.65%), β-ocimene (41.3 & 42.2%) and lower dihydrotagetone (20.69 and 18.26%), respectively as compared to control (Fig. 4)

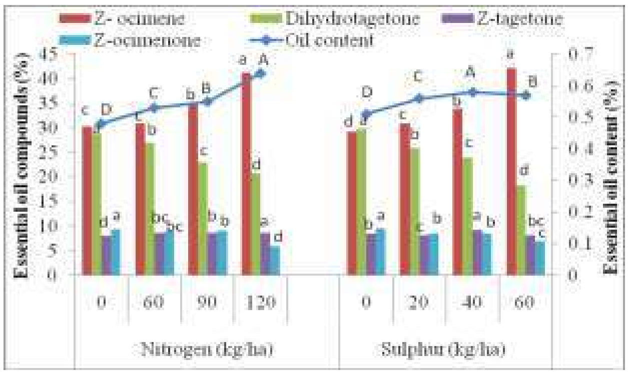


Fig. 4 Effect of nitrogen and sulphur on growth and yield of *T. minuta*

Effect of elevated carbon dioxide (CO_2) and temperature on medicinal and aromatic plants

Two experiments were conducted during 2019-2020 to study the effect of elevated CO_2 and temperature on *Hypericum perforatum and Valeriana jatamansi* at institute FACE and FATI facility. Results showed that plant height (cm) of *H. perforatum* was significantly higher in FACE (46.3 cm) as compared to ambient (41.4 cm) but remained at par with FACE+FATI (45.7 cm). Plant spread (EW) (cm) was significantly higher in FATI (47.6 cm) as compared to FACE + FATI (40.1 cm) but remained at par with ambient (45.5 cm). Similarly, plant height and spread (NS) were significantly higher in fertilized plants (46.8 and 44.8) as compared to unfertilized (Fig. 5). Total dry biomass (g/plant) of *V. jatamansi* after 280 days of exposure was significantly higher in FACE + FATI (13.1 g/plant) over control (8.6 g/plant). Total dry biomass was significantly higher (11.7 g/plant) in fertilized plants than unfertilized plants (10.3 g/plant) (Fig. 6).

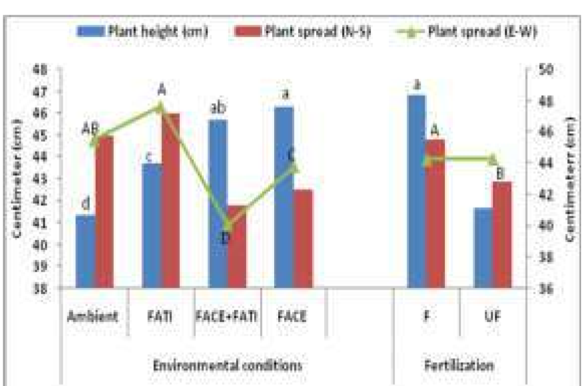


Fig. 5 Effect of elevated conditions and fertilization on plant growth attributes of *H. perforatum*

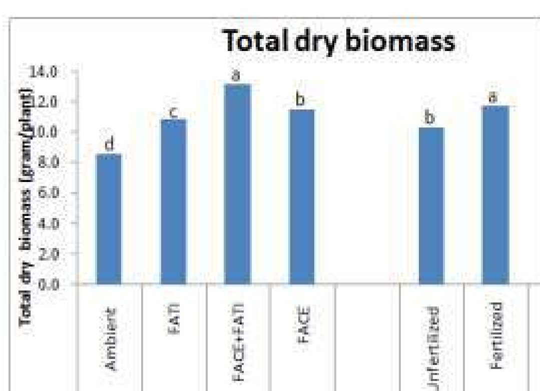


Fig. 6 Effect of elevated conditions and fertilization on dry biomass of *V. jatamansi*

Probir Kumar Pal, Principal Scientist
palpk@ihbt.res.in
Agronomy

Our group is to develop region specific agrotechnology of medicinal, aromatic and commercially important plants for increasing productivity and quality under western Himalayan conditions as well as for plains. The demand of medicinal and aromatic plants (MAPs) are increasing day by day in the domestic and international markets. The main challenges in the MAPs are lack of standard agronomic practices, shortage of characterized plant materials, and sustainable supply of quality raw materials.

Demand for stevia (*Stevia rebaudiana*), a low caloric natural sweetener, is steadily increasing. However, the yield and quality are mainly governed by the availability of soil-water and nitrogen. Experiment was conducted to understand how soil moisture and N influence growth, development, anatomy and physiological and biochemical activities of *S. rebaudiana*. The results revealed that plants irrigated at 50 kPa soil moisture level registered up to 21 % higher dry leaf yield compared to plants irrigated at 20 and 75 kPa soil moisture level (Fig 1). However, the concentration of total steviol glycosides (TSGs) was not significantly ($P \leq 0.05$) affected due to different moisture regime. Total soluble sugars (TSS), proline, total phenols concentrations and SOD were decreased significantly ($P \leq 0.05$) with plant irrigated at 20 kPa. Other physiological parameters like photosynthetic rate, stomatal conductance and enzymatic activities were affected due to moisture regimes. The biomass yield and physiological activities were also significantly influenced by the availability of nitrogen.

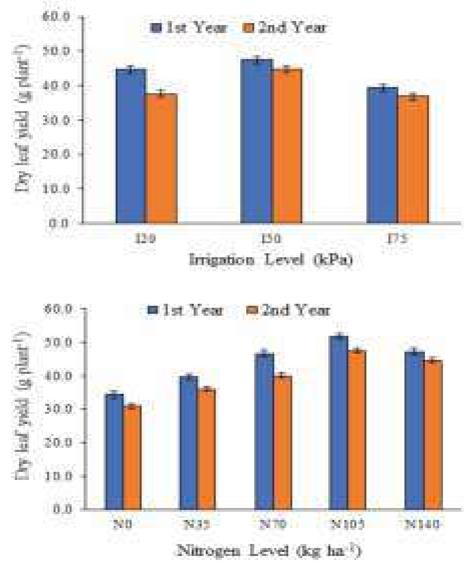


Fig. 1 Effect of soil moisture regime and nitrogen level on leaf yield of stevia

Our group also evaluated the germplasm of stevia, and four potential lines have been identified based on the agronomic traits and steviol glycosides profiles.

In another experiment, we evaluated performance of *Valeriana jatamansi* under agroforestry systems for utilizing under utilized forest land. The root biomass and essential oil content in fresh root were estimated for different treatments. We did not observe any differences on root biomass due to different planting method. However, the root yield was significantly influenced by the agroforestry systems, and the maximum and lowest value were recorded with plants grown under open field and with Crataegus plantation, respectively. On the other hand, oil content was substantially lower in the fresh root harvested from open field conditions. The major component of essential oil is Patchouli alcohol, and highest percentage (~50 %) was recorded with plants grown in Ginkgo agro-forestry system, irrespective of method of plantation (Fig. 2).

Fig. 2 *V. jatamansi* with different agro-forestry system

Our research emphasis is also placed on newly introduced monk fruit (*Siraitia grosvenorii*) plant, which is recognized throughout the world for its intense sweet taste due to occurrence of cucurbitane-type triterpene glycosides known as Mogroside. So far, the anatomy of leaf, stem, and root of *S. grosvenorii* is not well reported so far. Therefore, we have studied the anatomy of *S. grosvenorii* through compound microscope and scanning electron microscope (Fig. 3). Results showed that, stem is pentangular with ridges and furrows (Fig. 3a) and vascular bundles are arranged in two rings at the base of each furrow and ridge. Transverse section of lateral root shows radial vascular bundles (Fig. 3e) and closed view of xylem and phloem (Fig. 3f) shows that xylem is in ring shaped and phloems are small compressed cells.

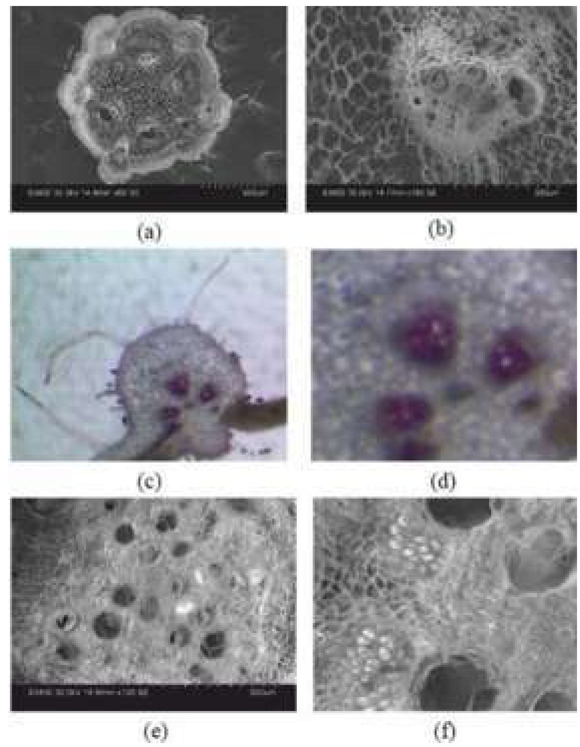


Fig. 3. Scanning electron microscopy (SEM) micrographs of transversal sections of stem (a); vascular bundle of stem (b); transverse section of leaf through midrib (c); vascular bundle of leaf (d); transverse section of root (e); root section showing xylem and phloem (f).

Our group is also developing agrotechnology of *Rosa damascenea*. Foliar application of glyphosate (25 ppm) reported maximum oil content. Maximum β-Citronellol + Nerol content was recorded with foliar application of gibberelic acid (at 75 to 225 mg L^{-1}).

Gireesh Nadda, Principal Scientist
girish@ihbt.res.in
Entomology and Pest management

Bioprospection of fungi for development of biopesticides

Entomopathogenic fungus *viz*. *Beauveria*, and other fungi *viz. Tolypocladium*, *Simplicillium, Leptobacillium*, *Trichoderma* and *Mortierella* spp associated with larval cadavers and soils were isolated, characterized and evaluated for insecticidal activities which have potential for development of biopesticides. About 91 gene sequences are submitted to NCBI.

Bio-efficacy of acaricide for the control of red spider mite (*Tetranychus urticae*) on tea

The acaricide, (CCP 4620 WG) at different concentrations were evaluated against red spider mite (*Tetranychus urticae*) in comparison with recommended acaricides. Results showed that, CCP 4620 @ 400g/ha and CCP 4620 @ 300g/ha reported more promising against *T. urticae* and were at par with each other. The efficacy of treatments in the order of CCP 4620 @ 400 g/ha > CCP 4620 @ 300g/ha > CCP 4620 @ 200g/ha >Hexythiazox > Propargite > Dicofol. Based on efficacy, phytotoxicity and safety to natural enemies, CCP 4620 WG @ 300 g/ha may be recommended for the control of mite in tea.

Ashok Kumar, Senior Scientist
ashok@ihbt.res.in
Plant Breeding

Our group is working on breeding of aromatic, medicinal, floricultural and other commercially important plants/crops for development of varieties/hybrid.

Introduction of Heeng (*Ferula assa-foetida* L.) in the country

F. assa-foetida is a perennial herb indigenous to Iran, Afghanistan and Turkmenistan. It is well-known condiment with pungently flavored oleo gum-resin obtained from the fleshy roots which has medicinal properties. India is not a producer of heeng and is imported from Iran, Afghanistan and Turkmenistan. Therefore, six accessions of heeng were introduced with the approval of ICAR- NBPGR, New Delhi (Import Permit No. 318/2018 and 409/2018) for the cultivation in India. Seed germination was standardized by overcoming seed dormancy which reported ~80% seed germination. The seedlings were raised in the controlled conditions at CSIR-IHBT, Palampur and transplanted at CeHAB, Ribling, (Lahaul and Spiti) and CSIR-IHBT, Palampur (Fig.1) and are being grown under the vigil of ICAR-NBPGR. Efforts are being made to identify suitable locations through multi-location trials for its cultivation.

Fig. 1 Heeng plant in field

Chrysanthemum breeding

To develop unique flower types in chrysanthemum, F1 hybrids were developed through controlled crossing program, multiplied clonally and characterized for morphological /floral traits under protected conditions and evaluated for field performance (2015-2018) in comparison with check (Purnima) with three replications at CSIR-IHBT, palampur. Nine potential selections (Fig. 2 & Table 1)

Table 1. 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-14-5	YP/WS-6	Creamish light-pink tubular florets	Tubular	Spray
2.	CH-14-6	YP/S-23	Dark peach coloured tubular florets	Tubular	Spray
3.	CH-14-9	YP/S-14	Red purple	Pompon Double	Spray
4.	CH-14-10	YP/S-47	Creamish white	Double	Spray
5.	CH-14-11	YP/S-32	White with yellow center	Double	spray
6.	CH-14-12	YP/S-6	Yellow orange	Pompon Double	Spray
7.	CH-14-13	YP/S-52	Orange red	Double	Spray
8.	CH-14-15	YP/S-28	Yellow	Double	Spray
9.	CH-14-19	YP/WS-3	Yellow	Double	Spray/ Pompon
10.	Purnima	-	White	Double	spray

Results indicated that CH-14-5, CH-14-6, CH-14-9, CH-14-10, CH-14-11 CH-14-12, CH-14-13, CH-14-15 and CH-14-19 were significantly superior w. r. to number of flowers/plant as compared to the check. CH-14-13 recorded highest number of flowers/plants followed by CH-14-19 and CH-14-10. Accession CH-14-5 is superior for flower head diameter (Table 2).

CH-14-5 CH-14-6 CH-14-9 CH-14-10

CH-14-11 CH-14-12 CH-14-13 CH-14-15 CH-14-19

Fig. 2. Potential F_1 hybrid selections of chrysanthemum

Table 2. Performance of eight F_1 selections of chrysanthemum under field conditions

Traits	F_1 hybrid selections	Pedigree	Years			
			2015	2016	2017	2018
Flower head Diameter (cm)	CH-14-5	YP/WS-6	9.58*	10.62*	5.88	7.55*
	CH-14-6	YP/S-23	7.65*	7.89*	5.58	7.31
	CH-14-9	YP/S-14	8.18*	6.98	5.79	6.25
	CH-14-10	YP/S-47	6.60	7.11	5.94	7.75*
	CH-14-11	YP/S-32	5.83	6.31	5.64	5.60
	CH-14-12	YP/S-6	5.55	5.54	5.00	6.54
	CH-14-13	YP/S-52	6.44	5.69	4.68	5.86
	CH-14-15	YP/S-28	8.51*	8.05*	6.53	6.78
	CH-14-19	YP/WS-3	7.40	7.48	4.31	6.31
	Purnima		7.28	7.00	7.54	7.33
	SE(d)		0.283	0.336	0.334	0.298
Total Number of flowers	CH-14-5	YP/WS-6	59.27*	57.68*	51.73*	56.58*
	CH-14-6	YP/S-23	59.78*	58.44*	64.60*	62.46*
	CH-14-9	YP/S-14	58.82*	59.35*	53.04*	57.38*
	CH-14-10	YP/S-47	63.90*	63.83*	64.61*	64.83*
	CH-14-11	YP/S-32	38.21*	45.75*	44.66*	52.67*
	CH-14-12	YP/S-6	57.20*	60.46*	60.52*	62.40*
	CH-14-13	YP/S-52	78.89*	80.19*	82.79*	82.82*
	CH-14-15	YP/S-28	55.14*	56.35*	42.73*	53.36*
	CH-14-19	YP/WS-3	59.81*	58.59*	58.97*	64.11*
	Purnima		29.33	34.75	35.49	33.20
	SE(d)		1.545	1.306	1.859	2.082

*significant at P=0.05

Calla lily breeding

To improve calla lily (*Zantedeschia aethiopica*), 14 selected F_1 clones developed through controlled crossing program at CSIR-IHBT and evaluated in the field (Fig. 3) along with check (CL-W-1) in RBD with three replications for morphological and floral traits for five years (2015-16 to 2019-20). Based on performance, selection CL-W-4 was superior with respect to number of flowers/plants (white color) among other genotypes (Fig. 3, Table 3). The genotype CL-W-7 was superior with respect to flower stalk length and flower stalk diameter.

Fig. 3. Field view of *Zantedeschia aethiopica* under field evaluation trial

Table 3. Field performance of calla lily genotypes along with check

Traits	F_1 hybrid selections	Years					
		2015-16	2016-17	2017-18	2018-19	2019-20	Mean
Number of flowers/plants	CL-W-4	4.32*	8.74*	11.36*	15.43*	17.60*	11.49
	CL-W-7	3.78	6.40*	7.77*	11.50*	13.41*	8.57
	Check	3.50	5.25	6.90	8.16	9.57	6.68
	S.E.(d)	0.172	0.231	0.192	0.217	0.144	-
Flower stalk length (cm)	CL-W-4	83.46*	78.52	81.98*	86.30*	81.26*	82.30
	CL-W-7	87.23*	95.84*	86.70*	88.35*	92.52*	90.13
	Check	78.45	81.63	76.84	75.56	83.51	79.20
	S.E.(d)	2.141	2.516	2.354	2.918	2.153	-
Flower stalk diameter (mm)	CL-W-4	14.42*	13.28*	12.51*	15.49*	13.52*	13.84
	CL-W-7	17.70*	15.24*	18.45*	16.35*	16.91*	16.93
	Check	10.63	11.27	10.83	12.82	9.78	11.07
	S.E.(d)	0.847	0.468	0.695	0.764	0.523	-

*significant at P=0.05

Marigold breeding

Out of 99 breeding lines of marigold (*Tagetes erecta*) developed through hybridization and selection approach, 10 breeding lines (MG-01 to MG-10) selected for morpho-agronomic traits based on preliminary trial were evaluated in the field for five years (2015-16 to 2019-20) along with check (Pusa Narangi) in RBD with three replications at CSIR-IHBT, Palampur. Results showed that selection MG-08 was superior for flower head diameter (cm), flower weight (g) and fresh flower yield (g/plant) followed by MG-03 (Table 4 & Fig 4).

Fig. 4 a) Flower of marigold selection MG-08 flower, and b) MG-08 plant type

Table 4. Field performance of marigold selections

Traits	Selections	Years					
		2015	2016	2017	2018	2019	Mean
Plant height (cm)	MG-03	65.27	68.48	67.34	68.52	66.44	67.21
	MG-08	53.52*	59.67*	54.68*	61.81*	60.13*	57.96
	Check	62.50	64.57	59.32	69.24	66.07	64.34
	S.E.(d)	1.498	2.189	3.153	2.516	2.953	-
Flower head diameter (cm)	MG-03	7.51*	8.37*	8.18*	6.52*	8.25*	7.77
	MG-08	9.08*	8.24*	8.98*	8.74*	9.16*	8.84
	Check	6.61	7.15	6.18	5.95	6.22	6.42
	S.E.(d)	0.196	0.173	0.205	0.223	0.214	
Flower weight (g)	MG-03	10.82*	11.81*	12.12*	10.64*	11.49*	11.38
	MG-08	14.37*	13.90*	15.43*	14.12*	15.46*	14.66
	Check	8.91	8.83	8.47	8.50	7.72	8.49
	S.E.(d)	0.547	0.631	0.497	0.618	0.513	-
Fresh flower yield (g) / plant	MG-03	494.92*	528.65*	483.82	512.56*	491.38*	502.27
	MG-08	542.80*	567.94*	536.41*	514.01*	552.69*	542.77
	Check	466.56	491.65	487.94	477.40	474.58	479.63
	S.E.(d)	9.245	8.267	7.489	10.247	9.475	-

*significant at P=0.05

S. G. Eswara Reddy, Senior Scientist
Entomology and Pest Management

Development of Biopesticides for Pest Management

My research group is working on screening of plant-based extracts, fractions, essential oils and pure compounds for their insecticidal properties against crop and stored grain pests for development of botanical formulation. My group also identified 10 native strains (IHBF7 to IHBF 16) of entomopathogenic fungi for microbial formulation and received the accession numbers (MT111130 to MT111139) from NCBI for submitted sequences. My group also developed customized flow hive (improved bee hive) in collaboration with CSIO, Chandigarh and evaluated successfully under field conditions for quality and hygienic extraction of honey.

Insecticidal properties of plant extracts, fractions, essential oils and pure molecules

Ageratum houstonianum (Asteraceae) is a predominant weed growing widely in the western Himalaya region was studied for chemical composition of essential oil (EO), characterization of pure compounds, screening of EO, fractions and pure compounds for their insecticidal activities against larvae of diamondback moth, *Plutella xylostella* (Lepidoptera: Yponomeutidae) and aphid, *Aphis craccivora* (Hemiptera :Aphididae).The volatile composition of the EO from above ground parts of *A. houstonianum* was extracted by steam distillation and characterized by Gas chromatography (GC) and gas chromatography-mass spectrometry (GC-MS). Precocene II (42.2%), precocene I (18.6%) and beta–caryophyllene (15.6%) were the main constituents. Ageratochrome and 1–heptadecene were isolated and characterized using mass, ^{1}H and ^{13}C NMR spectroscopy. EO, hexane/methanol fractions and isolated compounds were tested against *P. xylostella* and *A. craccivora*. Results indicated that EO, hexane fraction, ageratochrome and 1–heptadecene showed more toxicity to larvae of *P. xylostella* (LC_{50}=2.8, 4.9, 2.1, 4.8 mg/mL, respectively); whereas methanol fraction was more effective against *A. craccivora* (LC_{50}=1.1 mg/mL). The EO also showed repellent activity to *P. xylostella* (RC_{50}=2.2 mg/mL).

In a similar study, EO from aerial parts of *Eupatorium adenophorum* was extracted by steam distillation and characterized by GC and GC-MS. Alpha-epi-cadinenol (16.63%), O-cymene (13.54%), bornyl acetate (7.7%), beta phellandrene (7.4%), and gama-2-carene (5.7%) were the major terpenoids. The EO showed promising toxicity (median lethal concentration i.e. LC_{50}= 3176.5 mg/L) and repellent activity (median repellent concentration i.e. RC_{50}=2071 mg/L) to larvae of *P. xylostella* within 24 h. Among fractions, hexane fraction was more effective to *P. xylostella* (LC_{50}=5056.7 mg/L), whereas methanol fraction to *A. craccivora* (LC_{50}=1175.8 mg/L).

EO of *Artemisia maritima* at different concentrations were evaluated for acaricidal activity against two-spotted spider mite (*Tetranychus urticae*) (Acarina:Tetranychidae). Results showed that, EO reported excellent fumigant activity against *T. urticae* with LC_{50} value of 323.8, 27.0, 15.5 and 12.1 mg/L after 1, 2, 3 and 4 h of treatment, respectively as compared to positive control i.e. Propargite 57% EC (755.7 mg/L). In repellent activity, EO at 10000 mg/L showed significantly higher repellency (95.8±1.7%) adult to *T. urticae* and was at par with positive control i.e. Azadirachtin 0.15% EC (96.7±3.3%) and 8000 mg/L (91.7±2.2%) as compared to other concentrations studied.

Apple pomace as substrate for the multiplication of entomopathogenic fungi (EPF)

Apple pomace (AP) the left-over waste after extraction of juice and due to rich source of carbohydrates, AP was standardized as a substrate for growth and spore production of EPF viz., *Lecanicillium lecanii*, *Beauveria bassiana* and *Paecilomyces fumosoroseus* by adding water, ammonium nitrate, as well as using different temperatures and pH. Results have shown that addition of 40 mL of water, 4 g of ammonium nitrate, and temperature at 30°C and alkaline pH (pH 8 & 10) in AP recorded significantly higher spore production of *L. lecanii* (50.5, 52.8, 151.2 and 50.2-52.2 lakh spores/mL, respectively), *B. bassiana* (50.4, 51.8, 152.2 and 50.1-51.6 spores/mL, respectively) and *P. fumosoroseus* (50.5, 52.18, 149.3 and 50.1-52.3 lakh spores/mL, respectively) as compared to positive control i.e. potato dextrose agar (41.7-43.8 lakh spores/mL).

Improved bee hive (Flow hive) for quality and hygienic extraction of honey

India is 8th largest producer of honey and exported 61333.9 MT of natural honey to the world for the worth of 732.16 crore during 2018-19. The honey market in India is estimated to reach Rs. 28,057 Million by 2024 at CAGR of 10.2%. Most of the fruit/vegetable/agricultural crops mainly depends on honey bees for pollination. Presently, farmers/growers/bee keepers are using traditional method of bee hive and extraction of honey through honey extractor. The honey production and its quality in India are up to the mark as per the global standard. Traditional method of harvesting of honey is time consuming, labour intensive, mortality of bees during harvesting, non-hygienic and of poor quality which gets low price in the market. In India, there is no improved bee hive (flow hive) and honey extractor is available in the market for quality and hygienic extraction of honey. Therefore, CSIR-CSIO, Chandigarh and CSIR-IHBT, Palampur developed improved bee hive and evaluated successfully in the field which had the following advantages.

- Extraction and harvesting of honey without disturbing the frames and honey bees.
- No mortality of honey bees during harvesting as compared to honey extractors.
- The harvested honey is hygienic and of high quality which fetches good price in the market.
- The bee hive is cost effective, easy to operate and less human intervention.
- Yield of honey /hive/year is approximately 30-35 kilograms.

Internal view of improved bee hive with frames and key

External view of improved bee hive

Harvesting of honey in improved bee hive

Research group

Ms. S.K.Dolma, Ms. Nandita Chouhan

Mr. C.S. Jayaram, Mr. Neeraj

Dr. Bhavya Bhargav, Senior Scientist
bhavya@ihbt.res.in
Floriculture

My research group is mainly focused on breeding and agrotechnolgy of floricultural crops. We also working on pollution abatement plants.

***In vitro* micropropagation of an epiphytic *Cymbidium aloifolium* (L.) Sw. orchid**

Different regeneration MS media (Murashige & Skoog) was fortified with 0.5 to 2.0 mg/l BAP (6-Benzylaminopurine), 1 to 3 mg/l BAP + IBA (Indole-3-butyric acid) and BM-2 (Basal Media-2) not only supported the formation of protocorm with leaf primordia but also shoot multiplication and root initiation. Results showed that, MS media fortified with 1 mg/l BAP (Fig. 1F) showed more number of shoots (39) and more root length (6.1 cm) while, the number of shoots with roots observed highest in MS media (21) fortified with 1.5 mg/l BAP and the maximum shoot length (8.1 cm) in BM-2 (0.6 mg/l BAP). All the media fortified with growth regulators took less time for root/shoot initiation as compared to media with no growth regulators. For hardening, well rooted plants were transferred from regeneration medium to pots containing different hardening mixtures. About 90% of the transplanted plants survived in cocopeat: perlite: wood saw mixture (1:1:1) with average length of 10 cm and 6 cm in plantlet and root, respectively (Fig. 1H & I). The survival rate of transplanted plantlet is directly related to the *in vitro* seedling vigour.

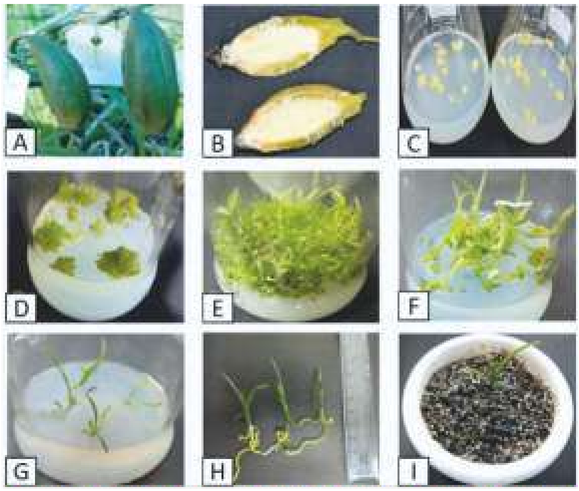


Fig. 1. Developmental stages of *C. aloifolium* (Seed germination to hardening)

A. Immature pods on the plant B. Dissection of seed pod into two halves; C. *In vitro* seed culture; D. *In vitro* PLBs on half strength MS basal medium; E. *In vitro* germinated seeds with protocorm formation; F. Multiplication of the shoots in MS with 1.0 mg/l BAP; G. *In vitro* root induction; H. Fully developed plantlets with roots; I. Hardened plant in a potting mixture containing cocopeat: perlite: wood saw mixture (1:1:1).

Analysis of flavonoids from *Phlomoides superba* (Royle ex Benth.) Kamelin & Makhm

P. superba is one of the medicinally important threatened tuberous perennial herbs used as folk medicine for veterinary and human health in India. For the first time, UPLC-DAD based non-targeted metabolomics has been employed to distinguish leaves, stem and rhizome organs. The major compounds identified in leaf and stem were luteolin and apigenine while gallic acid, catechin, caffeic acid, syringic acid, rutin, hyperoside, isoquercetin, quercetin, cinnamic acid and kaempferol were not detected. Equal amount of luteolin (0.10 & 0.1 mg/g) and apigenine (0.05 & 0.05 mg/g) were detected in both leaf and stem part of *P. superba*, respectively. Significant amount of rutin was identified in roots, so that it can be explored for therapeutic use by pharmaceutical companies in order to develop safe drugs for various ailments.

Indoor air pollution abatement in Civil Hospital, Palampur, Kangra (H.P.)

The real time monitoring (twice a day i.e., 9:30-12:00 and 14:30-17:00) was carried out at four locations in Civil Hospital, Palampur (OPD, CT Scan, Gynaecology and Kitchen) with 3, 6, 9 and 12 spider plants. The parameters viz. carbon dioxide (ppm), temperature (˚C), relative humidity (%), dew point (˚C), total volatile organic compounds (ppb) and carbon monoxide (ppm) was recorded using Indoor Air Quality Handheld Monitor (IAQ Monitor) (Model 7575 Q-TRAK, TSI, India make). The results showed that maximum CO_2, VOC and CO was observed in all the locations without any plants whereas reducing trend was observed with increasing the number of plants. The highest reduction of CO_2 was found in Kitchen (59.32%) followed by Gynaecology (40.61%), OPD (34.33%) and CT Scan (16.98%). Maximum reduction of VOCs was observed in Gynaecology (95.77%) followed by OPD (90.16%), CT Scan (86.21%) and Kitchen (83.65%). The maximum amount of CO was observed in kitchen area without any plants which was reduced to 97.77% after increasing the number of plants to 12.

Dr. Jeremy Dkhar, Senior Scientist
jeremydkhar@ihbt.res.in
Agrotechnology and Biotechnology of Himalayan Plants

Research in my lab currently focuses on three aspects. Discovery and development of novel products from the insectivorous plant, *Nepenthes khasiana* for the natural control of plant diseases. Another aspect is to find a suitable substitute for *Nardostachys jatamansi* but related plant species viz., *Valeriana*, *Selinum* etc., commonly found in the wild or in the form of a genetically engineered microbial platform (e.g. yeast) with the ability to synthesize the metabolites of interest. Finally, establishment of a small and hi-tech nursery under the restructured national bamboo mission to supply quality bamboo planting material through cuttings and tissue culture techniques to meet the demand for raw material by Indian bamboo industry.

Fig. 1 a. *Nepenthes khasiana* plant b; Close-up of the pitcher c; Captured prey

Fig. 2 *In vitro* raised plantlets of *N. khasiana*

Research group
Left to Right: Ms Kiran Dhiman & Dr. Jeremy Dkhar,

Satbeer Singh, Scientist
satbeer@ihbt.res.in
Plant Breeding

Our group is working on different breeding aspects for genetic improvement of high value medicinal and aromatic crops like chamomile (*Matricaria recutita* L.), lavender (*Lavandula angustifolia*) and rosemary (*Rosmarinus officinalis* L.). Despite the potential to be good source of farmer's income, chamomile is not commercially cultivated on large scale due to lack of good varieties and un-synchronous flowering habit. Hence, efforts are being done to study reproductive biology and breeding systems in chamomile for its genetic improvement towards one-time harvesting, flower yield and essential oil content. Lavender and rosemary are lacking in genetic variability due to continuous asexual propagation. Thus, work has been also commenced to generate new genetic variability in lavender and rosemary through hybridization. Breeding behavior was also being studied to decide future breeding programs in these crops.

Being a cross pollinated crop, heterosis may significantly contribute to higher and synchronous flowering in chamomile. Hence, inbred line development program has been initiated in chamomile. About 70 diverse chamomile plants were selfed for generation advancement from the current populations based on appearance and desired trait behavior. Data on floral and reproductive biology and breeding systems in chamomile was recorded. Anthesis flush and pollen dispersal were also observed to identify new tools of breeding in chamomile. It has been found that removing disc florets could be used as an emasculation tool for crossing in chamomile. Moreover, essential oil content and composition in relation to different reproductive stages was also being studied to determine the right stage of harvesting to get maximum oil content and quality. The oil content was maximum during full blossom stage (0.37 %) as compare to pre-blossomed (0.15%) and over blossomed (0.33%) stages.

Fig. 1. Controlled pollination on selected plants in chamomile population

Poonam Kumari, Scientist
poonam@ihbt.res.in
Floriculture

My group is focused on breeding and agrotechnolgy of floricultural crops. We also working on characterization and micro propagation of ornamental bulbous plants. Collection of different varieties of rose for future research programme.

Effect of plant growth regulators on growth and flowering of daffodil, *Narcissus pseudonarcissus* cv. Tahiti

An experiment was conducted to study the effect of plant growth regulators on vegetative and floral characters of *N. pseudonarcissus*. Healthy bulbs were treated with different concentrations of growth regulators (GA_3, IBA, IAA) prior to planting in pots. Results indicates that maximum leaf length (22.23 cm) and leaf width (1.53 cm) was recorded when treated with IAA @ 60 ppm, whereas maximum leaf thickness (0.72 cm) and number of leaves (11.33) were recorded in plants treated with IAA @100 ppm. Maximum plant height (27.00 cm) and plant spread (20.62 cm) observed in IAA@100 ppm (Table 1). Minimum days to flowering (57 days) was recorded when bulbs treated with GA_3 @ 500 ppm. Maximum bud diameter (13.60 mm) was recorded in IAA @100 ppm, whereas bud length (4.2 cm) was found maximum in treatment GA_3 @100 ppm. Maximum stalk length (22.8 cm) in the plants treated with IAA @ 60 ppm (Fig 2).

Fig. 1 *N. pseudonarcissus* at vegetative/flowering stage

Micro-propagation of calla lily (*Zantedeschia ellotiana* cv. Him Sumukh)

Calla lily tuber fragments (1 cm^2) containing eyes were cultured on MS media supplemented with different concentrations and combinations of plant growth regulators. Minimum days for shoot initiation and maximum number of shoots were observed when tuber fragments were cultured on MS medium supplemented with IBA (1mg/l) +BAP (4 mg/l) (Fig. 2 and 3).

Fig 2. Initiation of *in vitro* cultures of calla lily (*Zantedeschia ellotiana* cv. Him Sumukh)

Fig 3. Shoot and leaf initiation of calla lily (*Zantedeschia ellotiana* cv. Him Sumukh)

Ramesh, Scientist
ramesh@ihbt.res.in
Agronomy

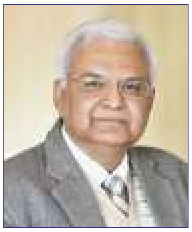
My research mainly focused on introduction of Heeng and other crops to nontraditional areas.

Breaking seed dormancy of Kala zeera (*Bunium persicum* Bioss)

B. persicum is a high value herbaceous spice widely used for culinary, flavouring food and beverages, perfumery, carminative purposes, gastrointestinal, urinary, indigestion, hysteria, obesity, piles and insomnia. Due to its increasing demand and over exploitation from the natural habitat, there is a need for its conservation and large-scale cultivation. Cultivation and expansion of kala zeera had two major problems which includes seed dormancy and long juvenile time. Therefore, lab experiment was conducted to study the influence of several factors for breaking seed dormancy in kala zeera. The dormancy was successfully broken and germination time was reduced using different phytohormone and chilling treatment. Generally, dormancy period of *B. persicum* is 50-60 days to start seed germination, which has been successfully reduced to 20 days. Further, application of Thidiazuron (TDZ) @ 6.3 μ mol/l with chilling temperature (5^0C) recorded 68% seed germination as compared to Gibberellic acid (GA_3) and 6-benzylaminopurin (BAP). However, synergic effect of plant growth regulators {TDZ (6.3 μ mol/l) + GA_3(100 μ mol/l) + BAP (10^{-5}M)} with chilling recorded highest seed germination (83%) after 40 days.

Fig. 1. Germination test of Kala zeera seeds under lab conditions

Biotechnology



Sanjay Kumar, Director
sanjaykumar@ihbt.res.in
Plant Adaptation and Secondary Metabolism

Our research focus has been on mountain biology with an endeavour to decipher mechanisms of plant adaption in the higher reaches of Himalayas, engineering of plant secondary metabolite biosynthesis, and bioprospecting of genes and proteins for industrial uses.

Genomics of *Picrorhiza kurrooa*

Working on *P. kurrooa*, we initiated genome sequencing of this important endangered medicinal herb. Initial results suggested that the genome of *P. kurrooa* is highly enriched for complex repeats like retrotransposons with total complex repeats content more than 76% of the genome. Large number of genes were found to exist in multicopy. Our previous work (***BMC Genomics***, 13(1):126, 2012) identified 15ºC and 25 ºC to modulate picroside content, and hence we also profiled differentially expressed miRNAs in leaf and rhizome tissue of *P. kurrooa* at the two temperatures. The study provided a repertoire of temperature responsive miRNAs and corresponding targets which could be used in enhancing stress tolerance in *P. kurrooa*. Work is underway to finalise the draft genome of *P. kurrooa* to facilitate discovery of novel genes and gene regulatory mechanisms to aid in genetic improvement and conservation of *P. kurrooa*.

Furthering the working on *P. kurrooa,* functionality of WRKY motifs, present in the promoters of regulatory genes of picrosides biosynthetic pathway, was established using the electrophoretic mobility shift assay. Also, the functionality of the two identified WRKY genes, *PkdWRKY* and *PksWRKY* was established through transient expression in tobacco. Out of PkdWRKY and PksWRKY, transcriptional activation property was observed for PkdWRKY through experimentation in yeast. Data showed *PkdWRKY* and *PksWRKY* could be a positive and negative regulator, respectively in picrosides biosynthetic pathway. These findings will be useful in metabolic engineering of picroside biosynthesis in *P. kurrooa*.

Fig. 1 Transcriptional activation by PkdWRKY: Yeast cells transformed with pGBKT7 vector harbouring *PkdWRKY* showed α-galactosidase activity on SD(-) Trp plates

Identification of key factors limiting overexpression of recombinant Cu, Zn superoxide dismutase in *E. coli*

In our previous work, a thermostable Cu, Zn superoxide dismutase (Pa-SOD) from the high-altitude plant *Potentilla atrosanguinea* was successfully expressed in *E. coli* (***Sci. Rep***., 2(1): 1-8, 2012). Data showed that enhancement in Pa-SOD expression stopped after a few hours of induction and also alterations in cell morphology and growth behaviour of *E. coli* was observed. To decipher the mechanism regulating these processes, MALDI-TOF/TOF-MS/MS analysis identified the importance of RNase E in regulating the expression of Pa-SOD in *E. coli*. Since Pa-SOD has commercial applications, modulation of *RNase E* could could be important for the improvement of host strain for large scale production of biologically active Pa-SOD.

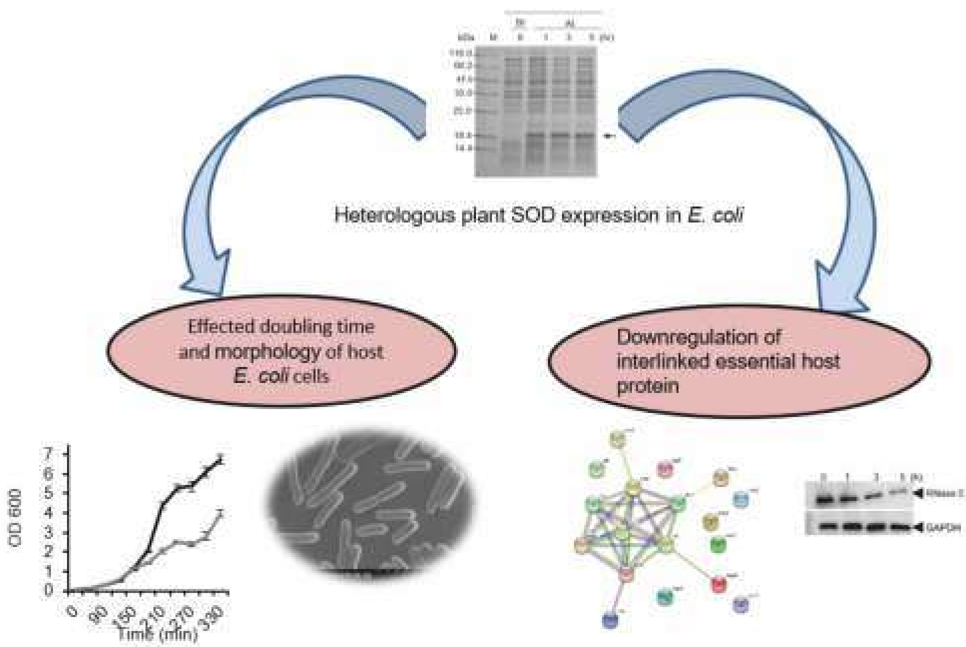


Fig. 2. Host RNase E limits overexpression of recombinant Pa-SOD in *E. coli.* (a) Heterologous expression of Pa-SOD in *E. coli* showing no increase in protein expression after 1 h of induction as indicated by arrow; (b) comparison of growth curve of Pa-SOD expressing cells (black line) and uninduced cells (grey line) indicates increased doubling time in Pa-SOD expressing cells; (c) scanning electron microscope image depicting increased size of *E. coli* cells expressing Pa-SOD; (d) string network analysis of differentially expressed essential proteins identified by mass spectroscopy, (e) western blot analysis of RNase E up to 5 h of induction of protein expression.

Universal stress proteins (USPs) as candidates to engineer economically important crops for enhanced stress-tolerance.

Earlier we showed (***Mol. Biol. Rep.*,** 46(2): 1985-2002, 2019) that heterologous co-expression of two genes encoding PaSOD and ascorbate peroxidase (RaAPX) from *Potentilla atrosanguinea* and *Rheum australe*, respectively resulted in higher biomass accumulation and cellulose content as compared to the wild-type (WT) plants under salt stress. And we showed the importance of H_2O_2 in imparting mechanical strength to plants through transcriptional activation of cellulose biosynthesis pathway, which in turn aid in plant biomass production. We also discussed that such a modulation of cellulose biosynthetic machinery through higher activities of antioxidant enzymes has the potential to engineer plants with enhanced cellulose content for biofuel use. Interestingly, the work showed heterologous co-expression improved callus growth and *in vitro* regeneration transgenic *A. thaliana* (***Plant Biotechnol. Rep.***, 13(3): 273-283, 2019). Results suggested that minimal amount of H_2O_2 accumulated, as a consequence of heterologous co-expression of *PaSOD* and *RaAPX*, has an important role in early callus induction and shooting regeneration in transgenic lines, and hence a role of antioxidant genes in *in-vitro* regeneration of plants might be important.

Moving ahead in identifying the candidate gene(s) in imparting stress tolerance, we performed genome-wide analysis in *A. thaliana*. The analysis coupled with expression profiling identified multi-stress responsive universal stress proteins (USP) genes in *A. thaliana* as a putative target. Notably, *AtUSP9* and *AtUSP12* were identified as multi-stress responsive in both shoot and root tissues under abiotic stresses, wherein expression of *AtUSP12* was also induced under various pathogens and elicitor treatments (***Plant Physiol. Rep.***, 24(3): 434-445, 2019). These USPs might serve as suitable candidates to engineer economically important crops for enhanced stress-tolerance.

Amita Bhattacharya, Senior Principal Scientist
amitabhatta@ihbt.res.in
Plant tissue culture

The major focus of the group is development of *in vitro* systems for various applications such as:

- Conservation of Rare, Endangered, Threatened Medicinal and Aromatic Plants (RET MAPs) of Himalayas.
- Understanding the adaptation behaviour of plants for their rehabilitation in natural habitat and secondary metabolite production in alternative systems
- Development of sustainable resource base of commercially important plants for industrial utilization and boosting rural economy.
- Linking up with tissue culture and other industry.
- Nurturing entrepreneurship through incubation.
- Skill development in young graduates and post-graduates to increase their employability.

Conservation of RET MAPs of Himalayas for their rehabilitation in natural habitats

In continuation to our previous activities on rescuing of high value medicinal plants of Himalayas from their RET status, repositories of the critically endangered *Dactylorhiza hatagirea, Nardostachys jatamansi* and *Fritillaria roylei*; and the endangered *Picrorhiza kurroa* were developed through tissue culture under the 'CSIR-Phyto pharmaceutical Mission' and the 'CSIR-Niche Creating Project entitled Conservation and Sustainable Resource Generation of High Altitude Bioresources'. In the current year, our standardized tissue culture protocols were used to produce fifteen thousand plants each of *P. kurroa* and *F. roylei* and five thousand plants of *N. jatamansi* for rehabilitation under natural habitat (Fig. 1).

Fig. 1 Rehabilitation of RET MAPs in natural habitat through tissue culture (A) *Nardostachys jatamansi* (B) *Picrorhiza kurroa* and (C) *Fritillaria roylei*

De novo transcriptome of _Dactylorhiza hatagirea_ for modulation of secondary metabolites and rehabilitation of plants raised through tissue culture

D. hatagirea, the critically endangered terrestrial orchid of Himalayas has a range of medicinal properties. Yet, the only secondary metabolites reported in the plant are dactyloses and dactylorhins. Since the compounds are commercially not available, no standards are available for their validation in high yielding *in vitro* cultures. The already reported compounds do not account for the wide range of medicinal properties that characterize the plant. On the contrary, several stage and tissue specific secondary metabolites that were not reported earlier in the plant were identified through *de novo* transcriptome analysis of the plant parts. The compounds also accounted for the various ethno-medicinal properties that had remained unaccounted-for in the plant. The leads can now be used for qRT-PCR and phytochemical analysis of 'secondary metabolites yielding callus/cell lines'. The *de novo* transcriptome analysis and *in vitro* studies also revealed maximum partitioning of primary metabolites towards below-ground parts followed by the synthesis of a range of secondary metabolites occurred at 15°C (the temperature characterizing the period before the onset of winter and also the end of growth period) (Fig. 2). The exact stage for *in vitro* modulation of morphogenic response and secondary metabolites production were thus, identified.

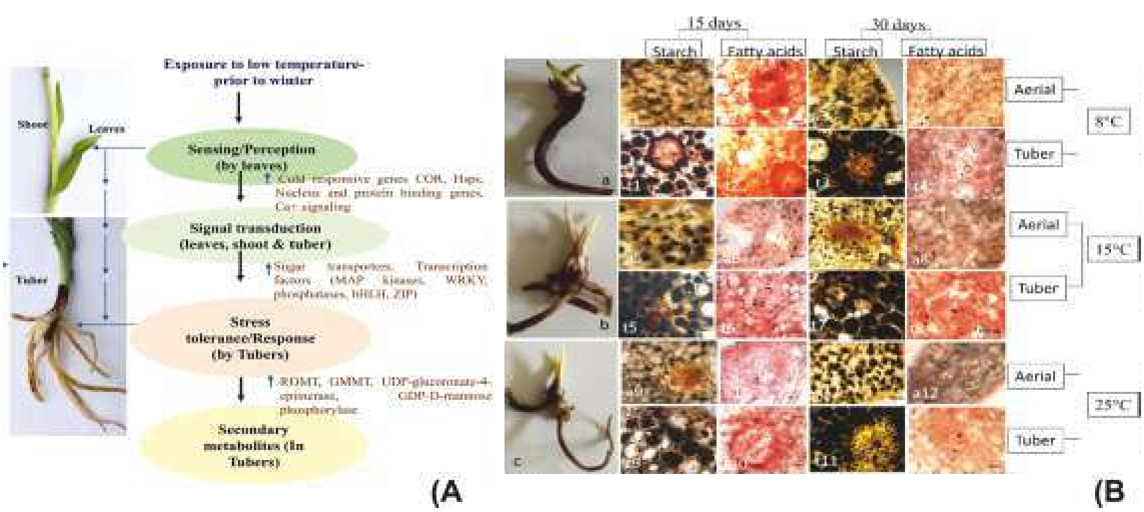


Fig. 2 (A) Phenological responses of *in vitro* plants of *D. hatagirea* to different temperatures (a-d) 8 °C (e–h) 15 °C and (i–l) 25 °C after 0, 7, 15 and 30 days. Scale bar = 1 cm. (B) Histochemical accumulation of starch and fats in (a1-a12) aerial and (t1-t12) below-ground parts after 15 and 30 days at 8, 15 and 25 °C

Nutritional and proteomic analyses of the gametophytes of the edible Himalayan fern _Diplazium maximum_

In vitro studies on *Diplazium maximum*, an edible fiddlehead fern (lungru) of temperate Himalayas revealed a strong stress response of the gametophytes to 3 and 6% sucrose. The 2-dimensional planar gametophytes multiplied profusely to form 3-dimensional clumps having higher photosynthetic surface area and closer proximity for sexual reproduction (Fig. 3a-c). The gametophytes were also up-scaled to large biomass in liquid as well as agar gelled media in a separate study. Analysis of the nutritional composition of the gametophytes revealed high contents of essential fatty acids, amino acids and minerals.

The changes in the proteome of the gametophytes in response to sucrose was also analysed. An abundance of proteins related to abiotic stress tolerance, secondary metabolite synthesis, detoxification and also those of nutritional components like vitamins were recorded in the 3-D clumps. The proteomic data, Protein- Protein Interaction network and Principal Component analyses revealed that the gametophytes employ multiple mechanisms of adaptation in response to slightest changes in their micro-environment (Fig. 3B). The findings of the study have potential use in crop improvement, metabolic engineering, phytoremediation and environmental protection programs.

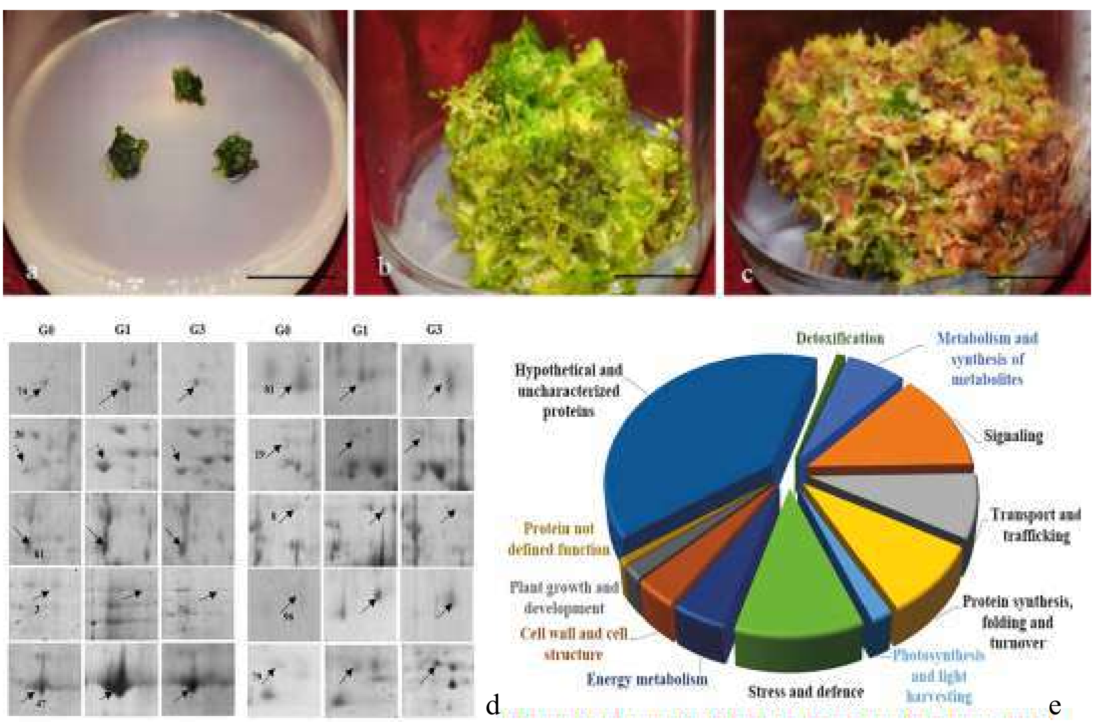


Fig. 3 Response of *in vitro* grown gametophytes of *D. maximum* to different sucrose concentrations; (a-c) Gametophyte multiplication after (a) 60, (b) 90 and (c) 120 days (d) 2-DE showing Differentially Abundant Proteins (e) Categories of proteins

Saffron cultivation in Palampur region

Disease free *in vitro* cormlets (1.8 kg) were cultivated in farmers' field of Palampur region during October 2018 and harvested (3.5 kg) However, flowering in control was several folds higher than those from *in vitro* raised corms (Fig. 4), but the quality of the spice was at par and comparable to that from Kashmir (84.62 mg crocin /100 mg stigmas). The farmer from Palampur region sold the spice at Rs. 3.5 lakhs per kg. Vigorous vegetative growth and formation of healthy daughter cormlets were recorded post-flowering.

The study, besides adding to the income of the farmers, confirmed the suitability of Kangra region as an alternative locale for large-scale cultivation of saffron.

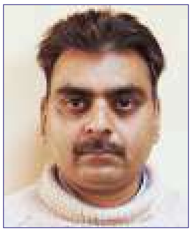
Fig. 4 Cultivation of saffron using corms produced in Palampur region (a) Corms harvested in June 2019 from farmers field (b) Sowing of corms in October 2019 (c) Flowering in 2019 (d-e) Flowers harvested from farmers field (g) Spice harvested from farmer's

Tissue culture of bamboos - Sustainable resource base for industry

In continuation to our previous activity, *in vitro* cultures of four additional bamboos namely, *Dendrocalamus asper*, known as timber bamboo because of its use in wood and food industries, *D. membranaceus* for its use in bamboo board, furniture, basketry, matting and handicraft industry and *Bambusa balcooa* for its use in wood, food, paper and pulp industries and *Phyllostachys pubescens*, a commercially important bamboo were established as per the demands of wood and plant tissue culture industry. *In vitro* cultures of these bamboos were supplied to industries under Material Transfer Agreements signed during the year. These included:

- M/s Shashanka Agrotech. Pvt. Ltd., Ranchi, Jharkhand on 09.12.2019.
- M/s Beej Sheetal Research Pvt. Ltd., Jalna, Maharashtra on 22.10.2019.
- M/s Ana Bioenergy, Kurukshetra, Haryana on 06.09.2019.
- M/s Pratyaksha Agro., Pvt. Ltd., Assam on 31.01.2020

In addition to this, in the current financial year, an ECF amounting to Rs. 6.8 lakhs was generated through the supply of bamboo plants to different agencies.



Vipin Hallan, Senior Principal Scientist
hallan@ihbt.res.in
Plant microbe interaction of plant viral pathogens

The lab works in the area of Plant microbe interaction involving viral and viroid 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 (CSIR NCP project activity); cucumber mosaic virus-arabidopsis system (SERB and CSIR sponsored activities) and lateral flow diagnostics against apple viruses (SERB).

AV2 protein of tomato leaf curl Palampur virus interacts with F-box Kelch protein of tomato and enhances phenylalanine ammonia-lyase activity during virus infection

Leaf curl diseases caused by tomato leaf curl Palampur virus (ToLCPalV) is responsible for considerable yield losses and one of the pathogenicity determinants of the virus is AV2 (second protein encoded by DNA-A in virion sense) protein. In order to elucidate the role of AV2 in virus infection, it was found that it interacts with tomato F-box Kelch protein (KFB), which was confirmed with yeast two hybrid screening (Y2H), bimolecular fluorescence complementation (BiFC) and docking (Fig. 1). Interestingly, transient co-expression of AV2 and KFB in *Nicotiana benthamiana* resulted in destabilization of the KFB protein. This in turn was associated with ~3.4-fold downregulation of KFB transcripts in ToLCPalV infected leaves. The N. benthamiana plants inoculated with wild-type or mutant ToLCPalV strains also showed a significant difference in phenylalanine ammonia-lyase (PAL) activity.

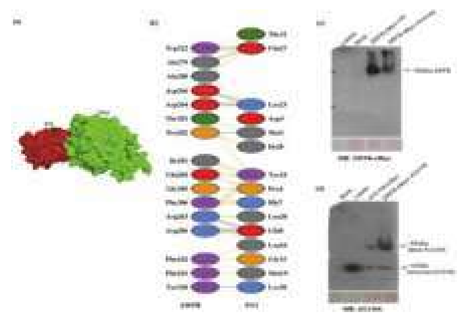


Fig. 1 (a) Docking study between the AV2 (red) and SlKFB (green) protein with Hex 8.0.0 server (b) Residual interactions at AV2 and SlKFB interface generated by LigPlot + indicate hydrogen and hydrophobic interactions. The coding scheme is as follows: blue color represents H-bonds; dashed orange lines represent hydrophobic interactions. (c) Immunoblot detection of SlKFB protein with cMyc antisera (raised in mouse) in N. benthamiana leaves co-expressing SlKFB-cMyc and AV2-HA constructs; ladder: Precision Plus Protein™ WesternC™ (BioRad, USA). (d) Western blot analysis for AV2 protein using HA antisera (raised in rabbit) in N. benthamiana leaves co-expressing SlKFB-cMyc and AV2-HA constructs; ladder: Precision Plus Protein™ WesternC™ (BioRad, USA). The PVDF membrane was stained with Ponceau S stain as a control for equal amount of protein loading. (For interpretation of the references to color in this figure legend, the reader is referred to the Web version of this article.)

AC4 protein of tomato leaf curl Palampur virus is an RNA silencing suppressor and a pathogenicity determinant

Plants deploy RNA silencing as a natural defence against invading viruses involving sequence-specific degradation of the viral RNAs. As a counter-defence strategy, viruses encode suppressor proteins that simultaneously target different steps of the silencing machinery. Tomato leaf curl Palampur virus (ToLCPalV) is responsible for significant reduction in the crop yield and quality. DNA-A of the virus encodes for six proteins whereas DNA-B codes for two proteins. In this study, all viral genes were screened for their role in suppression of green fluorescent protein (GFP) silencing in *Nicotiana tabacum* cv. Xanthi, employing agrobacterium based co-infiltration assay (Fig. 2).

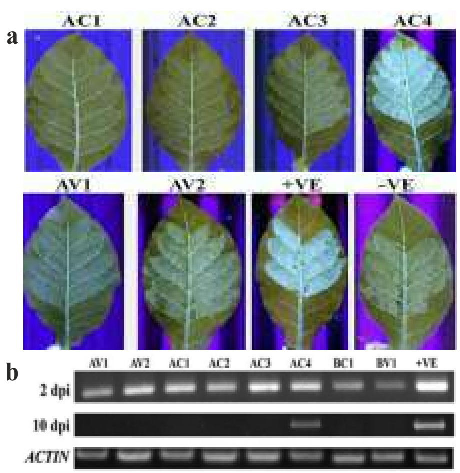


Fig. 2 Co-infiltration assays for identification of RNA silencing suppressor protein (a) N. tabacum cv. Xanthi leaves were co-infiltrated with a mixture of Agrobacterium strains harbouring 35-GFP and individual constructs indicated above each image. Positive control (+VE) represents infiltrated mixture of agrobacterium harbouring 35S-GFP and MYMIV-AC2. Negative control (-VE) was infiltrated with 35S-GFP only. GFP fluorescence was observed at 10 dpi under UV illumination. (b) RT-PCR analysis of GFP transcripts of the above samples at 2 and 10 dpi. Total RNA was extracted from the inoculated leaves. An endogenous ACTIN gene was used as an internal control to ensure an equal amount of cDNA was loaded

The assay identified AC4 as a potential suppressor of RNA silencing. In addition, AC4 expression also suppressed virus-induced gene silencing (VIGS) of the phytoene desaturase (PDS) gene in *N. benthamiana*. Potato virus X (PVX) mediated transient expression of the AC4 in *N. benthamiana* showed enhanced symptoms that include downward leaf curling, leaf puckering and tissue necrosis. Further, *N. benthamiana* lines stably expressing AC4 showed severe developmental abnormalities. Mutational analysis suggested that glycine at 2nd position is essential for AC4 pathogenicity. Collectively, these findings demonstrate the role of ToLCPalV AC4 in viral pathogenesis, disease establishment and suppression of gene silencing.

Molecular characterization and infectivity analysis of a bipartite begomovirus associated with cotton leaf curl Multan betasatellite naturally infecting *Rumex nepalensis*

Rumex nepalensis (Nepal Dock) is an Indian traditional medicinal herb of the Western Himalayas. During a survey, typical begomovirus-like symptoms were observed on naturally growing *R. nepalensis* in the Bandla region of Palampur, Himachal

Pradesh, India. PCR-based detection identified a bipartite begomovirus and a betasatellite in all the symptomatic plant samples. Complete sequence characterization established their identity as tomato leaf curl Palampur virus (ToLCPalV) and cotton leaf curl Multan betasatellite (CLCuMuB), respectively. 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 in any of the above combinations. PCR and Southern blot analysis confirmed the replication and systemic spread of ToLCPalV and CLCuMuB in both *R. nepalensis* and *N. benthamiana* infiltrated plants. The present report shows R. nepalensis as a new natural host of the bipartite ToLCPalV associated with CLCuMuB. It also demonstrates the efficient trans-replication compatibility of CLCuMuB by a bipartite ToLCPalV in both of its natural and experimental hosts.

Production of polyclonal antibodies to the coat protein gene of Indian isolate of Apple stem grooving virus expressed through heterologous expression and its use in immune-diagnosis

Apple stem grooving virus (ASGV) belonging to the genus Capillovirus under family Betaflexiviridae is one of the widely distributed latent viruses mainly on pome fruit trees. It infects apple causing considerable economic losses that is a threat to the apple industry. To study the occurrence and incidence of ASGV disease, sensitive antisera based diagnostic tool has been developed, which would be helpful in large scale indexing, certification and quarantine programmes. Coat protein gene of ASGV was cloned into pET-32a(+) and pHIS-Parallel expression vectors for expression and purification. Purified protein was used for raising antisera in rabbits. Sensitivity and specificity of the antiserum against virus infection was compared by Double Antibody Sandwich (DAS-ELISA). It was observed that the antisera raised from the protein expressed from pHIS-Parallel expression system (smaller ~ 3 kDa His tag) was more sensitive as compared to the antisera raised from the protein expressed from pET-32a(+) expression system (~ 18 kDa His tag) and the commercially available antisera. The antisera could also be successfully used for western blotting of infected samples and in DAS-ELISA.

Ram Kumar Sharma, Senior Principal Scientist
ramsharma@ihbt.res.in
Biotechnology Department

Our current goal is 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. In continuation to the previous reports, during the period under report following achievements were made by the group.

Transcriptional analysis for drought dissection and ascertainment of nucleotide variations in tea (*Camellia sinensis* (L.) O. Kuntze)

Drought affects growth and yield negatively and is considered as the primary cause of crop loss worldwide. Countries like India are facing consecutive drought conditions since last decades. This is causing significant losses in farm economy and food security is worsening. Tea [Camellia sinensis (L.) O. Kuntze], a perennial evergreen woody plant of family, Theaceae is a highly cross pollinated and heterozygous plantation crop. It is consumed by millions of people worldwide for its numerous health benefits. India being the second largest producer of tea in the world. Nevertheless, tea cultivation is significantly constrained due to the impact of climate change and prolonged rainless periods leading to drought conditions. Tea production has reduced by 14–33 % with mortality of up to 6–19 %. Therefore, the focus of breeders is now on identification and development of high yielding quality tea varieties better adapted to drought conditions.

Considering enormous gene pool with abundance of vigorous and high level of genetic diversity, traditional tea cultivars in India exhibits inherent genetic variations among wide range of desirable traits (quality & yield) including tolerance to drought stress. However, due to out-breeding and long gestation periods, tea requires next generation breeding strategies to improve drought tolerance *via* deeper understanding of key regulators and their variants for precision introgressions to have better yield and quality under drought conditions.

Therefore, comprehensive transcriptome sequencing of multiple tea genotypes exhibiting tolerant and sensitive response to drought stress generated more than 140 million reads. *De novo* and reference-based assembly and functional annotation of 67,093 transcripts with multifarious public protein databases yielded 54,484 (78.2 %) transcripts with significant enrichment of GO and KEGG drought responsive pathways in tolerant genotypes (Fig.1).

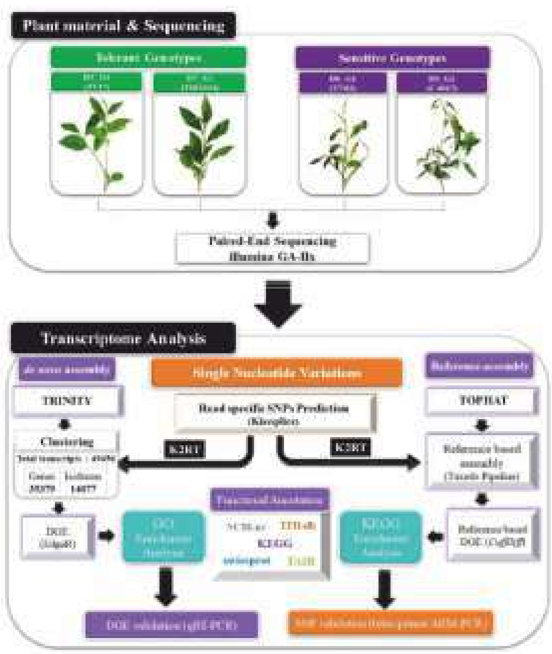


Fig. 1 Transcriptional strategies, plant materials and functional inferences of drought dissection in tea.

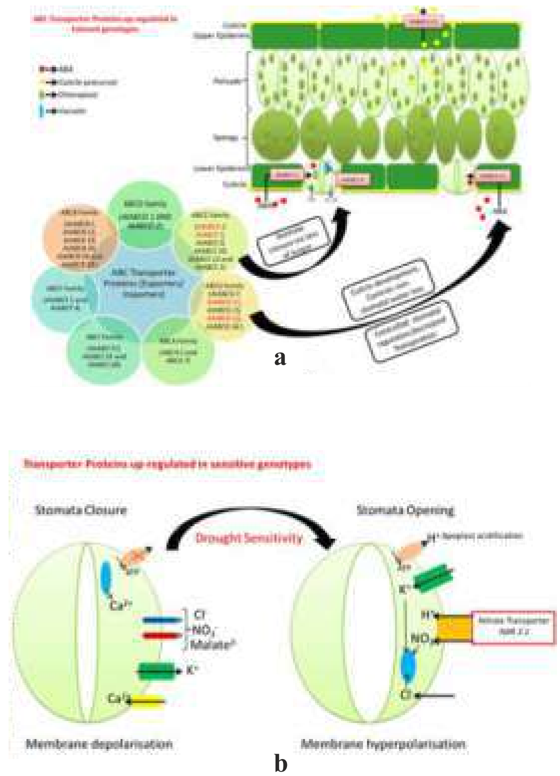


Fig.2 Role of transporters in opening and closing of stomata during drought stress response in tea. (a) ABC transporter activity in tolerant genotypes. (b) Nitrate transporter activity in sensitive genotypes.

Further, *de novo* DGEs analysis using control for each treatment in tolerant and sensitive genotypes identified overall 3361 and 2250 transcripts were commonly up-regulated in tolerant and sensitive genotypes, respectively. GO and KEGG enrichment analysis was carried out to critically discern the drought responsive key pathways enriched in tolerant and sensitive genotypes.

Comprehensive transcriptome analysis of tolerant and sensitive genotypes indicated the role of key pathways such as ABA-dependent and independent pathway, metabolic pathway & antioxidant defense enzymes, membrane transporters and ubiquitinization are crucial for drought tolerance in tea (Fig.2).

Comparative DGE and qRT analysis revealed key role of ABA dependent & independent pathways, potassium & ABC membrane transporters (AtABCG22, AtABCG11, AtABCC5 & AtABCC4) and antioxidant defence system against oxidative stress in tolerant genotypes, while seems to be failed in sensitive genotypes. Additionally, highly expressed UPL3HECT E3 ligases and RING E3 ligases possibly enhance drought tolerance by actively regulating functional modification of stress related genes (Fig. 3).

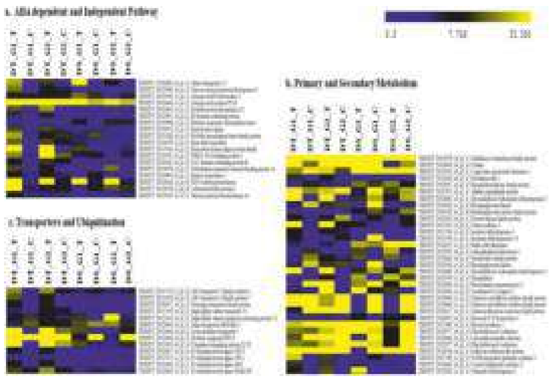


Fig.3 Heat map of differentially expressed genes during drought stress response in tea. (a) ABA-dependent and independent pathway (b) Primary, Secondary metabolic pathways and antioxidant enzymes (c) Transporters and Ubiquitination.

Further, ascertainment of, 80803 high quality putative SNPs with functional validation of key nonsynonymous SNPs suggested their implications for developing high-throughput genotyping platform in tea

Genome-wide molecular characterization revealed gamma-irradiation mediated disruption of floral integrator gene(s) leading to prolonged vegetative phase in *Stevia rebaudiana* Bertoni

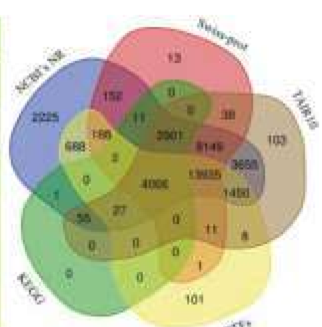
Overburden of calories, i.e. an imbalance between calories intake and consumption, is a major cause for various metabolic diseases such as obesity/overweight, diabetes, hypertension, heart, and musculoskeletal disorders. These metabolism-associated diseases in low- and middle-income countries, including India, is a matter of great concern. Routinely, limiting daily sugar intake is one of the prominent ways to manage diabetes, nevertheless, opening the commercial demands towards low/no calorie sweeteners (LNCSs). Unfortunately, several health issues associated with the uses of artificial synthetic low-calorie sweeteners (saccharin, aspartame and sucralose) causing significant reduction of their consumer acceptability, therefore, driving the scientific and corporate interest towards naturally derived LNCSs, such as steviol glycosides (SGs) derived from *Stevia rebaudiana* Bert.

Being natural, with 300 times greater sweetening potency than common table sugar, SGs derived from *S. rebaudiana* plant have become an excellent choice as a natural LNCSs, globally. Generally, the higher SGs accumulation was noted in vegetative phase with maximum accumulation during vegetative to reproductive phase transition (just prior to the emergence for floral buds). Therefore, selection of potential genotypes with prolonged vegetative phase is also a desirable trait to provide higher metabolic flux with extended ontogenetic time period for SGs accumulation. Interestingly, a mutant genotype with desirable prolonged vegetative phase was generated using gamma-irradiation in Stevia. During this period, comparative global transcriptome analysis to characterize mutant cultivar and identify key molecular components responsible for prolonged vegetative phase/delayed flowering to enhance breeding efforts for its genetic improvement. Sequencing of four cDNA library samples generated 91,298,216 (93.22%) high quality filtered reads. The high-quality filtered reads were de novo assembled into 60,322 contigs, which were further clustered into 55,902 non-redundant transcripts. The transcript length was ranging from 301 to 14,604 bp with an average length of 992.68 bp. The N50 length, N75 length and GCs content were estimated to 1,356 bp, 750 bp and 38.96 %, respectively. Fig.7 Components of floral induction pathways in Stevia. Heatmap showing DGEs of all flowering related genes in background (SBG_V and SBG_F) and mutant (SMG_V and SMG_PV) genotypes. → symbol showing activation of downstream gene by upstream gene, ⊥ symbol showing suppression of downstream gene by upstream gene.

Functional annotations with multifarious protein databases (NCBI's NR, Swiss-Prot, TAIR 10, KEGG, PTF and EggNOG) resulted into the functional attributes of 37,809 (67.63 %) transcripts. Among these, maximum transcripts were annotated in NCBI's NR database (37,505 hits) followed by Swiss-Prot (34,582 hits), TAIR10 (34,398 hits), PTFs (20,477 hits), EggNOG (6,987 hits) and KEGG (6,930 hits) databases with 4,066 common hits (Fig. 4A and B).

Database	Total hits
NCBI's NR	37,505
Swiss-Prot	34,582
TAIR10	34,398
PTFs	20477
EggNOG	6987
KEGG	6930

A



B

Fig.4 Functional annotation of assembled transcripts with different databases (A) Table representing number of hits with different databases, (B) Venn diagram representing uniquely and commonly annotated transcripts with different databases.

Comparative DGEs analysis via mapping of tissue-specific high-quality reads to assembled transcripts recorded higher expression level (RPKM>20) recorded during vegetative and flowering transitions in background genotypes; and vegetative and prolonged vegetative phases in mutant genotype. Interestingly, 1,417 and 197 transcripts were uniquely showed higher expression in SBG_F and SMG_PV, respectively, indicating transcriptional alteration between mutant (SMG) and background (SBG) genotypes (Fig. 5).

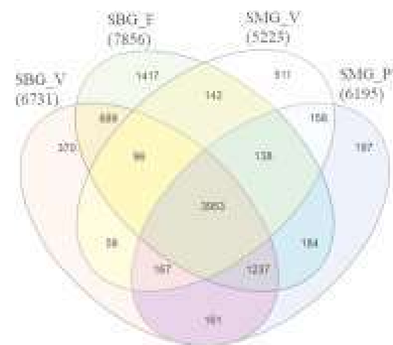


Fig. 5 Components of floral induction pathways in Stevia. Heatmap showing DGEs of all flowering related genes in background (SBG_V and SBG_F) and mutant (SMG_V and SMG_PV) genotypes. → symbol showing activation of downstream gene by upstream gene, ⊥ symbol showing suppression of downstream gene by upstream gene.

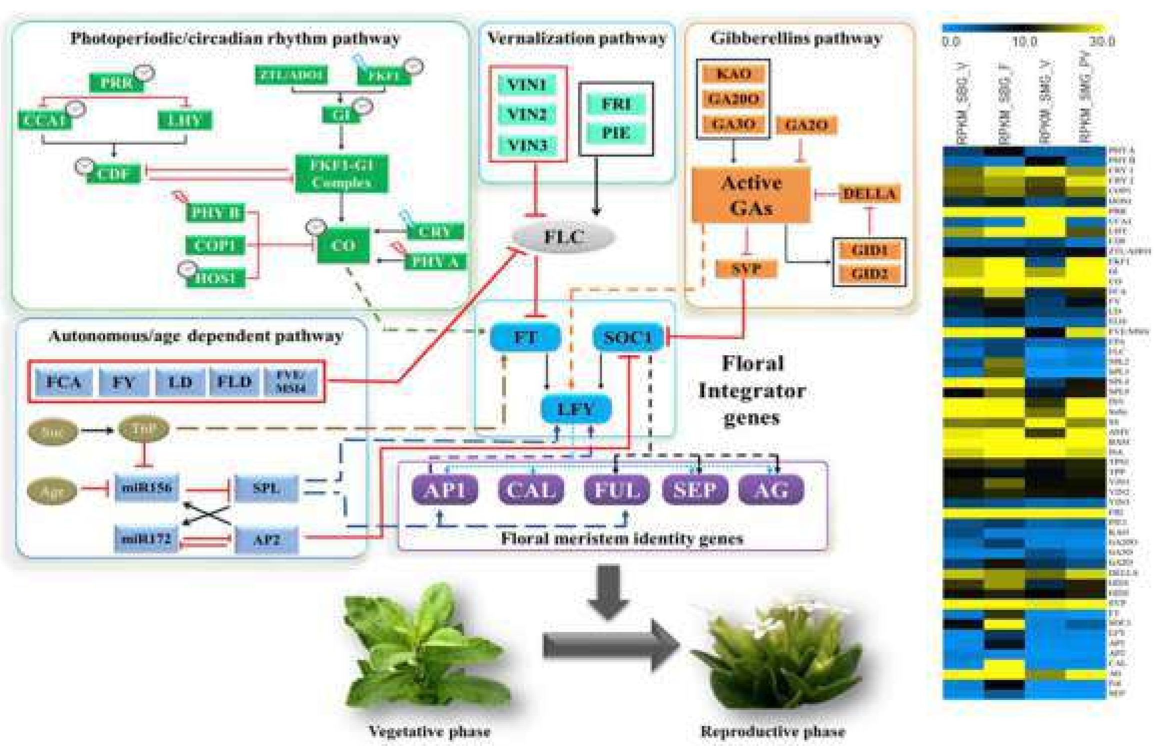
Further, pairwise comparisons of DEGs with edgeR statistics also recorded differentially expressed (logFC ≥1) in between mutant (SMG) and background (SBG) genotypes, respectively (Fig. 6)

Fig.6 Tissue-wise comparison of differentially expressed genes from edgeR statistics of background and mutant stevia genotypes.

In conclusion, comparative transcriptional analysis of low dose (5 kR) gamma-irradiated mutant genotype (SMG) with prolonged vegetative phase vis-à-vis background genotype (SBG) was identified.

DGEs of major floral transition pathways, and expressed according to their physiological fate irrespective to SMG & SBG. Contrarily, reduced expression of floral integrator genes (FT and LEAFY) in mutant genotype suggests their involvement in prolonged vegetative phase phenotype. Likewise, GO and KEGG enrichment of photosynthesis and carbon assimilation efficiency might be associated with prolonged vegetative phase and higher accumulation of Stevioside content in mutant genotype. Furthermore, deviation of flowering related transcription factors (higher expressions except MIKS-type MADS-box SMG_PV compared to SBG_F) may possibly be correlated with low expression of floral integrator genes .

Findings of current studies will facilitate the genetic manipulations and crop improvement efforts in Stevia through conventional breeding and genome editing approaches for increased SGs biosynthesis.



Ravi Shankar, Principal Scientist
ravish@ihbt.res.in
Studio of Computational Biology & Bioinformatics

Plant Regulomics Portal (PRP): The first ever intergrated database and information portal for plant regulomics

After the release of draft genome sequence of humans in 2000, it was realized that the genome and life is more than just protein coding genes which barely account for 3% of the genome. Henceforth, the ENCODE project was born and is considered to be more important than the HGP itself. ENCODE helped the world to understand that regions beyond 3% coding regions include regulators like TFBS, epigenetic components, and regulatory and non-coding RNAs etc. These control the system and also contribute towards a given cell state and condition. A good progress has been made in animal science in this regard, but an integrated view of such a system is lacking in plant science.

Thus, Big data analytics approach was used for the first time integrated regulatory models of regulation in plants were developed for four species namely, arabidopsis, maize, rice, and soyabean while processing more than 25 TB of experimental and high-throughput data. The database hosts 571 GB finally processed data and includes data for DNA methylation, histone modification, RNA expression, sRNAs and miRNAs, TFBS and CHIP-seq, genome data, annotations etc. It provides tools to analyse genomes and genomic components both qualitatively and quantitatively. It is first of its kind toll and information portal where plat biologists can perform integrated regulatory analysis.

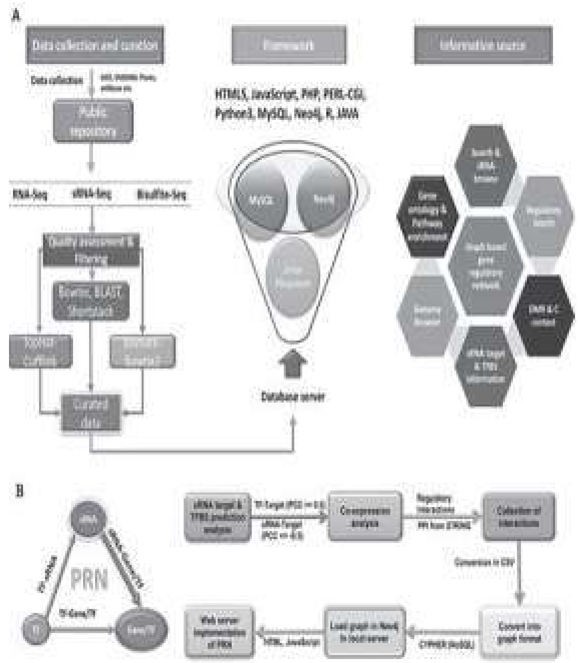
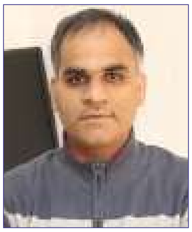


Fig. 1 The implementation protocol of plant regulomics portal. PRP implements state-of-the-art data structuring, management, and visualization modules. It is highly interactive and uses NOSQL databases like Neo4J, D3J JS scripts and PHP, to name a few. It also provides a dynamic genome browser as given below



Rituraj Purohit, Sr. Scientist
rituraj@ihbt.res.in
Biotechnology (Bioinformatics)

Computational strategy to eliminate the bitter-off taste of Stevioside

Stevioside is a natural non-caloric sweetener. It is 150–300 times sweeter than sugar. According to The International Market Analysis Research and Consulting group, the global market value of stevia is projected to reach nearly US$ 818 million by 2024. Stevioside, in addition to its sweetening effect, gives unwanted sensory attributes such as bitter-off taste in foods and beverages sweetened with stevioside. The reason for this undesirable taste is that it binds with both sweet as well as bitter taste receptors. The major challenge in the commercialization of stevioside as a natural sweetener is its bitter-off taste. In this study, we prepared molecular models of potential taste receptors of stevioside, both sweet and bitter. With appropriate modifications on stevioside backbone, we performed molecular docking of prepared ligands with both sweet and bitter taste receptors. Based on binding energy, we found that one of the potential substituent, Kamiya-8, shows a good affinity towards sweet taste and a weak affinity for bitter receptors. Further, we selected Kamiya-8 for molecular dynamics simulations to improve the prediction of binding energy and to check the binding strength of Kamiya-8 with taste receptors. Moreover, we also performed MM-PBSA calculation for calculating the end state free energies of molecules in solvent and found that Kamiya-8 gives a 2-fold effect as it interacts with sweet receptors (T1R2, T1R3) with lowest binding energy conformation (-285.265 kcal/mol, -571.481 kcal/mol). Secondly, it gives high binding energy (-273.319 kcal/mol, -355.500 kcal/mol) with bitter taste receptors (T2R4, T2R14) as compared to stevioside. Based on this study, we found that Kamiya-8 can be the potential substituent that can improve the palatability of stevioside. The study workflow of the analyses is depicted in Fig. 1.

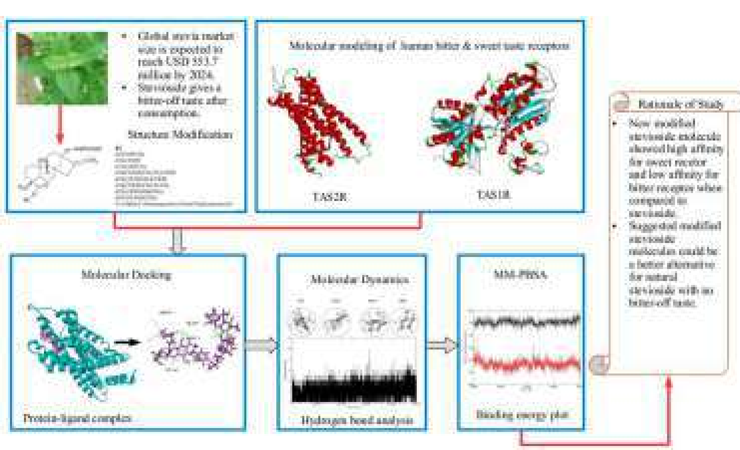


Fig. 1 Overview of computational strategy and key findings of the study

Deciphering the effect of mutations in PCNA on mismatch repair pathway and protein-protein interactions

Genomic DNA replication is a complex and coordinated process which uses an ordered sequence of steps to form a diverse set of paramount protein assemblies at the origin of replication. From bacteria to mammals, DNA mismatch repair (MMR) pathway plays an essential role in eliminating mismatched nucleotides and insertion-deletion mismatches during the process of DNA replication. Among many of the proteins which participate in the mismatch repair process, proliferating cell nuclear antigen (PCNA) remains the principal conductor at the replication fork. The pol30-201 and pol30-204 are the two mutated alleles which encode for C22Y and C81R: mutant forms of PCNA proteins. We performed long term molecular dynamics (MD) simulations analysis (0.8 ls) to understand the dynamic behavior and alterations in the structure of wild type and mutated forms of PCNA at the atomic level. We observed changes in the structural characteristics like length, radius, rise per residue of alpha helices in both the mutated forms of PCNA. Apart from it, disfigurement of the charge distribution which effects binding with the dsDNA due to mutant C22Y and other structural perturbations were also seen in regions significant for the formation of a biologically active trimeric form of PCNA due to mutant C81R. Our analysis of native and mutated forms of PCNA provides an insight into the essential structural and functional features required for proper and well-coordinated DNA mismatch repair process and consequences of the mutation leading to an impaired process of MMR. These structural characteristics are fundamental for the MMR process and hence our analysis likely contributes to or presents the novel mechanism involved in the process of MMR. The study workflow of the analyses is depicted in Fig. 2.

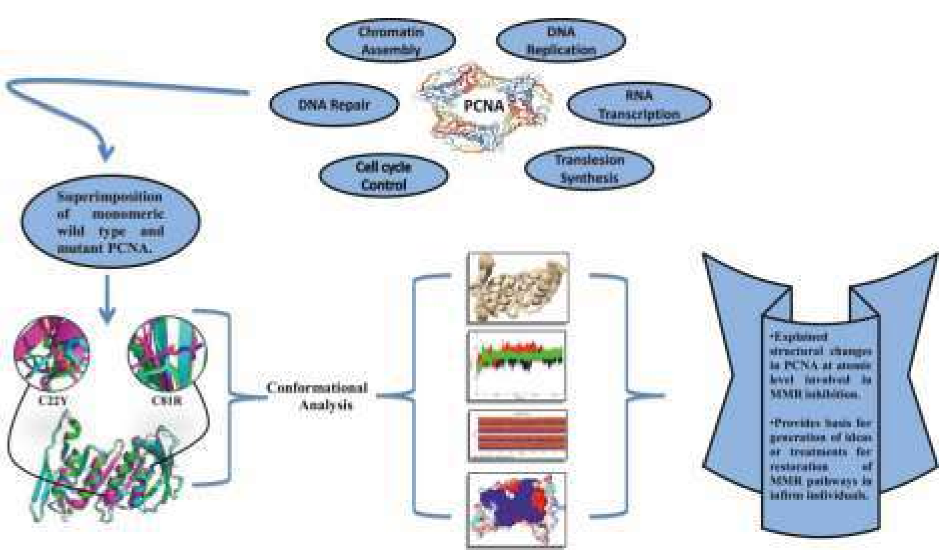


Fig. 2 Flowchart depicting the overall workflow of the study

PCNA binds and interacts with a variety of proteins required in different cellular functions. Structural investigations of PCNA bound to many of its interacting proteins have been accomplished and these have given important bits of knowledge into how PCNA binds with these proteins. In this research, we analyzed the complex of yeast PCNA bound to the peptide of Cdc9 yeast DNA ligase I to understand the interaction between the two proteins at the molecular level by performing molecular dynamics (MD) simulations. We observed the binding of the yeast Cdc9 peptide on two mutant PCNA structures which are deficient in mismatch repair (MMR) pathways and compared them with the native complex. Our study revealed significant changes at sites responsible for a functional trimeric form of PCNA. This study also unveils the dynamic behavior of IDCL, central loop, and the C -terminal tail, which are essential regions for protein binding with PCNA and the effect of mutations on binding with the Cdc9 peptide. The observation of Cdc9 peptide complexed with native and mutants (C22Y and C81R) structures possibly reveals the mechanism by which PCNA recruits different proteins required for various biological processes and also highlights the importance of dynamic behavior of key regions involved in PCNA protein - protein interactions. The study workflow of the analyses is depicted in Fig. 3.

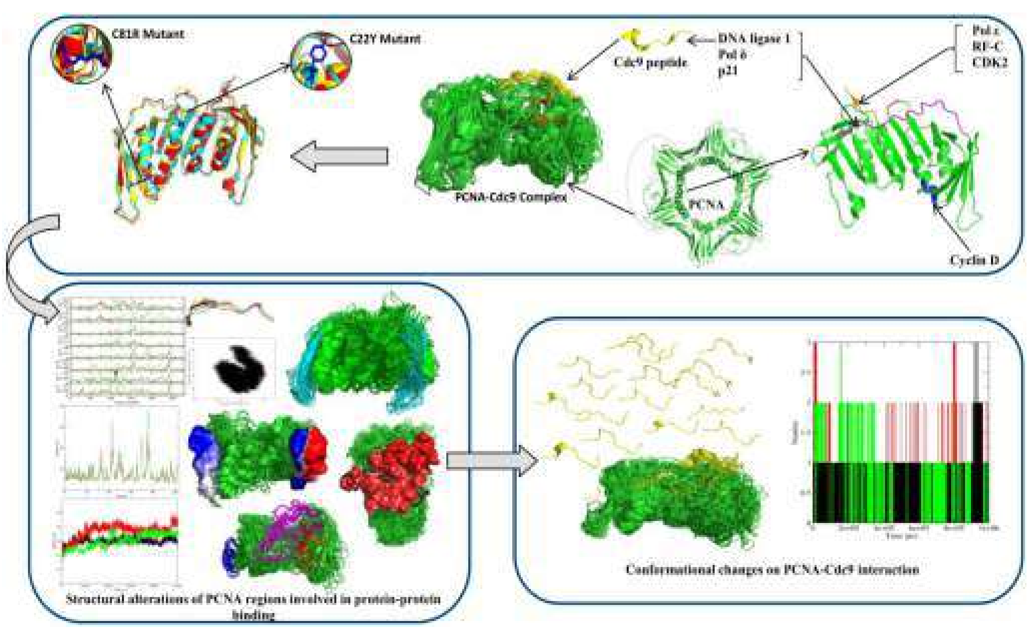


Fig. 3 Pictorial representation of the workflow

Dharam Singh, Senior Scientist
dharamsingh@ihbt.res.in
Molecular and Microbial Genetics

Bioprospection of Microbiome from Himalayan Niches (CSIR-NCP)

Himalayan niches have great potential for discovery of microorganism for novel enzymes/metabolites with unique properties. Despite the tremendous opportunity, only a few culturable and metagenomic microbial bioprospection studies from Himalayan niches had been reported so far. Therefore, a large scale and systematic study on Himalayan microbiome in the lineup with standardized protocols and common analytical frameworks of Earth Microbiome Project will be of considerable importance. Considering this, the study on Himalayan microbiome was designed and is undergoing in our laboratory at CSIR-IHBT.

Our research group have explored the Himalayan microbiome by using conventional culture based as well as metagenomic approaches. The culturable bacteria identified and characterized, and whole genome of selected isolates sequenced by PacBio platform. Other NGS platform i.e. Oxford Nanopore and Illumina used for whole genome metagenome and 16 S based metagenome sequencing, respectively.

The current study revealed affluent microbial diversity and provides an opportunity to understand microbial adaptation to highly fragile and hostile environment of high altitude Himalaya. Himalayan bacteria show fascinating metabolic diversity and adaptive features as revealed by genomic and physiological approaches. Apart from the fundamental aspect, the applied research on microbes for the production of bioplastic, antifreeze proteins, pigments and various industrially important enzymes were also explored and currently underway.

Further, the study on Himalayan microbiome will answer many key questions in details, for instance, who and how many microbes in Himalaya? what they are doing (structure and functions of microbial communities), what are the significance to microbial ecology to the environment and vice-versa? and how to use good microbes for the benefit of society and environment?

Major findings:

- Total 868 bacterial isolates from high altitude soil and water samples. A total of 213 bacterial isolates were identified using 16S rDNA sequencing.
- Whole genome of 16 number of unique bacteria sequenced using PacBio RS II.
- Whole genome metagenome sequencing of two environmental samples carried out using Nanopore MinION generated ~15 Gb of raw data, ~2 million total reads and 1.5 million passed reads.
- Metagenomic library of amplified V3V4 region from 24 samples were prepared for sequencing using Illumina platform.

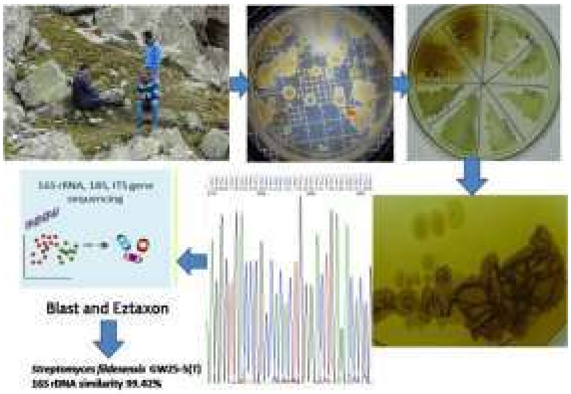


Fig. 1 Bioprospection of Himalayan microbiome

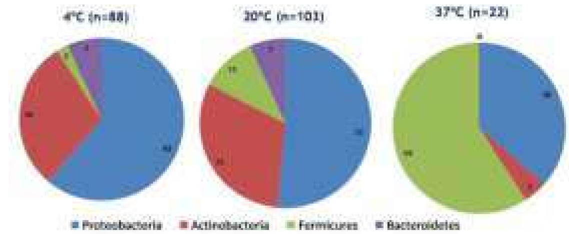


Fig. 2 Culturable microbial diversity of Himalayan is number of identified bacteria

Amitabha Acharya, Senior Scientist
amitabha@ihbt.res.in
Chemical Nanotechnology and Nanobiology

The chemical nanotechnology and nanobiology group at CSIR-IHBT has been actively working on isolation and characterization of nanomaterials from bioresources. We intend to use these nanomaterials for different biomedical applications with specific focus on anti-biofilm activity and as inhibitors for protein aggregation related diseases.

Organic-inorganic hybrid nanocomposite as inhibitor against human serum albumin (HSA) aggregation.

Protein aggregation leads to the transformation of proteins from their soluble form to the insoluble amyloid fibrils and these aggregates get deposited in the specific body tissues, accounting for various diseases. To prevent such an aggregation, organic−inorganic hybrid nanocomposites of iron oxide nanoparticle (NP, ~6.5−7.0 nm)-conjugated cellulose nanocrystals (CNCs) isolated from *Syzygium cumini* (SC) and *Pinus roxburghii* (PR) were chemically synthesized. Transmission electron microscopy (TEM) images of the nanocomposites suggested that the in situ-synthesized iron oxide NPs were bound to the CNC surface in a uniform and regular fashion. The ThT fluorescence assay together with 8-anilino-1-naphthalenesulfonic acid, Congo Red, and CD studies suggested that short fiber-based SC nanocomposites showed better inhibition as well as dissociation of human serum albumin aggregates. The TEM and fluorescence microscopy studies supported similar observations. Native polyacrylamide gel electrophoresis results documented dissociation of higher protein aggregates in the presence of the developed nanocomposite. Interestingly, the dissociated proteins retained their biological function by maintaining a high amount of α-helix content. The in vitro studies with HEK-293 cells suggested that the developed nanocomposite reduces aggregation-induced cytotoxicity by intracellular reactive oxygen species scavenging and maintaining the Ca^{2+} ion-channel. These results indicated that the hybrid organic−inorganic nanocomposite, with simultaneous sites for hydrophobic and hydrophilic interactions, tends to provide a larger surface area for nanocomposite−protein interactions, which ultimately disfavors the nucleation step for fibrillation for protein aggregates (Fig 1).

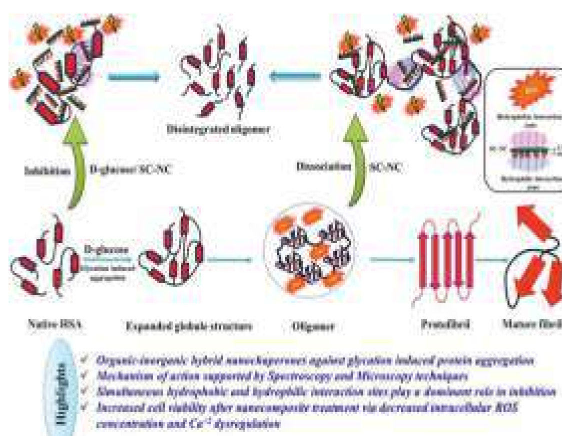


Fig. 1 Plausible mechanism for the inhibition/dissociation of HSA aggregates by organic –inorganic hybrid nanocomposite. Reprinted with permission from ACS [Copyright © 2019, American Chemical Society)

Monitoring protein-nanoparticle interactions

Protein-nanoparticle (NP) interaction, which inevitably form protein corona (PC), has been the subject of much debate about its role in modern biomedical research. In this regard, PC associated with two different NPs viz., magneto-fluorescent (MF) and chitosan coated MF (CMF) NPs were investigated to analyze the effect of polymer coating on protein adsorption. Bradford assay, along with the spectroscopic and microscopic studies suggested increase in adsorbed protein quantity, though the results varied significantly on moving from bare to polymeric coating and in vitro to ex vivo conditions. Interestingly, polymer coated NPs showed increased protein adsorption and induction of minimal changes in protein structural integrity under the same conditions. We predict that the changes in secondary structure of primary corona determine the overall signature of surface binding proteins in PC. Our findings suggested that rapid diagnosis of immunoglobulins is possible using the concept of protein corona formation *ex vivo* (Fig 2).

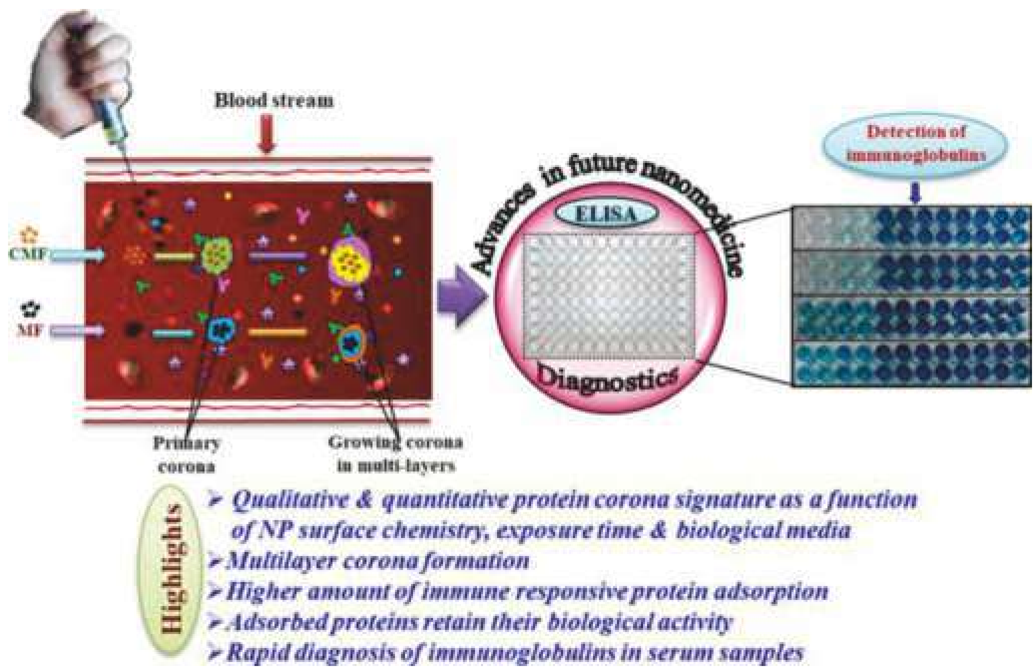


Fig. 2 Schematic representation of protein-nanoparticle interactions. Reprinted with permission from Elsevier [Copyright © 2019, Elsevier)

Vishal Acharya, Scientist
vishal@ihbt.res.in
Computational functional genomics & system biology

Next generation sequencing of Himalayan microbes and its genomic insights and molecular adaptation at the amino acid level

Next generation sequencing (NGS) of Himalayan microbes viz., *Pseudomonas frederiksbergensis* ERDD5:01 isolated from the Sikkim Glacier region was carried out using a computational pipeline (several assemblers and annotation platform) for generating a complete and quality draft genome. Assembly of the generated subreads was performed *de novo* using popular assemblers like Canu, Celera and HGAP. RS hierarchical genome assembly process (HGAP) protocol version 3.0 in SMRT Analysis version 2.3.0 (Pacific Biosciences, US) was found to be one of the best assembler for this isolate ERDD5:01 strain with a complete circular chromosome of 5,746,824 bp with 58.7% GC content and a plasmid of 371,027bp with 55% GC content with average mean coverage of 104X. We have carried out genome-wide comparison and molecular adaptation at the amino acid level for this strain ERDD5:01. 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 survivability at extreme cold and radiations corroborating with the bacterial physiological findings.

Starting with the comparison of the proteome of psychrotrophic *P. frederiksbergensis* ERDD5:01 (5471 coding sequences (CDS) against the database of 15 publically available mesophilic genomes of *Pseudomonas* sp. provides functional insight into the strategies for adaptation at low temperature. The final 2317 homologues protein CDS among ERDD5:01 and 15 mesophilic genomes were used for estimating cold-adaptor indicators namely acidic residues, proline residues, aromaticity, aliphatic, hydrophobicity and ratio of arginine (R) and lysine (K). Total of 1304 protein CDS with at least one of the cold adapter indices were recorded. Furthermore, 131 protein CDS were observed to be cold adapted with more than three indices hence may be presumed as significantly cold-adapted. Many proteins that are functionally associated with cold adaptation were observed to have amino acid substitutions as revealed by cold adaptation score that might have allowed them for efficient functionality at cold temperature (Table 1). The genomic data also revealed the presence of industrially important enzymes. Identification of gene clusters responsible for cold adaptation and UV radiation tolerance may allow further understanding of its survival mechanism in the harsh high altitude aquatic environment. Additionally, genomic information on various industrial enzymes may serve as the basis for its further exploration for bioprospection opportunities. Moreover, the complete genome of *P. frederiksbergensis* species may assist in its comparative genomic studies. The github link can also be provided as requested to the biological researchers can be applied for other researchers interested for studying molecular adaptation at cold temperatures.

Proteins subsets involved in DNA repair systems, transcription and translation namely AraC family transcriptional regulators, ATP depen-dent RNA helicase DbpA and DNA polymerase III subunit alpha showed high cold adaptation scores with four indices (Table 1). The transcriptional regulators of the AraC family are ubiquitous in bacterial domain. Many members of the family have been identified that play a role in regulating genes encoding diverse functions ranging from carbon metabolism to stress responses in virulence. ATP dependent RNA helicase DbpA, a DEAD-box rRNA helicase that participates in mRNA and rRNA processing, are considered vital for cell survival. Another cold adapted CDS under this category was tRNA pseudouridine synthase TruB that is an RNA modification enzyme, also having a tRNA chaperone activity responsible for the folding of tRNA, and hence maintaining cellular fitness in extreme environments (Table 1). DksA protein that is an important transcription factor for rRNA regulation was also observed to be cold adapted. It binds to RNA polymerase and increases its binding affnity to ribosomal promoters (Table 1).

Table 1. Selected genes encoding cold adapted proteins of *Pseudomonas frederiksbergensis* ERDD5:01

Function	Gene ID	Name of Gene	1	2	3	4	5	6
Cold, Osmotic and oxidative stress response	APC19202	MFS transporter	−	+	+	+	−	+
	APC18662	Na+/H+ antiporter subunit D	+	−	−	−	+	+
	APC14758	Peroxidase	−	+	+	−	−	+
	APC14476	Peroxiredoxin	−	+	+	−	−	+
	APC17354	Thioredoxin	−	+	+	+	−	−
	APC17213	stress response serine/threonine protein kinase YihE	+	−	−	−	+	+
	APC18639	Two-component sensor histidine kinase KdbD	−	+	+	+	−	−
	APC14272	Two-component sensor histidine kinase	+	−	+	+	−	−
	APC15244	Phosphohistidine phosphatase SixA	+	−	+	−	+	−
DNA repair system, transcription and translation	APC15802	DNA-binding response regulator	−	−	+	+	+	−
	APC15950	tRNA pseudouridine synthase TruB	+	−	−	+	+	−
	APC17708	Histidine-tRNA ligase	+	−	+	−	+	−
	APC16372	LysR family transcriptional regulator	−	+	+	+	−	−
	APC19048	Cro/Cl family transcriptional regulator	+	−	−	+	+	−
	APC14660	AraC family transcriptional regulator	+	−	+	+	+	−
	APC19263	ATP dependent RNA helicase DbpA	+	−	+	+	+	−
	APC15696	DNA polymerase III subunit alpha	+	+	−	+	+	−
	APC17475	RNA polymerase binding protein DksA	+	−	+	−	+	−
	APC17855	Exodeoxyribonuclease I	−	−	+	+	+	−
Fatty acid and phospholipid alteration and biosynthesis	APC17254	LPS biosynthesis protein	+	−	−	+	+	−
	APC17050	Phosphoenolpyruvate-protein phosphotransferase	−	+	+	+	−	−
	APC15868	Acyltransferase	+	+	+	−	−	−
Plasmid	APC19520	Integrase	−	−	+	−	+	+
	APC19483	S49 Family Peptidase	+	−	+	−	−	+
	APC19365	Replicative DNA helicase	−	+	−	+	−	+

1.Frequency of acidic residues; 2: Proline residues; 3: Aliphacity; 4: Aromaticity; 5: Arginine to lysine ratio; 6: Grand average of hydropathicity (GRAVY); +: Protein was cold adapted for that index; −: Negative result for cold adaptation for that index.

Rohit Joshi, Senior Scientist
rohitjoshi@ihbt.res.in
Plant Tissue Culture

Mass propagation of economically/ medicinally important plants

The lab works on the development of *in vitro* protocols for mass propagation of economically/ medicinally important plants. At present we are focusing on standardizing the protocols for mass propagation of *Ferula asafoetida* (Heeng), *Siraitia grosvenorii* (Monk fruit) and bamboo (*Dendrocalamus spp.* and *Bambusa spp.*). Asafoetida is native of Iran and Afghanistan deserts having medicinal and nutritional properties. In addition, *Siraitia grosvenorii* is an herbaceous perennial vine of cucurbitaceae family and is native to southern China. Its medicinally important fruit pulp contains bioactive constituents such as mongrosides, and of those mogroside V is nearly 300 times sweeter than sucrose. Further, bamboo also known as 'green gold' is a member of poaceae family and primarily utilized for fiber and food, by about 2.5 billion people representing over 40% of the world's population. To establish the cultivation practices of these plants to fill the huge gap between their production and demand in India, we are designing their mass propagation protocols in our lab.

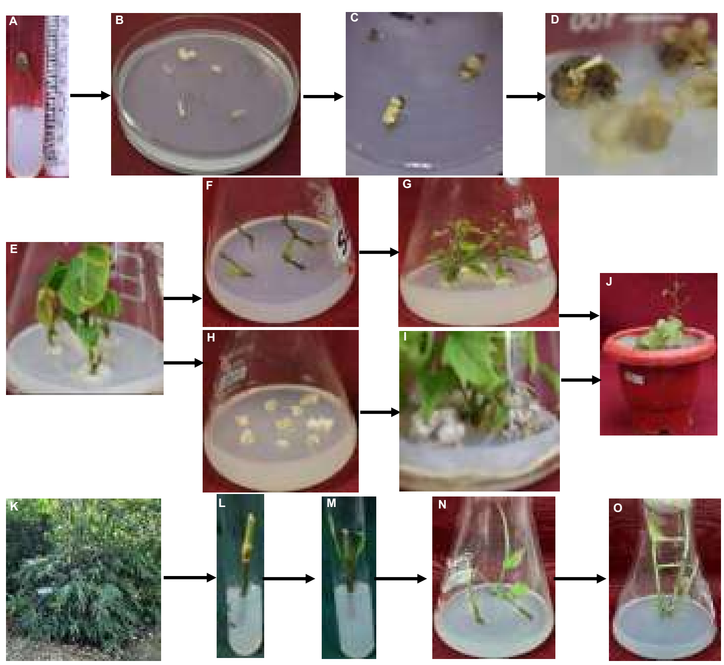


Fig. 1 Standardization of mass propagation protocols for (A-D) Ferula asafoetida, (E-J) Siraitia grosvenorii and (K-O) Dendrocalamus giganteus

Shiv Shanker Pandey, Senior Scientist
shivpandey@ihbt.res.in
Plant-Microbe Interaction, Plant Adaptation and Plant Physiology

The major focus of our research group is to explore the endophytes of Himalayan medicinal plants for improvement of secondary metabolite production and amelioration of stress tolerance in plants. We are trying to explore the endophytes of selected Himalayan medicinal plants including *Trillium govanianum, Valeriana jatamansi*, *Podophyllum hexandrum, Arnebia*, *Fritillaria, Hippophae rhamnoides* for enhancement of therapeutically important secondary metabolite production and plant productivity.

Probiotics for plant tissue culture using endophytes

Poor hardening efficiency and acclimatization of tissue culture generated plants in the greenhouse and field conditions restrict the successful micropropagation of most of the Himalayan plants. Apart from this continuous reduction in the biosynthesis of secondary metabolites after repetitive subculturing also limiting the use of *in-vitro* system for enhancement of secondary metabolite production. As tissue culture generated plants lack endophytes due to their continuous cultivation in aseptic conditions, therefore we are exploring the endophytes as probiotics to solve these problems. We found that endophytes were associated with *in vitro* generated *T. govanianum* and *P. hexandrum* plants during micropropagation (Figure 1). We are testing the efficacy of these endophytes for improvement of hardening, acclimatization of plants in the field and improvement of *in planta* secondary metabolite production.

Fig. 1 Representative picture showing the presence of endophytes in selected Himalayan plants during micropropagation. Endophytes in *Trillium govanianum* (a, b, c) and *Podophyllum hexandrum* (d)

We are also involved in the exploration of endophytes as a biotic elicitor for the enhancement of secondary metabolite biosynthesis in selected Himalayan medicinal plants.

Endophytes for the amelioration of stress tolerance in plants

Cultivation of high-altitude medicinal plants at low-altitude for their conservation and making these plants more lucrative for farmers to increase their income is in practice. Major

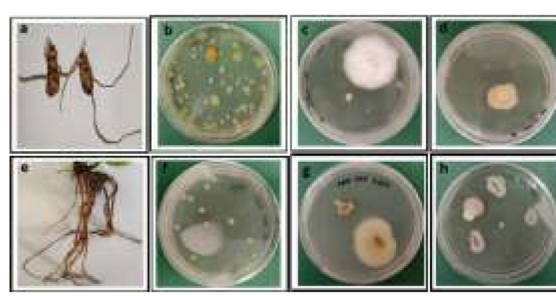


Fig. 2 Representative picture showing the presence of endophytes in selected Himalayan plants. *Trillium govanianum* rhizome (a) associated bacterial (b) and fungal endophytes emerging from plant tissue (c,d). *Valeriana jatamansi* roots and rhizome (e) associated bacterial (f) and fungal endophytes emerging from plant tissue (g, h)

problems in the cultivation of high-altitude Himalayan plants include their poor adaptability and reduced content of secondary metabolites at low altitude. We found that different endophytes are associated with selected Himalayan plants (Fig. 2).

Our research group is also involved in the exploration of phytohormonomics approach to solving the problem-related to seed dormancy/germination, bud dormancy, flowering, fruit and seed setting and long waiting time for the production of specific secondary metabolites. We are identifying different phytohormones combinations including their biosynthesis inducer and inhibitor for this purpose. We are involved in the development of an efficient method for breaking seed dormancy of *Bunium persicum* and its sustainable cultivation.

Research group : Ms. Manju, Ms. Ankita Thakur

Arun Kumar, **Senior Scientist**
arunkumar@ihbt.res.in
Enzyme and Metabolic engineering, Host-pathogen interactions, Crop improvement

Research interests and long term goals of our lab are: (1) to identify enzymes with novel functions and exploit them in healthcare and agriculture industry (2) to understand the mechanisms of genetic resistance in crops against bacterial and fungal pathogens at the molecular and biochemical levels, and (3) exploit this information for crop improvement. In line with these goals, we are currently focusing on the following projects:

Enzymatic interventions for the expedited degradation of lignocellulosic biomass

Lignocellulosic biomass, such as paddy straw, is a non-utilized source of renewable biomass generated in large quantities. The conversion of lignocellulosic biomass into simple monomers requires the synergistic action of multiple enzymes like glycolytic hydrolases (GHs), which can work under adverse conditions like extremes of temperature and pH, and in the presence of inhibitory components. The LPMOs are the recently discovered classes of copper metalloenzymes that have received considerable attention because of their ability to boost the enzymatic conversion of recalcitrant polysaccharides such as plant cell walls and chitin polymers. LPMOs oxidatively cleave the glycosidic chain on the crystalline surface of cellulose or chitin to create an entry point for hydrolytic cellulases or cutinases. This ability of LPMOs in attacking bonds that are not accessible to other glycolytic hydrolases (GHs) makes them attractive candidates for biotechnological utilization of abundant lignocellulosic plant waste. With this background, the group is focusing on the bioprospection of Himalayan-bioresources from identified niche areas to clone kinetically stable LPMOs as promising biocatalysts for enhancing the degradation of lignocellulosic biomass.

Identification and validation of potentially bioactive molecules from Himalayan bioresources against SARS-CoV-2 proteins:

CSIR-IHBT has a rich Himalayan plant repository that has been screened using biocomputational tools to identify potential plant-based molecules having strong activity against SARS-CoV-2 proteins. Our lab endeavours to validate these results by doing *in-vitro* interaction studies of these molecules with some of the important proteins of SARS-CoV-2, including RdRp, M^{pro}, and Spike proteins. Leads from our studies will help in developing plant-based products that could be commercialized to combat the COVID-19 pandemic.

Cisgenetic engineering of rice (*Oryza sativa*) susceptible elite cultivars for enhanced disease resistance using genome editing tools

Sheath blight (ShB) of rice caused by a fungal pathogen *Rhizoctonia solani* Kühn is a major disease in rice, that causes great losses of quality and yield in all rice-growing regions of the world. So far, no major sources of resistance to ShB have been identified, but substantial differences in susceptibility to ShB among rice cultivars were observed under field conditions, and associated resistance genes have been studied. In general, Rice ShB resistance is controlled by quantitative trait loci (QTLs), which might explain the durable resistance and hence is one of the most promising measures for disease control. Several QTLs for ShB disease resistance were detected; however, the validity of these QTL is still not confirmed because of a lack of concurrence between the QTL identified by different groups. Phenotypic variations due to environmental factors may affect disease resistance and make evaluation difficult. In addition, morphological traits such as plant height and heading date have been reported to affect the resistance of rice cultivars to ShB. A detailed understanding of Rice-*R. solani* interactions at the molecular and biochemical level can give us some insights into virulence mecahnsism of the pathogen and host resistance/susceptibility related factors. With this idea, we are dissecting molecular and biochemical mechanisms of ShB resistance/susceptibility in rice using various -OMICs based approaches. The resulting information will be used for rice improvement using genome editing tools.

Kunal Singh, Scientist
kunal@ihbt.res.in
Plant microbe interaction and molecular biology

My group is involved in the area of plant-microbe interaction along with empirical work on understanding the stress and growth biology of *Crocus sativus*. In plant-microbe interaction the group is focusing on the (a) identification of beneficial microbes and their characterization (b) identification of member of TIR-NBS-LRR gene family from important crops and their characterization to identify the 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 the 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 is characterized by necrotic lesions in leaf and stem. The symptom spreads during early winter season ultimately causing plant death. The fungal spores overwinter i.e. remain present 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. In our work we have focused on one sub set of the gene family NBS-LRR, known as TIR-NBS-LRR (TNL) characterized by their N-terminal TIR domain. To identify the members of this gene family, an *in-silico* approach was formulated utilizing appropriate pfam ids of TIR, NBS and LRR domain & motif resulting in identification of ~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. In continuation of our previous work, primers were designed using primer express v3.0 tool and used for quantitative real time PCR experiments to assess the expression analysis of selected genes under three potato variety namely Kufri Pukhraj, Kufri Jyoti and Kufri Chandramukhi. Majority of the selected TNLs showed high expression in Kufri Jyoti, considered to be early blight tolerant variety at seven day post inoculation (dpi). In future, characterization of selected TNLs based on their transcript expression data will help in identification of putative resistance genes against early blight disease.

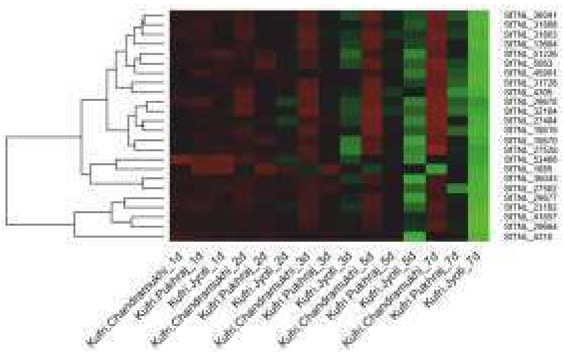


Fig. 1 Heat map showing expression data of different TNL genes based on QRT-PCR experiments

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 been used for a long period of time 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 a valuable source of many compounds of medicinal importance such as crocin, safranal and picrocrocin. As plants are being raised since hundreds of years through vegetative propagation through corms various factors have started affecting growth of plants due to biotic/abiotic stress along with the 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. Field trial experiment was performed using available PGPRs, and at the end of the season corms were harvested to assess their effect on daughter corm development. Results showed improved corm growth (Fig. 2).

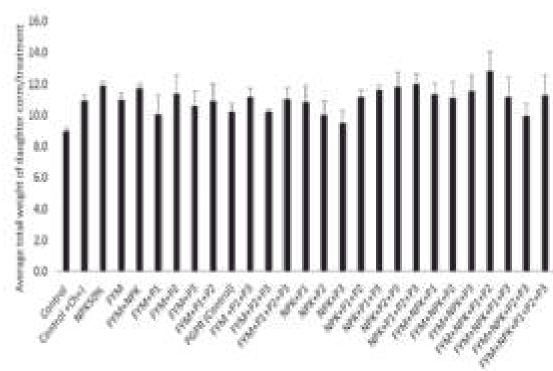


Fig. 2 Result of Saffron field trial under shade net (rain protected) facility at CSIR-IHBT

Research Group : Dr Umesh Pankaj, Namo Dubey, Kanchan Yadav, Anjali Chaudhary, Pooja Yadav, Ms Priyanka, Ms Gayatri

Ashish Warghat, Scientist
ashishwarghat@ihbt.res.in
Plant cell culture, Hydroponic and aeroponic cultivation and Molecular biology

The lab is working on metabolite enriched callus biomass production of medicinal plants using plant cell culture techniques and modern agriculture techniques such as hydroponic and aeroponic cultivation for large scale production of medicinal and spice crops. Lab is engaged in micropropation of RET species under Phytopharmaceutical mission mode projects and grant aided projects. Also is involved in fast tract translational projects i.e. Optimization of aeroponic and hydroponic condition for increasing biomass productivity.

Aeroponic cultivation of *Valeriana jatamansi* for quality biomass production

Soil-less farming, especially aeroponic systems, offers an alternative and sustainable agro practice to cultivate a variety of plant species. In the present study, we evaluate the aeroponic cultivated *Valeriana jatamansi* plants by measuring their growth and secondary metabolites content (Fig. 1). In aeroponic cultivation, the maximum growth biomass and metabolite content was observed in methyl jasmonate treatment as compared to control. The results revealed that instead of roots, leaves could also be utilized as a prominent sources for targeted secondary metabolites usage. It also offers an ease to access subsequent roots harvest without sacrificing endangered plants for year around metabolite enriched quality biomass production.

Fig. 1 Aeroponically cultivated *Valeriana jatamansi* plants

Callus culture of *Rhodiola imbricata* and metabolite quantification

Rhodiola imbricata is a rare medicinal herb of trans-Himalayan Ladakh region of India. Natural supply of this herb is rapidly decreasing, due to habitat destruction and overexploitation, as this herb is used in Amchi system of medicine. In the present study, callus cultures were developed for high yield metabolite production. Callus cultures induced from leaf and root explants of *R. imbricata* were established and screened for rapid growth rate and high metabolite content. Callus was initiated from juvenile leaves in MS medium enriched with various combinations of plant growth regulators, while MS medium containing 0.5 mg/L TDZ and 1 mg/L NAA was the best for callus initiation and subculture (Fig. 2). The salidroside, rosavins and other metabolites levels in the callus cultures, *in vitro* raised and wild plants were quantified using ultra high performance liquid chromatography equipped with PDA detector.

Fig. 2 Development of callus culture from leaf of *Rhodiola imbricata* a. Leaf explant b. Compact callus

Picrosides accumulation in cell culture of *Picrorhiza kurroa* Royle ex Benth

The rising demand for picrosides commercially has initiated searches for alternative sustainable platform of these natural metabolites. Therefore, callus culture of *P. kurroa* was established from leaf explant for *in-vitro* production of picrosides content under different culture conditions (Fig 3). The results revealed that under light culture condition, maximum metabolite accumulation were observed as compared to other treatments. Study revealed that callus culture of *P. kurroa* may offer a cost effective and environmentally friendly platform for sustainable production of picrosides.

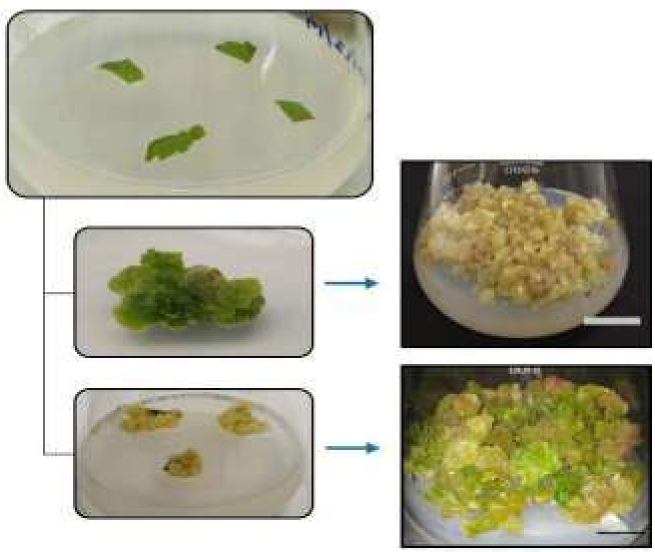


Fig. 3 Development of callus culture from leaf explants

Callus culture studies in *Stevia rebaudiana*

Stevioside and rebaudioside A constitutes a major part of steviol glycoside, which is 250-300 times sweeter than sucrose. Unlike stevioside, rebaudioside does not possess a lingering bitter aftertaste. Metabolite profiling/ UHPLC-MS revealed the presence of important metabolite in established leaf derived callus cultures grown in MS + 3 mgL^{-1} NAA + 3 mgL^{-1} BAP. Callus biomass accumulation by substituting GA_3 was evaluated over a period of 30 days in controlled environment of 16:8 hr photoperiod and 25±2 °C (Fig. 4). Study can pave way for cost effective and sustainable production of economically important steviol glycosides.

(a) Control (b) 5mg/L GA_3 (c) 10 mg/L GA_3

Fig. 4 (a) 30 days old callus (b) 30 days old callus in media enriched with 5 mg/L GA_3 (c) 30 days old callus in media enriched with 10 mg/L GA_3

Research Group (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
rajiv@ihbt.res.in
Department of Biotechnology

Role of metabolic signatures in *Picrorhiza kurroa* adaptation along the altitude in Himalayan region

Adaptation is an evolutionary process that increases plant survival in a newly encountered climate condition. Understanding of adaptation to climate change at molecular level has an important implication in evolutionary ecology. Altitude offers steep environmental gradients across short spatial distance representing exciting biological experiments in nature. Along the altitude, environmental factors like low and high-temperature, UV-radiation, hypoxia, wind speed, soil conditions, duration of snow cover and length of vegetation period vary significantly that affect plant performance and distribution. For example, it has been reported that an increase of 8% of total irradiance, 9% of UV-radiation and 18% of erythemal effective radiation per 1000 m of altitude. In addition, mean air temperature also decreases by 6-7 °C per 1000 m of altitude. Altitude gradients have been used to explore adaptation mechanism of plants including *Arabidopsis,* however, information regarding medicinal plant adaptation is less available. *Picrorhiza kurroa* Royle ex Benth. (Plantaginaceae) is one such high altitude medicinal plant having huge medicinal values. Besides their medicinal importance, it has also adaptive significance, reflected by its successful acclimation in the Himalayan niche ranging from 3000-5000 meters above sea level. To maintain their internal homeostasis, plants synthesize and store a variety of metabolites. It is believed that storage and synthesis of metabolites are used by plants for survival in their niche to combat various biotic and abiotic stresses. However, less information is available about how metabolic constituents of plant respond to multiple environmental variables along the altitude gradient in the Himalayan region. Therefore, spatial estimation of metabolites provides an insight into different biochemical processes and their interactions with environment.

In the present study, we investigated the adaptation strategies of *Picrorhiza kurroa* Royle ex Benth. along the altitude in organ specific manner using metabolomic approach (Fig. 1). A total of 220, primary and secondary metabolite (SMs) were identified ($p<0.05$) representing an extensive inventory of metabolites and their spatial distribution in *P. kurroa* (Fig. 2). Differential accumulation of metabolites suggests source-sink carbon partitioning, occurrence of partial TCA cycle, ascorbate metabolism, purine catabolism and salvage route, pyrimidine synthesis, lipid alteration besides gibberellins and cytokinin inhibition, might be an adaptive strategy to alpine environmental stress along the altitude. Further, marked differences of organ and altitude specific SMs reflect alteration in secondary metabolic pathways. Significant accumulation of picrosides suggests their probable role in *P. kurroa* adaptation. This study provides a platform that would be useful in deciphering the role of metabolites considered to be involved in plant adaptation.

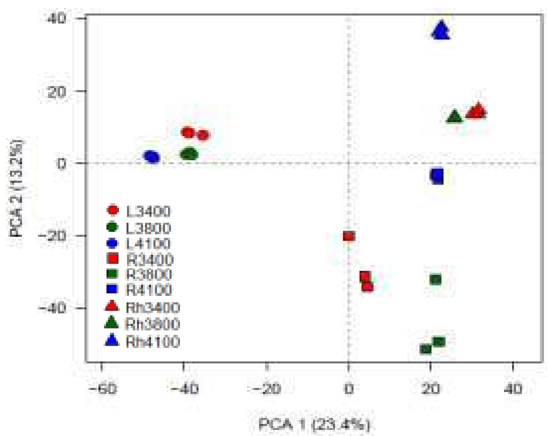


Fig. 1 Principal component analysis of metabolites clearly depicts metabolic difference among organ and altitude in *P kurroa.* PCA 1 and PCA2 account a variance of 23.4% and 13.2 % respectively

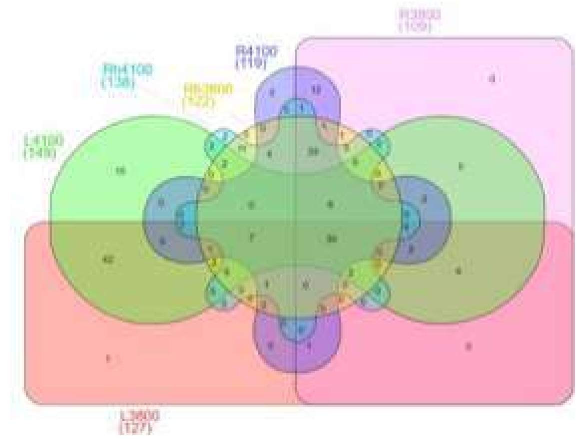


Fig. 2 Venn diagram depicting organ-specific comparison of differentially abundant metabolites normalized to 3400 masl. L; leaf, R; root and Rh; rhizome

Research Group: Manglesh Kamari, Shweta Thakur, Satyakam and Dr. Robin Joshi

Rakshak Kumar, Scientist
rakshak@ihbt.res.in
High Altitude Microbiology Laboratory (HAM-lab)

Our laboratory aims on exploring the microbial community from high altitude extreme environments of the Himalaya. One of the areas that we explore in the glacier ecosystem is the microbial succession and colonization patterns and, bioprospection of extremophiles. Currently we are exploring psychotropic efficient hydrolytic bacterial community to improve/accelerate organic waste degradation in alpine regions. Additionally, we have also been exploring the higher fungi (mushroom) of economic importance. We have begun with *Lentinula edodes* and currently we have developed its improved captive cultivations using local substrates and enriched it with Vitamin D. The research work of our lab can be discussed under following categories:

Process development for early fruiting *shiitake* mushroom on varied substrates available across Indian Himalayan region

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 using the substrates locally available across the Himalayan states.

The yield achieved so far ranges from 0.5-0.6 kg fresh mushroom from 1 kg dry sawdust substrate. Additionally, using photoconversion experiments we have enriched the mushroom for high Vitamin D concentration. The technology has been commercialized to three industrial partners and the possible products to be commercialized by the industry are high Vitamin D_2 fresh and dried shiitake and High Vitamin D_2 *shiitake* powder (Fig. 2).

High Vitamin D_2 Fresh & Dried *shiitake*

High Vitamin D_2 *shiitake* powder (for nutraceuticals and food processing)

Fig. 1 Range of products ready to be commercialized

The developed process has an advantage that its a zero-waste technology, it utilizes the timber house waste (saw dust) as substrate and the spent mushroom substrate can be evaluated as a source of biofertilizer

Microbiological intervention to save winter dry toilets of high-altitude regions

Lahaul and Spiti, the largest district of Himachal Pradesh is a picturesque landscape in the rain-shadow region of the PirPanjal mountain range. The region experiences no to minimum rainfall during monsoon and heavy snowfall during winters, making availability of water difficult. To overcome this hurdle, this region has been practicing a unique system of dry toilets known as 'ghop' since generations. This practice has helped the inhabitants deal with not only the problem of water scarcity but the end product is also a useful agricultural input. Ghop is a two-tiered structure in which the upper section is attached to the living room of the house and the lower section is used as a store for collecting the night soil (Fig 2A). After every time the toilet is used, the feces are covered by a dry mixture of wood chips, ash, animal dung etc. locally called as 'fot' (Fig 2B). The heap of the night soil is manually taken out every 6 months and left in the fields to mature (Fig 2C-D). The compost thus prepared is rich in nutrients and is a very useful input for the agricultural activities in the region.

Fig. 2 Traditional winter dry toilet of Lahaul valley: A) Ghop: The upper storey is used for defaecation, while lower storey is the collection chamber where composting takes place. B) Inside view of Ghop with C) Collection of night-soil compost sample from the collection chamber. D) Compost pile dumped in open fields for further curing.

However, due to the effect of modernization and introduction of modern septic toilets, the practice of dry toilets and night soil composting is nearing demise. Other factors such as availability of subsidized chemical fertilizers, rise in the standard of living, difficulty of finding labour and social apprehensions have also contributed to the decline of the age old practice. Decomposition of any biomass of organic nature is dependent on the microbial population. During winters in the region, with the mercury dropping below 5⁰ C, the degradation of the night soil slows down as the mesophilic bacteria become inactive in this temperature range. We have developed bacterial consortia of efficient hydrolytic psychrotrophic bacteria isolated from the matured night soil compost that accelerates the rate of degradation. These psychrotrophic bacteria remains active even at low temperatures (up to 4°C) and produces enzymes that bring about the breakdown of the biomass. Additionally, the bacteria possess plant growth promoting attributes so that the end product is enriched compost high in nutrients (Fig 3).

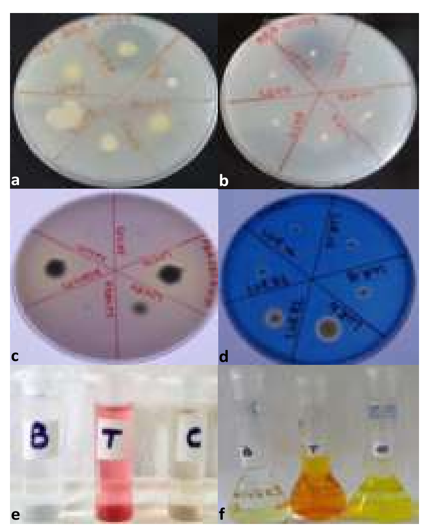


Fig. 3 Bacterial isolates with PGPR trait a) N2 fixing, b) Potassium mobilizing, c) Phosphate solubilizing, d) Siderophore producing, e) Indole acetic acid producing and f) Ammonia producing

The bacterial formulations mixed with suitable carrier material have been distributed to the

"Ghop" users as part of field trials of their technology in 3 experimental households of villages of Lahaul valley namely Goshal, Mooling and Jhalma (Fig. 4).

Fig. 4 Bacterial consortia mixed with suitable carrier distributed to the villagers of Lahaul valley and demonstration for its usage

The formulations laced material termed as "Compost Booster" has been accepted well by the users and we have received positive feedbacks pointing the reduction in the foul odor of the night soil. Encouraged by the efforts of the institute, the farmers have expressed their willingness to become part of the experimentation and demanded for supply of the bacterial formulation in larger quantity. With further improvements in the technology, we aspire to keep the traditional practice of dry toilets and night soil composting alive. The practice is a key component of maintaining sustainability of the agro-ecosystems in the region.

Implementation of the developed technologies through MSME clusters

For the dissemination of the technologies developed at laboratory scale, a unique initiative was taken in collaboration with Ministry of Micro, Small & Medium Enterprises (*MoMSME*) under Scheme of Fund for Regeneration of Traditional Industries (SFURTI). Two of the technologies from the laboratory, viz. "Captive cultivation and enrichment of Shiitake mushroom" and "Efficient psychrotrophic bacterial formulation for preparation of enriched compost in cold hilly region" have been used as technical inputs for the setting up of clusters (co-operative societies). Under this Cluster, a Common Facility Centre (CFC) will be established in collaboration with a non-profit making organization. The objective of the scheme is to provide common facilities and tools and equipment to the beneficiaries to impart advanced technologies and provide support for their long-term sustainability, sustained employment and, enhance marketability of the products.

With CSIR-IHBT as a Technical Agency and KVIC as Nodal agency, *MoMSME* has sanctioned setting up of three clusters namely Sumbuk, West Sikkim and Norbo Choeling *Shiitake* mushroom and other food processing cluster at Sikkim. These three clusters will impact 750 farmers and it is projected that farmers can earn additional Rs 50,000/- per year by selling fresh and dried *shiitake* and other products made using the shiitake powders. Further, five more *shiitake* cluster are proposed across the hilly region (Manipur, Nagaland, and Himachal Pradesh) (Fig. 5).

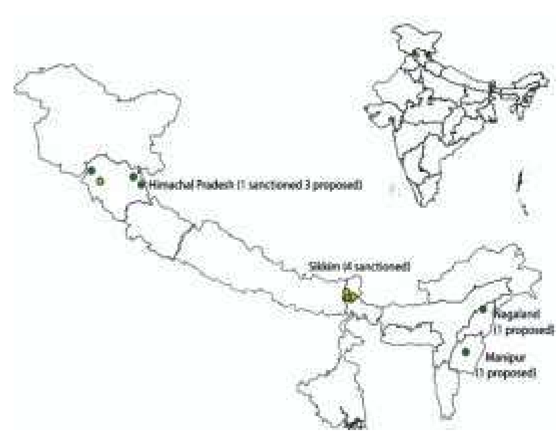


Fig. 5 Map showing the sanctioned and proposed cluster across Himalayan states

To implement our technology on efficient bacterial formulations for enriched compost in cold hilly region, MoMSME has sanctioned two cluster with CSIR-IHBT as technical agency and Foundation of MSME clusters as Nodal Agency. The two clusters are, Triloki and Moonew Tareybhir Enriched Composting/ Vermicomposting Cluster, respectively at Himachal Pradesh and Sikkim. These two cluster will impact 400 farmers and it is projected that farmers can earn additional Rs 30,000/- per year by selling enriched compost. Further, one more cluster is proposed in Himachal Pradesh.

Under these projects, the financial assistance will help in establishment of a CFC building comprising all the advanced instruments for captive cultivation of *Shiitake* mushroom and its processing and production of enriched compost.

Antimicrobial activity of *Tagetes minuta* L. essential oil collected from different locations of Himalaya

Antimicrobial activity profiles of *T. minuta* grown in 16 altitudinal locations of three states in India were explored against two Gram-positive bacteria viz. *Micrococcus luteus* MTCC 2470, and *Staphylococcus aureus* MTCC 96, and two Gram-negative bacteria viz. *Klebsiella pneumoniae* MTCC 109 and *Pseudomonas aeruginosa* MTCC 2453 (Fig. 6). The agar well diffusion method demonstrated better activity of *T. minuta* EOs in Gram positive bacteria as compared to Gram negative bacteria. Best activity was demonstrated against *S. aureus* with zone of inhibition above 9 mm. Best potential EOs (three locations of HP and one location of Manipur) demonstrated an MIC of 25–30% (v/v). Based on the current study, EOs of *T. minuta* from Indian Himalayas may be regarded as potential antibacterial agents against *S. aureus* and selected EOs may have potential application as bactericidal agents.

Fig. 6 Inhibition zones of *T. minuta* essential oils against pathogenic strains

Technology / Know-how transferred:

Development of efficient psychrotrophic bacterial formulation for preparation of enriched compost/ vermicompost in cold hilly region and, production and testing of enriched compost/ vermicompost. Technology transferred to Triloki Enriched Composting/ Vermicomposting Cluster, Distt. Sirmaur, Himachal Pradesh and, Moonew Tareybhir Enriched Composting/ Vermicomposting Cluster, Distt. West, Sikkim

Cultivation of *Shiitake* mushroom and its enrichment with Vitamin D_2. Technology transferred to Sumbuk Shiitake mushroom and other food processing cluster at South Sikkim; West Sikkim Shiitake mushroom and other food processing cluster, at West Sikkim; Norbo Choeling Shiitake mushroom and other food processing cluster at South Sikkim

Vidyashankar Srivatsan, Scientist
vshankar@ihbt.res.in
Algal Biotechnology and Nutraceuticals

Combating iron and zinc deficiency using microalgae based foods Micronutrient malnutrition is one of the major health concern in India. According to national health and family survey (NHFS) 4, 2015-16, 53% of Indian women are iron deficient and anaemic and 38% of children below 5 years are anaemic and micronutrient deficient. Synthetic inorganic micronutrient forms such as salts are conventionally used for treatment. However, they have poor bio-availability and are chemically unstable. They are also prone to oxidation and create side effects when consumed. Supplementation of bioavailable micronutrients is a big challenge and microorganisms could be an effective tool for supplementing bioavailable micronutrient forms. In this context, microalgae are proposed as biological matrix for supplementing essential micronutrients mainly iron and zinc.

Microalgae have the ability to accumulate trace metals or micronutrients such as iron, zinc, cobalt, selenium etc., owing to presence of special proteins and low molecular weight molecules called phytochelatins or metallothioneins. In addition, microalgae have very low nutrient requirements, utilize solar radiation for multiplication and have high environmental adaptability. Apart from these, microalgae accumulate high value nutraceuticals under specific growth conditions that are scalable. Further microalgae do not accumulate anti-nutrition factors that inhibit micronutrients such as iron, zinc and others unlike higher plants. Thus envisaging higher bioavailability of micronutrients, two edible microalgae such as *Spirulina platensis* and *Chlorella* sp. (*Chlorella vulgaris*/ *Chlorella pyrenoidosa*) have been considered for fortification considering their GRAS and edible status across countries.

Cultivation process to enhance simultaneously both micronutrients and nutraceuticals in microalgae

An incremental supplementation dosage strategy was devised for enriching the iron and zinc content in microalgae biomass. 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 to 160 mg L^{-1} was studied and found that Spirulina could not tolerate levels beyond 40 mg L^{-1} when direct dosage was provided to cultures. Therefore, an adaptive strategy of continuouos incremental dosage supplementation, was devised and it was observed that microalgae cells tolerated iron levels up to 120 mg L^{-1}. Microalgae cultures exposed to iron and zinc at regular intervals with incremental concentration accumulated 8 times higher intracellular iron content (16 mg g^{-1} biomass) compared to standard cultures (2.2 mg g^{-1} biomass). However, with enhanced iron accumulation the biomass yield was reduced to 1.35 gL^{-1} compared to standard cultures which accumulated biomass up to 2.50 gL^{-1}. The reduction in biomass content was mainly due to increased oxidative stress in cells as indicated by increasing levels of reactive oxygen species (ROS) (Fig. 1), and lipid peroxidation as indicated by intracellular malonaldehyde levels.

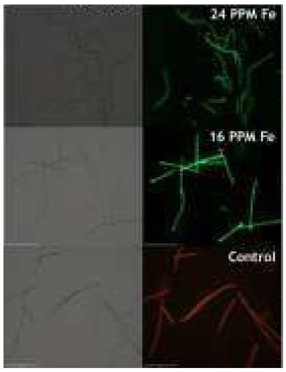


Fig. 1 Reactive Oxygen Species (ROS) accumulation in microalgae with increased iron levels in growth medium

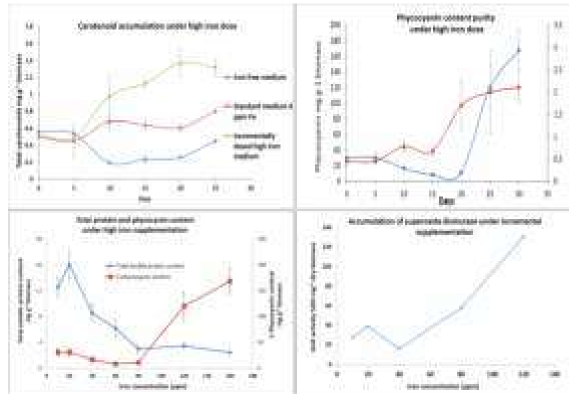


Fig. 2 Accumulation kinetics of high value nutraceuticals under iron supplementation in microalga – *Spirulina platensis*

Although the biomass content was compromised, incremental supplementation enhanced nutraceutical content of the biomass such as carotenoids, phycocyanin, and antioxidant enzymes such as super oxide dismutase (Fig. 2) as a defensive response to high iron accumulation.

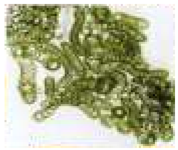
Thus, a cultivation process to enhance both micronutrients and nutraceuticals simultaneously was developed for commercial applications.

Food fortification with microalga – *Spirulina platensis*

Fortification of food products with micronutrients was achieved through incorporation of iron enriched microalgae biomass. Different types of food products such as ready to eat, ready to cook and ready to reconstitute formats were developed for wider commercial outreach (Fig. 3). Some of the salient features of the food products are:

- Provide 1 gram Spirulina per serving
- 100% natural free from preservatives
- Meets 25% recommended dietary intake levels of iron and zinc per serving
- Traditional Indian products
- Low cost and suitable for mass supplementation programs
- Long shelf life greater than 4 months

The products were evaluated for their complete nutritional profile, shale life stability, sensorial properties and bio-efficacy.



Spirulina platensis

Iron & zinc enriched Spirulina bars

Spirulina beverage mixes

Spirulina enriched traditional Indian foods - Dalia

Bio-efficacy of microalgae based foods

In vivo experimental animal studies indicated the ability of *Spirulina platensis* to promote hemoglobin recovery and improve the overall growth and physiology in anaemic and protein malnourished rats (IAEC No. IAEC/IHBTP-9/May 2019). Experimental rats were fed with iron deficient diet along with frequent bleeding. This induced anemia and associated co-morbidities such as weakness, poor feed intake, loss of body weight and low serum albumin and total protein content. In the recovery phase, anemia induced animals were fed with Spirulina based food products. The hemoglobin levels in malnourished rats increased from an average 9.0 g dL^{-1} to 12.5 g dL^{-1} when supplemented with Spirulina based foods. Further, the study indicated safety of *Spirulina platensis* biomass and incorporated foods at 5000 mg/kg body weight.

The research outcomes of this work was commercialized in the form of transfer of technologies for commercial production of Spirulina based food products to various industries such as

- M/s. Access India Impex Centre Pvt. Ltd., New Delhi
- M/s. Yujo Agriculture and Aquaculture Society, Meerut (U.P.)
- M/s. Sirimiri Nutrition Foods Pvt. Ltd., Bengaluru
- M/s. Daziran Health Priducts, Coimbatore, Tamil Nadu

Research Group (1st Row L to R): Ms. Priyanka Parmar, Dr. Vidyashankar, Ms. Sampa Das, Ms. Anika **(2nd Row L to R):** Mr. Saurav Gurung, Mr. Nishant, Mr. Kartik Sharma, Mr. Raman Kumar

Vandana Jaiswal, Scientist
vandana@ihbt.res.in
Molecular Finger Printing Lab (Biotechnology Division)

Our major research focus is on development of molecular markers, genetic dissection and molecular breeding for important traits in high altitude plants including saffron, *Nordostychus jatamansi, Bunium persicum*, rose etc.

Genetic diversity enrichment in saffron

Saffron (*Crocus sativus*) is the most expensive spice, known as "red gold"; and India is the second largest producer of saffron after Iran. However, it has been noticed that saffron is losing popularity among farmers due to its low productivity (2.0 – 2.5 kg ha^{-1}) as well as disease susceptibility. Farmers do not have any high yielding and disease free clones or lines. Saffron is a sterile crop due to its triploid nature and is vegetatively propagated through corms which lead to the very narrow genetic base of this crop. Our laboratory is focusing on the enrichment of genetics base of saffron. For this purpose, we are following two approaches- (1) chemical treatment and (2) introgression from wild relatives (Fig. 1).

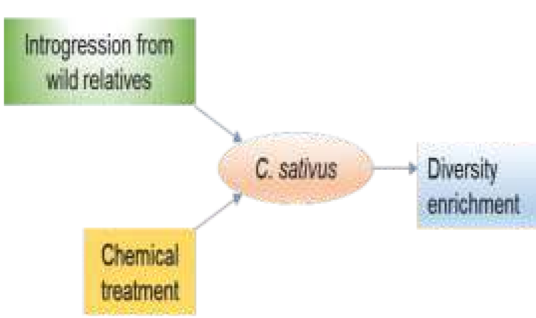


Fig. 1 Work flow to enrich the genetic diversity in saffron

Diverse germplasm lines will be proven useful for saffron sustainability and improvement. Important traits like tolerance against biotic and abiotic stresses may also be introduced from wild progenitors. Diverse saffron germplasm would be useful for genetic and genomic studies on saffron, which ultimately utilized for saffron improvement.

Genetic dissection of important traits in rose

Rose is also very important crop particularly for cosmetic and perfume industry, thus gaining attention to work with. If we see the international rose market, India occupies first position in terms of production area and share ~50% of total area cover across the globe; however, shares only 0.2% total export value of international rose market. Quality of Indian rose is not reaching the international class. Price of Indian rose is only Rs 12/stem, however, Italian roses cost around Rs 40/stem. Thus, there is anurgent need to focus on the improvement of Indian rose. Our laboratory is focusing on genetic dissection of economically important traits of rose. These traits include- colour, vase life, fragrance, thornlessness,

Fig. 2 Rose germplasm with diverse flower colour and morphology

recurrent and profuse flowering. We have total 200 rose accessions with diverse flower related traits like colours, size, flowering time etc (Fig. 2).

The above mentioned accessions belong to four different categories- (i) hybrid tea, (ii) floribanda, (iii) miniature and (iv) climbers. Genome-wide association studies (GWAS) is being utilized to identify genomic regions harboring important genes and QTLs. Furthermore, blue coloured rose is always demanding, and only little success has been achieved in this direction. It has been suggested that introduction of *F3'5'H* gene from other violet colour flowerlike pansy and downregulation of *DFR* gene may lead to development of blue colour in rose petals. Further, *In-silico* global protein interaction analysis suggested that protein encoded by DFR gene interacts with number of proteins which are encoded by genes involved in anthocyanin biosynthesis (Fig. 3). Downstream analysis is being conducted in order to identify potential genes and desirable alleles from germplasm for utilization in rose breeding.

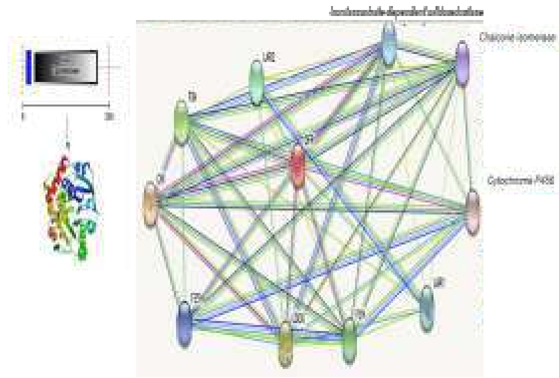


Fig. 3 Protein-protein interaction network of DFR

Research Group : Ms. Priya

Sarita Devi, Scientist
sarita@ihbt.res.in
Fermentation technology and Microbiology

The main focus of my group is to explore the important microbial bio-resources of Himalayan region for understanding the biology of medicinal mushrooms and probiotic microorganisms from indigenous cow's and goat's milk with an aim to produce the important metabolites and their industrial applications.

Development of production system for *Morchella* sp.

The present research work is focused on development of production system for *Morchella* sp. The wild edible *Morchella* sp. (true morels or morels) are among the most sought after edible fungi in world markets with a premium demand by suppliers, and paid by consumers. Morels play a very important role in the economy of a country due to their health benefits which were attributed to polysaccharides, amino acids, important vitamin, fatty acids, organic acid and mineral profile. They possess a wide range of therapeutic properties which include antioxidant, antitumor, antimicrobial, anti-inflammatory and immune-stimulatory properties. Hence, there will be a need to screen diverse bioactive compounds from *Morchella* sp. for use in food, nutraceutical and pharmaceutical formulations. *Morchella* samples collected from different parts of Himalayan regions of Himachal Pradesh (Fig. 1) were subjected to molecular and chemical characterization for ecological variations, optimization of production conditions and growth medium components to enhance the mycelial growth of *Morchella* sp.

Production of dairy based functional food using indigenous cow's and goat's milk of Himalaya

The probiotic microorganisms colonize small intestine and provide array of health benefits to host organism. The milk and milk based dairy product offers an acceptable means to supplement the probiotic live bacteria in a desirable number. Due to increasing number of life-style diseases, probiotic acts as a preventive measure. Therefore, the present research work offers to produce shelf-stable probiotic fermented dairy products with bacterial culture from milk and milk based products having anti-inflammatory and anti-diabetic properties with potential to reduce serum cholesterol in animal models. Indigenous cattles were identified for the collection of milk and milk based products from different regions of Himalalya (Fig. 2). Dairy based functional foods derived from indigenous cow's milk supplemented with active probiotic strain is being targeted for gut health, inflammation, and deficiency disorders.

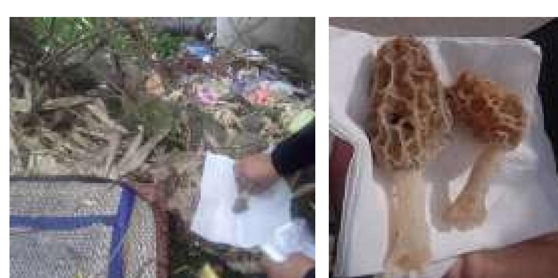


Fig. 1 *Morchella* samples

Siri cattle

Khasi cattle

Yak cattle

Churu cattle

Desi cattle

Goat

Fig. 2 Indigenous cows and goats from different high altitude regions of Himalaya

Chemical Technology

Pralay Das, Principal Scientist
pdas@ihbt.res.in
Natural Product Chemistry & Process Development Division

Research methodology: Our research group has been working on development of different new and challenging synthetic methodologies through reagent and catalyst chemistry. Among these, development of nano-particles as heterogeneous catalyst and their applications in carbon monoxyde fixation reaction for quinazolinones synthesis have been achieved in this year.

Lignocellulosic bio-waste utilization: Lab scale process has been developed for commercially important 5-hydroxymethyl furfural (HMF), furfuraldehyde, 5-methylfurfuraldehyde (MFA) and 2-methyl furfural (MF) synthesis from rice-straw, sugarcane bagasse, corn-cob and other carbohydrates. The process was patented and further scale-up is under progress for future technology development.

Iodine (III) promoted ring-rearrangement reaction of 1-arylamino-2-oxocyclopentane-1-carbonitriles to synthesize N-aryl-δ-valerolactams: The first example of N-aryl-δ-valerolactam synthesis via an intramolecular ring rearrangement reaction of 1-arylamino-2-oxocyclopentane-1-carbonitrile promoted by phenyliodine bis (trifluoroacetate) (PIFA) was reported. It was demonstrated that this unprecedented regio-selective ring-rearrangement reaction driven by hypervalent iodine (PIFA) involves C5–H elimination, C1–C2 bond opening, and C1–N bond rearrangement steps and restraining the leaving tendency of the CN group. The structure of the lactam was further confirmed by single crystal X-ray diffraction (XRD) analysis. The presented protocol showed a broad functional group tolerance under the reaction conditions and offered good to excellent yields of different lactams.

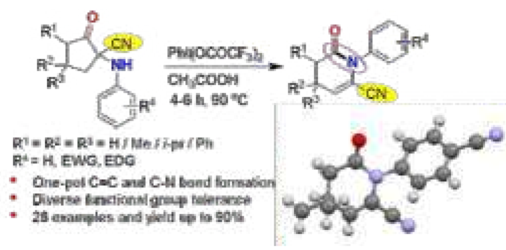


Fig. 1. Synthesis of *N*-aryl-δ-valerolactams

Polystyrene-supported palladium (Pd@PS)-catalyzed carbonylative annulation of aryl iodides using oxalic acid as a sustainable CO source for the synthesis of 2-aryl quinazolinones: An efficient and convenient strategy for the synthesis of diversely substituted quinazolinones from o-carbamoyl/cyano aniline and aryl iodides using oxalic acid as a CO source under Pd@PS nanoparticles (NPs) catalyzed conditions has been developed. In the developed protocol, oxalic acid has been employed as safe, economical, environmentally benign, sustainable and bench-stable, solid CO surrogate under Double-Layer-Vial (DLV) system for the synthesis of 2-aryl quinazolinones. The developed method does not require any sophisticated high-pressure equipment like autoclaves, microwaves, etc. Moreover, simple procedure for catalyst preparation, catalyst recyclability, easy handling of reaction, additive and base free generation of CO, excellent to good yields and vast substrate scope are the additional features of developed Protocol.

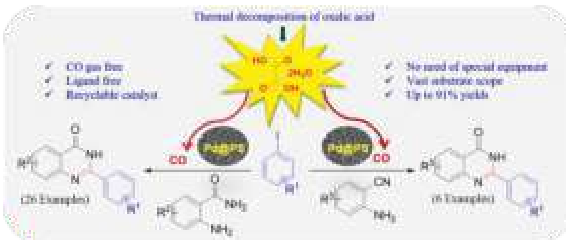


Fig. 2 Synthesis of 2-aryl quinazolinones

Synthesis of α, β-alkynyl ketones *via* the nickel catalysed carbonylative Sonogashira reaction using oxalic acid as a sustainable C1 source:

An efficient and economic nickel-dppb catalyzed, carbonylative Sonogashira cross-coupling reaction was demonstrated to provide rapid access to various α, β-alkynyl ketones from aryl iodides and terminal alkynes using oxalic acid as the *ex-situ* C1 source in a double layered vial (DLV) system. Notably, the role of the ligand in combination with the Ni catalyst for the selective formation of carbonylative Sonogashira products was investigated and supported with control experiments. In this process, for the first time, oxalic acid is used as an *ex-situ* solid, bench stable, easy to handle and efficient CO surrogate in a DLV-system for the carbonylative Sonogashira coupling reaction with vast substrate scope.

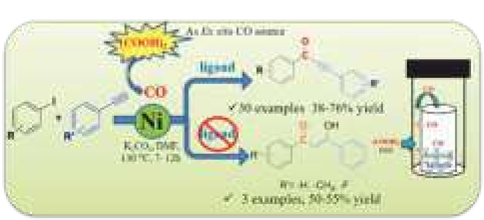


Fig. 3 Synthesis of α, β-alkynyl ketones

Process development for 5-hydroxymethylfurfural (5-HMF) synthesis from carbohydrates: The present invention relates to a new protocol for process development for 5-hydroxymethylfurfural (5-HMF) synthesis from carbohydrates. A convenient, atom-economic, highly selective and cost-effective process has been developed for the preparation of 5-HMF from cellulose, hemicellulose, starch, different sources of carbohydrates and further extended to glucose and fructose.

Metal catalyst and hydrogen gas free approaches for selective reduction of aldehyde to methyl group of different substituted furans: The present invention disclosed a new approach for 5-methylfurfuryl alcohol (5-MFA) production from 5-hydroxymethylfurfural (5-HMF) following green and sustainable process. A metal catalyst and hydrogen gas free, atom-economy, highly selective, environmentally benign and low-cost process has been developed for the preparation of 5-MFA from 5-HMF following selective aldehyde group reduction. The process is easy to scale-up and there is no need of tedious purification to achieve high purity. The 5-MFA is a very good feedstock chemical for bio-fuel (2,5-DMF, ethyl levulinate, etc.) production following an economic, energy efficient and cost-effective approach.

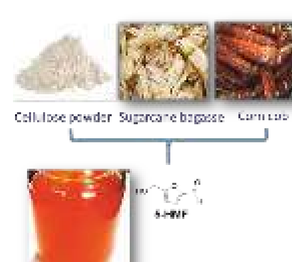


Fig. 4 Process for production of 5-HMF

Vijai Kant Agnihotri, Principal Scientist
vijai@ihbt.res.in
Natural products and essential oils bio-prospection

Phytochemical studies of *Jurinea macrocephala* roots from Western Himalaya

Phytochemical investigation of the *Jurinea macrocephala* roots afforded six compounds namely *β*-sitosterol (**1**), lupenone (**2**), physcion (**3**), ptiloepoxide (**4**), 20, 21*α*-epoxytaraxastan-3*β*-ol (**5**) and chlorogenic acid (**6**). All the compounds are being reported for the first time from the roots. In NMR analysis, ERETIC2 (electronic reference to access *in-vivo* concentration) method was used for the quantification of identified metabolites. High quantity of chlorogenic acid (**6**, 130 mg/g), lupenone (**2**, 33.4 mg/g) and amyrins (*α*, *β*) (170.6 mg/g) were detected in ethyl acetate and chloroform fractions.

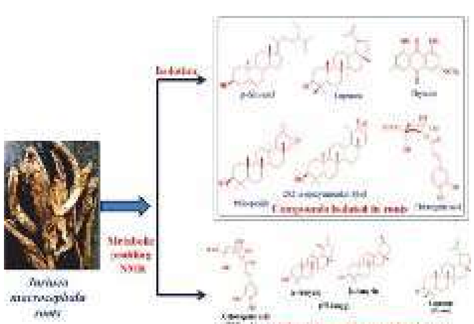


Fig. 1 Phytochemical studies of *J. macrocephala*

Pd-Catalyzed Four-Component Sequential Reaction Delivers a Modular Fluorophore Platform for Cell Imaging

A Pd-catalyzed cascade reaction of four versatile privileged synthons is described. The sequential reaction involves the formation of five new chemical bonds by concatenating three distinct chemical steps. One of the derivatives exhibited absorption in the visible region, fluorescence with a high quantum yield, and excellent photostability. Application of this fluorophore is explored in live cell imaging, which exhibited cytoplasmic and mitochondrial specific staining with no toxicity.

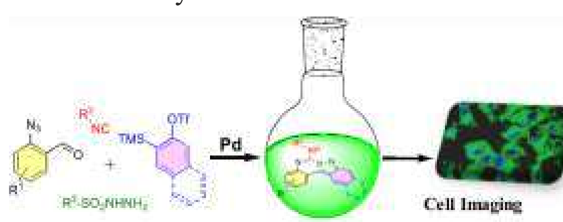


Fig. 2 Pd-catalyzed four-component sequential reaction

An unprecedented N- to C-sulfonyl migration in the reaction of azomethine amine and allenoates: access to arylsulfonylmethyl substituted pyrazolo- [1,5-c]quinazoline and mechanistic studies

A serendipitous discovery of [1,3]-sulfonyl migration has been made in the two-component reaction of azomethine imine and allenoates. Current methodology involving N–S bond cleavage and C–S bond formation provided easy access to biologically important arylsulfonylmethyl substituted pyrazolo[1,5-c]quinazolines. Subsequently, a one-pot sequential protocol has been developed from the easily available starting material. The mechanistic investigation using quantum chemical methods revealed that the sulfonyl migration step is a concerted [1,3]-sigmatropic shift.

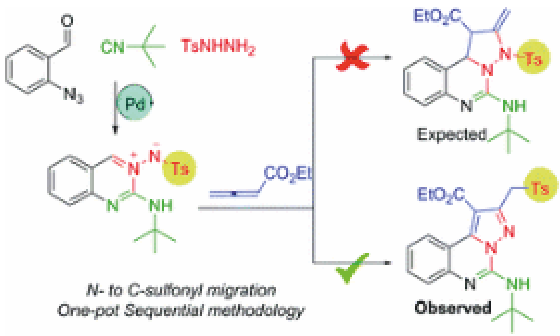


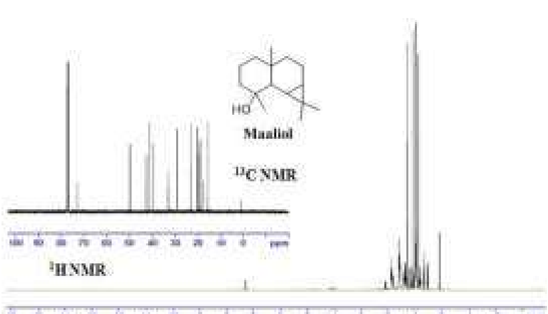
Fig. 3 Arylsulfonylmethyl substituted pyrazolo-[1,5-c]quinazoline

Standardization of fractionation technology

Compounds, maaliol and kessane from *Valeriana jatamansi*, citronellol from *Dracocephalum heterophyllum* and 1,8-cineole from *Hedychium spicatum* were isolated. Value added product, *β*-patchoulene was developed from patchouli alcohol (Fig. 4 and Table 1)

Table 1. Fractionation products

Essential oils	Fraction	Capacity level
V. jatamansi	Maaliol	25 g level (2-3 g)
V. jatamansi	Kessane	5 g level (0.2-0.5 g)
V. jatamansi	β-Patchoulene	2 g level (1.2 g)
D. heterophyllum	Citronellol	10 g level (6-7 g)
H. spicatum	1,8-Cineole	35 g level (4-5 g)



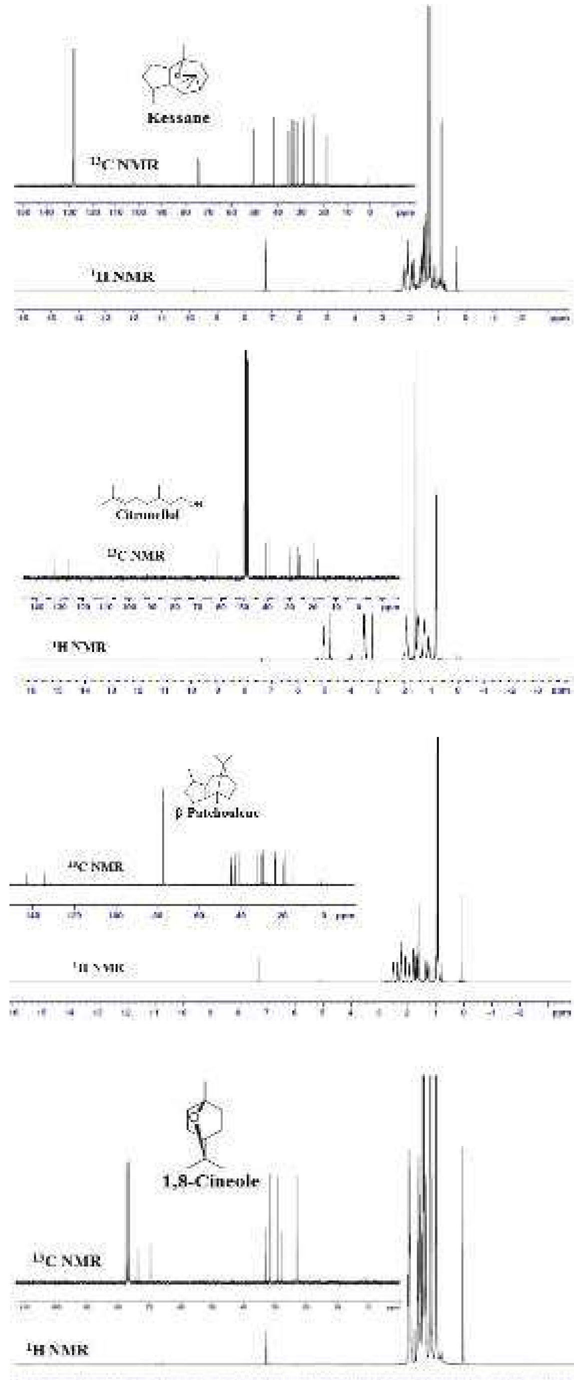


Fig. 4 Fractionation products developed by CSIR-IHBT

Development of Value Added Products

CSIR-IHBT has developed technology for commercial production of six air freshener gels based on natural products and essential oils. The gel does not use any synthetic aroma chemicals, hence does not have any adverse effects on human health and environment.

Fig. 5 Products developed by CSIR-IHBT

Aroma bank by utilization of Himalayan biodiversity

Under aroma bank project on different aromatic and medicinal crops form the Himalayan bioresources, we have prepared aroma library from the essential oils (EOs). 31 EOs were added to the library during this year (Table 2).

Table 2. EOs added to the aroma bank

Plants	Quantity	% Yields (mfb basis yield)
Callistemon citrinus	50 ml	0.41 (1.06)
Cedrus deodara (Needle)	50 ml	0.08 (0.17)
Cinnamomum tamala	50 ml	0.26 (0.56)
Murraya koenigii	50 ml	0.15 (0.36)
Hedychium spicatum (Rhizomes)	50 ml	0.22 (0.92)
Ageratina adenophora (Flowers)	50 ml	0.3 (1.28)
Cinnamomum camphora (L.)	50 ml	0.7 (1.71)
Artemisia dracunculus (L.)	50 ml	0.24 (1.02)
Eucalyptus globulus	50 ml	0.56 (1.33)
Eucalyptus camaldulensis	50 ml	0.4 (0.77)
Mentha piperita	50 ml	0.2 (0.63)
Erigeron annuus	50 ml	0.11 (0.25)
Artemisia maritima	50 ml	0.4 (1.4)
Cymbopogon flexuosus	50 ml	0.8 (2.8)
Zanthoxylum armatum (Unripe fruits)	50 ml	1.3 (3.3)
Zanthoxylum armatum (Aerial part with fruit)	50 ml	0.84 (2.5)
Juniperus communis	50 ml	0.30 (0.64)
Skimmia laureola	50 ml	0.29 (0.89)
Ocimum gratissimum	50 ml	0.23 (0.97)
Rosmarinus officinalis	50 ml	0.63 (1.65)
Curcuma aromatica (Leaves)	50 ml	0.25 (1.23)
Curcuma aromatica (Rhizomes)	50 ml	0.33 (2.72)
Dracocephalum heterophyllum	50 ml	0.2 - 0.8
Valeriana jatamansi	50 ml	0.32 (0.36)
Tagetes minuta	50 ml	0.32 (1.02)
Pinus wallichiana	50 ml	0.35 (0.89)
Curcuma longa (Rhizome)	50 ml	1.33 (1.52)
Pinus gerardiana	50 ml	0.36 (0.88)
Pinus roxburghii	50 ml	0.12 (0.31)
Hedychium spicatum (Dried leaves)	50 ml	0.22 (0.53)
Curcuma aromatica (Dried leaves)	50 ml	0.33 (2.14)

mfb- moisture free basis

Research Group (Left to Right): Sachin Vashisath, Paritosh Sharma, Deeksha Rani, Pallavi, Kanika Devi, Priya, Ram Chander, Dr. Vijai Kant Agnihotri, Gaurav Aggarwal, Antim Kumar Maurya, Kushal Kumar, Vikas Yadav

Sushil K. Maurya, Sr. Scientist
skmaurya@ihbt.res.in
Synthetic Organic & Medicinal Chemistry

Novel methods for chemical transformation and 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. A novel formic acid assisted rapid and efficient route for the C-S bond construction via thiol-ene reaction reported. Exclusively the Anti-Markovnikov product was obtained in good to excellent yield using developed protocol. Various styrenes and thiols bearing different functionalities were well tolerated. The reaction is also provided a good yield of sulphones in one-pot two-step protocol. The developed method is operationally simple, green, metal free, solvent free, and having a high atom economy with high regioselectivity.

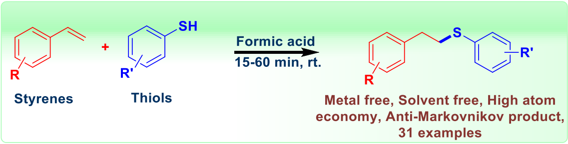


Fig. 1 Formic acid driven rapid and green Anti-Markovnikov hydrothiolation of Styrenes

Utilization of Non-edible vegetable oil for value added products including biofuels

Non-edible vegetable oils with higher unsaturated fatty acid content are underexplored for the production of various value added products such as biofuels, polymeric material and therapeutic applications. Sapium oil, obtained from the *Sapium sebiferum* seeds contains high unsaturated fatty acids, could be a valuable feedstock for such value added products. Products/molecule developed from sapium oil will support productive activities, and enhance the farmer's income. The plant is abundantly available in the Himalayan region of Indian sub-continent. Our initial analysis showed that sapium oil (triglycerides) is rich in unsaturated fatty acids and can be converted to various value-added products such as biofuels and molecules of therapeutic importance. We have initiated our efforts in the direction to develop bio-based value added products and therapeutic molecules from this renewable natural resource by using chemical transformations under greener conditions.

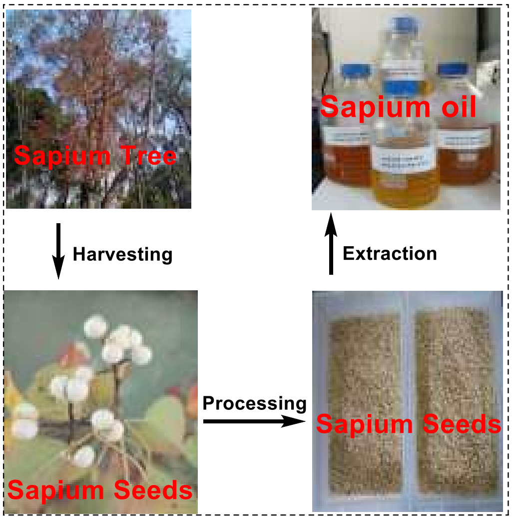
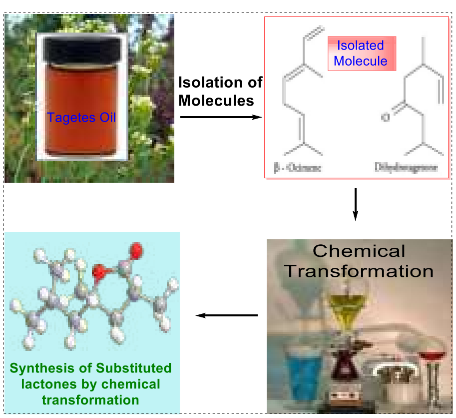


Fig. 2 Process for the extraction of Sapium oil

Value addition to essential oils from western Himalayan region

There are large number of plants growing in the Western Himalayan region. *Tagetes minuta, Valeriana jatamansi, Dracocephalum heterophyllum, Artemisia species, Juniperus communis L., Rosa damascene Mill., Zanthoxylum armatum* are the western Himalayan region plants, used for the essential oil extraction. These plants have shown different biological activities and being utilized in aroma and cosmetic industries for various products. Lemongrass, *Cymbopogon* produce the most used natural repellents in the world. Lemongrass, *C. citratus* essential oil is obtained from the aerial parts of the plant. On the other hand, the essential oil of the Mexican marigold, *T. minuta*, has been shown to have both larvicidal and adulticidal effects.



The active components were isolated from different parts of the *Tagetes minuta* plant. It shows the antiviral activity in the extract of *Tagetes minuta* flowers. The Tagetes genus is rich in aromatic compounds and resinous exudate and the EOs of these plants are rich in ocimenes, limonene, terpinene, myrcene, tagetones, dihydrotagetone, and tagetenones which are the primary odorants, and lower amounts of sesquiterpene hydrocarbons and oxygenated compounds. A protocol was developed to transform dihydrotagetone (DHT) in to various lactones which have application in flavor and fragrance industries.Column chromatography of *Tagetes minuta* oil at 400 mL scale was standardized. 250 mL (Z)-β-Ocimene was isolated from *Tagetes minuta* (85% purity GC-MS). 50 mL DHT was isolated from *Tagetes minuta* (70% purity GC-MS). 5 Lactones were synthesized via chemical transformation starting with isolated DHT from Tagetes oil (lactones at 500 mg to 5.0 g Scale)**.**

Structure elucidation of a novel molecule tridecaptin M,

A polypeptide molecule isolated from mud bacterium, and have evaluated its potential against colistin-resistant Enterobacteriaceae *in vitro* and *in vivo*. The work also emphasizes the importance of natural products in our shrunken drug-discovery pipeline.

Research Group: Amita Kumari, Deepika, Kajal

Kalia, Shashi Kumar, Dr. Sahil Mishra, Tarang Madhu Bharti, Rohit Rana, Dr. Sushil K. Maurya, Rahul Upadhyay, Arti Sharma, Deepak Dabur, Shreya Guleria

Mohit Sharma, Senior Scientist
mohit@ihbt.res.in
Natural Product Chemistry & Process Development Division

Development of process for converting raw cellulosic biomass into textile fiber and nanocellulose (under ANB theme MLP-0141)

Finding alternative sources for the natural fibers is essential to have adequate supply of fibers in future for various applications. The increasing cost and decreasing availability of petroleum resources and limitations in the availability of land, water, and other resources required to grow natural fibers could restrict the availability and may impact the price of common fibers making them unaffordable for commodity applications. Natural cellulose fibres have successfully proven for their qualities as well as ecological concern and are important materials for textile and other technical applications, e.g. bast or stem fibres. Retting which is the process of separating fibres from non-fiber tissues in plants, involves bacterial and fungal treatments as well as mechanical and chemical processes for fibres extraction. Dew/ water retting requires long processing time, weather dependent, create foul smell, huge water consumption and lastly leads to environment pollution. Therefore, to overcome the above mentioned drawback, an alternative process for natural fibers is highly desired. A process has been developed to find alternative fiber source based on inexpensive, underutilized, abundantly available and renewable lignocellulosic biomass which is less time consuming, efficient and environment friendly as compared to conventional methods.

Development of eco- friendly process for extraction of fibre from plants (under ANB theme MLP-0141)

A low cost and eco-friendly process has been developed for the extraction and preparation of phloem fibres of high quality and high counts. The process is suitable for plants having stalk diameter of range 8-13mm. In this process industrial waste is utilized for separation of fibers during downstream processing. Additionally, green protocols for bleaching of fibers is also optimized. The extracted fibers have been used for making pure yarns and blended yarns. The physical properties of the extracted fibers were also analyzed by standard methods.

Plant Material

Degumming

Cottonized Fibre

Yarn

Design, fabrication and setting up of distillation units and catalyzing setting up of farmer's cooperatives for marketing of the produce (HCP-0007 Mission Aroma)

Essential oils are the main ingredient of the aromatic crops which are extracted by means of distillation. To enable farmers to distill the oil from their crops, 39 multipurpose essential oil distillation units were designed, fabricated, installed and commissioned to various registered societies (Fig. 2)

Processing of Damask rose flowers on pilot plant: About 1464.7 kg fresh Damask rose flowers were processed in the on pilot plant which produced 82 ml rose oil during the season. Besides the production of rose oil, 834 L rose water was also produced for sale and as complimentary samples.

Fig. 3 Installation and commissioning of different capacities distillation units at farmers' sites (under Aroma Mission)

A process was developed to obtain volatile component of *Valeriana jatamansi* Jones by supercritical fluid extraction method and hydro distillation. The extraction method is performed on the comminuted *Valeriana jatamansi* Jones using different mesh size of root/ rhizome under a pressure ranging from about 220-360 bar and temperature about 45°C utilizing carbon dioxide as a supercritical fluid. Further the volatile fractions are separated from the supercritical fluid at reduced pressure in the range of about 10-60 bar. In addition to this, an efficient hydro-distillation process using different particle size is also optimized and developed. The qualitative comparison of essential oil has been done with hydro distillation and supercritical fluid extraction.

Commercial Scale Production of Tea Catechin from green tea leaves, Development of Formulations as Nutraceuticals and their Human Intervention Studies (DBT- BIRAC GAP-0242)

Catechins has a great potential to be used as nutraceutical ingredient in food and other pharmaceutical products. Tea leaves contains 15-20% of total polyphenols of which catechins constitute up to 80%. The major catechins in green tea are EGCG, (-) -epicatechin-3-gallate, (-) - epigallocatechin, and (-) - epicatechin. EGCG has also demonstrated other beneficial effects in studies of diabetes, possesses antioxidant activity, Parkinson's disease, Alzheimer's disease, stroke, and obesity. These catechins are high value antioxidants with nutraceutical properties. During the Phase-1, seasonal variation studies for quality and quantity of tea catechins were conducted at 20 kg per batch fresh tea leaves on pilot plant. Process upscaling and optimization at 100 kg per batch fresh tea leaves (3 batches) was successfully executed at industrial partner site M/s Baijnath Pharmaceuticals Pvt. Ltd. Paprola. In addition to above, batch to batch studies were performed for uniformity in yield and quality comparison with international samples was also done. Lastly, shelf-life and stability studies of catechins was also done.

The second phase of the project was sanctioned and the process was further up scaled up to 500 kg per batch at M/s Baijnath Pharmaceutical Pvt. Ltd. Paprola for the development of efficient improved process for value added products from green tea shoots. Optimization and validation of 500 kg per batch green tea leaf processing capacity plant at M/s Baijnath Pharmaceutical Pvt. Ltd., Paprola. This technology is beneficial for upliftment of tea industry through value addition of tea leaves.

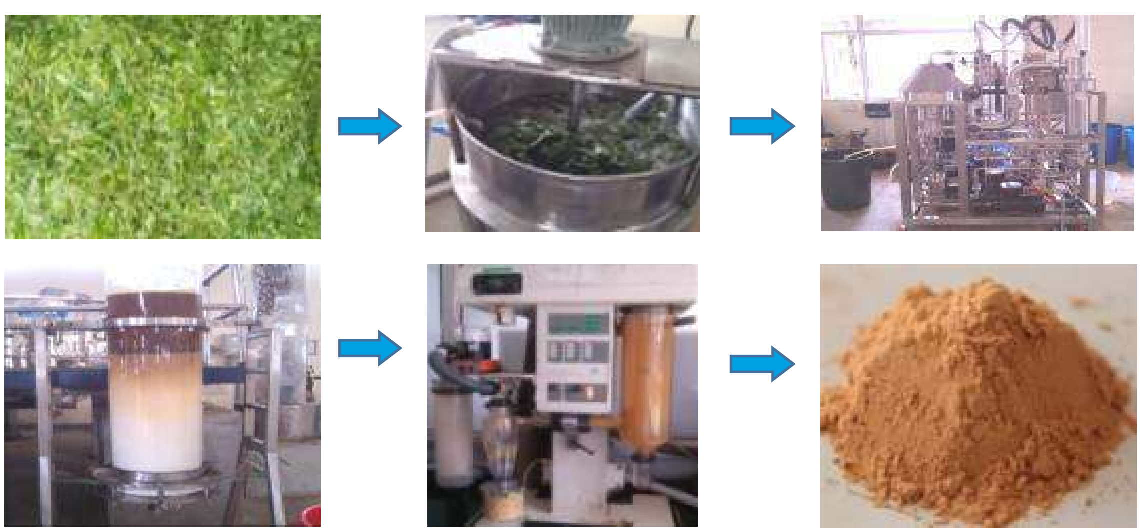


Fig. 3 Production of tea catechins from green tea shoots

Manufacture of tea catechin technology to M/s Indco Serve, Tamil Nadu (SSP-0086)

Kaikatty Industrial Co-operative Tea Factory Ltd., India representatives namely Dr. S. Vineeth, I.A.S., MD INDCOSERVE, Tmt. J. Akila, MD, Kaikatty, Thiru. Akbar, GM, INDCOSERVE, Thiru. M. Sivasubramaniam, Mechanic visited institute regarding technology transfer for extraction of tea catechins. Technical discussion regarding establishment of plant was done. In addition to this, as per MoU, tea catechin technology was also demonstrated. Based on technical discussion, technology transfer document for 100 kg per batch including design of plant & machinery, standard operating procedures for operating the plant, analytical methods for stage wise monitoring of the quality of the product, safety measures, plant layout and all the civil foundation drawing for entire plant was handed over to them.

Upscaling of process for extraction of coloring compounds from red cabbage on pilot scale:

The lab scale process for extraction of anthocyanins was up scaled and various process parameters were optimized at pilot scale.

Fig. 4 Upscaling of process for extraction coloring compound at pilot scale

Formulation of stevia liquid drops

A green process is developed for direct processing of dry stevia leaves into formulated liquid drops. MoU were signed with following parties for production of Stevia liquid against processing charges

- M/s Himalayan Natural & Herbal Products, Palampur
- M/s Agri Natural, Ludhiana

Technology name	Transferred to
Process for extraction and stabilization of natural colours and their application in food and cosmetics	M/s Nano Tech Chemical Brothers Pvt. Ltd. Chandigarh
Development of stevia liquid formulation (under incubation facility)	1. M/s Himalayan Natural & Herbal Products, Palampur 2. M/s Agri Natural India, Ludhiana
Process for Tea wine and RTD	M/s Camelia Beverages Pvt. Ltd., New Delhi

Pamita Bhandari, Senior Scientist
pamita@ihbt.res.in
Natural Product Chemistry & Process Development Division

Exploration of anthocyanins in medicinal plants

Colors are important in human's daily life and found applications in various forms such as food, textiles, paintings, hair dyes etc. Claims have been made that synthetic colors/dyes cause serious side effects, such as hyperactivity in children, cancer and allergies. Owing to various hazardous effects of synthetic colors, natural colors are preferred by the food industries. Anthocyanins are water soluble pigment and provides red to blue colorant in fruits, flowers, roots and vegetables and have been diligently studied for their vivid color range and associated health benefits. In recent times, due to safety concerns, the trend for replacement of synthetic dyes by these natural colorants has grown tremendously. Due to health and safety concern, edible natural colors caught attention from various researchers worldwide. The exploration of pigment bearing plants for their applications mainly on food, cosmetics & pharmaceuticals have been considerable attention. In accumulation to its food application, therapeutic potential of anthocyanin has also been well explored and have several associated health benefits, such as anti-inflammatory, antidiabetes, antiobesity, anticancer, antioxidative, protection against DNA damage and neuroprotective effects. Anthocyanins provide high possible colorant power, high water solubility and low toxicity, which permits their unification in numerous food systems. The unstable nature (influenced by pH, light, storage temperature, chemical structure, oxygen and solvents) of anthocyanins limits its shelf life and quality of the product. Therefore, in continuation of our studies towards natural colorants, the *Ipomea nil* plant was studied. *I. nil* is an herbaceous annual or perennial plant, belonging to the *Convolvulaceae* family. The flowers of *I. nil* are purple and are rich sources of anthocyanins. During this year we have quantified and characterized the anthocyanins content in the flowers of *I. nil*. The different extracts of *I. nil* were assessed for total phenolics and antioxidant activity by different assays i.e. DPPH, ABTS & FRAP.

Characterization of anthocyanins in *I.nil*

The structural characterization of the individual anthocyanins and non-anthocyanin was accomplished by UPLC-ESI-MS/MS analysis. The tentative characterization of the compounds was carried out by UPLC-ESI-MS/MS in positive ion mode. The UPLC-ESI-MS of Peak 6 with retention time (RT) = 5.02 min (Fig. 1b) afforded a molecular ion peak at *m/z* 949.27 and showed three fragments ions at *m/z* 787.21, 463.12 and 301.07. The fragment obtained at *m/z* 787.21 represented the loss of one glucose unit $[M-162]^+$ and the fragment observed at *m/z* 463.12 was due to the loss of both sophoroside and caffeoyl moiety $[M-324-162]^+$. The fragment at *m/z* 301 represented the loss of glucoside, sophoroside and caffeoyl units $[M-324-162-162]^+$ and thus the peak identified was peonidin-3-*O*-(6"-caffeoylsophoroside)-5-*O*-glucoside. Similarly, the other peaks (5,7,8,) were identified and characterized on the basis of fragmentation behavior as peonidin-3-*O*-galactoside, delphinidin-3-*O*-galactoside and delphinidin-3,5-*O*-diglucoside respectively.

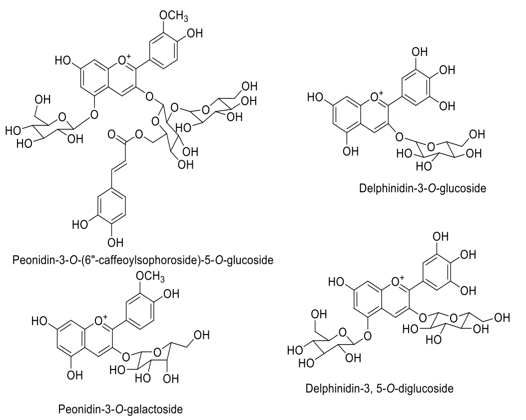


Fig. 1 Structures of the compounds identified in *I. nil*

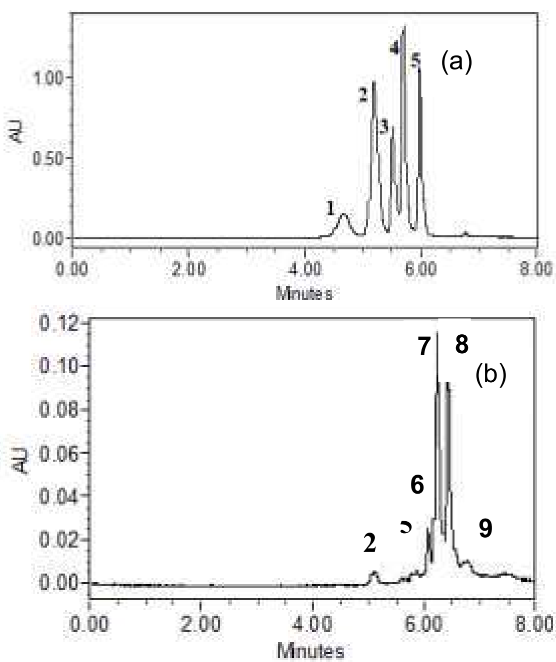


Fig. 2 (a) UPLC chromatogram of standards: (1) Cyanidin-3, 5-diglucoside (t_r=4.802); (2) Delphinidin-3-*O*-glucoside (t_r=5.171); (3) Cyanidin-3-*O*-glucoside (t_r=5.388); (4) Cyanidin-3-*O*-galactoside (t_r=5.531); and (5) Peonidin-3-*O*-glucoside (t_r=5.836); (b) UPLC chromatogram of *I. nil* at 520 nm

Co-pigmentation and CIE L* a* b* analysis

The effect of co-pigmentation with different additives was studied for 1 hour, 2 days, 10 days & 15 days. During 15 days of storage at room temperature, co-pigments addition enhanced anthocyanin colour. The observations revealed that colour and stability enhancement effect was higher with phenolic acid compared to saccharides and cyclodextrin.

Total anthocyanin content, Total phenolics and antioxidant activity

The total monomeric anthocyanin content of the extract and purified fraction of *I. nil* was found to be 0.45 and 5.89 mg/100 g respectively as cyanidin-3-*O*-glucoside equivalent.

The total phenolics of *I. nil* extract and purified fractions enriched with anthocyanins were found to be 49.69±1.74 and 331.54±9.14 mg Gallic acid equivalent/g, respectively.

Table 1. Total phenolic content of *I. nil*

Samples	TP mg GA equivalent /g	Total anthocyanin content (mg Cyanidin-3-*O*-glucoside equivalent/100g)
I. nil Crude fraction	49.69±1.74	0.45
I. nil purified fraction	331.54±9.14	5.89

Antioxidant activity

The antioxidant activity was determined based on ABTS, FRAP and DPPH assays. The scavenging effects of *I. nil* decreased in the order as L-ascorbic acid > purified fraction > crude extract at concentration of 100 µg/ml, against DPPH (Fig. 2). Similar observations were obtained by FRAP assay. In ABTS assay, the purified fraction demonstrated more antioxidant potential compared to crude extract and is recorded as 241.97±3.90 µM Trolox equivalent/ g.

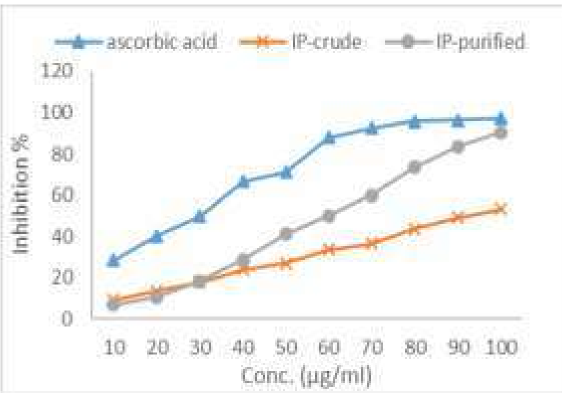


Fig. 3 Antioxidant activity of *I. nil* determined by DPPH.

The antioxidant activity conducted by different methods revealed that purified fractions enriched with anthocyanins had excellent antioxidant potential.

Acute oral toxicity

To study the toxicological aspects, acute oral toxicity was studied. The observations indicated that there is no clinical sign, behavioral change and mortality in the rats (Fig. 3 a & b).

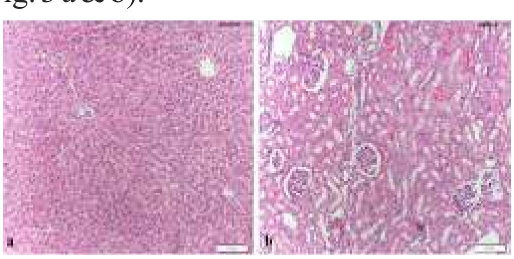


Fig. 3 (a) Liver and (b) kidney tissue of rats in acute oral toxicity study showing normal tissue architecture.

From the studies it is concluded that due to the presence of anthocyanins and other polyphenols and their potential antioxidant activities, the *I. nil* flowers could be a good source for production of natural food colorants.

Safe eco-friendly natural colorants for cosmeceuticals

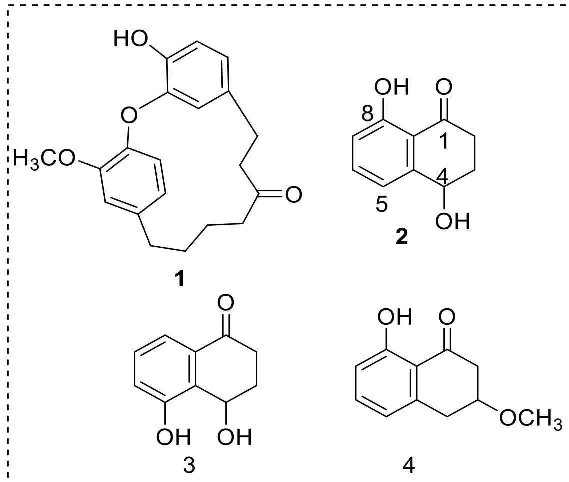
For the utilization of natural colors specifically in cosmetics to avoid side effects of the synthetic colors, an initiative was undertaken to developed a green, cost effective extraction and purification methods for natural colorants for cosmetic applications for example lipsticks.

The lipsticks were formulated in different shades, blended with various aromatic compositions to provide health protective/promotive effects with additional attributes like beautifying lips texture and preventing the darkening of lips.

Phytochemical Investigation of *Carya illionensis*

Carya illinoensis, belongs to the family Juglandaceae, commonly known as Pecan, is a tree originated to North America and commercially adapted and grown in Australia, Brazil, Canada, Israel, Mexico, South Africa and in the states of Jammu & Kashmir and Himachal

Pradesh of India. The phytochemical studies on *C. illinoensis* revealed the presence of sterols, phenolics, carbohydrates, fatty acids, proteins, minerals, and vitamins. C. *illinoensis* exhibits various biological activities such as antimicrobial, antioxidant, hepatoprotective, antibacterial, keratolytic, antidiarrheal, astringent and hypoglycemic. The phytochemical investigation of ethyl acetate extract of green husk of *C. illinoensis* lead to the isolation of 11-oxo-1, 17-epoxy-7-(2-hydroxylphenyl)-13-(16-methoxy phenyl)-heptane (1), 4,8- Dihydroxytetralone (2), 4,5-Dihydroxytetralone (3), 8-Hydroxy-3-methoxytetralone (4). The structures of compounds were established by IR, ^{1}H NMR, ^{13}C NMR, DEPT, HSQC, HMBC, COSY spectroscopic techniques and ESI-MS analysis.



Structures of the isolated compounds (1-4)

Dinesh Kumar, Senior Scientist
dineshkumar@ihbt.res.in
NMR, Metabolomics and Natural Product Chemistry

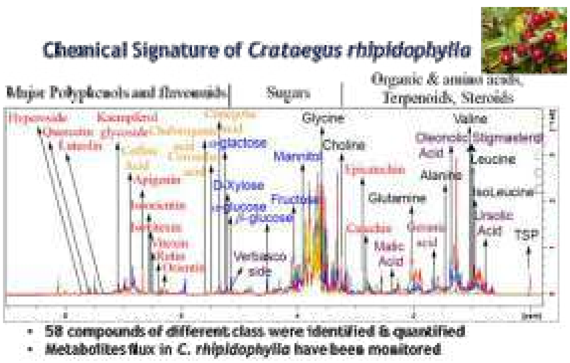
The group is currently focusing on metabolomics, development of chemical signatures, isolation and characterization of natural molecules, identification and isolation of chemical markers and quality control for medicinally important resources of western Himalaya using various techniques.

Enhancement of picrosides content in *Picrorhiza kurroa* Royle ex Benth. Mediated through nutrient feeding approach under aeroponic and hydroponic system.

Medicinal plants cultivation under hydroponic and aeroponic conditions offers an opportunity for quality biomass production on a commercial scale. Medicinally important herb *Picrorhiza kurroa* for the production of quality biomass was first time cultivated using this system. Plants were incubated under controlled conditions such as temperature 25±2°C, photoperiod 16h light/8h dark, humidity 65±5%, electrical conductivity 0.5–1.5mS cm^{-1}, pH 6.8–7.0, temperature 10°C and photosynthetic photon flux density (PPFD) 150µmolm^{-2} s^{-1} respectively. The growth of biomass, physiological parameters, and alterations in metabolite content were measured in *in-vitro* raised and nursery plants, after 12–14 weeks of cultivation. The maximum growth of biomass, leaf physiological parameters, and picroside I and II contents were observed in nursery treated plants cultivated under aeroponic condition. Various parameter found as plant height (6.51cm), leaf length (4.09cm), leaf width (1.59cm), stem diameter (2.72mm), photosynthesis rate (7.55µmol $m^{-2}s^{-1}$), stomatal conductance (0.10mmol $m^{-2}s^{-1}$), transpiration rate (2.55 mmol $m^{-2}s^{-1}$); picroside I and II content in leaf (3.79%) and stem (1.34%). While, in hydroponic; nursery treated plants achieved the highest number of rootlets/plant (13.20), rootlets length (14.96cm) and rootlets width (0.36cm) respectively. The results revealed that *Picrorhiza kurroa* cultivation is suitable under the aeroponic system for the production of quality biomass and can become an alternative approach to produce quality material required for industrial products.

NMR for metabolomics studies of *Crataegus rhipidophylla* Gand.

Crataegus is important for food, nutritional, and pharmaceutical products. The aerial parts are used to treat cardiovascular, respiratory, liver disorders and cancer. Comprehensive metabolite profiling (qualitatively and quantitatively) of different tissues [leaves, flowers, stems, fruits (without seeds), and seeds; n = 5] of *Crataegus rhipidophylla* Gand. was performed by NMR techniques in one session. Fifty-eight compounds of different classes were unambiguously identified with the use of 1D and 2D NMR techniques (^{1}H, ^{13}C, DEPT-135, correlation spectroscopy, HSQC, HMBC) and quantified by a relative quantification method. Compounds such as amygdalin (seeds), rutin (flowers), isovitexin (fruits), shikimic acid (leaves), and epicatechin (stems) were identified as authentication as well as discrimination markers for the respective *C. rhipidophylla* tissues. The fruits contain a significant quantity of important metabolites, followed by flowers and leaves. Trends of metabolite levels, upregulation, and downregulation in plant tissues were found, which highlights the responses of plant tissues in a specific time. NMR-based comprehensive metabolite information was used to develop the chemical signature, quality control chemical markers, and strategies to understand the chemical diversity of *C. rhipidophylla*. This chemical information from different aerial tissues will provide guidance for the extensive utilization of Crataegus.



Assessment of sorption potential of paddy straw biochar for lead (pb^{2+}) removal from waste water

The rapid industrialization and insufficient waste disposal techniques are paving the way for heavy metals to enter into the environment. Lead is one of the major heavy metal pollutant and potential neurotoxin to human. The paddy straw waste, an easily available material, may act as a cost-effective and eco-friendly sink for heavy metal pollutant. Therefore, the present study explores the adsorption potential of paddy biochar (BR-300) prepared at 750 °C for the removal of lead metalions from wastewater. The BR-300 showed adsorption capacity (q_{max} = 111.111 mg/g) at very low adsorbent dose of 20 mg and at the optimum pH 5 and temperature 25 °C. The rate of adsorption was quite rapid and equilibrium was attained in 30 min contact time. It obeyed the pseudo-second order kinetics along with Langmuir isotherm followed by Freundlich and Temkin isotherms. The Langmuir separation factor indicated towards the favorable adsorption with constant correlation coefficient (0.997) at all temperature levels. The Freundlich and Temkin isotherms for current study displayed the coordinated adsorption as well as the endothermic nature of the reaction. The paddy biochar was capable to completely remove the Pb^{2+} metal ions from the spiked (50 ppm) wastewater samples. It was also observed that BR-300 changed the pH of solution after adsorption from acidic to near neutral pH. The results indicate that BR-300 is quite efficient in the removal of Lead from waste water samples. Paddy Biochar thus can be exploited for the removal of heavy metals from the environment.

Quantitative analysis of flavonols, flavonol glycoside and homoisoflavonoids in *Polygonatum Verticillatum* using UHPLC-DAD-QTOF-IMS and evaluation of their antioxidant potential

Polygonatum is widely used as a part of food in different regions of the world which covers five main categories such as drinks, vegetables, snacks, staple and seasoning foods. Presently, no analytical method is available for the quality control of Polygonatum. Development and validation of a method using ultrahigh-performance liquid chromatography diode array detector quadrupole time-of-flight (UHPLC-DAD/QTOF) technique for the estimation of six compounds including a flavonol glycoside [rutin (1)], two flavonols [quercetin (2) and kaempherol (3)] and three homoisoflavonoids [5,7-dihydroxy-3-(2-hydroxy-4-methoxybenzyl)-chroman-4-one (4), 5,7-dihydroxy-3-(2-

hydroxy-4-methoxybenzyl)-8-methylchroman-4-one (5) and 5,7-dihydroxy-3-(4-methoxybenzyl)-8-methylchroman-4-one (6)]. In addition, screening of extract, fractions and compounds of *P. verticillatum* for antioxidant activity was also done. The separation was achieved on C-18 column using acetonitrile and water containing 0.1% formic acid. The method was validated as per ICH (International Council for Harmonisation of Technical Requirements for Pharmaceuticals for Human Use) guidelines. The validated method was applied for the simultaneous identification and quantification of compounds 1-6 in extract (E) and fractions (F1-F4) of *P. verticillatum*. Furthermore, antioxidant potential of E, F1 and F2 and compounds was evaluated using DPPH (2,2-diphenyl-1-picrylhydrazyl) assay. The method was within the linear range (r^2) of 0.982 to 0.999, precise (intra- and inter-day percentage relative standard deviations < 2.72 and 2.26) and accurate with recoveries (89.1-98.3%). The limit of detection and limit of quantification were in the ranges 0.02-0.16 and 0.06-0.48 ng/mL, respectively. Compounds 1-6 were quantified in all the

samples. Compounds 1, 2 and 5 showed higher activity with half maximal inhibitory concentration (IC_{50}) values 0.41, 0.39, 0.72 at 10, 20 and 30 µg/mL, respectively. The developed method will be helpful to assess the quality of *P. verticillatum* raw material and their derived products.

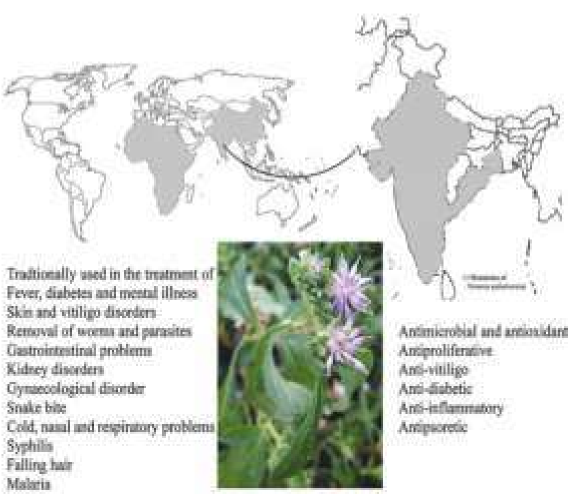
***Vernonia anthelmintica* (L.) Willd.: An ethnomedicinal, phytochemical, pharmacological and toxicological review.**

Vernonia anthelmintica (L.) Willd. (Asteraceae; Purple Fleabane) has a long history of traditional use for the management of several disorders related to skin, central nervous system, kidney, gynecology, gastrointestinal, metabolism, and general health. The review aims to provide updated systematic information on ethnomedicinal uses, phytochemistry, pharmacological uses, toxicity studies, and patented formulations of *V. anthelmintica*. Scientific reports revealed that *V. anthelmintica* is a popular medicinal plant used in local and traditional medicine to manage various disorders. Phytochemical studies have identified 193 chemical constituents amongst which steroids form the most abundant class, followed by terpenes. Crude extracts and isolated compounds exhibited various pharmacological activities such as anti-vitiligo, anti-diabetic, anti-inflammatory, antipsoriatic, neuroprotective, hepatoprotective, analgesic, antipyretic, antioxidant, antiparasitic, antimicrobial, antiproliferative, immunomodulatory and also helped in managing pulmonary fibrosis and promoting the synthesis of estrogen. Approximately 45 chemical constituents were found to be biologically active. There are only three toxicity reports and 37 patents available on *V. anthelmintica*. The review suggests that *V.*

anthelmintica act as a promising source for drug development. The potential uses of *V. anthelmintica* are owing to the presence of phenolic acids, steroids, fatty acids, and terpenes in its composition. However, further studies are needed to explore the exact mechanism of action, pharmacokinetics, chronic toxicological studies, safe dose consumption, and possible interactions with other herbs.

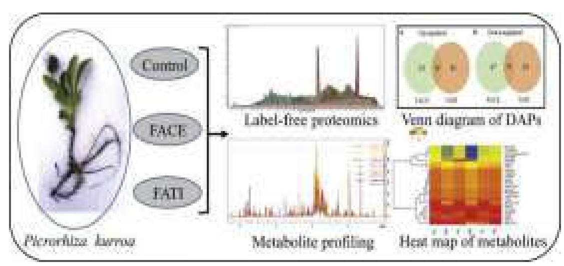
Assessment of CO_2 and temperature effects on *Picrorhiza kurroa* metabolites using analytical techniques *viz.* NMR, UPLC and HPTLC

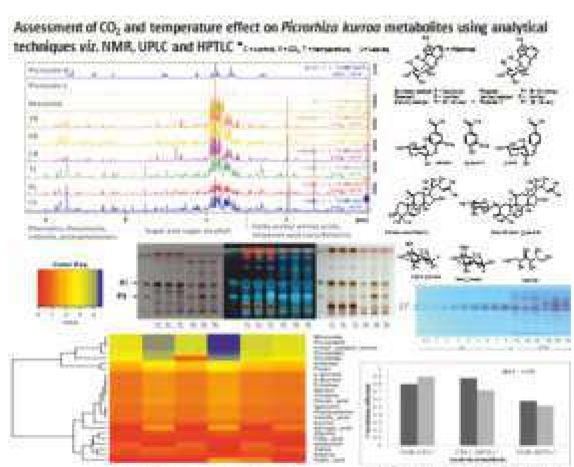
Environmental factors are continuously affecting the climate and plant growth as well as their metabolites. With this fact we have conducted the metabolomic study of *P. kurroa* (leaves and rhizomes) using NMR, HPTLC and UPLC techniques under control, elevated temperature and CO_2 conditions. Significant qualitative and quantitative differences were noticed in



Vernonia anthelmintica Willd.

metabolites as compared to control using NMR and statistical methods. Total 31 compounds were identified and 24 of which has been quantified using NMR and clustered for discriminations in control, elevated temperature and CO_2 samples using statistical heat plot. NMR, HPTLC and UPLC were found reliable and variation in picroside-I and II were determined in different conditions. This study revealed that elevated CO_2 increased the content of picrosides particularly picrosides-I and II, sugar and sugar alcohol in rhizomes while decrease in picrosides-I and increase in P-II was observed in leaves. Slight alterations were only noticed in elevated temperature condition. The increase in picrosides and other carbon rich metabolites were may be due to the utilization of carbon from elevated CO_2. Hence, the climate change due to CO_2 and temperature causes the alteration in metabolites of *Picrorhiza Kurroa*. This knowledge will be crucial to better understand that how plants metabolites affected in future by changing environments.





Research Group: Shruti Sharma, Dinesh Kumar, Ranjana Sharma, Bindu Rawat, Pradeep Bhatia, Vandana Kumari, Anil Kumar, Anchal Sharma, Nidhi, Jigyasa Mahalotra, Manish Kumar, Rishabh Kaundal (JRF's, Project Fellows)

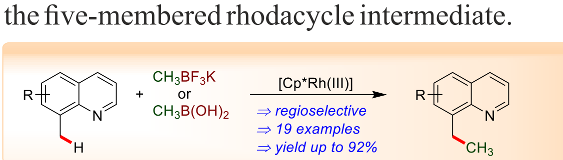
Technical Staff: Mr. Shiv Kumar, Mrs Vijaylata Pathania, Mr. Ramesh Kumar

Upendra Sharma, Scientist
upendraihbt@gmail.com; upendra@ihbt.res.in
Natural Product Chemistry & Process Development Division

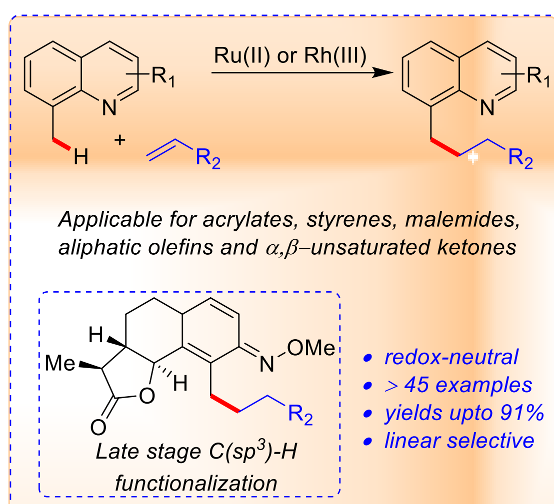
C-H Activation and Functionalization: Efficient Bioactive Molecule Synthesis: In continuation of our group's main focus on the synthesis of new quinoline derivatives *via* C-H activation this year we initiated work on challenging $C(sp^3)$-H activation. We have developed six innovative catalytic methods for the synthesis of >175 new quinolines derivatives and were assessed for their anti-malarial potential to identify the lead molecules.

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. Phytochemical investigations of *Camellia sinensis*, *Cissampelos pareira*, *Cassia fistula* L., *Fritillaria roylei*, *Trillium govanianum* and *Narcissus tazetta* have been carried out.

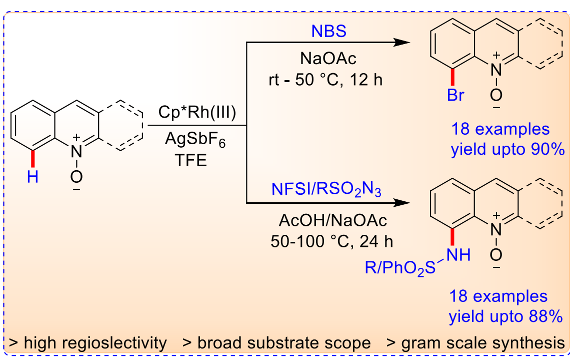
Cp*Rh(III)-Catalysed Regioselective $C(sp^3)$-H Methylation of 8-Methylquinolines with Organoborons: A Rh(III)-catalyzed highly regioselective methylation of unactivated $C(sp^3)$-H bond of 8-methylquinolines with bench stable organoboron reagents was carried out. Complete chemo and regioselectivity was observed in all cases as methylation at C2-position or dimethylation of $C(sp^3)$-H of 8-methylquinoline was not detected. The mechanistic study uncovered that the reaction may proceed through the five-membered rhodacycle intermediate.



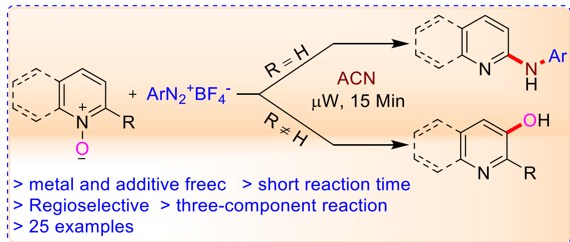
Ru(II)/ Rh(III)-Catalyzed $C(sp^3)$-$C(sp^3)$ Bond Formation through $C(sp^3)$-H Activation: Direct alkylation of $C(sp^3)$-H bond of 8-methylquinolines with olefins (acrylates, styrenes and aliphatic) is discovered. The alkylation also proceed with other conjugated system such as malemides and α,β-unsaturated ketones. The reaction is highly regioselective, forms only linear product and tolerates a variety of functional groups on quinoline and olefin moieties. Control experiments, deuterium labeling and kinetic studies have been carried out for preliminary understanding of the reaction pathway. The reaction possibly proceeds through five-membered metallacycle under redox-neutral condition. Diversification of alkylated product and late stage functionalization of ketoxime derivatives of (-)-santonin have also been carried out to demonstrate the applicability of the developed method.



Rh(III)-Catalyzed C(8)-H Activation of Quinoline *N*-oxides: Regioselective C-Br and C-N Bond Formation: A highly efficient and regioselective, Rh(III)-catalyzed protocol for C8-bromination and amidation of quinoline *N*-oxide has been developed. The transformation is found successful up to gram scale with excellent functional group tolerance and wide substrate scope. The mechanistic study revealed five-membered rhodacycle with quinoline *N*-oxide as a key intermediate for regioselective C8-functionalization. In addition, NFSI has been explored as an amidating reagent for C8-amidation of quinoline *N*-oxide for the first time.

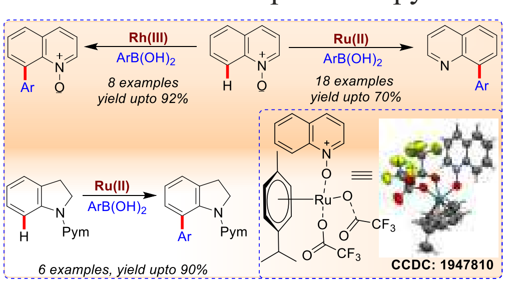


Catalyst-Free Rapid Synthesis of 2-Anilinoquinolines and 3-Hydroxyquinolines *via* Three-Component Reaction of Quinoline *N*-oxides, Aryldiazonium salts and Acetonitrile: A rapid microwave-assisted catalyst-free, three-component synthesis of various 2-anilinoquinolines from quinoline *N*-oxides and aryldiazonium salts in acetonitrile under microwave irradiation is reported. This reaction utilizes acetonitrile as a single nitrogen source and involves the formation of two new C-N bonds *via* formal [3+2] cycloaddition reaction. In the case of 2-substituted quinolines, 3-hydroxyquinoline was observed as the main product *via* 1,3 shift of oxygen atom from *N*-oxide to the C3 position of quinolines.



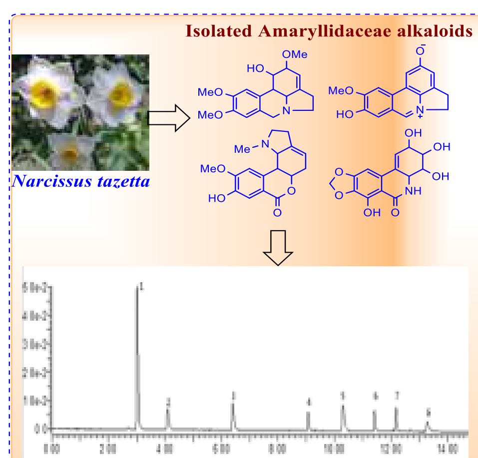
Microwave-Assisted Metal-Free Rapid Synthesis of C4-Arylated Quinolines *via* Povarov Type Multicomponent Reaction: A rapid microwave assisted, (±) camphor-10-sulfonic acid (CSA) promoted Povarov type multicomponent synthesis of 4-arylated quinolines from anilines, alkynes, and paraformaldehyde is described. This reaction proceeds through [4+2] cycloaddition of imine (formed *in situ* from aniline and paraformaldehyde) and alkynes in presence of CSA, without any metal catalyst. Mechanistic study revealed that CSA inhibit the synthesis of Troger's base and assist the cycloaddition of imine with alkyne by activating imine.

Regioselective Arylation of Quinoline *N*-Oxides (C8), Indolines (C7) and *N-tert*-Butylbenzamide with Arylboronic Acids: A Ru(II)-catalyzed regioselective distal C(sp^2)-H arylation of quinoline *N*-oxide with arylboronic acids to 8-arylquinolines is carried out. In developed method Ru(II)-catalyst is showing dual activity *i.e.* distal C-H activation of quinoline *N*-oxides followed by *in situ* deoxygenation of arylated quinoline *N*-oxide in same pot. Current catalytic method features use of Ru metal as catalyst and arylboronic acids as arylating source under mild reaction condition. Use of Rh(III)-catalyst in place of Ru(II) under same condition afforded 8-arylquinoline *N*-oxides with excellent regioselectivity. Further, developed Ru(II) catalytic system is also extended for the C(sp^2)-H arylation of indolines, *N*-*tert*-butylbenzamide and 6-(5H)-phenanthridinone. Formation of quinoline *N*-oxide coordinated ruthenium adduct is found to be key reaction intermediate, which have been characterized by SC-XRD and NMR spectroscopy.



Phytochemical Investigation of Medicinal Plants: Chemical Profiling and Characterization of Bioactive Secondary Metabolites

Chemical Profiling of *Narcissus tazetta* by UPLC-MS/MS: *Narcissus tazetta* is used traditionally for treatment of sores, wounds, skin diseases, cancer in different parts of world. Present study focus on the analysis of amaryllidaceae alkaloids in this plant using an ultra-performance liquid chromatography-diode array detection method. The method was developed for simultaneous quantification of eight Amaryllidaceae alkaloids *i.e.* pseudolycorine, lycorine, galanthamine, 8-O-demethylhomolycorine, N-methylhaemanthidine chloride, homolycorine, narciclasine and zefbetaine in Narcissus tazetta. The method was validated using a BEH C18 column with linear gradient. Standard calibration curve for the analytes showed good linearity ($r2\geq0.999$). The method was validated for intra-day (RSDs<0.91%) and inter-day (RSDs<0.65%) precisions and accuracy (recovery 92.2-112.5%). The developed method was successively applied for studying the variation of alkaloids in different parts of Narcissus tazetta, i.e. bulbs, roots, flowers, flower stalks, leaves. The study showed a significant variation of these alkaloids in different parts of the plant. Among the alkaloids under investigation, pseudolycorine had highest content in all the parts. Furthermore, application of the developed method to the identification of phytocomponents allowed the identification of sixteen alkaloids.



Simultaneous quantification and identification of

Amit Kumari, Scientist
amitkumari@ihbt.res.in
Chemical Engineer, Natural Product Chemistry and Process Development

Green Process for Alternative Natural Sweetener (Monk Fruit)

Multiple studies have found that over consumption of sugar, leads to the several adverse events such as insulin resistance, metabolic syndrome, diabetes, fatty liver and high levels of free fatty acids, mostly through the accumulation of body fat and intra-abdominal fat. Therefore, to limit the use of sugar, alternative sweeteners are gaining considerable interest in the past few years. The prominent areas where the alternative sweeteners are majorly used are in the food and beverage industry, which includes soft drinks, sauces, chewing gum, baked goods, candy, fruit juice, ice cream, etc. Global artificial sweetener market is projected to reach 2.70 billion USD in 2024 by registering a CAGR of 3.7% during the forecasted period (2019-2024).

Globally, more than 420 million people have diabetes and 8.8% adults i.e. ~70 million populations in India is diabetic. Due to several drawbacks associated with artificial/synthetic sweeteners people are showing interest in natural sweeteners. Stevia is one of the natural sweetener however due to taste after taste its use is limited. Therefore, there is urgent need for widely acceptable alternative natural sweetener with no bitter taste after taste. Considering this, CSIR-IHBT has been successful in introducing seeds of Monk Fruit from China through NBPGR-ICAR. Monk Fruit is recognized throughout the world for its intensely sweet taste due to presence of cucurbitane-type triterpene glycosides known as mogrosides, and it has been used as a noncaloric natural sweetener in some countries however not yet available in India.

The work has been initiated, wherein we are developing and optimizing a green process for the Monk Fruit Extract using Green Method. Further, Simultaneously the toxicological and safety studies for safe human consumption of this natural sweetener will also be carried out (Fig. 1).

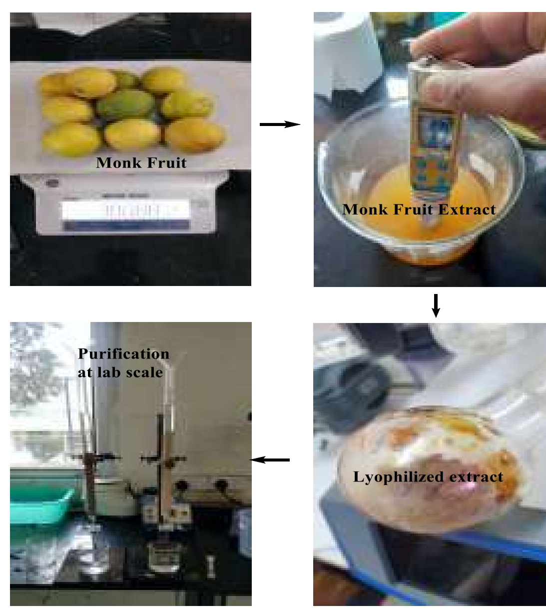


Fig. 1 Extraction process for Mogrosides

Dietetics and Nutrition Technology

Shashi Bhushan, Principal Scientist & Head
sbhushan@ihbt.res.in
Plant Cell and Tissue Culture

Alternative systems for the production of industrially important plant metabolites

In continuation to previous work, adventitious root cultures were induced from *Arnebia euchroma, Valeriana jatamansi*, and *Picrorhiza kurroa*. The process was standardized for their cultivation in liquid cultures so that possible scale-up in bioreactors can be done. The generated material is also evaluated for specific metabolites in respective plant species. The experimental leads clearly indicating the use of *in vitro* induced adventitious roots as an alternative to the wild collection. 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 a sustainable basis.

Induction of adventitious root culture from *A. euchroma* (MLP-144):

Young leaves were cut into 1×1cm section with the help of an autoclaved scalpel. The cut sections of leaves were inoculated on Murashige and Skoog (MS, 1962) and Schenk & Hildebrandt (SH, 1972) medium supplemented with different concentrations of Indole-3-butyric acid (IBA) (1.5, 2.0, 2.5 & 3.0 mg/L) (Fig. 1 & 2). In both the cases, leaves showed swelling and little callusing at the mid rib as well as cut edges after five days of cultivation. Adventitious root formation was visible after 8-10 days of inoculation. Amongst both media, SH was found to effective for root induction. The maximum adventitious root induction (91.67 %) was obtained in 2.5 mg/L IBA after four weeks of inoculation. The average number and length of adventitious root in this medium was 24.66±5.43 and 0.84±0.13 cm, respectively.

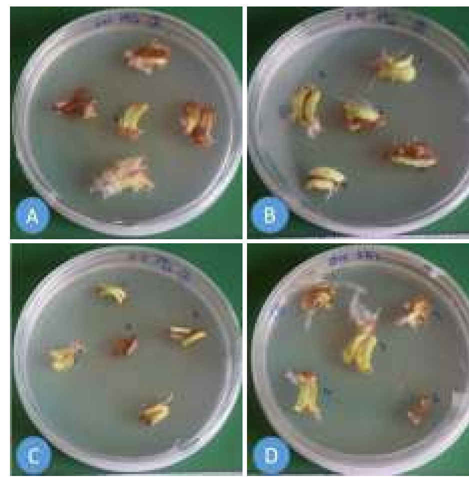


Fig. 1 Effect of IBA on adventitious root induction in MS medium A) 1.5, B) 2.0, C) 2.5 and D) 3.0 mg/L IBA

F i
2 Effect of IBA on adventitious root induction in SH medium A) 1.5, B) 2.0, C) 2.5 and D) 3.0 mg/L

Establishment of shoot culture of *Arnebia euchroma*

In addition, the shoot culture of *A. euchroma* was also established. The rhizome buds inoculated on MS medium supplemented with 0.5 mg/L kinetin (Kn), 4.0 mg/L thidiazuron (TDZ) and sucrose (3%). *In vitro* shoot multiplication was done in MS medium supplemented with different concentrations of Kn (0.3, 0.5 and 1.0 mg/L). The maximum shoot number (9.16±0.70) was observed in MS4 medium (Table 1); however, cultures showed signs of shoot vitrification and callusing at the base. Therefore, further multiplication of shoots was done in medium enriched with different concentrations of Kn (0.3, 0.5, 1.0 mg/L). The maximum number of shoots (3.80±0.72), leaves (14.0±1.46) and leaf length (1.68±0.12 cm) were observed in MS medium fortified with 1.0 mg/L Kn (Fig. 3). Also, MS medium supplemented with different concentrations of Kn showed rooting in the shoots.

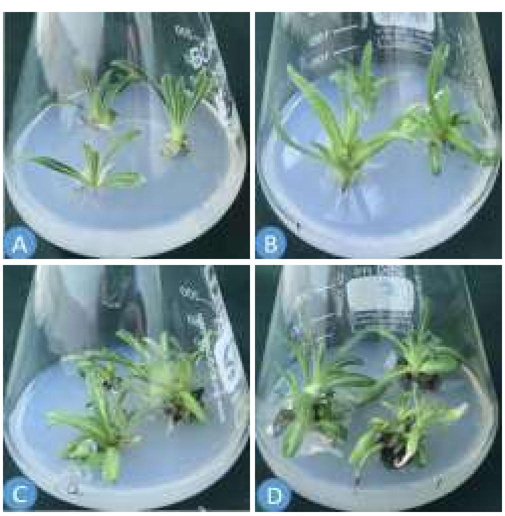


Fig. 3 Shoot cultures of *A. euchroma* after four weeks of cultivation A) Basal medium B) 0.3, C) 0.5 and D) 1.0 mg/L Kn

Table 1. Effect of TDZ and Kn on the proliferation of rhizome buds of *A. euchroma* after four weeks of cultivation

Treatment (mg/L)		No. of shoots (Mean ± SE)	Leaf length(cm) (Mean ± SE)
TDZ	Kn		
0.0	0.0	0.00±0.00	0.00±0.00
0.1	1.0	1.33±0.21	1.84±0.19
0.5	1.0	9.16±0.70	1.11±0.19

***In vitro* adventitious root culture from *Picrorhiza kurroa* (GAP 229)**

Effect of different media on adventitious root induction:

Leaf explant were inoculated on different basal medium, i.e. White root culture medium (WRCM), Murashige and Skoog (MS, 1962), Gamborg's B5 (1968), Schenk and Hildebrandt (SH, 1972) and White's Medium (1943) for induction of adventitious roots. Around 50% induction response was observed in B5 medium after four weeks of inoculation, and therefore, further experiments for the establishment of adventitious roots was performed using B5 medium. Two different auxins, Indole-3-Butyric Acid (IBA) and 1-Naphthaleneacetic Acid (NAA) were evaluated to improve further efficiency of adventitious root induction. Due to conjugated form, stability and its insensitivity to auxin degrading enzymes, IBA showed more adventitious root induction than NAA. The maximum adventitious root induction (100%) response, with the highest average number of roots (9.06±1.14) and length (0.87±0.11cm), was obtained at 4.0 mg/l IBA addition as compared to NAA at the end of four weeks of cultivation period. Also, NAA treatment resulted in more callusing than adventitious root induction (Fig.

Fig. 4 Effect of auxins on adventitious root induction a) IBA and b) NAA

Considering the pronounced effect of IBA in root induction, further experiments were conducted to find out its optimum concentrations (0.25 - 10.0 mg/l) by fortification of B5 medium. The data revealed the highest adventitious roots (100%) induction in B5 medium supplemented with 4.0 mg/l IBA after four weeks of cultivation. Here also, the maximum number of roots (9.06±1.14) and length (0.91±0.37 cm) was observed in B5 medium having 4.0 mg/l IBA, followed by 5.00 and 7.00 mg/l respectively.

Varietal influence on phenolic constituents of pomace (MLP 204)

Apple fruit processing is not variety specific in India, which affect the overall quality of the final processed product. Therefore, pomace from five widely cultivated apple varieties (Royal Delicious, Red Delicious, Golden Delicious, Red Chief and Red Gold) was evaluated. Among different varieties, the pomace from Royal Delicious had the highest dietary fibre content (42.63 ± 1.26%). The data showed that hydro alcoholic extract of Royal Delicious pomace had higher phenolic content and antioxidant capacity (Fig. 5). The linear relationship between antioxidant activity and total polyphenol content was also established for selected varieties to establish the level to which these phenolics contributed. Further, these results are confirmed by HPLC analysis that revealed the presence of phloridzin (487.07 ± 0.04 µg/g), quercetin (241.18 ± 0.03 µg/g) and quercetin-3-glucoside (195.21 ± 0.05 µg/g) as major constituents. Hence, Royal Delicious variety is a good candidate for nutraceutical formulations among the studied apple varieties.

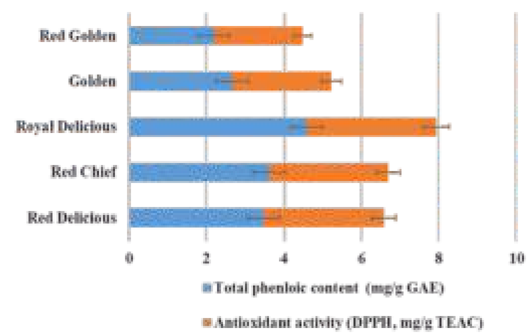


Fig. 5 Phenolic content and antioxidant activity of apple pomace from five cultivars

Mahesh Gupta, Principal Scientist
mgupta@ihbt.res.in
Food Science and Technology

Development of Roasted barley grain-based beverages

The coffee consumption in India has been largely concentrated in the southern region, contributing ~90% of the total domestic production of coffee beans. However, from the last two decades, consumption of coffee beverages has been spread to other parts of India, especially in urban centres. Coffee beans are known to be rich in caffeine; bitter in taste, strong oily flavor as well as regular consumption can have severe implications on human health. Coffee substitutes are non-coffee products used to imitate coffee without caffeine, can be used for medical, economic and regular habit reasons. Roasted grain beverages are novel substitutes for coffee beverages. Roasted grain drinks are popular in East Asian cuisines, Korea, Japan and China, each having one or more versions. In India, CSIR IHBT, Palampur has developed and standardized the process for grain beverage from selected hull-less barley grains of high altitude regions Kaza, Lahaul & Spiti (Himachal Pradesh). Barley grain beverage is a caffeine free alternative of coffee drink with a specific aroma and health benefits. Besides, it gives a similar mouthfeel and relish with respect to the original taste of the coffee beverage. Nutritional analysis of barley coffee showed a good nutritional profile as compared to the coffee bean with crude protein content (10.75%), Total ash (03.09%) and total phenolic content (36.30 mg GAE/g).

Salient Features of Product

- Caffeine-free
- No bitterness
- Ready to reconstitute
- Without any chemical preservatives
- Health benefits of barley grains
- Shelf-life up to 6 months

Development of polyphenol-rich microencapsulate from *Murraya koenigii* bark extract

In the present study, electrostatic extrusion encapsulation method was utilized for efficient binding and delivery of natural polyphenolic compounds. Polyphenolic content and quantification was made on *Murraya koenigii* (L.) Spreng, bark, fruit pulp, fruit seed, and leaves extracts. Bark extract determined highest phenolics (98.96 ± 0.95 µg GAE/mg), flavonoids (24.05 ± 1.52 µg RU/mg) and antioxidant activity. Thereby, a natural phenolic compound exhibited in bark extract was utilized for microencapsulation. Higher structural stability and sphericity were results in three maintained systems S_1; 5% alginate, 10% $CaCl_2$, 1.25% chitosan, 2.5% ascorbic acid S_2; 5% alginate, 10% $CaCl_2$, 0.5% chitosan, 2.0% ascorbic acid and S_3; 5% alginate, 5% $CaCl_2$, 0.5% chitosan, 2.0% ascorbic acid. Maximum encapsulation efficiency (88.92%) and controlled release were determined in S_1 system beads while lesser irregularity in beads were determined through scanning electron microscopy (SEM) after lyophilization. Ultra performance liquid chromatography (UPLC) analysis showed the delivery of myricetin (1.75 µg mg^{-1}) and cinnamic acid (2.07 µg mg^{-1}) in *in vitro* simulated intestinal conditions. While rheological properties and particle size distribution also contributed to the higher polyphenolic encapsulation in S_1 system beads. The current study also supported the development of nutraceuticals through microencapsulaltion technology enhanced with higher binding efficiency and controlled release of polyphenolic compounds in the gut.

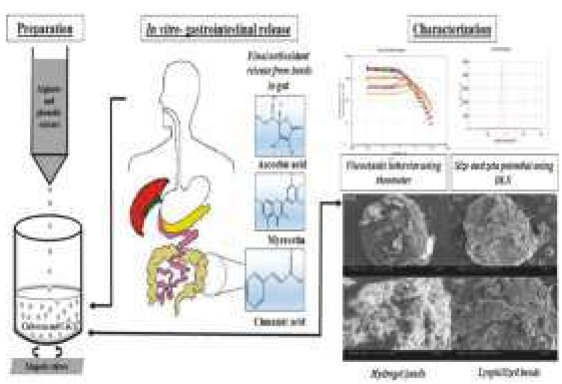


Fig. 1 Methodology and analysis of *Murraya koenigii* bark extract microencapsulate.

Physicochemical and functional properties of pearl, finger and green sorghum millet proteins

In the current study, improvement in physicochemical and functional properties due to in vitro enzymatic hydrolysis of pearl millet (PM), finger millet (FM), and green sorghum millet (GSM) protein isolates were examined. PM, FM, and GSM protein isolates were in vitro enzymatically hydrolysed using pepsin and pancreatin. No significant effects on moisture and fat contents were observed; however, ash content was increased, and protein content slightly decreased after hydrolysis. Free amino acids especially essential amino acids such as leucine and threonine content were increased after hydrolysis and found to be higher in PM protein hydrolysate (PMPH) (128.04 mg/g and 33.19 mg/g, respectively). GSM protein hydrolysate (GSMPH) possessed significantly higher surface hydrophobicity (708.11) and disulphide bond content (23.11 µM/g). However, PMPH exhibited better gelation property (7%). Water absorption capacity was also increased and was found to be higher in GSMPH (90.5 mL/g), though oil absorption capacity was decreased after hydrolysis. Emulsification ability of FM protein hydrolysate was found to be highest (93.49 m2/g). Moreover, hydrolysates sowed significantly higher solubility at all pH 2-10. These results proposed that millet protein hydrolysates possess better physicochemical and functional properties compared to protein isolates and may be used as a potential ingredient in functional food and nutraceutical development.

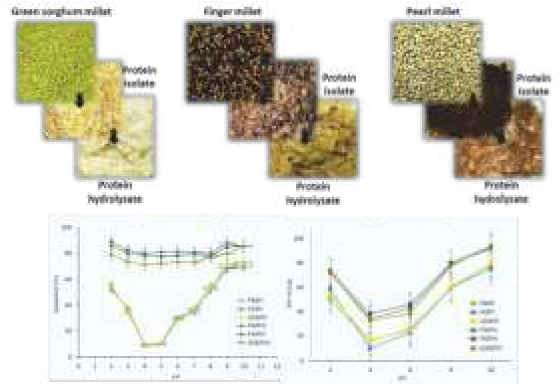


Fig. 2 Process for millets to protein hydrolyzate and its properties

Characterization of an exopolysaccharide-producing *Weissella cibaria* from the cheese of the western Himalayas

Probiotic fermented foods are considered an important component of the human diet due to their nutritive value and purported health benefits. *Weissella cibaria* (CH2) is an exopolysaccharide (EPS) producing bacterium, isolated from cheese. Maximum EPS production (81.3%) was observed with sucrose at 20°C. The *Weissella cibaria* strain was tolerant of simulated gastric juice (pH 3) with a 5.3% decrease in the viable count after 180 min. Similarly, no significant decrease in the viable count was observed in the presence of simulated intestinal juices (pH 8) and bile salts (0.3%) after 240 min. The *Weissella cibaria* strain showed good aggregation ability and antimicrobial activity against representative pathogenic bacteria that may promote the colonization of the *Weissella cibaria* strain in the gastrointestinal tract. This study highlights the potential of the *Weissella cibaria* strain for use as a probiotic.

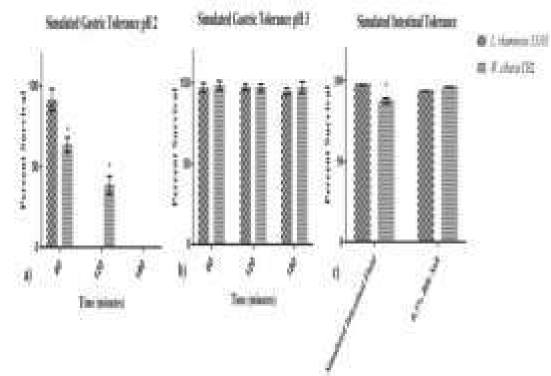


Fig. 3 Simulated gastrointestinal tolerance of *W. cibaria* CH2

Yogendra Padwad, Senior Scientist
yogendra@ihbt.res.in
Biochemistry and Molecular Pharmacology

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

First report on crucial role of MAPKAPK2 (Mitogen Activated Protein Kinase Activated Protein Kinase -2) in the progression of HNSCC (Head and Neck Squamous Cell Carcinoma)

Head and neck squamous-cell carcinoma (HNSCC) ranks sixth among cancers worldwide. In India, 77,000 cases of HNSCCs are diagnosed every year, making it the second most common cancer in the subcontinent with various environmental and lifestyle risk factors as the primary causes. Post-transcriptional regulation of gene expression in tumor versus normal tissues is a highly unexplored area and is especially not well understood in HNSCC. Transcript processing is being increasingly recognized as the most important regulatory step of gene expression in mammals. It is believed that specific interactions between cis-acting structural elements (AREs) located in the 3′-UTRs of proto-oncogenes, growth factors, cytokines, transcription factors and other important proteins with trans-acting RBPs tend to change the protein translation landscape of stressed cells. A better understanding of the role of MK2 in tumor progression could provide new insights into the enigma of the post-transcriptional gene regulation in cancer.

We have elucidated the role of MAPKAPK2 (MK2) in HNSCC pathogenesis using clinical tissue samples, MK2-knockdown (MK2KD) cells and heterotropic xenograft mice model. In this study, we observed overexpression and activation of MK2 in human HNSCC tissues as well as cell lines. Further, we investigated the expression levels of selected genes in clinical tissue samples harboring binding sites for MK2-regulated RBPs in their 3′-UTR and regulating HNSCC pathogenesis. We established that MK2 knockdown ($MK2_{KD}$) in normoxia stabilized cyclin-dependent kinase inhibitor 1B (p27) but destabilized tumor necrosis factor-alpha (TNF-α) and vascular endothelial growth factor (VEGF) transcripts. Furthermore, we found that $MK2_{KD}$ in tumor milieu mimicking hypoxic conditions stabilized p27 and mitogen-activated protein kinase phosphatase-1 (MKP-1) but destabilized TNF-α. Taken together, our findings demonstrate a clear link of MK2 in regulating HNSCC progression. This can contribute significantly to the understanding of inhibiting malignant development by controlling MK2 signaling, thereby, unveiling the importance of MK2 to functionally modulate HNSCC pathogenesis. Thus, MK2 can be taken forward as an alternative potential therapeutic target to the p38/MAPK mediated interventions in limiting HNSCC progression

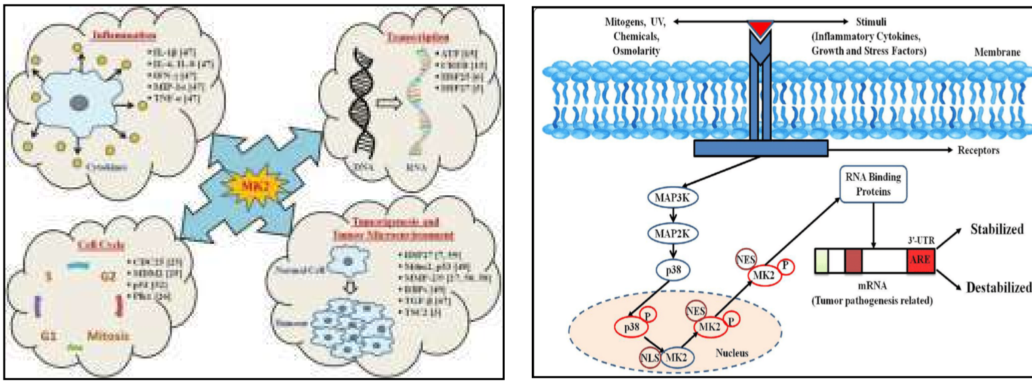


Fig. 1 MK2 is the master regulator of tumorigenesis (Soni *et al.* 2019).

Green tea catechin epigallocatechin gallate (EGCG) inhibits senescence in immune cells

Emerging evidences suggest that senescent cells accumulate with age in various tissues and organs and are vital contributors to the progression of systemic effects of aging and disease. However, it is yet unclear how senescent cells affect resident macrophage phenotype and functions. There is also limited knowledge regarding the role of EGCG or other natural bioactive molecules in influencing macrophage senescence during aging (Fig. 2). Thus, a study was designed to understand how senescent preadipocytes affect macrophage phenotype and functional changes, and whether such deleterious effects could be mitigated by pre-treatment of macrophages to EGCG.

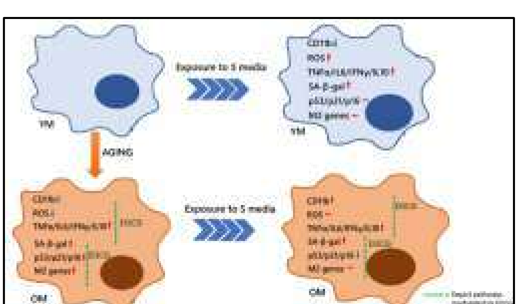


Fig. 2 Age-related dysregulation in macrophage functions (Sharma A *et al*, 2019)

Results revealed strong age-related dysregulation in macrophage functions as evident by decreased CD11b expression, enhanced expression of cytokines (IL-6/TNF-α/IL-1β/IL-10) and cell cycle inhibitors p53/p21^{WAF1}/p16^{Ink4a}, as well as augmentation of M2 phenotype (Arg1/Msr1/Mrc1) and SA-β-gal activity. *Ex vivo* exposure of Young Macrophages (YM) and Old Macrophages (OM) to secretory factors of preadipocytes induced differential effects, and treatment with senescent culture media largely showed an augmentation of senescent phenotype. Pre-treatment with EGCG (10 μM) to OM caused a dramatic reversal of both age-associated and preadipocyte media-induced changes as evident from upregulation of CD11b and ROS levels, inhibition of inflammatory makers, attenuation of p53/p21^{WAF1}/p16^{Ink4a} expression and SA-β-gal activity. These results indicate that EGCG is a promising candidate in developing preventive therapies aimed at alleviating macrophage inflamm-aging and senescence that may help curb incidences of inflammatory disorders in elderly.

Role of *Berberis lycium* Royle fruits as potential modulators of colon inflammation and injury

Ulcerative colitis (UC) is a multifactorial autoimmune inflammatory bowel disease with yet unresolved etiology and pathogenesis. UC is mediated by persistent inflammation of the colon tissue and is characterized by robust activation of immune cells, pro-inflammatory cascade and production of adhesion molecules that ultimately result in damage and dysfunction of the intestinal mucosal epithelial barrier. *Berberis lycium* Royle is one such high-valuable medicinal herb of *Berberidaceae* family which is wildly distributed in the Western Himalayan region at an altitude of 2000–2700 m. The potential of *Berberis lycium* Royle fruit extracts (BLFE) in amelioration of severity and progression of UC, using DSS-induced colitis in murine model was explored. It needs to be emphasized that despite a relatively robust bioactive profile, the efficacy as well as the underlying molecular mechanisms governing the protective and healing effects of BLFE against UC are least understood. BLFE treatment effectively improved animal survival rate, DAI score, colon length, and structural damage in DSS-exposed mice. Expression of oxi-inflammatory markers such as MPO, IgE, iNOS, ICAM-1, MCP-1 and RANTES as well as Th1/Th2/Th17 cytokines were decreased in BLFE treated animals. On the other hand, an increased mRNA expression of anti-inflammatory cytokines (IL-4/IL-10), tight junction proteins and IgA levels were also observed during BLFE treatment. BLFE appeared to modulate intestinal epithelial cell proliferation (PCNA) and apoptosis (Bcl2/Bax) thereby suggesting its role in the maintenance of intestinal integrity. Analysis of inflammatory signalling pathways indicated robust activation and expression of NF-κB/c-Jun/MAPKs (JNK and p38) in DSS treated animal which was strongly abrogated by BLFE treatment. BLFE supplementation also enhanced the proliferation of $CD3^{+}CD4^{+}CD25^{+}$ Treg cells indicating suppression of inflammatory activation. These observations provide compelling evidence that BLFE could be considered as a viable natural strategy in the prevention and management of ulcerative colitis.

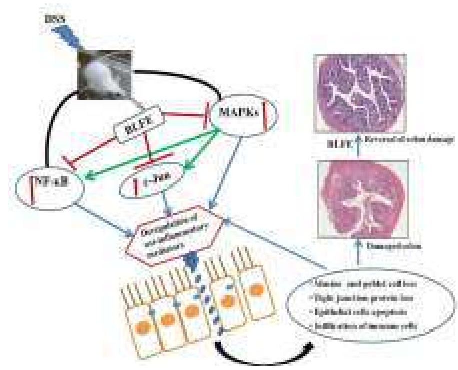


Fig. 3 Effect of *Berberis lycium* Royle fruit extract (BLFE) in the alleviation of colon inflammation and injury

Research Group (Top row Left to Right) :
Mr. Shiv Kumar, Mr. Mahesh S., Dr. Rohit Sharma, Dr. Yogendra Padwad, Mr. Dharmesh Kumar, Mr. Prince Anand
(Bottom row Left to Right) : Mr. Shiv Patil, Mr. Abhishek Goel, Ms. Anamika Sharma, Ms. Jyoti Chhimwal, Ms. Kajal Sinha, Ms. Sanyukta Darnal, Ms. Smita, Mr. Ravi Thakur

Vikram Patial, **Senior Scientist**
vikrampatial@ihbt.res.in
Animal Pathology and Toxicology

My research group focus on validation of natural products, nutraceuticals and synthetic molecules for their therapeutic effects in animal models of liver and renal diseases. We also conduct the preclinical toxicity studies of various products as per standard International guidelines.

Crocin prevents progression of liver fibrosis via PPAR-γ mediated mechanisms

Liver fibrosis is the outcome of various liver-related ailments and one of the major health burden globally. It is the 11th most common causes of death with a growth of 10·3% from 2005 and leads to around 1.16 million deaths/year globally.

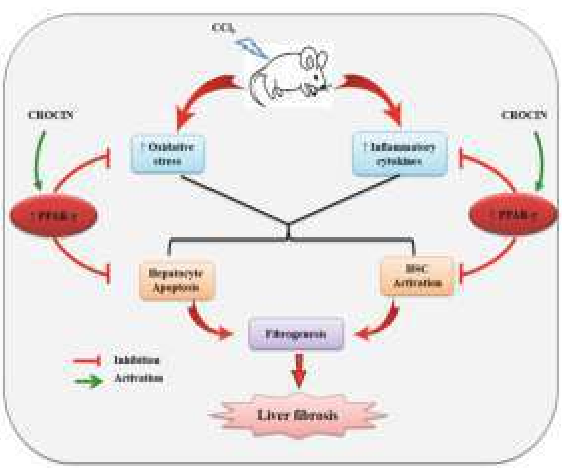


Fig. 1 Showing the mechanism of crocin action against CCl_4 induced liver fibrosis

Crocin is a naturally occurring carotenoid commonly present in the stigma of *Crocus sativus L.*, saffron. Repeated exposure of CCl_4 was used to induce the development of liver fibrosis. CCl_4 resulted in raised levels of alanine aminotransferase and aspartate aminotransferase. CYP2E1 is mainly involved in the metabolism of toxicant in the liver, and the reduced activity of CYP2E1 was observed in the liver tissue. Microscopic pathology showed hepatocyte swelling, vacuolization, necrosis, inflammation, and fibrotic changes. The crocin treatment significantly improved the levels of liver enzymes in serum and CYP2E1 mRNA levels in liver tissue. Crocin also lowered the severity of microscopic changes in the liver tissue. The proinflammatory cytokines, NF-κB, IL-6 and TNF-α and fibrogenic factor, TGF-β, and α-SMA levels were found increased in the liver tissue by the CCl_4 administration. However, crocin treatment significantly lowered the expression of these factors. Crocin also prevented the apoptosis of the hepatocyte. We demonstrated that the expression of PPAR-γ in liver tissue decreases with the progression of liver fibrosis. In contrast, crocin treatment improved the PPAR-γ expression in the liver, indicating its role in the therapeutic effect of crocin. Overall, crocin prevented the progression of liver fibrosis via activation of PPAR-γ pathways.

Anti-obesity efficacy of tea catechins and tea vinegar

The anti-obesity effect of tea catechins was evaluated in the high-fat diet-induced obesity model of rats. The feeding of high fat diet for six months resulted in high body weight and body fat deposition in the rats. The administration of tea catechins at 75, 150, and 300 mg/kg orally resulted in a significant ($p < 0.05$) reduction in the body weight as compared to vehicle control. Tea catechins treatment significantly ($p < 0.05$) lowered the total cholesterol and triglyceride levels in the high diet-fed rats. Histopathology of adipose tissue showed reduced adipocyte size in tea catechins treated groups. Similarly, we have studied the anti-obesity effect of tea vinegar in obesity-induced mice. Both the product found effective in preventing obesity in animal models.

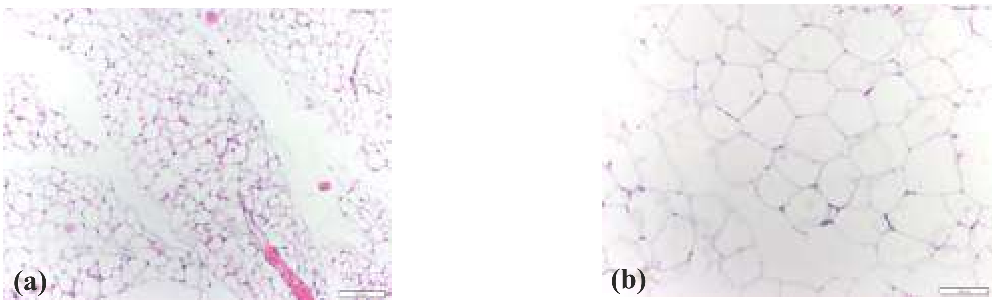


Fig. 2 Showing comparative adipocytes size in (a) normal control and (b) high fat diet group in mice

Regulatory studies In Regulatory studies, we evaluated the acute dermal toxicity of herbal lipstick developed at CSIR-IHBT. Similarly, the acute and subacute oral toxicity of *Tagetes minuta* oil was also evaluated. Both the products were found safe within the recommended doses. Besides this histopathology and clinical pathology services were also provided to outside institutes.

Collaborative work

In collaborative work, we studied the role of mTOR pathway in spontaneous recurrent seizures mediated cardiac dysfunction. The lithium pilocarpine-induced recurrent seizures in rats lead to elevated cardiac injury marker enzymes (lactate dehydrogenase and creatine kinase-MB) hypertrophy, necrosis and fibrous tissue deposition in the myocardial tissue. The epileptic rats showed upregulation of mTOR Pathway and related genes.

Research Group (Left to right) : Swati Katoch, Vinesh Sharma, Dr. Vikram Patial, Garima Dadhich and Ancha

Damanpreet Singh, Senior Scientist
damanpreet@ihbt.res.in
Neuro Pharmacology

α-linolenic acid exposure to reduce seizure susceptibility:

Foods containing omega-3 fatty acids have shown protective effects against several neurological disorders. We investigated the effect of α-linolenic acid (ALA), an essential omega-3 fatty acid exposure during embryonic/larval stage in developing zebrafish (*Danio rerio*) against pentylenetetrazol (PTZ)-induced seizures. Wild-type zebrafish embryos were treated with system water containing ALA (varying from 1–20 μM) till 7 *dpf* (days post-fertilization). Following the incubation period, each larva at 7 *dpf* each larva was exposed to 8 mM of PTZ solution. The induced seizures were recorded using a devised scale. It was observed that ALA exposure at 10 μM and 20 μM concentrations reduced PTZ seizure severity in a dose-dependent manner indicated by a decrease in hyperactive responses and an increase in latency to clonus-like seizures. Further, a marked reduction in mRNA expression of *c-fos* was also observed. A marked increase in the level of ALA and docosahexaenoic acid was also seen in the treated group. The study ultimately concluded that embryonic exposure of ALA reduced PTZ-induced seizures in zebrafish larva.

Identification of some potential agents for the management of epilepsy:

The involvement of PI3K/AKT/mTOR signalling pathway is well reported in the genesis of epilepsy. 2-(4-Morpholinyl)-8-phenyl-4-H-l-benzopyran-4-one (LY294002; Fig. 1) is a selective inhibitor of phosphatidylinositol-3-kinase (PI3K). The present study was designed to explore the antiseizure potential of LY294002 in a PTZ model of zebrafish. The treatment reduced the seizures in larva and adult zebrafish. A marked reduction in the fish brain mRNA of *AKT1, mTOR, PIK3CA, PIK3R1, Rps6* and *Rps6kb1* was also observed. The study concluded that LY294002, a specific reduced the PTZ mediated seizures in larva and adult zebrafish via inhibiting PI3K/AKT/mTOR signalling pathway (Fig. 2).

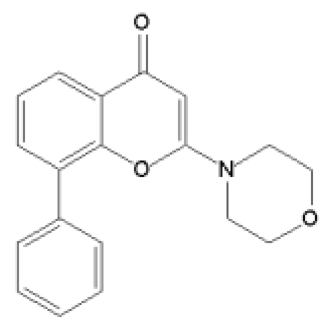


Fig. 1 Structure of 2-(4-Morpholinyl)-8-phenyl-4-H-l-benzopyran-4-one (LY294002)

In another collaborative work, the efficacy of a series of semi synthesized compounds was studied in the zebrafish seizure model. Pyrrolone-fused benzosuberene (PBS) compounds were synthesized by chemistry group from α,β,γ-Himachalenes isolated from *Cedrus deodara* essential oil. The structure of the synthesized compound was subjected to *in silico* studies to identify affinity, interactions profile. Based on the results, two compounds were selected and subjected in vivo efficacy testing studies using a zebrafish model of PTZ-induced convulsions. Apart from that, gene expression studies were also performed. Both the compounds showed suppression of PTZ-mediated seizures in zebrafish larvae. Furthermore, the expression of all the downstream genes of PI3K/AKT/mTOR signalling pathway *i.e. AKT, mTOR, Rps6* and *Rps6kb1* was reduced dramatically following reatment with the compounds (Fig 2.).

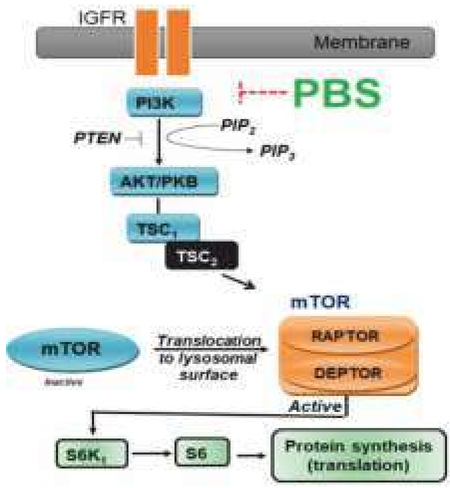


Fig. 2 Proposed mechanism of Pyrrolone-fused benzosuberene (PBS) compounds in the suppression of PTZ-mediated seizures

Study of the effect of chronic seizures on cardiovascular changes

There is an alteration in cardiac electrophysiology during chronic epilepsy that leads to a life threatening condition called as Sudden Unexpected Death in Epilepsy or "SUDEP". However, the exact cardiovascular changes that occur during epilepsy are still not clear. Hence, we designed a study to understand the cardiac parameters and molecular changes during different phases of epileptogenesis in a rat model of temporal lobe epilepsy. The rats were subjected to the lithium-pilocarpine protocol to induce spontaneous recurrent seizures (SRS). It was observed that the mean arterial pressure reduced during the latent phase of epileptogenesis, and increased progressively during the initial and the late phases. Histopathological studies of the heart showed degenerative changes, hypertrophy and fibrous tissue deposition. Furthermore, there was an increase in the levels of creatine kinase-MB and lactate dehydrogenase in the serum. We also observed increased expression of phospho-S6, phospho-mTOR, HIF-1α, TGF-β, Na+/K+-ATPase α1 and collagen proteins in the cardiac tissue. Increased mRNA levels of mTOR, Rps6, HIF-1α, Scn3b, Scn1b, Nav1.5 and TGF-β was also observed in the heart tissue. The results concluded that chronic epilepsy leads to cardiac abnormalities via mTOR pathway upregulation.

Research Group : Arindam G. Mazumder, Supriya Sharma, Anil Kumar, Shubham N. Rahmatkar, Savita Kumari, Avantika Bhardwaj, Aditi Sharma, Amit Kumar, Ankush Chauhan and Pooja Sharma

Narendra Vijay Tirpude, Scientist
narendra@ihbt.res.in
Animal Breeding and Toxicology

Topical and oral herbal formulations for cartilage health

Fig: Oral (left) and Topical (right) formulation for maintaining cartilage health.

In India, the major population is affected by osteoarthritis, which is the second most common musculoskeletal disorder with a prevalence of 22% to 39% in the Indian population. Women are more affected by than men. However, the cost of treatment and requirement of surgical interventions makes it unaffordable for common people. Thus, there is an utmost need for finding an alternative cheap and affordable curative remedy for OA. Traditional knowledge of the Indian Ayurvedic system mentions several plants which provide relief from such disorders. However, such vast traditional knowledge lacks sufficient scientific validation.

Two important plants, *Vitex negundo* (Nirgundi) and *Cissus quadrangularis* (Hadjod) are known for their potential to relieve pain and support osteogenesis.

Standardized extracts from these plants were prepared and analyzed for the presence of various chemical compounds. Product formulation using a combination of extracts was done. Different combination of product in the form of water-dispersible sachet with different bases such as fructo-oligosaccharide and maltodextrin were prepared. The topical formulation in the form cream was also prepared to be applied over the affected part.

To check the efficacy of these products, Mono-iodoacetate-induced experimental osteoarthritis was developed. It was observed that the formulation showed better efficacy than unformulated combinations. During stability testing, no visible microbial growth, no crystal formation, sedimentation of particles was observed at different temperatures for six months.

Docking studies of important chemical compounds with selected targets of osteoarthritis also supported our hypothesis as major chemical constituents of the formulation showed better binding affinity to target molecules as compared to the chosen reference standard.

Ankit Saneja, Scientist
ankitsaneja@ihbt.res.in
Food and Nutraceuticals

Our laboratory works on two main aspects *viz.* (i) development of value-added products from aromatics and herbals, and (ii) development of nutraceutical formulations for improvement of bioavailability and therapeutic efficacy.

Development of value-added products from aromatics and herbals

India is gifted with 8,000 medicinal and 1,200-2,500 aromatic plants. They have been extensively used for the preparation of drugs in various systems of medicine, herbal cosmetics, and functional foods.

Further, essential oils from aromatic plants have also been extensively used in flavour, fragrance, cosmetics industries and aromatherapy.

The main focus of our laboratory is to develop value-added products from medicinal and aromatic plants utilizing pharmaceutical technology (formulations) to produce commercially marketable products.

In this context, we are currently working on the development of herbal lipsticks and semi-solid preparations such as creams/ointments utilizing Himalayan bioresources such as superoxide dismutase (SOD), sapium wax, and catechins.

Development of nutraceutical formulations for improvement of bioavailability and therapeutic efficacy

The consumption of dietary phytochemicals is consistently linked with protection from chronic diseases such as diabetes, cardiovascular disease, cancer and neurodegenerative diseases.

However, these phytochemicals have significant therapeutic limitations because of their low aqueous solubility, low permeability, short half-life, and low bioavailability to humans.

Advanced pharmaceutical technologies can overcome these limitations. The current theme of our laboratory is to utilize self-emulsifying drug delivery systems (SEDDS), solid dispersions, nano-emulsions, lipid nanocapsules and polymeric particles based approaches to enhance the bioavailability as well as the therapeutic efficacy of nutraceuticals (Fig. 1).

In this context, we are working on phloretin, which is one of the bioactive constituents of apple/apple pomace and exhibits a wide variety of pharmacological activities such as antidiabetic, antioxidative, anti-inflammatory, and anticancer.

However, its efficacy is hampered due to its poor aqueous solubility (20 µg/mL) and bioavailability because of its rapid and extensive metabolism. Therefore, to overcome this issue, we are utilizing formulations based approaches to improve the bioavailability of phloretin in the view to enhance its therapeutic efficacy.

Further, the investigation is also being done on the investigation of novel formulation based approaches for enhancing the bioavailability and therapeutic efficacy of tea bioactive constituents.

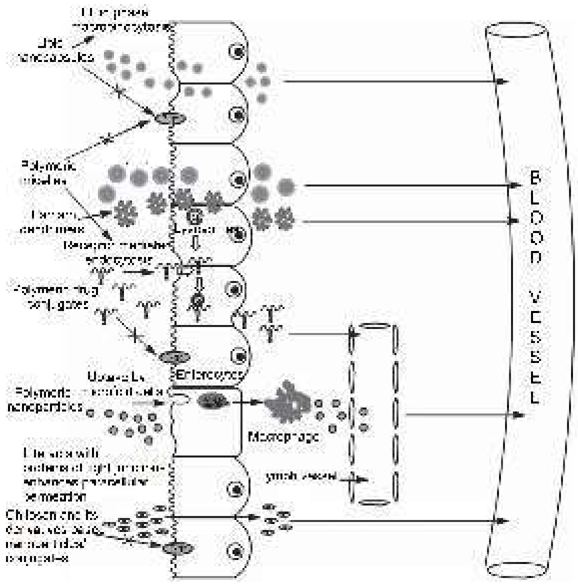
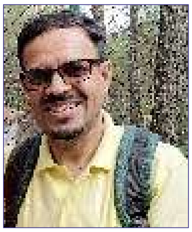


Fig. 1 Proposed absorption mechanisms for improving the bioavailability and consequently therapeutic efficacy of nutraceuticals through various formulation approaches: lipid nanocapsules and polymeric micelles (macropinocytosis), dendrimer (permeation through transcellular and paracellular routes), polymeric drug conjugate (receptor-mediated endocytosis), polymeric nanoparticles (endocytosis), chitosan-based delivery system (interaction with tight junction). Additionally, some of the excipients of the formulations possess the potential to inhibit P-glycoprotein (P-gp), thereby facilitating drug absorption. (Source: A. Saneja et al., Expert opinion on drug delivery, 11(1) (2014) 121-38). [Copyright © Informa UK)

Research Group : Ankit Saneja, Rakesh Kumar Dhritlahre

Environmental Technology



Sanjay Kr. Uniyal, Senior Principal Scientist
suniyal@ihbt.res.in
Biodiversity Conservation, Ecology, and Traditional Knowledge

Our team longs for any and every opportunity to be in the wilderness so as to explore its diversity and learn from it varied facets. We characterize biodiversity, document traditional knowledge systems, prepare plant databases, and maintain repositories. This year was special, we were privileged to have Dr. Shekar C. Mande, DG CSIR, accompanying us in one of our plant surveys. In addition to enriching herbarium, estimating plant populations, and analyzing altitudinal patterns of species diversity; we documented ecosystem services and resource use by indigenous communities of Kangra and Chamba districts of Himachal Pradesh (HP). Brief of the activities carried out during the year is provided below.

Field Surveys and specimen enrichment: We conducted 18 surveys to the hinterlands of HP for sampling diversity and documenting use patterns The highlight was accessioning specimens of 38 species belonging to 18 families that were collected by the DG CSIR (Fig. 1&2). Digitization of all the specimens has also been accomplished.

Fig. 1 Plant exploration survey in the lesser Himalaya

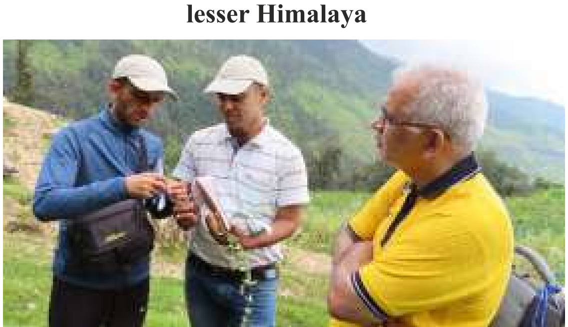


Fig. 2 Specimen collection and information recording

Sampling plant populations: Sampling of medicinal plants was carried out using 350 quadrats in the alpine areas of HP. Medicinal plants richness was highest (n=13) in the "gaps within shrubs" habitat while based on rapid assessment *Aconitum heterophyllum* was revealed to be the most vulnerable species. Rampant extraction of medicinal plants for trade is a major conservation issue.

Altitudinal patterns of species diversity: Vegetation patterns and turnover in plant communities along a vertical gradient of 2000 to 4000 m in the Dhauladhar Mountains was analyzed. This was done by marking 20 × 20 m plots (n=21) at every 100 m rise in elevation. An inverted hump-shaped pattern for evenness, a unimodal hump-shaped pattern for Shannon index and β-Whittaker diversity, and a mild-hump-shaped pattern for Simpson index across the gradient was observed. It is largely attributed to the ecotonic nature of mid-altitudes. A total of 255 plant species representing 47 families were identified from the plots (Fig. 3).

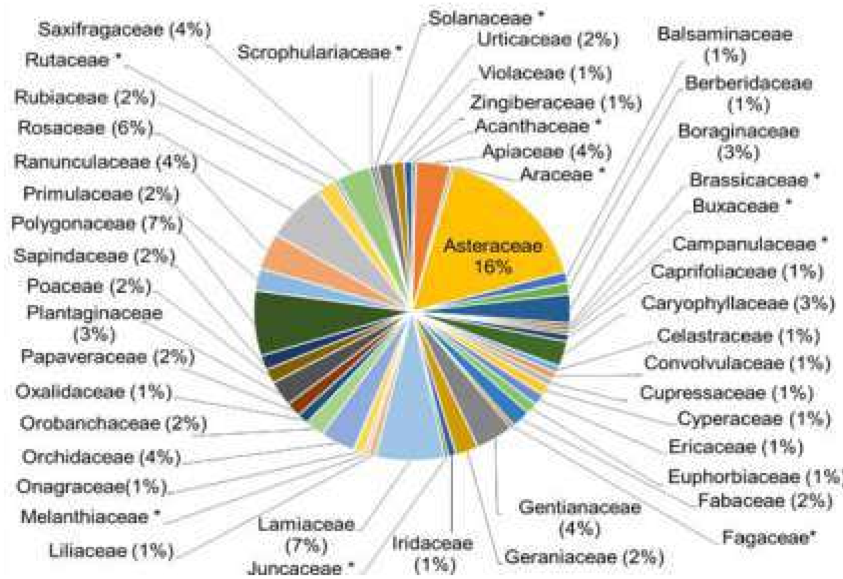


Fig. 3 Percentage of species in different families. Family name with * indicates that it was represented by only one species (Source: Science of The Total Environment. 716).

Traditional knowledge and practices: Perception documentation and recordings from the Chhota Bhangal, Kangra (n=430 households) led to identification of 11 climate change indicators. "Decrease in precipitation" was the most reported (~97%) indicator. The respondents' perceptions were in agreement with the available temperature and rainfall data of the area for the past three decades.

On the other hand, indigenous people of Churah, Chamba were found to use 78 plant species for curing 13 ailments. Of the total species, highest were used for curing dermatological problems (42 species) followed by respiratory problems (20 species) and digestive problems (19 species). Lesser known therapeutic uses of 21 plant species were noted (Fig. 4).

Fig. 4 Recording traditional knowledge and practices

Environmental Monitoring: Degrading air quality is a major environmental issue. We therefore carried out air quality monitoring in Palampur. The average concentration of PM1.0, PM2.5 and PM10 was recorded to be 11.39 ± 2.50, 28.98± 4.37 and 0.50± 0.05 ug/m^3, respectively. The mean concentration of trace gases, CO (0.50± 0.05 mg/m^3), SO2 (7.14±0.86 ug/m^3), NO_2 (35.32± 15.72 ug/m^3) and O_3 (70.25± 16.01 ug/m^3) was also analyzed. Highest concentration of particulate matter and trace gases were recorded during the post-monsoon season.

Database creation: In a coordinated effort, information on 300 wild edible plants of Himalaya was collected from secondary sources. Data was digitized as per the standard format of Indian Bioresource Information Network that includes data fields namely taxonomy, distribution, habit, habitat, uses, part(s) used, and mode of use.

Conservation & Awareness: Conservation and awareness programmes were carried out in three schools located in the vicinity of Palampur. Presentations on biodiversity loss and environmental challenges were given in local dialect and a total of ~200 students (class 8-12) were involved in evaluating nature relatedness (Fig. 5).

Fig. 5 Imparting conservation education at schools

Amit Kumar, Senior Principal Scientist
amitkr@ihbt.res.in
Geospatial Mapping

My group is involved in 'nextGen' multispectral, hyperspectral and LiDAR remote sensing for Himalayan forests as well as commercially important medicinal and aromatic crops using drone and terrestrial platform. We are also undertaking climate change studies to understand alpine ecotone structure and function through space and *in-situ* observations. We are extensively utilizing ecological niche modelling to know the suitable habitat of RET: species for their conservation and to introduce the commercially important crops in new non-traditional regions.

Recording of Hyperspectral signatures of Himalayan flora

Spectral library of 10 medicinal plants under cultivation in Himachal Pradesh and Uttarakhand was prepared by recording the spectral signatures of the plants by using handheld spectroradiomter in field (Fig. 1) from 43 locations. The details of plants and their respective locations are- *Aconitum heterophyllum* (4 locations), *Asparagus racemosus* (3 locations), *Bergenia ciliata* (1 location), *Dactylorhiza hatagirea* (1 location), *Picrorhiza kurrooa* (5 locations), *Rheum australe* (1 location), *Rauvolfia serpentina* (1 location), *Saussurea costus* (13 locations), *Sinpodophyllum hexandrum* (3 locations), and *Valeriana jatamansi* (11 locations). The spectral library thus developed is being analyzed for non-destructive and onsite estimation of age, root weight and growth quality of these medicinal plants.

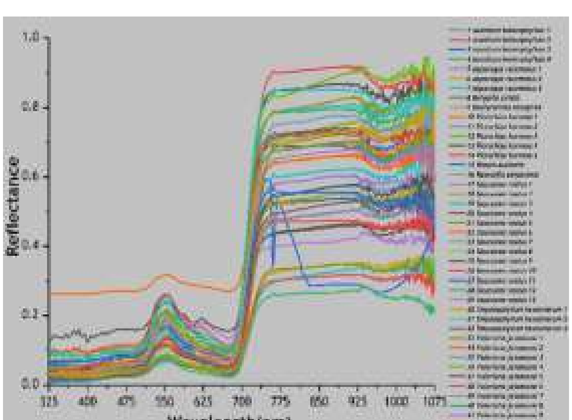


Fig. 1 Spectral Library of medicinal plants in cultivation

Climate change studies

Long term ecological monitoring plots (trees: 07 of 20x20m; shrubs: 14 of 5x5 m; herbs: 68 of 1x1 m) were established in alpine and tree line ecotone at Chansal pass, Rohru, Shimla district, Himachal Pradesh (Fig. 2) as per Global Observation Research Initiative in Alpine Environments (GLORIA) protocols for climate change studies in collaboration with Space Applications Centre (SAC), ISRO, Ahmedabad.

Fig. 2 Long term ecological monitoring plots at Chansal pass, Himachal Pradesh

The study will help in understanding the alpine ecotone structure and function through space based and *in-situ* observations.

Ecological Niche Modelling of threatened medicinal plants

Ecological Niche Modelling for identifying niche habitats of *Picrorhiza kurroa*, a threatened medicinal plant species in western Himalaya, was carried out (Fig. 3). Of the total area, 11.56 % area was found as a niche habitat for *P. kurroa* (Ladakh= 1.30%, J&K = 4.75%, H.P. = 3.88% and UK = 1.63%). *In-situ* plantations in these identified niches will help in its conservation and management.

Fig. 3 Modelled niche habitat of *Picrorhiza kurroa* in western Himalaya

Drone based remote sensing

In a pioneer effort, protocols for drone data acquisition, processing and analyses for *Rosa damascena* (a commercial crop of mountainous region) were achieved (Fig. 4) leading to its automated plant counting, plant height calculation, and very high resolution land use mapping with just a brisk survey through drone. The manual counting of flowers was done in 5.94 hrs while the automated counting with the help of drone images took 30 minutes for $4363\ m^2$ area and 2002 plants. The canopy height modelling provided height of each plant for biomass and crop growth studies. The land use map was produced at a scale of 1:500 with ground sampling distance of 2 cm at 40 m altitude.

Fig. 4 Drone image acquisition for *Rosa damascena* plot using Mica Sense Altum multispectral camera

LiDAR based remote sensing

The standard protocol for LiDAR data acquisition in field was developed. LiDAR 3-dimensional point clouds were acquired from *Rosa damascena* experimental farm at Chandpur, CSIR-IHBT. The 3-dimensional data of *R. damascena* was derived from above LiDAR data (Fig. 5). It will help in rapid and geo-tagged measurements of physical attributes (such as number, height, canopy cover, Leaf Area Index) of each plant.

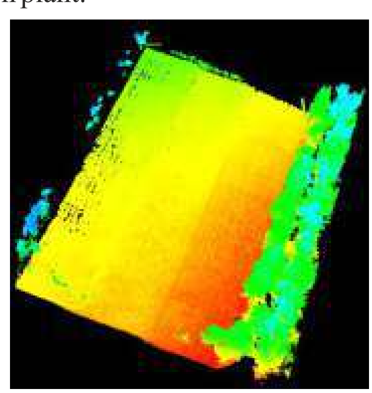


Fig. 5 3-dimensional view of *Rosa damascena* plot derived from LiDAR point clouds

Research Group (Left to Right) : Meenakshi, Mamta Devi, Sonam Bahuguna, Shivani, Shikha Rana, Shambhvi, Shubham Anchal, Kishor C Kandpal, Amit Kumar and Sunil Kumar

Amit Chawla, Senior Scientist
amitchawla@ihbt.res.in
Ecology

(I) Functional Characterization of High Altitude Vegetation

(a) Functional trait variability studies

Plant functional traits (PFT's) vary across ecological scales (spatio-temporal and organisational) and range from 'within individuals' to 'across communities'. We studied patterns to understand the casual mechanisms of functional trait variation for high altitude vegetation. Variance in key functional traits was partitioned across nested ecological scales using a linear model with nested and crossed factors. For all the traits studied, the 'intra-specific trait variation' was found to be low as compared to inter-specific variation. Our study could be helpful in determining the factors shaping distribution and function of high altitude plant communities.

(b) Reliability of key leaf functional traits after delayed measurements

When handling a large number of samples for functional traits assessment which are obtained from remote locations, processing delays are difficult to avoid. Keeping this in view, we studied the effect of delayed measurements of key functional traits *viz*., Leaf area (LA), Specific Leaf Area (SLA), Leaf Dry Matter Content (LDMC) and Leaf Rehydration, on a set of 25 high altitude species representing different functional types. Our results suggested some key generalizations: (i) for samples stored in dark at 4°C, LA, SLA and LDMC can reliably be estimated after a delay of up to 7 days; (ii) these key leaf traits should be estimated after 24h of mandatory rehydration; (iii) trait measurements after prolonged rehydration of leaves should be avoided.

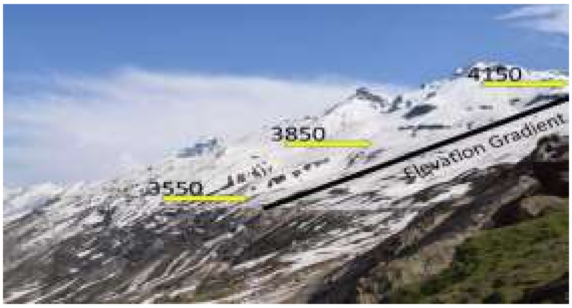
(II) Studying Impact of Climate Change on Treeline and Alpine plants

(a) Monitoring of timberline forests The nutrient cycling study was undertaken in our previously established Long Term Ecological Research (LTER) Plots.

We have studied decomposition of *Betula utilis* leaf litter at three distantly located LTER sites in Western Himalaya. We found that leaf litter decomposition process was slow and after 5 years of incubation, the mass loss was reduced to ~ 52% of the initial mass. Further, the decay rate declined with incubation time. The slow process helps release of key nutrients at later stages that help in nutrientThe decay rate for ligno-cellulose contents and nutrient release pattern was also studied.

(b) Monitoring of alpine vegetation

A series of LTER plots were established along an elevation gradient at Rohtang (32°22' N 77°16' E). The dominant alpine species are being monitored for assessing the changes in vegetative and reproductive traits including the phenology. In addition, we also investigated the role of alpine dwarf shrubs in habitat modification which influences functional response of herbaceous communities.



(III) Adaptation Strategies of High Altitude Plants

Eco-physiological and anatomical traits were studied for the leaves of *R. anthopogon* an alpine woody evergreen dwarf shrub at Rohtang. Field sampling was undertaken at ten different time-points spanning a period of one year to gain insight into their potential adaptive significance to tolerate low temperatures. Our results indicated a higher temporal variability in all the eco-physiological traits, and relatively high plasticity index (PI) for a few biochemical traits (e.g. soluble sugars), whereas, anatomical traits were found to be relatively consistent with low PI. It is inferred that species need to modulate their traits (e.g. low SLA and increased soluble sugars) which will increase their fitness (e.g. leaf toughness and lowering the freezing point) to survive low temperature conditions.

(IV) Conservation of threatened medicinal plants

The trade chain and trade patterns of 15 threatened medicinal plants of high altitude Himalaya were studied. Field surveys and interviews with local medicinal plant collectors were undertaken; as well as the herbal market of Amritsar (Majith Mandi) and Delhi (Khari Baoli) were surveyed. The market chain of medicinal plants extracted from high altitude areas of Himachal Pradesh was elucidated for the key species.

Further, a field genebank was established at CSIR-Centre for High Altitude Biology for four threatened medicinal plant species *viz.*, *Dactylorhiza hatagirea*, *Nardostachys jatamansi*, *Aconitum heterophyllum* and *Arnebia euchroma*.

1st Row (L to R): Dinesh Thakur, Amit Chawla, Elennie Hopak, Nikita Rathore

2nd Row (L to R): Nandita Mehta, Dipika Verma, Kumari Sita, Diksha

3rd Row (L to R): Neeraj Kumar, Anupam Bhatt, Rahul Kumar, Lakhbeer Singh, Manish Sharma, Vaneet Kumar.

Ashok Singh, Scientist
ashoksingh@ihbt.res.in
Plant Ecology

My team focusses on ecological studies for generating qualitative and quantitative data on threatened and economically important plant species of the Himalayan region. We are also involved in maintaining conservatries at the *Centre for High Altitude Biology* (CeHAB), Ribling, Lahaul-Spiti (HP).

- **Ecological studies:**
- Ecological studies on rare, endangered and threatened (RET) plants like *Sinopodophyllum hexandrum, Picrorhiza kurrooa, Trillium govanianum, Aconitum heterophyllum, Fritillaria roylei, Rheum australe, Hippophae rhamnoides* sub sp. *turkestanica, Hippophae salicifolia, Carum carvi, Arnebia euchroma, Angelica glauca, Artemissia maritima, etc.* were carried out in the North- Western Himalaya, India.
- Quadrat based sampling was carried out in Lahaul-Spiti (Hikkim, Chicham, Kibber, Qyang), Kullu Bathad (Ranipani), Chamba (Bharmour, Pangi, Kugti, Ranikot, Holi, Sissu, Rarik, Guwadi, Gramphu), Mandi (Kamrunaag), Kangra, Sirmaur, Shimla (Shillaru).

District wise surveyed wild populations	Plant height (cm)	Root length (cm)	No. of leaves	Avg. density (100 m^2)
Angelica glauca				
Lahaul-Spiti	157±20	21±8	54±6	35±10
Kullu	105±11	15±6	46±6	50±20
Chamba	68±8	13±4	37±3	55±10
Arnebia euchroma				
Lahaul-Spiti	27±7	15±4	52±13	65±20
Carum carvi				
Lahaul-Spiti	38±10	15±5	35±10	32±10

- **Ex-Situ Conservation of plants in the Conservatries (Field Gene-banks and Herbal garden):** Accessions of the targeted plant species were collected and conserved in the conservatries at CeHAB Ribling, Lahaul-Spiti, (3450m AMSL) and Mohani-Banjar Panchayat Kullu (2065 m AMSL). The conservatories cover an area of ~2.4 ha
- ***Sinopodophyllum hexandrum:*** Conserved 33 accessions, 1685 plants and 5.48 Kg seeds were collected from different habitats in the field gene-bank. A total of 1000 Sq.m area was covered under conservation.

- ***Aconitum heterophyllum*:** Conserved 12 accessions and 8820 plants in the field gene-bank at CeHAB Ribling, Lahaul-Spiti. Further, harvested 5.5 kg seeds from the CeHAB nursery. A total of 3000 sq. m area covered under conservation.

- ***Picrorhiza kurrooa***: Conserved and successfully raised 20000 plants from the 5 accessions collected from Chamba, Lahaul-Spiti in the field gene-bank at CeHAB. A total of 1200 Sq. m area covered under conservation.

- ***Angelica glauca*****:** Conserved 11 different accessions and 725 plants in the field gene-bank at CeHAB. A total of 200 S.qm area covered under conservation.
- ***Carum Carvi*****:** Conserved 5 accessions of *Carum carvi*. Also, harvested 5 Kg seeds from the nursery at CeHAB Ribling, Lahaul-Spiti (HP). A total of 800 S.qm area covered under the conservation.
- ***Arnebia euchroma*****:** Conserved 7 different accessions and 410 plants in the CeHAB field-gene bank. A total of 300 Sqm area covered under conservation.

- ***Fritillaria roylei:*** Conserved 14 accessions, 710 bulbs & plants in the field gene-bank at CeHAB Ribling, Lahaul-Spiti (HP) and Mohani Panchayat Banjar in Kullu (HP).
- ***Rheum australe:*** Conserved 14 accessions, 1 Kg seeds and 400 nursery raised plants in the field gene-bank at Mohani-Banjar (2065 m AMSL) and CeHAB Ribling (3450 m AMSL).
- ***Trillium govanianum***: Conserved 12 accessions, 350 plants at field gene-bank of CeHAB Ribling, Lahaul-Spiti (HP).
- **Hippophae Germplasm banks:** National Seabuckthorn germplasm resource centre at CeHAB Ribling was strengthened. To meet the raw material requirements, fruits samples of Seabuckthorn (50Kgs), seeds (48Kgs), and leaves (44 Kgs) from various locations in the Lahaul-Spiti area were collected for multi-institutional partners.
- **Herbal garden at CeHAB Ribling, Lahaul-Spiti H.P.:** A total of 40 species of medicinal & aromatic plants including 18 RET plants and 12 native/endemic were conserved.
- **Mass-multiplication of RET plants:** *Saussurea costus* (20000 plants in area 0.3ha);

Valeriana jatamansi (7000 plants in 0.1ha); *Inula racemosa* (15000 plants in 0.2ha); were multiplied at the Centre for High Altitude Biology Ribling, Lahaul-Spiti (H.P.).

- **Selected elite accessions:** Elite accession of *Aconitum heterophyllum* from Shansha; *Arnebia euchroma* from Spiti valley; *Carum*

carvi from Sissu in Lahaul; *Angelica glauca* from Naingar in Lahaul, *Sinopodophyllum hexandrum* from Hinsa in Lahaul, *Picrorhiza kurrooa* from Hadsar-Manimahesh area *etc.* were selected on the basis of their physical appearances.

- **Technology demonstrated:** Medicinal plant cultivation technologies for *Aconitum heterophyllum, Saussurea costus, Sinopodophyllum hexandrum, Rheum australe, Rheum australe, Fritillaria roylei* and *Fagopyrum tataricum*, were demonstrated in the farmers' field (>60 farmers).
- A total of 5820 plants and 2.0 Kg seeds (*Aconitum heterophyllum, Fritillaria roylei*, *Sinopodophyllum hexandrum* and *Rheum australe)* were successfully conserved at Mohani Panchayat, Banjar, Kullu
- At CeHAB, extracted virgin aromatic oil (4 litres) of *Artemissia maritima* with the help of progressive farmers from the Shansha and Udaipur Panchayat, Lahaul-Spiti (HP)
- Fresh Snow-water harvesting technology demonstrated to the IPH department Keylong (Lahaul-Spiti) and visitor from the Leh-Laddakh Union-territory area
- **New farm area Development:** ~2ha area developed at Centre for High Altitude Biology Ribling Lahaul-Spiti HP.
- Expanded the capacities of Snow water harvesting technologies for water collection.

Research Group : (Front row Left to Right): Mr. Narender Kumar, Dr. Ashok Singh, Mr. Anuj Kaushal,
(Back row Left to Right): Mr. Rajat Bhardwaj, Mr. Umesh Thakur, Mr. Gaurav Katoch, Ms. Kanika Kiran

•

Vikas Kumar, Scientist
vikas@ihbt.res.in
Herbarium and Plant Taxonomy

My research focusses on Himalayan biodiversity, plant systematics, collection of specimens, their characterization and documentation. I am also involved in *ex-situ* conservatories and maintaining plant repositories.

Taxonomic studies of Himalayan plants: Presently, we are involved in taxonomic characterization along with their economic utility of trees found in Himachal Pradesh. Moreover, we are also solving taxonomic ambiguity of taxa found in the Himalaya region (Fig. 1&2).

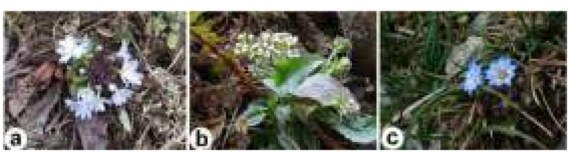


Fig. 1 Species recently collected for herbarium from Kangra district of H.P. a. *Primula denticulata* b. *Valeriana jatamansi* c. *Gentiana argentea*

Fig. 2 Tree species collected from Palampur a. *Litsea monopetala* b. *Murraya koenigii* c. *Ehretia acuminata*

Updation of Herbarium and Museum: The Institute maintains an internationally recognized herbarium (PLP). Updated scientific names of ~150 botanical specimens housed at PLP. Besides, systematic arrangement of samples at IHBT museum and their proper naming, enriching the museum with new collections was also done (Fig. 3 a & b).

Ex-situ conservation: The tubers of Amarkand (*Eulophia specatabilis* (Dennst.) Suresh) sourced from Amarkantak, Madhya Pradesh was planted for *ex-situ* conservation in IHBT, Palampur. It is an ayurvedic medicinal herb and the tuber of this species is used as an anthelmintic, bronchitis, antidote for snake bike and spider bite. Besides this, the tuber is also used for to enhance vigor and in treatment of rheumatoid arthritis (Fig. 3 c).

Fig. 3 a & b. Botanical specimens and handicraft item housed at IHBT Museum; c. tuber of *Eulophia spectabilis*

Planning, Project Monitoring and Evaluation/ Business Development and Marketing Unit

PLANNING PROJECT MONITORING & EVALUATION

Institutional Research Planning

Facilitated formulation of documents sent to CSIR Headquarters viz., major achievements of CSIR-IHBT during the last 5 years (2014-15 to 2018-19), Action Taken Report on monthly meeting of DG CSIR with the Directors and selected staff, Information on women specific initiatives, Report of relief efforts carried out by the institute in Orissa, pending issue with different states, Institute's interventions on agricultural improvement and in North East Region, etc. and action taken towards achievement of goals were regularly furnished to the competent authority.

For constant updating of institutional data on various domain 34 programme were uploaded on to C-DIS portal during 2019-20. PPME recorded initiation of 23 new projects funded by various agencies (DBT, DST etc.). As a part of routine activity, carried out updation and maintenance of databases pertaining to project, staff, paper, patent, ECF, resource management etc. To facilitate decision making, carried out monitoring of Institutional performance with respect to publication, ECF, patent, technology transfer and societal impact. Compiled Institutional information for CSIR Annual Report. Conducted 58th and 59th Meeting of Research Council of CSIR-IHBT, Palampur on 10-11th September 2019 and 12-13th March 2020, respectively at Palampur and supported in follow-up actions. Furnished inputs to 48 Parliament questions received form CSIR. In addition to above, following events of national importance were also organized:

- National Technology Day
- CSIR Foundation Day Celebrations
- CSIR-IHBT Foundation Day
- Constitution Day
- National Science Day
- Visit of Hon'ble Governor of Himachal Pradesh, Shri Bandaru Dattatraya to CSIR-IHBT Palampur on March 3, 2020

Resource planning and monitoring: Facilitated in the fund allocation and expenditure as per the need and mandate of the Institute. Coordinated meetings to plan new infrastructures and equipments. To cater to manpower need of the Institute, appropriate steps were taken to seek approvals and induct new manpower.

IT based activities: Information related to Institute's activities were promptly posted in social media (facebook, tweeter, youtube etc.). Information were regularly updated and flashed in intranet. Through in house efforts, developed a website for Nayudamma Memorial Cricket Tournament-2019 hosted by CSIR-IHBT, Palampur during October 21-24, 2019. Also, an Online Rolling Advertisement system to engage of SRF/JRF/Project Staff has been deployed.

Right to Information: Furnished information on 59 queries under RTI Act and filed quarterly report to RTI portal www.rti.gov.in.

Rakesh Kumar Sud, **Senior Principal Scientist and Head**
rksud@ihbt.res.in
Agrotechnology, Advisory and Extension,
Planning, Project Monitoring and Evaluation

Our major research and development activities include standardization and extension of agrotechnologies of tea and other commercially important crops. Our group played a key role in revival of Kangra tea industry by bringing it back from oblivion, development of abandoned and neglected tea plantations and extending tea in non-traditional areas in Himachal Pradesh and Uttarakhand. For improving profitability of tea plantations and addressing issue of shortage of tea farm workers, popularisation of tea farm mechanization is being done.

Currently, the group managing resource planning and project monitoring, IT based activities, addressing parliament questions, conducting meeting of Research Council of the Institute, organising events of national importance viz, National Science Day, National Technology Day, CSIR Foundation Day, Institute's Foundation Day, visits of VIPs etc. In addition, we are connecting the Institute with the society through press & media, and handling social sites.

1. Mechanization of tea harvesting with different levels of fertilizer application : The trial was conducted on China hybrid in Experimental Tea Farm of the Institute to assess the four plucking methods, i.e. one man plucking machine, two men plucking machine, hand shear, and manual plucking. This trial was performed in association with three fertilizer levels of Nitrogen, Phosphorus and Potash, i.e. F1 (90:90:90::N:P2O5:K2O kg/ha), F2 (120:90:120::N:P2O5:K2O kg/ha) and F3 (180:90:180::N:P2O5:K2O kg/ha) to study the effect on green leaf yield and fineness of the harvest. The results showed that across the different fertilizers, the mechanical methods of plucking had a slightly higher yield than hand plucking. Across different methods of plucking, the fertilizer level 120:90:120 (F2) showed the highest yield than the other combinations (Table 1). The 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 fineness of leaf decreased gradually. Fertilizer level 90:90:90 showed the highest value of leaf grade than the other combinations. (Table 2).

Table 1. Effect of plucking methods and fertilizer levels on green leaf yield (kg/ha)

Methods of Plucking	Fertilizer levels			
	90:90:90	120:90:120	180:90:180	Mean
Hand Plucking	6,060	9,300	8,340	7,900
Shear Plucking	7,860	10,140	8,880	8,960
One man plucking M/c	7,800	9,900	8,940	8,880
Two men plucking M/c	7,800	9,600	8,520	8,640

LSD	Methods of Plucking	Fertilizer levels	Interaction
	378	330	654

Table 2. Effect of plucking methods and fertilizer levels on leaf grade (Fineness of leaf)

Methods of Plucking	Fertilizer levels (N: P_2O_5: K_2O, kg/ ha)			
	90:90:90	120:90:120	180:90:180	Mean
Hand Plucking	72.69	69.04	67.10	69.61
Shear Plucking	54.72	50.61	49.69	51.67
One man plucking M/c	50.15	45.79	44.64	46.86
Two men plucking M/c	49.49	45.37	43.73	46.20

LSD	Methods of Plucking	Fertilizer levels	Interaction
	0.45	0.39	NS

2. Mechanized tea plucking using battery operated machine: A battery-operated plucking machine "Microlite Harvester" (weight ~2.4 kg, single man operated, battery operable for 4 hours when fully charged), marketed by a Chennai based company, M/s Ignition Products India Pvt Ltd (Fig. 1), was also experimented during this year. The performance of the machine under China hybrid tea plantation at Kangra conditions is described below.

Table 3. Details of leaf harvested using battery operated tea plucking machine

Description of cost componant	Detail
Use of machine / day (hrs.)	6.00
Depreciation cost of machine (Cost Rs 13,300; life 3000 working hrs) (Rs.)	4.43
Cost of manpower @ Rs. 279.84 for 1 person (Rs.)	279.84
Cost of charging (1 unit) @ Rs. 5.50/unit (Rs.)	5.50
Repair and maintenance @ 40% of charging cost (Rs.)	2.20
Total cost (Rs.)	291.97
Leaf plucked (Kg)	70.00
Unit cost of plucked leaf (Rs.)	4.17

The unit cost of plucking was Rs. 4.17 against Rs. 12.00 with hand plucking.

Fig. 1 Battery operated plucking machine "Microlite Harvester"

3. Demonstration of Skiffing Machines

Seven field demonstration on mechanized skiffing were held in different tea gardens of the small tea growers, as detailed below (Table 4 & Fig. 2).

Table 4. Field demonstration on mechanized skiffing in the growers field

S. No.	Demonstration Location	District	Beneficiary Tea Planter	No. of tea bushes covered
1	Paprola	Kangra	Abhimanyun Katoch	4,000
2	Chauntra	Mandi	Anil Thakur	4,000
3	Dehluhar	Mandi	Chander Paul	3,500
4	Band Vihar	Kangra	Prem Vyas	3,000
5	Mowli Chak	Kangra	Parshotam Vedwa	3,000
6	Sulah	Kangra	Mahender Sanotri	3,500
7	Chambi, Rakh	Kangra	Somnath	4,000

Fig. 2 Demonstration of tea skiffing machines

4. Special demonstration of advanced tea farm machinery cum training & educating programme

A program on demonstration of advanced tea farm machinery cum training and educating tea growers' was held at the institute's experimental farm where M/s Stihl India Mobile was invited to demonstrate the range of farm machines and tools suitable for tea farm operations under Himachal Pradesh conditions. Various latest machines for tilling, pruning, skiffing, pit making, weeding, spraying, tree lopping, and other intercultural operations were demonstrated in a one go on October 19, 2019 (Fig. 3).

Fig. 3 Exhibition on various types of tea machines arranged in Institute's Experimental Tea Farm

5. Field Demonstrations on improved tea agro-technologies and advisory services

Details of the demonstration held and advisory visits made have been shown below:

Date	Area visited	Purpose
10/04/2019	Khilpat tea estate, Sulah tea estate, Saloh tea estate, Sungal tea estate, Thandol tea estate	Demonstration of plucking machine
14/05/2019	Thandol, Sulah, Saloh	Advisory on young tea maintenance & tea farm mechanization
16/05/2019	Chauntra	--do--
17/05/2019	Paprola, Langu area	Advisory on young tea maintenance and Integrated Nutrient Management, Integrated Pest Management & tea farm mechanization
22/05/2019	Thandol & Bhawarna area	Demonstration of power spray
06/06/2019	Khalate tea estate, Raipur tea estate, Sulah tea estate, Sungal tea estate, Bhadal tea estate, Thandol tea estate	Training and demonstration of plucking machines
19/07/2019	Paprola, Chauntra, Deluhar, Jogindernagar area (Mandi)	Advisory visit for shade regulation and drainage & tea farm mechanization
24/07/2019	Dharamshala Tea Company and Hudal tea estate	Demonstration of tea plucking machine
09/08/2019	Gugga, Saloh , Sulah	Advisory visit on IPM and drainage & tea farm mechanization
23/08/2019	Paprola, Langu Sakri, Samlotu	Demonstration of mechanized spray pump
28/08/2019	Thandol, Khalet	Infilling of tea plants in the demonstration plot & tea farm mechanization
19/09/2019	Paprola, Langu Sakri	Tea farm mechanization
10/10/2019	Baijnath tea estate, Langoo Sakri area	Attended Tea Board meeting and promotion of tea farm mechanization
11/10/2019	Baijnath & Samlotu area	---do--
14/10/2019	Saloh tea estate, Thandol tea estate	Advisory and winter work demonstration & tea farm mechanization
16/10/2019	Chauntra region, Mandi	Promotion of tea farm mechanization
01/11/2019	Thandol , Sulah	Advisory visit for winter farm operations & tea farm mechanization
02/11/2019	The Palampur Cooperative Tea Factory limited	Tea Planters' Association Meeting and promotion of tea farm mechanization

Date	Area visited	Purpose
04/11/2019	Thandol , Maserna	Winter work demonstration & tea farm mechanization
05/11/2019	Deluhar, Mandi	Demonstration of tea skiffing machine
06/11/2019	Chauntra, Mandi	--do--
11/11/2019	Patti, Salyana, Band Bihar	--do--
13/11/2019	Mowli Chak, Sulah	--do--
19/11/2019	Paprola area	--do--
20/11/2019	Sungal tea estate, Thandol tea estate	Machine pruning and skiffing demonstration
25/11/2019	Chambi tea estate	Demonstration of tea skiffing machine
02/12/2019	The Palampur Cooperative Tea Factory limited	Tea Planters Association meeting and promotion of tea farm mechanization
04/12/2019	Thandol tea estate, Bhadal Devi tea estate, Sulah tea estate	Advisory visit for winter tea operation & tea farm mechanization
05/12/2019	Chauntra tea estate, Rakh area, Kangra valley tea estate, Sidhbari tea estate	Advisory visit for winter tea operation & tea farm mechanization
05/12/2019	Gopalpur area	Demonstration of tea skiffing machine
09/12/2019	Rakh, Nagri area	--do--
11/12/2019	Sungal, Langu area	--do--
27/12/2019	Chambi, Bahli, Kangra Valley, Pathiar area	Pruning program and demonstration of mechanical pruning and skiffing

Aparna Maitra Pati, Senior Principal Scientist
aparna@ihbt.res.in
Microbiology

My group is mainly working on bioformulations. Attempts were made to isolate bacteria and arbuscular mycorrhizal fungi harboring rhizosphere, assessing their plant growth promoting potential and their impact on target plants. The phylogenetic analysis of promising bacteria and their genes of interest will be carried out. Further, technology for the production of microbes in bioreactor is also being standardized for transfer of technologies.

Multiplication of Arbuscular Mycorrhizal Fungi

Arbuscular Mycorrhizal Fungi associated with tea were multiplied in maize as host in pots under greenhouse conditions for 120 days. Abundant coilings were noticed after 40 days of inoculation. Active arbuscules were observed after 55 days, and numerous vesicles filled the roots by 75th day (Fig. 1). By 90 days after inoculation, extensive extramatrical hyphae and spores were noticed (Fig. 2).

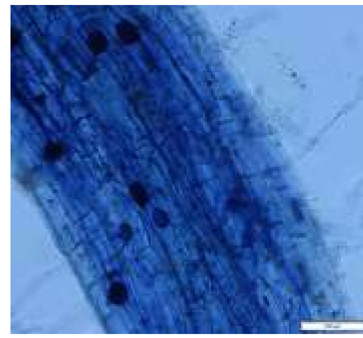


Fig. 1 Vesicles

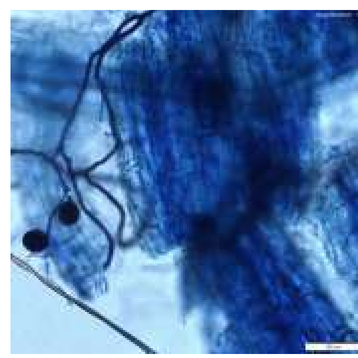


Fig. 2 Spores

Saffron Associated PGPR

Bacteria associated with the rhizosphere of saffron grown in Patti area of Kangra district (H.P.) were isolated and pure cultures were maintained in Tryptone Soya Agar. Three dominant strains were screened for plant growth promoting attributes. Out of the three, two strains showed promising growth-promoting attributes including phosphate solubilisation (Fig. 3), production of indole-3-acetic acid (IAA), siderophore and 1-aminocyclopropane-1-carboxylic acid (ACC) deaminase. Interestingly, one of the strains showed luxuriant growth even in temperature above 50^{o}C. Bioformulations of these two strains were developed using bamboo charcoal (produced at CSIR-IHBT, Palampur) as an effective carrier. Further, field trials of saffron were laid to assess the effectiveness of bioformulation. Conventionally grown and micropropagated corms of saffron were treated with the targeted bioformulation (Fig.4) and trials were laid in farmers field at Patti (Fig.5). Observations will be recorded at the time of harvest during June- July 2020.

Fig. 3 Phosphate solubilisation

Fig. 4 Treated corms

Fig. 5 Planting of corms

Evaluation of PGPR on Stevia

Impact of Plant Growth Promoting Rhizobacteria (PGPRs) viz. IHB B745 (*Pseudomonas trivialis*); IHB B13662 (*Bacillus aryabhattai*); and IHB B13662 (*Bacillus aryabhattai*) + FYM were assessed in stevia (*Stevia rebaudiana*) in polyhouse at CSIR- IHBT (Table1). Thirty days old stevia seedlings were procured from Chandpur farm of CSIR-IHBT and roots were treated with bamboo charcoal-based PGPR bioformulations. Control plants were treated only with bamboo charcoal without PGPRs. Height of the plants was recorded every fifteen days and all the plants were harvested on 45th day after treatment. Results showed that bioformulation treated plants were significantly taller, and had higher fresh and dry weight (Fig. 6) compared to that of untreated controls. However, there was no significant difference between PGPRs on the impact of growth on stevia.

Table 1. treatment of Stevia saplings

S.NO	Treatments	Combinations
1	**Control 1**	Soil +Sand (1:1)
2	**T1**	Soil +Sand (1:1) +IHB B745 (*Pseudomonas trivialis*)
3	**T2**	Soil +Sand (1:1) +IHB B13662 (*Bacillus aryabhattai*)
4	**Control 2**	Soil +Sand+FYM *(1:1: 0.5)*
5	**T3**	IHB B13662 (*Bacillus aryabhattai*)) + Soil +Sand+*FYM (1:1:0.5)*

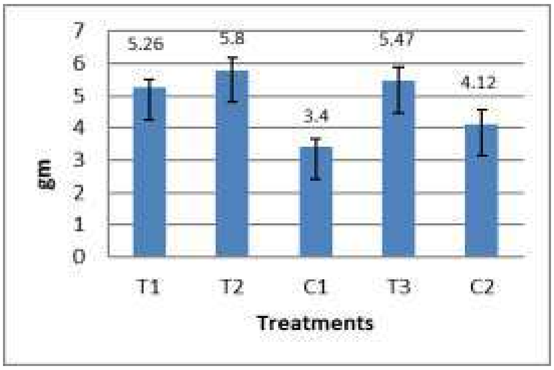


Fig. 6 Dry weight of stevia shoots

Evaluation of PGPR on pea

Impact of three PGPR bacterial strains viz. IHB B13602 (*Arthrobacter psychrochitiniphilus*), IHB B745 (*Pseudomonas trivialis*) and IHB B13662 (*Bacillus aryabhattai)* were evaluated in pea at Udaipur (district Lahaul- Spiti of H.P.). The pea seeds were treated with jaggery solution (5%) and targeted bioformulation (1:10) and dried for 4 hrs in shade prior to sowing (Fig. 7 & Table 2). The trial was laid in completely randomized block design as per following treatments.

Table 2. Layout of pea field

S.No	Treat-ment	Isolated strain	Details of PGPRs
1	T1	IHB B13602	IHB B13602 (*Arthrobacter psychrochitiniphilus*)
2	T2	IHB B745	IHB B745 (*Pseudomonas trivialis*)
3	T3	IHB B13662	IHB B13662 (*Bacillus aryabhattai)*
4	T4	T1 +T2 + T3	Consortium
5	T5	NPK (50%) + FYM	FYM (10 t/ha)
6	T6	NPK (100%)	As per recommended
7	T7	Charcoal + Jaggery	Control
8	T8	Farmers practices	As per farmer practice

The seeds were sown as per prevalent practice by farmers. The yield parameters were evaluated w.r.t pod length, number of pods per plant and number of seeds per pods three months after planting. Overall, application of NPK (100%) exhibited the best yield and *Bacillus aryabhattai* performed better compared to other two biofertilizers tested (Fig. 8).

Fig. 7 Treated pea seeds

Fig. 8 Pea seedlings after 2 months

Research Group: Dr. Aparna Maitra Pati, Ms Nilofer and Mr. Raj veer

BUSINESS DEVELOPMENT AND MARKETING UNIT (BDMU)

This Unit strives to convert high end R&D technologies into the business. BDMU is involved in economic and social impact analysis, organizing scientific & 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 of disseminating technologies and products to the society.

During 2019-20, BDMU facilitated signing of 100 agreements/MoUs including, thirteen technology transfers, twenty-five material transfer agreements (MTAs), two consultancy agreements for stevia cultivation, forty-six miscellaneous MoU's signed including thirty-three MoUs with different farmer societies, four MoUs for academic and R&D collaborations with government institutes/universities (SCVB Palampur, CIAB, Mohali, RPGMC, Tanda and CSKHPKV, Palampur), two need based agreements for R&D sponsored by companies (M/s Baijnath Pharmaceutical Pvt. Ltd., Paprola (H.P.) and SS Sujalam Suphalam Foundation, Gurgaon), one MoU with All Mizoram Farmers Unions for livelihood promotion in Mizoram state, one MoA with KVIC to release funds under MSME SFURTI scheme, One MoU with M/s Anodyne Bio Spargyric for formulation of Electro homeopathic Medicine and monk fruit cultivation and processing technology, one MoU with National Research Institute of Chinese Medicine (NRICM), Taiwan to improve understanding between their respective academic institutions and to establish mutually beneficial collaborations among their academicians, scientists and students, one agreement for 3rd party production with M/s. Mother India Organics and Naturals Pvt Ltd. for manufacturing of dehydrated Fruit bars, one agreement extended for facility use for production of stevia liquid drops, one MoU with M/s IoTechWorld Aviation Pvt. Ltd. to collaborate and leverage on each other's expertise and knowledge base sharing to DRONE based agriculture application in India. Fourteen MoU's signed for different innovation projects including 11 MoUs for startup under "Chief Minister's Start up Scheme" and three agreements for incubation and facility use of CSIR-IHBT. BDMU was also intensively involved in showcasing institute's technologies and products in various business meetings, trade fairs and exhibitions at regional as well as 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 MoU's 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 2019-20, CSIR-IHBT has signed thirteen agreements for transfer of technology i.e. (i) Large scale production of Shiitake mushroom with Mr. Satish Kumar Gill, Nadaun, Hamirpur (H.P.) (ii) Commercial production of Ready to Eat (RTE) foods free from additive and preservatives with M/s A Qube Inc., Ludhiana, Punjab (iii) Technology for commercial production of Tea Wines & RTD Tea with M/s Camelia Beverages Pvt. Ltd., New Delhi and (iv) Commercial production of Natural Soap with Mr. Sandeep Kumar and Company, Nadaun, Hamirpur (H.P.) & (v) Manufacturing/ processing of Spirulina based PRODUCTS with M/s Yujo Agriculture & Aquaculture Farm Society, Meerut (U.P.), (vi) Manufacturing/ production of Tissue culture plants (gerbera, potato, *Bambusa balcoa* sp.) with M/s Pratyaksha Agrotech Private Limited, Assam, (vii) Making herbal incense cones from temple offering flowers at Mata Bala Sundari Temple Trilokpur with Deputy Commissioner-cum-Commissioner Trilokpur Temple Trust, Sirmour (H.P.), (viii) Manufacturing/ processing of Multigrain Protien powder with The Unati cooperative Marketing- cum Processing Society Ltd., Talwara, Punjab, (ix) Manufacture Granola bars - (millet and cereals based) products with M/s Sirimiri Nutrition Food Products Pvt. Ltd., Bangalore, (x) Production of natural colours and herbal lipsticks from different natural sources with M/s Nano Tech Chemical Brothers Pvt. Ltd., Village Mangarh, Ludhiana, (xi) Making Herbal incense Cones and Herbal Soap with M/s A B Scientific Solutions, Palampur (H.P.), (xii) Technology for commercial production of hand sanitizer transferred to M/s AB Scientific Pvt. Ltd., Palampur (H.P.) and (xiii) M/s Sandeep & Company, Nadaun (H.P.).

Sukhjinder Singh, Senior Scientist
sukhjinder@ihbt.res.in
Transfer of Technologies, Business Development, Techno-economics, Promotion of technologies, Socio- economic Impact Evaluation

Transfer of Technologies: Meetings with the interested industries/ entrepreneurs/ startups/ farmers were carriedout to transfer the technologies. Drafted agreements as per mutually decided terms and conditions. Ten agreements were signed for the transfer of ten technologies, i.e. (i) Making of Herbal Soaps, (ii) Manufacturing/ processing of Spirulina based products, (iii) Manufacturing/ production of Tissue culture plants (gerbera, potato, bamboo balcoa sp.)., (iv) Technology for making herbal incense cones from temple offering flowers (two numbers), (v) Manufacturing/ processing of Multigrain Protein powder, (vi) Manufacture Granola bars (millet and cereals based) products, (vii) Production of natural colors, (viii) Production of herbal lipsticks from different natural sources and (ix) Production of hand sanitizers (two numbers).

Besides this, seventeen material transfer agreements; nineteen MoUs with farmer's societies for establishing distillation units; five agreements with startups; one International MoU with National Institute of Chinese Medicine (NRICM) Taiwan; four MoUs with Government Institutions (CIAB Mohali; CSK HPKV, Palampur; SCVB Govt College Palampur and RPGMC Tanda) for Academic and Collaborative R&D work; and five other miscellaneous. MoUs/ agreements (including agreements with KVIC and FMC under SFURTI scheme) were also signed. Details of agreements/ MoUs signed are provided in Rolled out Technologies.

Business Development: New clients (44 numbers) were added to the organization through ToT/MTA/Consultancy agreement and technical service. About 300 number of queries (related to tea-based technologies, hand sanitizer, herbal soap, medicinal and aromatic plants, floriculture, herbal incense cones, herbal lipstick, etc.) from new potential clients were also reverted through mail and telephone. Also focused on client retention; upsell and cross-sale of technologies to the customers; and customer satisfaction. BDMU is also selling the Institute's (R&D) products. Prepared Business Plan to transfer CSIR-IHBT's technologies and shared it to CSIR, Hqr (RPPBD). Prepared technology profile as per the format

Facilitating industry partners/ startups to market their CSIR-IHBT technology-based products. Two industry partners, and three startups launched their products (Natural soap, hand sanitizer, indoor plants, and aloe vera juices) in the market.

During the Covid-19 Pandemic (in the month of March 2020), we facilitated our Industry partners (two industries signed agreements for the transfer of hand sanitizer technology during March 2020) to start production of hand sanitizer and its market outreach.

Techno- economic feasibility evaluation of technologies: Evaluated the TRL (Technology Readiness Level) of technologies, and techno-economic feasibility/ cost of production of technologies (for tea wine, RTDs, natural colours, ready to eat foods, herbal incense cones, hand sanitizer, hydroponics) as this information is required during deal for transfer of technologies.

Promotion of technologies: Participated in seven national and international exhibitions/ trade fairs to represent CSIR-IHBT for the promotion of technologies and to develop linkages with the industries/ entrepreneurs/ farmers for the transfer of technologies. Drafted and floated expression of interest (EoI) on the Institute's website for inviting EoI from interested industries/ entrepreneurs/ startups.

Socio-economic Impact evaluation: Provided inputs (list of entrepreneurs, terms of references, established linkages of farmers with NPC to provide data to NPC) to National Productivity Council (NPC), New Delhi regarding third Party Socio-economic impact evaluation of Wild Marigold (*Tagetes minuta*). Also evaluated income and employment generation of the Institute's technologies (stevia, flower crops, medicinal and aromatic crops).

Registered Technology Transfer Professional (RTTP): Officially recognized as Registered Technology Transfer Professional (RTTP) by Alliance of Technology Transfer Professionals (ATTP). The Alliance of Technology Transfer Professionals (ATTP) is an alliance of fourteen knowledge and technology transfer associations. ATTP was formed in March 2010, and is registered as a not-for-profit company limited by guarantee in Scotland. ATTP's mission is to promote and maintain global standards in knowledge and technology transfer. ATTP does this via the Registered Technology Transfer Professional (RTTP) designation, the international professional standard for knowledge transfer, and commercialization practitioners working in universities, industry, and government labs.

Project Scientist, WOS-A
Inspire Faculty
CSIR-Pool Officers
SERB-National
Post Doctoral Fellow

Ajay Rana, Project Scientist
ajay21rana@gmail.com
Food and Nutraceuticals

Process optimization for up-scaled production of tea catechins and development of dosage forms/ formulations of catechins based products

Process optimization for up-scaled production (extraction and purification) of tea catechins (Fig. 1) with a batch capacity of 500 kg tea leaf processing under, BIRAC sponsored project entitled "Commercial-scale production of tea catechins from green tea leaves, development of formulation as Nutraceuticals and their human intervention studies" Phase – II, along with industry partner M/s Baijnath Pharmaceutical Pvt. Ltd. The seasonal batch variability on the yield and quality of tea catechins was also determined. Development of formulation and process optimization for preparation of tea catechins based products viz. capsules, catechins based premix, and ointment was performed.

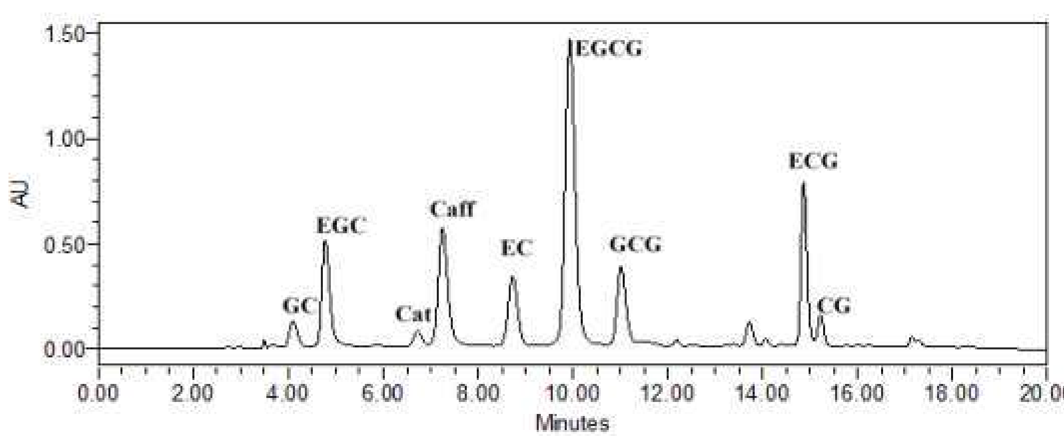


Fig. 1 HPLC profile of tea catechins from 500 kg batch

1. Development of tea-based hand sanitizer

Development of new formulation of alcohol-based hand sanitizer (Fig. 2) using tea constituents and aromatic oil. This hand sanitizer is free from parabens, triclosan and synthetic fragrance. For the preparation of this product, underutilized tea and tea plant parts were used as a source of active tea constituents. This formulation showed antibacterial activity against all the tested gram-positive bacteria (*Bacillus subtilis* MTCC 121, *Staphylococcus aureus* MTCC 96, *Micrococcus luteus* MTCC 2470) and gram-negative bacteria (*Salmonella typhi* MTCC 733, *Escherichia coli* MTCC 43, *Klebsiella pneumoniae* MTCC 109). This formulation was found to have enhanced antibacterial properties as compared to the WHO formulation due to the presence of tea constituents and essential oil.

Fig. 2 Tea based Hand Sanitizer

2. Development of tea-based vinegar

A tea vinegar was developed for value addition to tea. This fermented tea vinegar (Fig. 3) contains natural antioxidants and organic acids solely produced during fermentation. This beverage is very refreshing with incredible taste and contains a higher content of antioxidants compared to apple cider (Table 1). The experimental feeding of this beverage to mice fed with high-fat diet showed prevention in weight gain, lowering of serum triglycerides level, reduced fatty infiltrationin the liver and reduction in the size of adipocytes in the abdominal fat over time.

Fig. 3 Tea Vinegar

Table 1. Comparison of biochemical parameters of tea vinegar and apple cider

	pH	°Brix	Acidity g/L (AAE)	Phenolics mg/L (GAE)	Antioxidants mg/L (TE)
Tea Vinegar	2.94	5	50	600	500
Apple cider	2.95	4	50	350	290

AAE (Acetic acid equivalent), GAE (Gallic acid equivalent) and TE (Trolox equivalent)

1. Comparative phytochemical screening and bioactivity studies of different teas

A comparative investigation study was performed to access the major phytoconstituents in different teas viz. green tea, oolong tea, white tea and black tea (CTC and orthodox leaf grade) and flowers of different tea cultivars. Further, investigation of major catechins (EGC, EC, Catechin, EGCG and ECG), major volatile constituents, total phenolic and *in vitro* antioxidants activity, reducing activity and cytotoxicity studies were also performed.

Outcome

Product Development and Technology Transfer

Sr. No.	Product/technology	Transferred to Industry
1.	Tea concentrate and wine	1. M/s Camelia Beverages Pvt. Ltd. Delhi
2.	Development of formulation for tea-based hand sanitizer	1. M/s AB Scientific Solutions, Palampur (H.P.) 2. M/s Nature Green Chamba Herbs (H.P.) 3. Ms VLCARE Health Jamshedpur 4. M/s Sandeep Kumar and Company (H.P.)
3.	Tea Vinegar	1. M/s Kaash I Wish, Dharamshala (H.P.)

Ranjana Sharma, WOS-A
529ranjana@gmail.com
Food and Nutraceutical

Phytochemical profiling of different parts of Camellia sinensis and comparative analysis among selected cultivars

Camellia sinensis flowers, fruit and coarse leaves are economically underutilized parts that produce huge biomass. Studies have reported valuable phytochemicals in agricultural by-products. There are varieties of flowers that are incorporated in flavoured teas. These teas are highly appreciated, and their beneficial health properties are quite popular. Volatile and fatty acid profiles of different tea flower cultivars were studied, and results demonstrated the presence of valuable saturated fatty acids along with aroma compounds. Cumulative category of identified compounds are alkanes, alcohols, aldehyde, esters, terpenoids, fatty acids and other volatiles. Major fatty acids are palmitic acid, linoleic acid, alpha-linoleic acid, stearic acid, eicosanoic acid. The variation in content among different cultivars is minor, and all the cultivars can be utilized for respective purposes.

NMR metabolomics is one of the techniques used to accelerate compound identification and quantification. To investigate the characteristic metabolites in different parts of tea, NMR based comparative phytochemical investigation among fruit, flower and leaves of *C. sinensis* was performed. NMR metabolomics studies performed for different cultivars of *C. sinensis* and phytochemical profile showed presence of health beneficial molecules. The identified metabolites are polyphenols, amino acids, sugars, saponins, triterpenes, phenolic acids and vitamins.

High-performance liquid chromatography used for the quantification of major polyphenols (catechins), flavonoids, and phenolic acids. Two new HPLC-DAD methods were developed for the quantification of phenolic acids and flavonoids present in *C. sinensis*. Comparative analysis among different parts of *C. sinensis* was also performed. Quantified polyphenols are EGC, EC, EGCG, ECG and their epimers GC, Catechin, GCG and CG, major amino acid theanine and major methylxanthine caffeine. Quantified flavonoids are rutin, kaempferol, kaempferol 3- glucoside, quercetin, apigenin and myristin (Fig. 1).

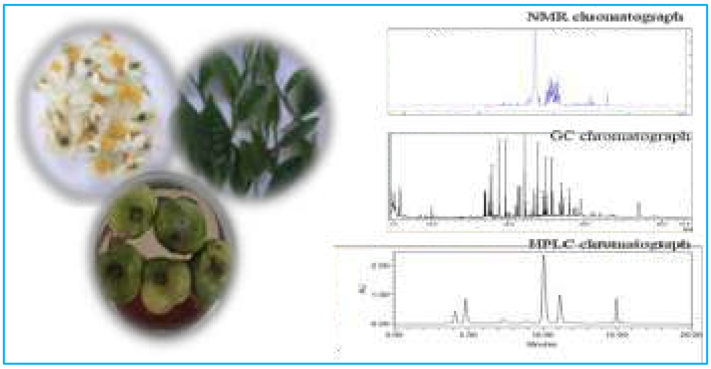


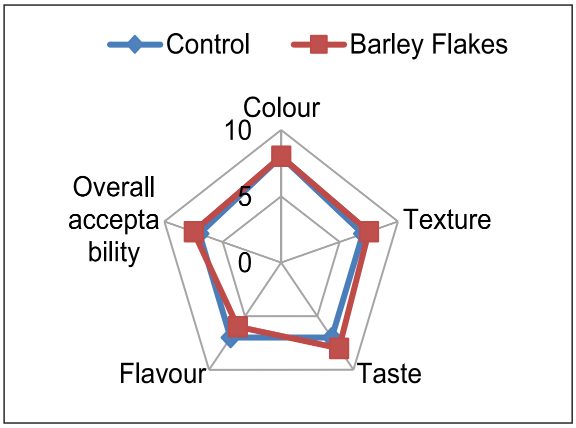
Fig. 1 Flower, leaf and fruit parts of *C. sinensis* along with NMR chromatograph, GC chromatograph and HPLC chromatograph

Rashim Kumari, DST - WOS-B
rashimk03@gmail.com
Food Science and Nutrition

Development of nutritionally rich instant breakfast cereal from traditional Himalayan food crops *viz.* Barley, Buckwheat and Berry

Barley and buckwheat are the major traditional crops of western Himalaya. These crops are rich source of fiber, rutin, many trace elements and antioxidants. These bioresources are not much explored for the development of food formulation. Under this project, nutritionally rich ready to use breakfast food will be developed using barley and buckwheat. Initially the process has been optimised for development of barley flakes under different condition of soaking, flaking and roasting. The nutritional analysis of developed flakes showed a good nutritional profile with protein content (8.23%), Total ash (03.55%) and fiber (02.10%). The developed flakes also exhibit significant antioxidant activity. The sensory evaluation also obtained the highest score when tasted by semi-trained panel.

Barley Flakes



Sensory evaluation of prepared barley flakes

Usha Kumari Rattan,WOS-A
rattan.usha77@gmail.com
Plant-host pathogen interaction

The current project is entitled "**Elucidating the role of host transcription factor(s) in disease development by cucumber mosaic virus"** focuses on plant viruses and their interaction with host and role of host molecular machinery in plant virus resistance. The functional analysis of interactions between transcription factors and other proteins is extremely essential for proper elucidation of the role of these transcriptional regulators in different signalling cascades. To develop cmv resistance in various crop plants we focused on the 2b protein of cucumber mosaic virus. 2b is multifunctional protein and its known as suppressor of gene silencing (Fig. 1,2&3).

Highlights of the work done

- Screening of Transcription factor only library through Yeast two Hybrid System.
- *In planta* confirmation of interaction of host transcription factor with the 2b protein of cucumber mosaic virus.
- Bimolecular Fluorescence complementation assay (BiFC): Biomolecular fluorescence complementation based on complementation between two non-fluorescent N-terminal and C-terminal fragments of a fluorescent protein.

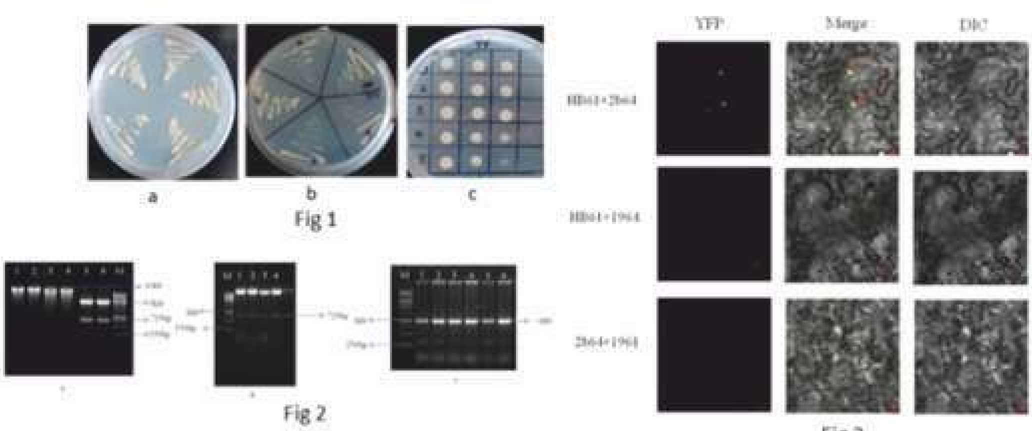


Fig. 1 Yeast two hybrid screening on nutritional media and confirmation of interaction,
Fig. 2 construct preparation of bifc construct preparation,
Fig. 3 Indicates the fluorescent bodies which confirm the interaction of HB27 protein with 2b protein in HB61+2b64 combination. In controls combination HB61+1964 and 2b64+1961, no fluorescence was seen.

Nishma Dahal, DST INSPIRE faculty

dahal.nishma@gmail.com

Ecology and evolution

Evaluation of genetic consequences of climate change on high altitude specialist species at the elevational range limit of the Himalayan mountains

Mountains tops and highlands represent parts of the world that provide an opportunity to investigate if all native communities have followed a similar route of adaptation to the challenges of high-altitude environment. We are working on Himalayan high-altitude specialists - birds and small mammals, to understand convergent genomic signature of high-altitude adaptation. Additionally, repeated glacial cycles in the past might have influenced the genetic structure and demographic history of the high-altitude restricted species. Modeling the past distribution of the species range can provide valuable hypothesis to improve inferences of demographic history.

Pikas (order Lagomorpha, family Ochotonidae) are identified as indicator species of climate change in the mountains. We have compiled occurrences of six pika species, from across their range (Fig. 1) to model the climatic niche preferences. The climatic model will be projected into the past and future climate change scenarios to identify regions in the Himalaya that had experienced significant climate change. The inferences from the climatic model will be used to validate the patterns of demographic history of populations from the Himalaya.

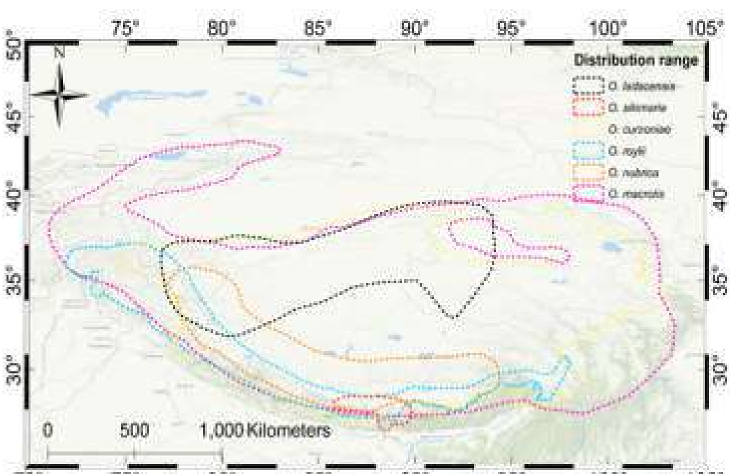


Fig. 1 Distribution range of six pika species selected for climatic model to be projected to past and future climate change scenarios. The map was made in ArcMap 10.8 and the species range was downloaded from IUCN red list)

Rohit Sharma, INSPIRE Faculty Fellow
rohit25sharma@gmail.com
Animal Biochemistry

Phytochemical berberine induces dose-dependent quiescence and apoptosis in lung cancer cells

The alkaloid berberine is recognized for its anti-cancer attributes, but its potential to inhibit proliferation in tumour cells by inducing cellular senescence is least understood. Considering this, a study was designed to assess the mechanisms of dose-dependent anti-proliferative effects of berberine in the perspective of senescence and inflammation using human lung cancer cell line (A549). It was observed that amongst the different tested bioactive phytomolecules, berberine treatment suppressed the proliferation of A549 cells regardless of the concentration applied. Application of low doses of berberine (up to 6.25 μM) induced a weak SA-β-gal activity and $p21^{WAF1}$ expression but did not show evidence of SASP activation due to absence of NF-κB activation and expression of proinflammatory genes. However, treatment with a higher dose of berberine (up to 50 μM) showed no evidence of SA-β-gal activity or $p21^{WAF1}$ expression, but instead induced apoptosis and suppressed the expression of cell cyclins. The proliferative capacity of berberine treated cells was at par with control cells, and no SA-β-gal activity could be observed in the first generation of berberine treated cells. mTOR pathway showed no distinct activation on account of berberine treatment, thereby further emphasizing that low dose of berberine induced quiescence and not senescence in A549 cells. Overall, our observations indicate that despite its strong anti-proliferative effects, low dose berberine treatment may only induce transient changes akin to quiescence that needs to be considered before implying pro-senescence attributes of berberine in cancer therapeutics (Fig. 1).

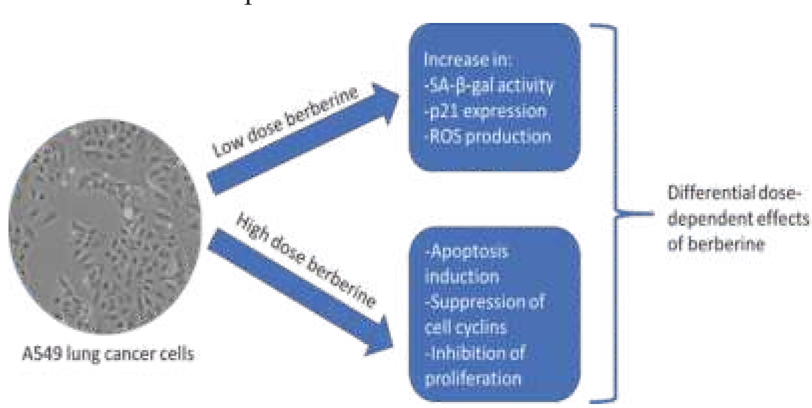


Fig 1. Schematic depiction of observed effects of berberine

Vijay Gahlaut, DST INSPIRE Faculty
vijaygahlaut@ihbt.res.in
Plant Epigenetics and Quantitative Genetics

The focus of work is elucidating the role of epigenetics in heat stress adaptation and stress memory in plants. We are also working on multi-locus genome wide association mapping of important phenotypic traits in plants.

Exploring Epigenetic Control of Grain Filling in Wheat under Heat Stress

Wheat (*Triticum aestivum*), as one of the main food crops, nurtures more than one third of the world population by providing nearly 55 % of the carbohydrates. Heat stress causes a dramatic reduction in wheat yield and quality loss which significantly intensifies the growing demand for food supply. It is predicted that a variation of 2°C above the optimal temperature could lead to wheat yield reductions of up to 50 % *via* perturbations in physiological, biological and biochemical processes. Heat stress during the grain filling stages is more harmful than during the vegetative phase due to the direct effect on grain number and dry weight. Recent evidence indicates that epigenetic mechanisms, such as DNA methylation and histone modification play a crucial role in regulating gene expression in plant responses to environmental stress. We performed RRBS (reduced representation bisulfite sequencing) using DNA samples extracted from grain tissues (15 DAA) under control and heat stress conditions. We discovered extensive DNA methylation at single-base resolution in wheat cultivars, identified the sequence context, and the extent of methylation at each site (Fig. 1). Now we are analyzing differentially methylated sites (DMSs) altered in response to heat stress in different wheat cultivars during the grain filling stage. We are also working on gene expression analysis using qPCR to reveal a constant relationship between the level of mCG methylation and the transcription abundance of some genes of potential importance in heat stress tolerance. These results will provide insights into interplay among DNA methylation and gene expression abundance, and suggest a role in heat stress adaptation during grain filling in wheat.

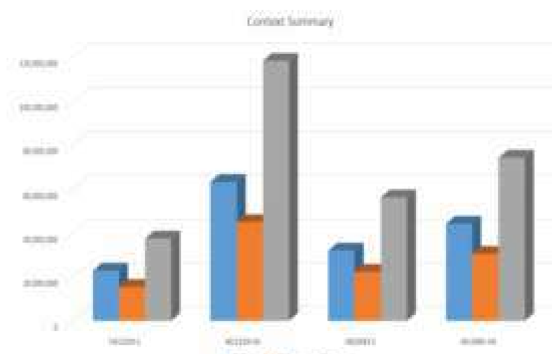


Fig. 1 The relative fraction of methylcytosines (mCs) identified in each sequence context (CG, CHG and CHH) in wheat cultivars.

Multi-Locus GWAS for Yield and its Contributing Traits in Wheat under Different Water Regimes

Multi-locus genome wide association study (GWAS) was undertaken using a set of 320 wheat accessions, which were each genotyped for 10 K SNPs. The association panel was grown in replicated trials in four environments [two each in irrigated (IR) and rainfed (RF) environments], and phenotypic data were recorded for five traits, including days to heading, days to maturity, plant height, thousand grain weight and grain yield (Fig. 2).

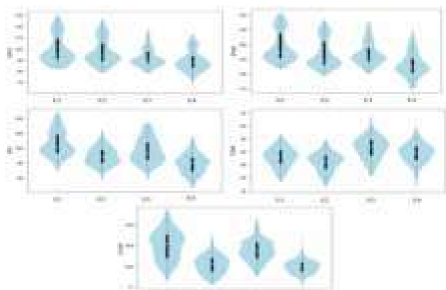


Fig. 2 Violin plots showing the distribution of values for five grain yield related traits.

Forty-six significant marker-trait associations (MTAs) were identified for five traits (Fig. 3). Five of these MTAs were co-localized with previously known QTL/MTAs and the remaining MTAs were novel and add to the existing knowledge. Eighteen (18) promising candidate genes (CGs) involved in seven different biological activities were also identified. The expression profiles of four (Trehalose-6-Phosphate, APETALA2/Ethylene-responsive factor, DNA-binding One Zinc Finger, and Gibberellin- dioxygenases) showed that they were induced by drought stress in the wheat seedlings.

Fig. 3 Manhattan plot showing Trehalose-6-Phosphate gene associated with MTA identified for DTH and expression profile of candidate gene during drought stress.

Introgression of a drought insensitive grain yield QTL for improvement of wheat cultivars using marker assisted breeding

In wheat, a major yield QTL (*Qyld.csdh.7AL*) contributing ~20% to the variation for grain yield under drought was introgressed into each of the four Indian wheat cultivars (HUW234, HUW468, K307 and DBW17) to develop high yielding drought tolerant genotypes. The marker *Xwmc273.3* (Fig. 4) linked to the yield QTL was used for marker assisted foreground selection, which was followed by phenotypic selection leading to the development of 55 advanced lines.

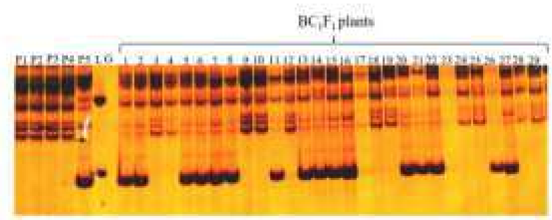


Fig. 4 Representative PCR amplification profile obtained using SSR marker Xwmc273.3 in four genotypes.

- These lines were evaluated under irrigated and rainfed conditions at two locations (Meerut and Niphad), which differed for agro-climatic conditions. Then we selected high yield lines on the basis following phenotypic data, number of grains per ear, grain weight, tiller number, biomass and lower canopy temperature. The line giving higher yield under rainfed condition also had low stress sensitivity index suggesting its ability to tolerate water-stress. The high yielding lines may be used for testing in a variety development programme.

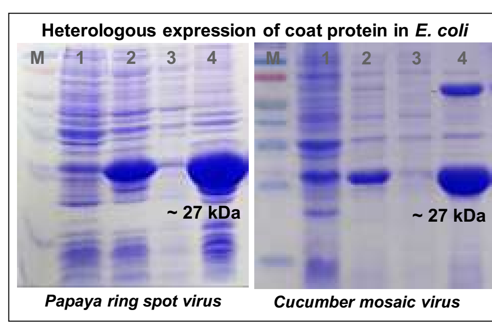
Yogita Maheshwari, DST INSPIRE faculty
maheshwari.yogita@gmail.com
Plant molecular virology

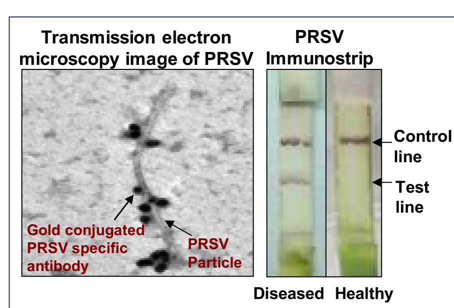
Serological diagnosis is limited in India due to the difficulty in producing high quality polyclonal antiserum to the viruses. Despite good progress in enzyme linked immunosorbent assay and polymerase chain reaction-based diagnosis of viruses, ready to use diagnostic technique is lacking. Membrane-based technology has been developed for few plant viruses and there is a further need to develop such technologies for the viruses causing major economic loss in India. My research focused on molecular characterization and development of membrane and probe-based technology for on-site, rapid and simultaneous detection of multiple viruses and viroid infecting fruit and vegetable crops. This will make virus diagnosis easy to the end users such as farmers, nursery owners, tissue culture industries, seed company, breeder and quarantine authorities. Currently, we are working on two projects sponsored by DST-INSPIRE "Development of rapid and cost effective 'on-farm' diagnostics for plant viruses" and DST-SERB project Rapid and on-site diagnostic for viruses and viroid infecting apple.

The following achievements were made during this period:

The complete genome sequence of *Papaya ringspot virus* (PRSV) (~10317 bp) from Palampur, Himachal Pradesh was determined first time and polyclonal antibody was produced in order to develop serology-based diagnostics. The nucleotide sequence identity of PRSV-Palampur was in the range of 78.5 to 89.7% with other 75 isolates of PRSV worldwide, and the highest identity of 89.7% was with Bangladesh isolate. The polyclonal antibody was developed against coat protein (CP) gene of PRSV. The CP gene was cloned in pET28a (+) expression vector and transformed into BL21 (DE3) *E. coli* strain. The polyclonal antibody (PAb) was produced by injecting purified CP intramuscularly in New Zealand white rabbits. The specificity of PAb was determined using purified CP in ELISA and western blot. The PAb was successfully detected PRSV from crude sap of papaya and showed minimum background reaction with healthy papaya leaf extract.

The PRSV specific PAb was further utilized for the development of immunostrip for field deployed detection of PRSV. The IgG was purified from PRSV PAb and validated using infected plant sample in Enzyme linked immunosorbent assay. The gold conjugation of IgG and development of lateral flow immunostrip was done successfully. Similarly, the coat protein gene of *Cucumber mosaic virus* (CMV) was cloned and polyclonal antibody was developed for development of on-site diagnostics.





Paromik Bhattacharyya, CSIR-Pool Officer
paromik@ihbt.res.in
Plant Tissue Culture of RET MAPs (Specialization-Orchid Biotechnology)

The past few decades have witnessed a tremendous resurgence in the interest and use of medicinal plant products worldwide. Surveys of plant medicinal usage have shown an exponential increase in its usage. Amongst the various medicinal plant taxa used in various pharmacopeias worldwide, orchids have shown a tremendous phytomedicinal potential and has been used in various traditional pharmacopeia worldwide including Ayurveda. In the traditional Indian medicine systems (Ayurveda), Astavarga or a group of eight medicinal herbs, is of utmost importance and in that formulation the use of four medicinal orchids namely *Malaxis muscifera* or Rishibak, *Habeneria intermedia* or Riddhi, *Habenaria edgeworthi* or Vridhi and *Malaxis acuminata* are used which deserves special mention. However, in spite of this huge ethno pharmaceutical potential, systematic molecular studies on Astavarga orchids have not been done till date, to the best of our knowledge and presently due to various anthropogenic pressures and deforestation, these plant species are severely threatened. Taking into consideration of the advances in genomic research in the field of plant sciences, deciphering genomes of medicinal herbs is a vital step in understanding and improving these poorly investigated class of plant kingdom i.e. Orchids. In the proposed research endeavour, Next Generation Sequencing (NGS) based approach was undertaken to sequence the transcriptome of *M. acuminata* and *M. muscifera* in order to identify and characterize transcripts potentially contributing to the observed medicinal properties.

In the present study, transcriptome of *M. acuminata* was mapped and the putative genes involved in the biosynthesis of important secondary metabolites of medicinal importance was determined and were validated using qRT-PCR techniques. Coupled with that we have also developed a high frequency regeneration protocol for *M. acuminata* using aromatic cytokinin *meta*-topolin in congruence with bioleicitors which provided a superior protocorm like body (PLB) formation. Along with that, we have also mapped the chemical bio constituents of *M. acuminata*. The module developed can be utilised in the transcriptome mapping and high frequency regeneration of slow growing medicinally important orchids of biopharmaceutical importance. The plants were hardened and acclimatized successfully and were maintained in the greenhouse of department of biotechnology, CSIR-IHBT. The transcriptome analysis of *M. muscifera* is under process.

Pankaj Kumar, SERB-National Post-Doctoral Fellow
pksharmabiotech@gmail.com
Plant cell culture, Transcriptomics and Molecular biology

My current project entitled "Enhancement of Steroidal Alkaloids Production Using Cell Suspension Culture and Elucidating Sipeimine Biosynthesis in *Fritillaria roylei*, a High Value Endangered Medicinal Herb of Himalayas" is focused on steroidal alkaloids production using plant cell culture in *Fritillaria roylei*, a high value (Fig. 1) endangered medicinal herb of Himalayas and identification of key genes contributing towards sipeimine biosynthesis through comparative and differential transcriptome profiling in bulb derived *in vitro* cultures of *F. roylei.*

Highlights of the work done

- *In vitro* cultures established for steroidal alkaloids production, for the first time.
- LC-ESI-MS based method development and validation for sipeimine and peimine.
- Analysed the metabolites and antioxidant profile in *F. roylei* for industrial usage.
- Expression analysis for putative steroidal alkaloids pathway genes.
- Callus culture as sustainable approach for secondary metabolite production.

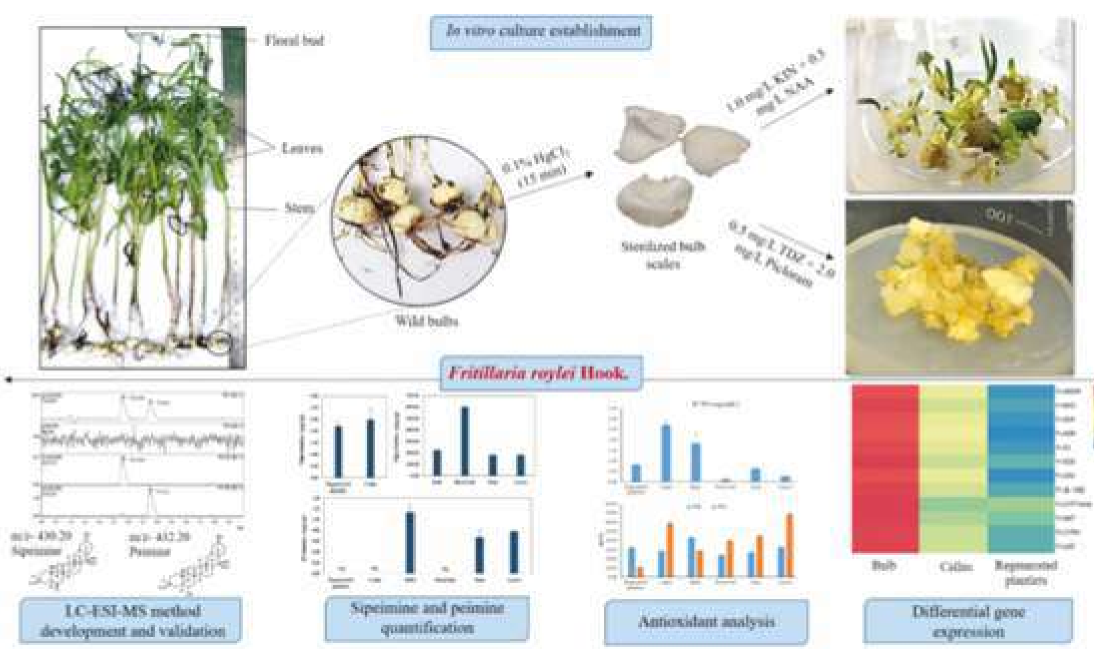


Fig. 1 *In Vitro* culture establishment, metabolite and expression profiling in *F. roylei*

Vidya Rajendran, SERB-National Post Doctoral fellow
aradhanarajendran@gmail.com
Structural Bioinformatics

Comparative structural modeling and simulation approach to improve the bio-physicochemical properties of industrially important enzyme Superoxide dismutase obtained from *Potentilla atrosanguinea*

Lab working in the area of Biochemistry, Biophysics and Molecular Biology (Life Sciences) I have been working on this project since 14th of February 2020.

Potentilla atrosanguinea (PA) is one of the plants growing in the high altitude of western Himalayan region. Due to the conditions of its habitat, including frozen ground, ice/snow cover, deficient precipitation, incidence of low illumination during the winter, and high UV radiation during summer on high levels of reactive oxygen species (ROS) are produced. Thus, as a response, high levels of peroxidase, glutathione reductase, and superoxide dismutase (SOD) activities are present in this plant. CuZnSOD forms the first line of defense in all aerobic organisms against reactive oxygen radicals and is vital to the survival of cells. SOD is widely used to augment the antioxidant defense system of the body. Apart from the enzymatic scavengers, non-enzymatic scavengers such as glutathione, flavonoids, urate, ascorbate, tocopherols, carotenoids, ubiquinol, and minerals can also be used for this purpose. SOD formulations may be included in cigarette and other tobacco products to reduce the free radical damage in oropharynx and respiratory tract.

SOD formulations can also be used to prevent alcohol-induced hangover. Several studies showed the importance of single amino acid substitution in modulating kinetic properties of enzymes. In this project we would like to develop multiple mutants by replacing amino acids at targeted positions and the improved phenomenon will be tested in *in silico* experiments. *In silico* validation will be performed on potential mutants designed by protein engineering approach and by all atomic molecular dynamics simulations. We would like to develop a range of Pa-SOD variants which could show activity under freezing conditions as well as holding high thermoresistance.

With this targeted properties, this enzyme could be useful for preventing the oxidation of refrigerated or frozen foods, as well as in the preparation of cosmetic and pharmaceutical products. The designed variant could be directly tested through wet-lab studies.

CSIR Skill Development Programs/ Jigyasa/ Incubation Centre/ AcSIR/ Important Events/ Rajbhasha

SKILL DEVELOPMENT PROGRAMME

This year various skill development programs were conducted under CSIR Integrated Skill Initiative, DBT and other sponsored programs. These were in the field of floriculture & landscaping, plant tissue culture, hydroponics & aeroponics, essential oil distillation, nursery raising, apiculture. Institute is providing trainings to Graduate/ Post Graduate/ Ph.D. students from different Institutes, Universities and affiliated colleges. This year, 159 UG/PG/ Ph.D. students from different educational and research institutes of Pan India were provided real time laboratory training, a requirement for fulfil of their degree, under the able supervision of CSIR-IHBT scientists.

Skill/ Training programme implemented during 2019-2020

S.No	Type of Skill/Training Prog.	Name of the Programme	Qualifications	Duration (in days)	Number of trainees trained
1	NSDC (Skill Councils) Aligned Prog. (DBT Sponsored)	Advanced diploma in plant tissue culture	B.Sc. Biology	April 2019-March, 2020 365 day	15
2	NSDC (Skill Councils) Aligned Prog. (DBT - Sponsored)	Skill Vigyan Program	B.Sc. Biology/ Biotechnology	March 2020- March 2023 90 days	Sanctioned to train 180 trainees in coming 3 years
3	Societal Skill/Training Programmes (excluding Aroma Mission)	Landscape Gardener	B.Sc.	June 17-21, 2019 4 days	12
		Hands on Training on Bonsai Making	10th	June 10, 2019 1 day	40
		Hydroponic Cultivation	No Bar	June 16-19, 2019 4 day	49
		Hydroponic and Aeroponics Cultivation	10+2	February 5-8, 2020 5 days	35
		Training on Beekeeping	10th	September 24-30, 2019 7 days	51

S.No	Type of Skill/Training Prog.	Name of the Programme	Qualifications	Duration (in days)	Number of trainees trained
		Tea (One day training programme at farmers field)	No Bar	Almost every month (19 No.) Almost every month (34 No.) 1 days	351
		Apple	No Bar	October 28-30, 2018 3 days	11
				December 3-5, 2018 3 days	25
				February 25-March 2, 2018 5 days	13
				April 5, 2019 1 day	10
				January 25, 2020 1 day	50
				January27, 2020 1 day	20
		Bamboo Propagation	10+2 (Forest Guard)	October 14, 2019 1 day	54

Skill Development Program on Advanced Diploma in Plant Tissue Culture

In continuation to our previous activity, 15 graduate and post-graduate students from different parts of the country were skilled in advances in plant tissue culture under a DBT sponsored Diploma Program on skill development (GAP-0225). The students were trained in plant tissue culture, virus indexing, hydroponic & aeroponic cultivation of plants, Cell and callus cultures and their up-scaling in bioreactors, and isolation of DNA and PCR amplification for clonal fidelity testing. They were also exposed to commercial floriculture, intellectual property rights, trouble shooting and cost-cutting and also business development using tissue culture technology. The students were taken to 'Neva Plantation' in Gopalpur near Palampur as an exposure visit to a plant tissue culture industry (Fig. 5).

Fig. 5 Skill development in advances in plant tissue culture (a-b) Trainees at Plant Tissue Culture Laboratory, CSIR-IHBT, Palampur (c) Lecture on commercial tissue culture of apples by Dr. Ashwani from Neva Plantations, Gopalpur (d) Visit to Neva Plantation – A plant tissue culture industry at Gopalpur, H.P.

JIGYASA Program

CSIR-Institute of Himalayan Bioresource Technology organized various activities under the Jigyasa programme. During 2019-20, a total of 2075 school students and their teachers participated in this programme through various model of engagement (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 aquatinted with different state-of-art facilities in the area of biotechnology, bioinformatics, agrotechnologies of commercial important crops, floriculture, natural product chemistry, synthetic chemistry, internationally recognized 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.

Table 1. Details of the students and teachers participated in Jigyasa Programme

S. No	Program Name	Duration in days	Student Grade	No. of teachers	No. of student trained			
					No. of KVS Students	No. of State Govt. Students	No. of NVS Students	Other schools
1.	National Technology Day Laboratory visits and Lecture by:- Dr. Sanjay Kumar, Director, CSIR-IHBT	01	08^{th} -12^{th}	21	140	127	50	-
2.	National Science Day	01	08^{th} -10^{th}	2	-	37	-	-
3.	Demonstration in different laboratories and fields	06	08^{th} -12^{th}	23	157	69	-	5
4.	Lab and field visit to apprise R&D activities of CSIR-IHBT	19	08^{th} -12^{th}	49	200	260	-	422
5.	Outreach Programme	02	08^{th} -12^{th}	30	-	400	-	-
6.	Teachers Workshop	03		83	-	0	-	-
	Total			208	497	893	50	427
	Grand Total					**2075**		

Students and teachers participated in Jigyasa Programme at CSIR-IHBT, Palampur

National Technology Day

Teacher's Workshop


















This year, 1199 students and teachers of various universities, institutes, colleges from 8 different states visited the institute.

S. No.	University/College	Date	No. of Students	No. of Teachers	State
1	Shoolini University Solan	04.04.2019	22	03	HP
2	Central University of Jammu (J&K)	08.04.2019	28	03	J&K
3	Jaypee University of Information Technology Waknaghat, Solan	16.04.2019	30	02	HP
4	Kurukshetra University	16.04.2019	29	04	HR
5	Himachal Institute of Engineering & Technology, Shahpur	01.05.2019	40	05	HP
6	CSK Himachal Pradesh Agriculture University, Palampur	02.05.2019	08	01	HP
7	Sri Sai University, Palampur	07.05.2019	58	03	HP
8	Dr GC Negi College of Veterinary and Animal Sciences, Palampur	08.05.2019 09.05.2019	61	01	HP
9	CSIO Chandigarh	31.05.2019	11	-	PB
10	GHG Khalsa College, Ludhiana	06.06.2019	33	06	PB
11	College of Horticulture and Forestry, Neri, Hamirpur	12.07.2019	32	01	HP
12	Rajiv Gandhi Govt. PG Ayurvedic College & Hospital, Paprola	05.08.2019	49	01	HP
13	Rajiv Gandhi Memorial PG College, Jogindernagar, Mandi	13.09.2019	34	02	HP
14	Shaheed Captain Vikram Batra Government College, Palampur	19.09.2019	57	02	HP
15	DAV University, Jalandhar	25.09.2019	15	02	PB
16	Swami Shraddhanand College Delhi University, Delhi	27.09.2019	35	11	DL
17	Graphic Era (Deemed to be University), Dehradun	27.09.2019	43	06	UK
18	ICAR - Indian Agricultural Research Institute, Delhi	07.10.2019	12	01	DL
19	Institute of Information Management and Technology (IIMT), Aligarh	10.10.2019	22	04	UP
20	Govt. Degree College, Naura, Kangra	11.10.2019	10	02	HP
21	Govt. College of Pharmacy, Nagrota Bagwan	21.10.2019	43	01	HP
22	National Institute of Technology (NIT), Hamirpur	25.10.2019	04	-	HP
23	Career Point University, Hamirpur	05.11.2019	40	02	HP
24	Odigos Hub, Mumbai	07.11.2019	42	01	MH
25	Govt. Mohindra College, Patiala	13.11.2019	31	02	PB
26	National Institute of Fashion Technology (NIFT), Kangra	14.11.2019	26	01	HP
27	College of Ayurveda & Reseach Center, Pune	09.01.2020	31	02	MH
28	Rashtrasant Tukadoji Maharaj Nagpur University, Nagpur	09.01.2020	38	5	MH
29	Ganpat Sahaai PG College, Sultanpur	27.01.2020	18	02	UP
30	Sri Venkateswara College, Dhaula Kuan	13.02.2020	22	02	DL
31	Shaheed Captain Vikram Batra Government College, Palampur	17.02.2020	55	02	HP
32	Jamia Hamdard (Deemed to be University), Delhi	20.02.2020	22	03	DL
33	Doaba College, Jalandhar	06.03.2020	48	12	PB
34	SGGS Khalsa College, Mahilpur	06.03.2020	51	04	PB
Total			**1,100**	**99**	**8 States**

INCUBATION CENTRE AT CSIR-IHBT

CSIR-IHBT has been recognized as one of the incubation center by Department of Scientific and Industrial Research (DSIR) and Micro Small and Medium Enterprises (MSME), Govt. of India. Department of Industry, Himachal Pradesh. Under this scheme, incubatees 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 (startups/ 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 dietary 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 of RET species
- MAPs, ornamentals, apple, bamboo, potato, rose, etc
- Soil testing
- Animal testing and preclinical trials
- Pac Bio analysis
- Pesticide residue analysis

A total of 24 startups joined CSIR-IHBT, Palampur and 10 incubatees already completed their tenure and also launched their products. Currently 14 incubatees are actively working in the area of process development, food processing, tea, floriculture, honey processing, aroma and e-marketing under the CM Startup Scheme. CSIR-IHBT has also demonstrated the incubation facilities in various events organized 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.	Details of Incubatees	Idea of Start-up and Start date
1	**Ms. Swati Sharma** M-150, Jal Vayu Vihar, Sector 25, Noida 201301 Cont. No. 9560035488	A complete detox drink which rejuvenates from within and nourishes you. Essential nutrients and provide immunity against several diseases. **21st Feb 2019**
2	**Mr. Vipin Kumar** Vill Bharmat PO Banuri, Teh. Palampur, Distt Kangra (HP)- 176061 Cont. 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**

Sr. No.	Details of Incubatees	Idea of Start-up and Start date
3	**Mr. Sandeep Kumar** Teh. Palampur distt Kangra (HP)- 176061 Cont. No. 8580753926	Development of package for pollution abatement plants for different location like house, hospital offices etc. **5th March 2019**
4	**Mr. Udhey Singh** H.No. 41, VPO Dehan Khas, Teh. Palampur, District Kangra (HP) Cont. No. 9857836950	Development of stevia coffee formulation **25th April 2019**
5	**Ms. Sudarshna** VPO Rait Teh. Shahpur, Distt. Kangra (HP), 176202 Cont. No. 8894124194	Development of products made from waste pine needles like mats, boxes, baskets, trays etc. **21st May 2019**
6	**Ms. CR Amshu** C/o Sharma House, 3334, Near Manali Public School, Aleu Village, Manali, 175131 Cont. No. 8219667968	Super Food: Based on value added functional food products **14th November 2019**
7	**Ms. Mona Singh** Village Bharmat, Palampur, Distt. Kangra (HP)- 176061 Cont. No. 8988232510	Development of cookies for postpartum **28th August 2019**
8	**Mr. Vipan Kumar** Vill. Magroo Suryala P.O. Aloh, Teh. Rakkar, Distt. Kangra (HP)- 177034 Cont. No. 9418273550	Value addition of herbal produce **26th August 2019**
9	**Ms. Ankita Rana** VPO Ghati Bilwan, Jaswan Kotla, Distt. Kangra (HP)- 176501 Cont. No. 9816103320	Organic Ayurvedic products **26th August 2019**
10	**Ms. Reena Chandel** Village- Gagal, P.O. Bharmoti, Teh. Nadaun, Distt. Hamirpur (HP), 177033 Cont. No. 8679223613	Papaya based variety of sweets **26th August 2019**
11	**Mr. Satish Kumar** Village Ghurkari, Tika Sunehar, Teh.7 Distt. Kangra, (HP)-176001 Cont.No. 9805565394	Himachal honey processing **07th October 2019**
12	**Mr. Subodh Kumar** VPO Saloh, Teh. Palampur, Distt. Kangra, (HP)- 176102 Cont.No. 9805691903	Nursery raising of aromatic crops **13th February 2020**
13	**Mr. Rajveer** Village Jandera, P.O. Rajpur, Teh. Palampur, Dist Kangra (HP)- 176061 Cont.No. 8894961559	Development of bio-fertilizers **13th February 2020**
14	**Mr. Sandeep Bhatia** VPO Nadaun, Ward No. 06, Tehsil: Nadaun, Distt. Hamirpur, H.P. Cont.No. 9882198421	Development of vedic, traditional and holistic based products from cow urine, dung and medicinal plants **21st January 2020**

ACADEMY OF SCIENTIFIC AND INNOVATIVE RESEARCH (AcSIR), CSIR- IHBT

The Academy of Scientific and Innovative Research (AcSIR) was established in 2010 (by a resolution of the Government of India on 17th July, 2010) and formalized by an Act of Parliament; that is the Academy of Scientific and Innovative Research Act, 2011 vide The Gazette of India (dated 7th February, 2012) and notified on 3rd April, 2012 as an Institution of National Importance. It has been set up based on a 'Hub and Spoke' model where hub (AcSIR Offices) is responsible for centralized administrative functions. The spokes are located in the 37 laboratories and 6 units of CSIR spread along the length and breadth of India, which act as actual campuses for different subjects or areas.

Since January 2011, under the banner of AcSIR, CSIR- IHBT has initiated Ph.D. programme in Biological and Chemical Sciences. Table-I contains the details of the courses being taught at CSIR-IHBT.

Table-I Details of AcSIR courses at CSIR-IHBT

Sr. No.	Course details	Number of courses
1	Biological Sciences	48 (9 compulsory & 39 optional)
2	Chemical Sciences	14 (compulsory)

During the year 2019-20, following key activities were 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 AcSIR Ph.D. students.
- Handling various administrative, financial, academic matters and other duties & 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 from time to time are adhered by the students for the timely completion of Ph.D. degree.
- Liaison between AcSIR- IHBT and external examiners regarding various activities like theses evaluation, viva voce examinations, guest lectures and comprehensive examination of the students.
- In August session, 42 candidates were interviewed and 21 were selected and in January session, 59 candidates were interviewed and 34 were selected for Ph.D. enrolment under AcSIR.

Till date, 242 students were enrolled for Ph.D. at CSIR-IHBT in Biological Sciences and Chemical Sciences (Fig. I) and 69 students had successfully defended their thesis during the viva voce examinations.

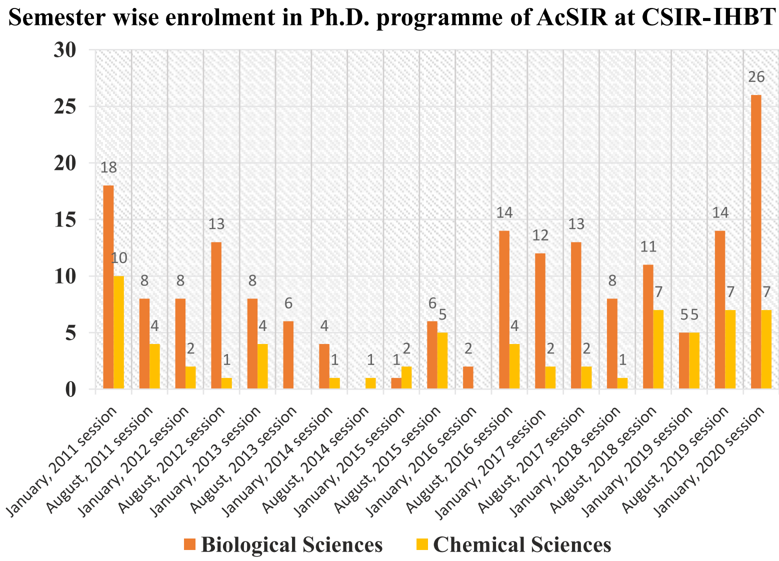


Fig. I Semester wise enrolment in Ph.D. programme of AcSIR at CSIR- IHBT

During 2019-20, 12 students successfully defended their thesis during the Viva voce examination and were awarded doctoral degree as per the following details

Sr. No.	Name of the Student (Registration)	Faculty	Supervisor
1.	Vishal Sharma (10BB13J33008)	Biological Sciences	Dr. Sanjay Kumar
2.	Arindam Ghosh Mazumder (10BB13A33001)	Biological Sciences	Dr. Damanpreet Singh
3.	Shanka Walia (10CC15A33010)	Biological Sciences	Dr. Amitabha Acharya
4.	Dinesh Thakur (10BB13A33002)	Biological Sciences	Dr. Amit Chawla
5.	Panzade Ganesh Prabhakar (10BB14J33001)	Biological Sciences	Dr. Ravi Shankar
6.	Rajni Parmar (10BB16A33004)	Biological Sciences	Dr. R. K. Sharma
7.	Shiv Kumar (10BB13A33006)	Biological Sciences	Dr. Y. S. Padwad
8.	Rakesh Kumar (10CC15J33004)	Chemical Sciences	Dr. Upendra Sharma
9.	Nidhi Sharma (10CC15J33003)	Chemical Sciences	Dr. Ashu Gulati
10.	Dhananjay Bhattacherjee (10CC15A33007)	Chemical Sciences	Dr. Pralay Das
11.	Deepali Katoch (10CC14A33001)	Chemical Sciences	Dr. Upendra Sharma
12.	Ritika Sharma (10CC15A33009)	Chemical Sciences	Dr. Upendra Sharma

IMPORTANT EVENTS

Visit of Hon'ble Governor of Himachal Pradesh, Shri Bandaru Dattatraya to CSIR-IHBT Palampur on March 3, 2020

Visit of Hon'ble Governor of Himachal Pradesh: Hon'ble Governor of Himachal Pradesh, Shri Bandaru Dattatraya visited the institute on March 03, 2020. The Governor witnessed R&D work, visited various research facilities, interacted with scientists, students, incubatees and entrepreneurs. He later inaugurated essential oil distillation units set up in different districts of HP through video link, bridge & road network and solar electricity facility of 350 KVA and laid foundation stone laying of 120 room hostel in CSIR-IHBT campus. In his address, the Hon'ble Governor applauded the Institute's achievements in different fields and stressed upon a healthy collaboration between scientist, entrepreneur and farmers for inclusive growth of the country and making HP the most progressive state in the country.

Release of varieties of aromatic crops viz., *Tagetes minuta, Valeriana jatamansi, Artemisia maritima, Dracocephalum heterophyllum* (one each) and floriculture crop *Chrysanthemum* (five)

E-inaugurated 21 essential oil distillation units set up in different parts of State

Inaugurations by Hon'ble Governor of Himachal Pradesh on March 3, 2020

Roof Top Solar Power Plant of capacity 350 KW

Foundation Stone of 120-Room Hostel

Road Network and Bridge

Hon'ble Governor of Himachal Pradesh, Shri Bandaru Dattatraya visited the exhibition of products developed by the incubatees on March 03, 2020.

Dr. Shekhar C. Mande, Secretary, DSIR and Director General CSIR, visited CSIR-IHBT Palampur from March 30-April 1, 2019 and was apprised of the Mission, Vision, and activities of the Institute by the Director. He visited the research infrastructures, farm & field facilities and addressed the scientists, scholars, and staff of the Institute. It has been a highly motivational and inspiring interaction for each member of the CSIR-IHBT family.







The Rose distillation session in the Institute was inaugurated by Dr. Sanjay Kumar, Director at Chandpur Farm on April 24, 2019.

SEMINAR SERIES 2019: "Science for Society"

The research scholars of CSIR-IHBT Palampur organized the 3rd Annual Seminar on the theme "Science for Society: Targeting the unmet demands of the Nation" in the Institute on the Teachers' Day, dedicated to Dr. Sarvepalli Radhakrishnan, former President of India and a great scholar. The Chief Guest of the occasion, Dr. Shekhar C. Mande, Director General of CSIR, New Delhi expressed happiness to see young people thinking of future problems and willing to offer solutions through science.

In 23 different presentations, the scholars put forth the possible scientific solutions to the challenges being faced, the kind of research work they have initiated as well as proposed the next generation initiatives in different fields. They specifically focused on artificial intelligence for gene regulation, microbiome, machine learning, plant-derived monoclonal antibodies, next-generation approach for biodiversity assessment, hygenic honey extraction, organic waste management, nano-catalyst, hydro-aeroponics, indoor air pollution, new low-calorie natural sweeteners, next-generation nanomedicines, β-galactosidase producing microbes, Himalayan enzymes, saga of miRNA, plant microbiome, nutriomics, genomics, virology, natural products, etc.

A 3-member expert panel evaluated the presentations and awards were given to the best presentations. Awards were also given to the winners of scientific writing competition and photography competition.

This mega event was sponsored by various national companies and was graced by eminent scientific personalities along with hundreds of research scholars and scientific staff.

Global Investors' Meet


Global Investors' Meet: CSIR-IHBT exhibited its various technologies in the area of Food & Nutraceuticals, value-added Agriculture including advancement in Apiculture and its integration aromatics & floriculture, Biotechnology, etc. Technologies exhibited by CSIR-IHBT attracted the attention of visitors and investors. The meet held at Dharmshala, was inaugurated by the Hon'ble PM on November 07, 2019.

Launch of Ready to Eat Foods

Dr. Shekhar C. Mande, Director General, CSIR & Secretary DSIR launching the food products (developed by CSIR-IHBT) at CSIR HQ, New Delhi on October 23, 2019.

CSIR-IHBT Participation in the Exhibitions

11^{th} Edition of Agrovision during November 22-25, 2019 at Reshimbagh Ground, Nagpur, Maharashtra

Exhibition-Cum-Workshop on Technologies in Food Processing-Developed by CSIR-IHBT on November 13, 2019 at Constitution Club of India, New Delhi

107th Indian Science Congress "Science & Technology: Rural Development" during January 3-7, 2020 at University of Agricultural Sciences, Bengaluru

Organized the CSIR Sports Promotion Board's Nayudamma Memorial Cricket Tournament (NMCT) - 2019 during October 21-24, 2019 by the Institute. There were six teams. The CSIR first lady Dr. Sharmila Mande and Mrs. Richa Kumar graced the final match with their kind presence. The final match was played between the teams of the CSIR and UPSC at International Cricket Stadium, Dharamshala and the CSIR team won the match.

The Institute organized Science Mela for students
May 11, 2019 on the National Technology Day- 2019

Prof. Arun Kumar Grover, Ex VC, Panjab University delivered a talk on "Lives and times of Dr. S.S. Bhatnagar, FRS (1894-1955) and Dr. B.P. Pal (1906-89): Nucleation of CSIR and ICAR" on May 27, 2019

Prof. Alok Dhawan, Director, CSIR-IITR, Lucknow delivered talk on "Supporting risk in science: Emergence of a new India" on May 29, 2019

Legal Advisor, Shri Jayesh K. Unnikrishnan CSIR, delivered talk on "Science, Technology and Law" on June 21, 2019

CSIR-IHBT Celebrated 5th International Yoga Day on June 21, 2019

A Taiwanese delegation represented by Professor Fang-Rong Chang, the Director of NRICM, Dr. Lie-Chwen Lin, Research Fellow/Director Division of Chinese Medicine Literature and Informatics; Dr. Mayeesha Yu-Hwei Tseng and Dr. Chang-Chang Chen, Assistant Research Fellows visited the Institute on July 1-4, 2019.

Meeting with Hon'ble Governor of HP
(August 27, 2019)

Sh. Kalraj Mishra, Hon'ble Governor of HP apprised by Dr. Sanjay Kumar, Director of the research activities of the institute on August 27, 2019 in Shimla.

CSIR-HRDC Training on "CSIR Manual on Procurement of Goods 2019" held during September 02-06, 2019

Dr. Shekhar C. Mande, DG CSIR, inaugurated the Institute's Staff Quarters and Multipurpose Hall on September 05, 2019.

Dr. Shekhar C. Mande, DG CSIR, laid Foundation Stone of Protein Centre on September 05, 2019

Dr. Sanjay Kumar, Director CSIR-IHBT motivated the staff to adopt Honesty and Integrity as part of their daily life during the Vigilance Awareness Week (October 28-November 2, 2019).

Constitution Day was organized in the Institute on November 26, 2019. Dr. Sanjay Kumar, Director of the Institute read out the Preamble of the Constitution to all the staff. On this occasion, copies of the constitution were kept in the library of the Institute for the perusal of all employees and scholars.

CSIR-IHBT, Palampur celebrated Republic Day with great enthusiasm. Dr. Sanjay Kumar, Director hoisted the National Flag, addresses the students, staff, and family members, followed by sweet distribution, tree plantation, and release of Staff Club Magazine "Manthan".

National Technology Day: The CSIR-IHBT celebrated the National Technology Day on May 11, 2019. An open day was observed for providing first-hand information to the students and public on the technological achievements and R & D activities of the Institute. A total of 400 students from different school of Himachal Pradesh were among the key participants. They were exposed to various scientific activities and were given demonstrations on the biological and chemical sciences. Dr Sanjay Kumar, Director, interacted with the students and delivered a motivational talk to inculcate scientific temperament amongst the students.

CSIR-IHBT Foundation Day: CSIR- Institute of Himalayan Bioresource Technology celebrated its 37th Foundation Day on July 2, 2019. Prof. Akhilesh Kumar Tyagi, JC Bose National Fellow, University of Delhi delivered the Foundation Day Lecture on "Approaching Bioeconomy through Agri-biotechnology". Prof. Sudhir K. Sopory, SERB Distinguished Scientist, ICGEB New Delhi and former VC Jawahar Lal Nehru University chaired the function. In his Presidential Address, he emphasized the importance of knowledge management. He suggested the need to integrate different domains in knowledge and come out with specific outcomes for the benefit of society.

Dr. Saroj K. Barik, Director, CSIR-NBRI, Lucknow and Guest of Honour of the function highlighted the multitude problems of Himalaya and suggested networking of Himalayan Institutes for solving problems of the Himalayan region, and use of genome data in the scenario of climate change keeping in view the ecosystem services of the Himalayas. On this occasion institute's Annual Report 2018-19 was released. In addition, an updated version of Technological Profile of CSIR-IHBT, Handbook of

General Rules and Regulations, Technical Folders on Agro-Technology of Calla lily, Indian Valerian, Quinoa, and Chia were also released for the benefit of the farming community.

CSIR Foundation Day: Institute celebrated Foundation Day of Council of Scientific & Industrial Research on September 26, 2019. Padmashree Dr. V. Prakash, Former Director of CSIR-CFTRI & Distinguished Scientist of CSIR, delivered Foundation Day Lecture on 'Health & Wellness through Tradition and Science-Farm to Folk.

National Science Day: Celebrated National Science Day on February 28, 2020. Dr. Srinivas V. Kaveri, Director, CNRS office in India, French Embassy delivered the keynote address on the topic "The impact of the environment on the society and our responsibility: the role of science". Dr. (Mrs.) Manju Sharma, Former Secretary, DBT, GOI, was the Chief Guest of the function. She interacted with the august gathering through video conferencing. The food processing unit was also inaugurated by her through video link.

राजभाषा गतिविधियां

हिंदी सप्ताह समारोह

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 डा. पूरनपाल, पूर्व वरि. हिंदी अधिकारी (चयन ग्रेड) सीसएसआईआर मुख्यालय ने 'राजभाषा नीतिः अनुपालन की अनिवार्यता' विषय पर संभाषण दिया। अपने संबोधन में उन्होंने राजभाषा नीति के संवैधानिक प्रावधानों, राजभाषा अधिनियम एवं राजभाषा नियमों के बारे में विस्तृत जानकारी देते हुए राजभाषा की अनिवार्यता का सरल, सहज एवं प्रभावी प्रस्तुतिकरण दिया। इस अवसर पर उन्होंने राजभाषा हिंदी के राष्ट्रीय, ऐतिहासिक एवं परिदृश्य पर महत्वपूर्ण एवं ज्ञानवर्धक मार्गदर्शन दिया।

संस्थान के निदेशक एवं कार्यक्रम के अध्यक्ष डा. संजय कुमार ने सभी कार्मिकों को राजभाषा हिंदी में मौलिक कार्य करने के लिए प्रेरित किया। उन्होंने संस्थान की वैज्ञानिक तथा प्रौद्योगिकीय उपलब्धियों को हिंदी में प्रकाशित एवं प्रसारित करने पर बल दिया ताकि विदेशी भी हमारी राजभाषा हिंदी को सीखने के लिए उत्सुक एवं प्रेरित हों।

इस अवसर पर हिंदी प्रतियोगिताओं के विजेताओं तथा हिंदी में मौलिक काम करने वाले कार्मिकों को सम्मानित तथा प्रोत्साहित भी किया।

हिंदी सप्ताह के दौरान आयोजित प्रतियोगिताओं तथा हिंदी टिप्पण/आलेखन प्रोत्साहन योजना के विजेताओं की सूची

पुरस्कारः प्रथम पुरस्कार – श्री बलदेव
द्वितीय पुरस्कार – श्री वेद प्रकाश
तृतीय पुरस्कार – श्री किरण कुमार

हिन्दी लोकप्रियविज्ञान लेखन प्रतियोगिता

पुरस्कारः	प्रथम पुरस्कार –	श्री वेद प्रकाश
	द्वितीय पुरस्कार –	श्री विराट अभिषेक
	तृतीय पुरस्कार –	श्री अशोक गहलोत

हिन्दी टिप्पण प्रोत्साहन योजना के अन्तर्गत वर्ष 2018–19

1	प्रथम पुरस्कार	श्रीमती संतोष
2	प्रथम पुरस्कार	श्री बलदेव
3	द्वितीय पुरस्कार	श्री मनोज कुमार
4	द्वितीय पुरस्कार	श्री अजय कुमार
5	द्वितीय पुरस्कार	श्री मुकुल शर्मा
6	तृतीय पुरस्कार	श्री वेद प्रकाश
7	तृतीय पुरस्कार	श्रीमती अरुणा
8	तृतीय पुरस्कार	श्री राजीव कुमार
9	सांत्वना पुरस्कार	डा. शशी भूषण
10	सांत्वना पुरस्कार	डा. अशोक गहलोत

हिंदी कार्यशाला

संस्थान में कार्यभार ग्रहण करने वाले नए वैज्ञानिकों के लिए 23 जनवरी 2020 एक हिंदी कार्यशाला का आयोजन किया गया। इस कार्यशाला का उदेश्य राजभाषा नीति की विविध प्रावधानों तथा अनुपालन के बारे में जागरुक करना था। संस्थान के हिंदी अधिकारी श्री संजय कुमार ने अपने प्रस्तुतिकरण में राजभाषा नीति के संवैधानिक प्रावधानों, राजभााषा अधिनियम, 1963 तथा राजभाषा नियम,1976 के बारे में जानकारी प्रदान की। इसके साथ ही उन्होंने प्रतिभागी वैज्ञानिकों को राजभाषा हिंदी को प्रोत्साहित करने की दिशा में संस्थान के प्रयासों के बारे में अवगत कराया। शोध कार्यों के आधार पर विकसित प्रौद्योगिकियों, उत्पादों एवं प्रक्रम तकनीकों को विभिन्न माध्यमों यथा प्रकाशित शोध एवं लोकप्रिय पत्रिकाओं, समाचारपत्रों, रेडियो, दूरदर्शन वार्ताओं, तकनीकी फोल्डर, ब्रोशर एवं वेबसाइट के द्वारा आम लोगों, किसानों, उद्यमियों तक पहुंचा कर हिंदी भाषा के माध्यम से विज्ञान एवं प्रौद्योगिकी के प्रचार–प्रसार में संस्थान की भूमिका पर भी प्रकाश डाला।


संस्थान के प्रशासन अधिकारी श्री आलोक शर्मा ने प्रतिभागी वैज्ञानिकों को राजभाषा नीति के अनुपालन में हमारे दायित्वों के बारे में विस्तार से समझाया तथा जांच बिन्दुओं के बारे में जानकारी दी। उन्होंने संसदीय राजभाषा समिति के निरीक्षण के बारे में भी अवगत कराया तथा आह्वान किया कि वे अपना दैनिक कार्य हिंदी में करें। उन्होंने आगे बताया कि उनको उपलब्ध कराए गए सभी कम्प्यूटरों में यूनिकोड के माध्यम से हिंदी में कार्य करने की सुविधा है। यदि राजभाषा में कार्य करने में कोई भी असुविधा हो रही हो या कोई जानकारी चाहिएहो तो वे निसंकोच संस्थान के हिंदी अधिकारी से संपर्क कर सकते है।

इस कार्यशाला में डा. शिव शंकर पाण्डेय, डा. जैरिम, डा. अंकित सनेजा, डा. पुनम कुमारी, डा. वंदना जायसवाल, डा. सतबीर सिंह, डा. रमेश, डा. सरिता देवी तथा डा. विकास कुमार ने प्रतिभागिता की।

प्रशिक्षण कार्यक्रम में प्रतिभागिता

दिनांक 01–02 अगस्त, 2019 को मानव संसाधन विकास केन्द्र (एचआरडीसी), गाजियाबाद द्वारा 'राजभाषा नीति के प्रभावी कार्यान्वयन की अनिवार्यता एवं व्यवहारिकता' विषय पर आयोजित कार्यशाला में श्री आलोक शर्मा, प्रशासन अधिकारी एवं श्री संजय कुमार, हिंदी अधिकारी ने प्रतिभागिता की।

सीएसआईआर – मानव संसाधन विकास केन्द्र, गाजियाबाद
राजभाषा नीति के प्रभावी कार्यान्वयन की अनिवार्यता एवं व्यावहारिकता
विषय पर प्रशिक्षण कार्यक्रम (01–02 अगस्त, 2019)

बायें से दायें
प्रथम पंक्ति – बिजेन्द्र सिंह, आलोक शर्मा, स्वाति चड्ढा, अम्बालिका नाग, आलोक गोयल, प्रियंकर पालीवाल, अजय मलिक, शैलेन्द्रनाथ, नागेन्द्र सिंह, मौसुमी मजुमदार, अनिता एस, मौहम्मद इदरीस, वेद प्रकाश, चि. वे. सुब्बाराव
द्वितीय पंक्ति – उमानन्द शर्मा, देवशुभ्र चटर्जी, कौशिक जाना, डी. वी. एस शास्त्री, महेन्द्र सिंह, राम कण्णन, सुदेश कुमार, लालचन्द, नरेश यादव, नीरुजा श्रीधरन, संजय कुमार मिश्र, सविता कुमारी, नूपुर रानी प्रसाद, सुधा नायर, सोना लमसाल, मीनाक्षी गौड, एम वाणी सत्यनारायण, अनिल कुमार, एस एस शुक्ला, विरंची सारंग, लोकेश शर्मा, के. आर. कुमरेश बापु
तृतीय पंक्ति – हेमन्त कुमार, आशीष सिंह, मेहर सिंह, संजय कुमार, जयकिशन, मणि भूषण सिंह, दिनेश कल्याणम, नीतिश कुमार, विजय कुमार महतो, सोमेश्वर पांडेय, विजय सिंह, धर्मेन्द्र कुमार, राजेश कुमार साव, वीरपाल सिंह, अनिरुद्ध तिवारी, सन्त लाल, कौशल किशोर, कलीम उद्दीन

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 106162/–रुपये की हिंदी पुस्तकों की खरीद की गई। हिंदी पुस्तकों की सूची संस्थान के पुस्तकालय 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 भेजी 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 किया गया।

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 /समरोहों के आयोजनों, निमंत्रण पत्र, विज्ञापन, प्रेस नोट आदि को तैयार करके प्रैस–मीडिया को उपलब्ध कराया गया।

Supports Services

ENGINEERING SERVICES UNIT

Construction of Houses

The construction of 16 houses comprising of 4 quarters of Type-V, 8 quarters of Type-IV and 4 quarters of Type-III was started in the financial year 2017-18. The work was completed in August 2019 and inaugurated by DG CSIR, Dr. Shekhar C. Mande on September 5, 2019.

Inauguration of Multipurpose Hall

The old farm store structure was renovated and attached toilet and kitchen was constructed. Old leaking roof was replaced and new tile floor and ceiling was provided. The multipurpose hall can be used for small functions. The area of the hall is 150 sqm and was inaugurated by DG CSIR on September 5, 2019.

Construction of Enzyme Bioprocessing Unit

Foundation stone of Enzyme Bioprocessing Unit was laid by Dr. Shekhar C. Mande, DG CSIR on September 5, 2019. The facility is of 230.00 Sqm. area and tentative cost is Rs. 7.00 Crores including instruments.

Construction of Hostel

The foundation stone of Hostel was laid on March 3, 2020 by Shri Bandaru Dattatreya Hon'ble Governor, Himachal Pradesh. The work approved by CSIR which estimated cost of Rs. 3020.00 Lacs. The proposed 5 storey building will be equipped with 120 double bedded rooms, with have washroom and covered balconies. The building will be equipped with Gymnasium, internet, Wi-Fi, furniture, reading rooms, laundaries, cooking area and dining space with solar heating system.

Construction of Bridge and Concrete Road Network

Inauguration of bridge & concrete road network was honoured by Shri Bandaru Dattatreya Hon'ble Governor, H.P. on March 3, 2020. The total cost of bridge & concrete road is Rs. 400.00 Lacs and road length is approximately 2 Kms.

Roof Top Solar Power Plant

The 350 KW grid connected roof top solar power plant under RESCO Model was inaugurated on March 3, 2020 by Sh. Bandaru Dattatreya, Hon'ble Governor, H.P.


Inauguration of Steel Bridge and Covered Path

Steel bridge and covered path was inaugurated by Dr. Anil Kush, Chairman, Research Council on March 12, 2020. This steel bridge is an important link between scholars hostel and lab campus.


Inauguration of Covered Path

Dr. Anil Kush, Chairman Research Council on March 12, 2020, inaugurated steel bridge and covered path. This construction is an important connectivity between Labs and canteens.


Inauguration of Parking and Covered Path

Parking and covered path was inaugurated by Dr. Anil Kush, Chairman, Research council on March 12, 2020.

ADMINISTRATION

The Administration is responsible for handling all the administrative legal and vigilance matters in addition to variety of support services for research and development activities performed towards realization of the vision of CSIR-IHBT, Palampur. Functioning as Central Facilitation Office the division plays critical role at every phase of career development for all the employees right from their recruitment, training, performance appraisal to their superannuation and thereafter. The division also acts as Compliance Office which ensures that all the employees and their dependents get all the benefits as per their entitlement, facilitating all the employees including research scholars so that they can perform their official duty smoothly. Other major activities performed by the administration may be enumerated as follows:

- Assists the authorities of Institute, namely, the Director, the Head of Departments and the Principal Investigators on issues and decisions of administrative nature.
- Maintains liaison with CSIR Headquarter, New Delhi on administrative and legal matters.
- Implements policies in pursuance of guidelines as issued by the CSIR Headquarter, New Delhi.
- Formulates policies concerning administrative procedures for smooth functioning at the institute level.
- Provide advice to functional bodies (Committees/Functional groups) within the organization.
- Provides healthy working conditions and environment in the laboratory through interpretation as well as implementation of

First Row (Left to Right): Sh. Baldev, Sh. Sanjay Kumar, Sh. Alok Sharma, Sh. Amarjeet, Sh. Parveen Singh and Sh. Boni Kumar,
Second Row (Left to Right): Sh. Baleshwar Prasad, Sh. Ajay Kaundal, Smt. Pooja Awastrhi, Sh. Thaman Bahadur, Smt Santosh Kumari, Sh Ved Prakash, Sh. Sandeep Kumar

governing rules and regulation.

The division is headed by the Administrative Officer, who is the over all In-charge of the activities. He is supported by Section Officers, a group of Assistant Section officers, Senior Secretariat Assistants, Junior Secretariat Assistants and supporting staff including Security Services and Hindi Cell. The security department which is managed by a security assistant is responsible for the safety and security of the institute.

In recent past, the Administration has undergone major transformation in terms of work culture and implementation of paperless processes. An improved work culture and decentralized leadership introduced at all levels to bring the desired changes. A trend of faster service delivery system has been inculcated in the staff to match the expectations of CSIR-Enterprise Transformation Initiative.

Achievements

- Recruitment process for total Number of 17 Scientists/Sr. Scientists was completed on time.
- Timely assessment and promotion of 11 Scientists, 11 Technical and other supporting staff.
- Sincere efforts have been made by Administration towards implementation of ERP in pursuance of directions issued by CSIR-Hqrs, New Delhi.
- Implementation of various guidelines issued time to time by Govt. of India, Govt. of Himachal Pradesh as well as local administration towards combating COVID-19.
- Facilitated CSIR-IHBT Staff Club for organizing Nayudamma Memorial Cricket Tournament at Nadaun and Dharmashala, Himachal Pradesh.

FINANCE AND ACCOUNTS

Finance and Accounts Division is catering to the financial needs of the scientific, technical and administrative officials of the Institute. The Division maintains the Accounts of the Institute on behalf of the Director. The utilisation of the budget allocation received from CSIR Headquarters is monitored and remedial measure for effective utilisation is suggested to appropriate authorities by the Division. Apart from Budget Allocation, charges for Technical Services and Sponsored and Grant-in Aid projects constitute the major sources of income cash flow.

Broad functions of the Finance & Accounts Division are as follows:

- Preparation and compilation of budget estimates, revised estimates and supplementary grants.
- Management of the financial resources received in the form of CSIR Grant, Externally Funded Projects & Lab Reserve of the institute with the due approval of the Competent Authority.
- Ensuring that the economy instructions of the Government of India are scrupulously followed and exercising necessary budgetary control.
- Releasing payment to all suppliers/ contractors/service providers for their services.
- Making payment to all staff for their personal claims and official advances.
- Maintenance of Vouchers and Accounts Registers/Ledgers.

- All matters related to Banks collecting debits, credits, bank statement, DDs, NEFT & RTGS transfers etc.
- Financial concurrence for pay fixations and other financial matters.
- Finalisation of pension and issue of pension payment orders, family pension, retiring pension and related payments.
- Coordinating the works related to Internal Audit and External Audit (CAG) and furnishing replies to the concerned authorities.
- Generating various financial statements, monthly account, annual accounts, transfer of funds statement, monthly progressive expenditure statement etc.
- Investing the funds from sponsored projects & lab reserve after obtaining necessary approval.

Left to Right: Sh. Deepak Sood, Sh. Yash Pal, Sh. S.N. Gulia, Smt. Aruna Kumari

STORES AND PURCHASE

The Stores and Purchase division ensures provision of adequate and timely supply of various materials required for execution of various R & D projects & other non - R & D items required for Lab and Colony maintenances, as per rules in force. The items are procured primarily through GeM (Government eMarketplace). For the items, which are not available in GeM, the procurement is done through e-tendering only. The entire Stores & Purchase operations are entirely carried out through ERP (onecsir) end-to-end. The division also maintains stock of stationery, cleaning and hardware items, which are regularly required in the Institute.

The division had purchased following major equipments during the financial year 2019-20

- Unmanned Aerial Vehicle (UAV)
- Distillation Units
- UPLC – MS
- Spectroradiometer
- Flow Cytometers
- Refrigerated Centrifuge
- Surface Plasmon Resonance based (SPR) Biosensor System
- AKTA Pure Protein Purification System (Lab scale)
- cGMP AKTA Protein Purification System (Production Scale)
- Reaction Station
- Wet Spinning Machine
- Multi purpose Membrane Unit
- Automated Flash Chromatography System
- Filtration System for Cell Separation

COMPUTER SECTION

This section takes care of Managing Existing IT resources in the Institute which has a fleet of servers from HP, IBM, Tyrone used for hosting website, DNS, Centralized Antivirus solution, Intranet website etc.

Institute is one of the nodal points of National Knowledge Network (NKN) 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) & wireless Internet facility has been provided in the campus including hostel and faculty residences with the use of 41 managed switches and 68 indoor and outdoor wireless access points. This year Internet facility was extended to newly constructed Type IV/V houses and to Lab extensions. All the internet users are managed centrally with the help of authenticator.

Network Security hardware used for LAN & WAN comprises of almost 41 high speed Managed switches, Unified threat management System (UTM/Firewall), Web application firewall, Wireless Authenticator, Wireless Controller on high availability and its policies have been 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 & Peripherals.

KNOWLEDGE RESOURCE CENTRE (KRC)

The IHBT-KRC/ Library has been an important support service for research and development activities in the institute. It subscribed to the relevant journals, books, databases in electronic and print format aligning to the institutional R&D projects. Library provided services to the scientists, scholars, project staff, trainees in addition to the scientists, technical and other staff of the Institute. During the year 2019-20, collection of library was strengthened with the addition of 12 theses, 29 books in print and 27 books in electronic mode. The collection of Hindi books in library was enriched with the addition of 276 books and this collection included books on science, literature, stories, tales, biography, religion, etc.

All the scientists, scholars and other staff have access to 2000+ scientific journals of major publishers such as American Chemical Society, Nature, Science, Springer, Wiley and Elsevier. Access is also available to the specialized databases of SciFinder, TAIR, and Web of Science. Most of the library reassures are being subscribed through the National Knowledge Resources Consortium (NKRC).

The library is contributing to improve the quality of scholarly output of the Institute with the assistance of databases viz. ithenticate-similarity/ plagiarism detection software and grammarly software to improve language which are being subscribed through NKRC.

The Library provided literature searches, citations analysis, patent searches to meet informational needs of users from internal and external resources in other libraries. Library staff assisted scientists and scholar by providing information on publisher, impact factor, author guide, online submission, etc. for selection of quality journals for publication of scholarly out.

The Online Public Access Catalogue (OPAC) database in KOHA software was updated with new additions to the collection and made available for online access on internet. The OPAC is searchable by keywords, author, title, publisher, accession number, ISBN, etc.

A number of 4700 visitors including scientists, students, research scholars, faculty members from several academic and R & D institutions visited library to consult library resources. More than 3 lacs pages prints were provided to scientists, scholars and staff of the project proposals/ reports, theses, office documents, training manuals.

Left to Right: Sh. Saurabh Sharma, Sh. Mukhtiar Singh, Smt. Jasveer Kaur, Smt. Rujala Devi

PHOTOGRAPHY UNIT

This unit provided direct support to research and development activities, recorded video clips of the field experiments at different time intervals to document the growth profile of targeted crops. Captured events of all the official functions, trainings, workshops, conferences, symposia and staff club activities in the Institute. In addition, committed to ensure best reproduction quality in theses and publications.

Designing- Designed title of Annual Report and layout of all pages of technology profile as per the suggestions of the Director.

CSIR-IHBT you-tube account: Maintaining of CSIR-IHBT you-tube account. In this account up load of documentary film, add-films and video clips on different activities of the institute, is a regular activity. Continue to receive positive comments.

Created repository of photographs: Cataloged the old and contemporary photographs as per date and time and events for their easy retrieval. Also, laid down structured norms for long-term storage of pictures.

In addition to the above, assistance was rendered to design brochures of processing technologies, banners & certificates to the participants in trainings, workshops, conferences, symposia, invitation & greeting cards, posters of research activities and labels for lab products. The important events and R&D activities were covered by way of photography.

Relevant photographs of various activities were clicked and provided for constant updating the institutional website and portal of CSIR Jigyasa.

Catered to the requirement of press & media by scientists in depicting their field & lab activities.

Participated in field surveys through the recording of interviews with farmers and entrepreneurs, particularly those who have been provided with the technologies of the Institute.

This unit strives for excellence in quality and timely delivery.

Pabitra Gain

Patents/Publications

Intellectual Property

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Thesis/Dissertations/Report Supervised

Ph.D

Arindam G. Mazumder (2019) Investigating the role of selected mTOR signalling pathway inhibitors in experimental models of epilepsy and associated comorbidities. Supervised by Dr. Damanpreet Singh.

Dhananjay Bhattacherjee (2019) Hypervalent Iodine(III) Promoted Ring-rearrangement and Functionalization Approaches in Organic Synthesis. Supervised by Dr. Pralay Das.

Rakesh Kumar (2020) Synthesis and Derivatization of N-Heterocyclic Compounds through C-H Bond Functionalization. Supervised by Dr. Upendra Sharma.

Ritika Sharma (2019) Synthesis of Quinoline Derivatives via Catalytic Remote C-H Activation". Supervised by Dr. Upendra Sharma.

Deepali Katoch (2019) Phytochemical and pharmacological investigation of *Zephyranthes grandiflora* and Narcissus tazetta for Amaryllidaceae alkaloids and their synthetic modification. Supervised by Dr. Upendra Sharma.

Mahpara Qadir (2019) Isolation, characterization and bioactivity evaluation of some high altitude species of genus Artemisia. Co-supervised by Dr. Vijai Kant Agnihotri.

Vishal Sharma (2019) Identification of apple (*Malus domestica* borkh.) DREB/CBF transcription factor and their characterization in tobacco. Supervised by Sanjay Kumar.

M.Sc./M.Pharma/B.Sc./B.Pharma/B.Tech.

Mohini Sharma (2019) Development of *in vitro* systems of *Coleus forskohlii* for forskolin production. CSK HPKV, Palampur, Supervised by Dr. Amita Bhattacharya.

Training Imparted: Summer and Winter

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
1.	Ms. Palak Sangari	Shoolini University, Solan, HP	B.Tech Biotechnology	1	Dr. Aparna Maitra Pati	Isolation and subculturing of bacteria from soil
2.	Ms. Priyanka Jarial	Gautam College, Hamirpur, HP	M.Sc. Biotechnology	3	Dr. Aparna Maitra Pati	Isolation and identification of bacteria from soil
3.	Ms. Rupali Kapoor	NISER, Bhubaneswar, Odisha	M.Sc. Biotechnology	1	Dr. Aparna Maitra Pati	Isolation and identification of bacteria from soil
4.	Mr. Yash Dawar	Amity University, Noida	M.Sc. Microbiology	6	Dr. Aparna Maitra Pati	Diversity analysis of microbiome associated with a Himalayan medicinal plant
5.	Mr. Anand G R	Loyola College (Autonomous), Chennai	B.Sc. Plant Biology & Biotechnology	1	Dr. Amita Bhattacharya	Basic techniques in plant tissue culture
6.	Mr. Sivanesan S	Loyola College (Autonomous), Chennai	B.Sc. Plant Biology & Biotechnology	1	Dr. Amita Bhattacharya	Basic techniques in plant tissue culture
7.	Ms. Nitika Sharma	Guru Nanak Dev University, Amritsar, PB	M.Sc. Biotechnology	1	Dr. Amita Bhattacharya	Basic techniques in plant tissue culture
8.	Ms. Aashina Puri	Jaypee University of Information Technology (JUIT) Waknaghat, Solan, HP	B.Tech Biotechnology	1.5	Dr. Amita Bhattacharya	Basic techniques in Plant Biotechnology
9.	Ms. Arushi Katoch	DAV, University, Jalandhar, PB	B.Sc. Microbiology	1	Dr. Amita Bhattacharya	Basic techniques in plant tissue culture and molecular biology
10.	Ms. Varinder Kaur	SUSECT, Tangori, Mohali, PB	B.Tech Biotechnology	1	Dr. Amita Bhattacharya	Basic techniques in plant tissue culture and molecular biology
11.	Ms. Nitika	Maharaja Agrasen University, Kalujhanda, Baddi, HP	M.Sc. Biotechnology	3	Dr. Amita Bhattacharya	Studies on 'Saffron' and 'Fern' two economically important plants of western Himalayan

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
12.	Mr. Kanishk Paul	Chandigarh University, Mohali, PB	B.Sc. Agriculture	2	Dr. Amita Bhattacharya	Basic techniques in plant tissue culture
13.	Ms. Nancy Sharma	Chandigarh University, Gharuan, Mohali (Punjab)	M.Sc. Biotechnology	6	Dr. Amita Bhattacharya	Basic techniques in plant tissue culture and molecular biology
14.	Ms. Sumandeep Kaur	Panjab University, Chandigarh	M.Sc. Biotech	1	Dr. Vipin Hallan	*In-silico* prediction of host targets of Apple Scar Skin Viroid (ASSVd)
15.	Ms. Aastha Baliyan	Panjab University, Chandigarh	M.Sc. Biotech	1	Dr. Vipin Hallan	*In-silico* prediction of host targets of Apple Scar Skin Viroid (ASSVd)
16.	Ms. Manjot Kaur	Panjab University, Chandigarh	M.Sc. Biotech	1	Dr. Vipin Hallan	*In-silico* prediction of host targets of Apple Scar Skin Viroid (ASSVd)
17.	Ms. Simran Utreja	Panjab University, Chandigarh	B.Sc. Microbiology	1	Dr. Vipin Hallan	Basic techniques in plant molecular biology
18.	Mrs. Shalini Devi	DAV University, Jalandhar, PB	Ph.D. Biotechnology	3	Dr. Vipin Hallan	Detection of Urdbean Leaf Crinkle Virus (ULCV) in Urdbean
19.	Ms. Sakshi Mehra	Guru Nanak Dev University, Amritsar, PB	M.Sc. Biotechnology	3	Dr. Vipin Hallan	Gene cloning and protein purification
20.	Mr. Avijit Chakraborty	RKMVC, Kolkata	Ph.D. Botany	1	Dr. Vipin Hallan	Hands on training on virus indexing
21.	Ms. Mokshda Seth	Thapar Institute of Engineering & Technology, Patiala, PB	B.Tech Biotechnology	6	Dr. Vipin Hallan	Molecular characterisation of HOMOBOX 27 in *Arabidopsis thaliana*
22.	Ms. Tanupriya	Chandigarh University, Gharuan, Mohali, PB	B.Sc. Agriculture	3	Dr. Vipin Hallan	Basic techniques of molecular biology
23.	Ms. Akshita Sharma	Govt. PG College, Dharamshala, HP	B.Sc. Biotech.	1	Dr. Vipin Hallan	Estimation of Phosphate content in Rosaceae plant family

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
24.	Ms. Sangam Thakur	Dr YS Parmar University, Solan, HP	M.Sc. Biotechnology	1.5	Dr. Vipin Hallan	Analysis of transgenic plants
25.	Mr. Abhinandan	Guru Nanak Dev University, Amritsar, PB	M.Sc. Environmental Sciences	1	Dr. Sanjay K. Uniyal	Continuous ambient air quality monitoring of Himalayan region
26.	Ms. Shreya Soni	Lovely Professional University, Phagwara, PB	B.Tech Biotechnology	1	Dr. Sanjay K. Uniyal	Vegetation assessment of forest types in the Bandla forest range of Palampur, Himachal Pradesh
27.	Mr. Mukesh Jaryal	Guru Nanak Dev University, Amritsar, PB	M.Sc. Env. Science	3	Dr. Sanjay K. Uniyal	Vegetation composition of Bohal spring forest in the Dhauladhar mountain range of Palampur, District Kangra
28.	Ms. Gunjan Bhargava	Maharishi Markandeshwar University (MMU), Mullana, Ambala	B.Tech Biotechnology	1	Dr. R.K. Sharma	Basic molecular biology techniques in plants
29.	Ms. Shivi Badyal	Shri Mata Vaishno Devi University (SMVDU), Katra (J&K)	M.Sc. Biotechnology	1	Dr. R.K. Sharma	Studies for development of DNA fingerprints in *Valeriana jatamansi*
30.	Mr. Avrodeep Paul	SHUATS, Allahabad, UP	B.Tech Agriculture Engineering	1	Dr. Amit Kumar	Basic tools and software used in Remote Sensing
31.	Mr. Prashant Sharma	Dr. Y.S. Parmar University, Solan, HP	Ph.D. Agroforestry	1	Dr. Amit Kumar	Remote sensing and digital image processing
32.	Mr. Swapnil Sengupta	SHUATS, Allahabad, UP	B. Tech Agriculture	1	Dr. Amit Kumar	Basic techniques in Remote Sensing
33.	Mr. Prashant Singh	Amity University, Noida, UP	B.Tech Biotechnology	1	Dr. Sanatsujat Singh	Studies on micropropagation and hardening of *Stevia* plant

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
34.	Mr. A. Yaswanth Sai Vardhan Reddy	Lovely Professional University, Phagwara, PB	B.Sc. Agriculture	1	Dr. Sanatsujat Singh	Studies on micropropagation and hardening of *Stevia* plant
35.	Ms. Aditi Singh	IILM College of Engineering & Technology, G. Noida	B.Tech Biotechnology	1	Dr. Sanatsujat Singh	Studies on micropropagation and hardening of *Stevia* plant
36.	Mr. Rajan Sharma	IILM College of Engineering & Technology, G. Noida	B.Tech Biotechnology	1	Dr. Sanatsujat Singh	Studies on micropropagation and hardening of *Stevia* plant
37.	Ms. Sunidhi Dhadwal	Shoolini University, Solan, HP	B.Tech Biotechnology	1.5	Dr. Sanatsujat Singh	Studies on micropropagation and hardening of *Chrysanthemum* Plant
38.	Mr. Prashant Singh	Amity University, Noida	B.Tech Biotechnology	3	Dr. Sanatsujat Singh	Micropropagation response of different genotypes of *Gerbera jamesonii* under *in-vitro* condition
39.	Ms. Saumya Maurya	SHUATS, Allahabad, UP	B.Sc. Biotechnology	1	Dr. Shashi Bhushan	Studies on development of process for preparation of dietary fiber from fruits waste and their incorporation in RTS juices
40.	Ms. Prashasti	SHUATS, Allahabad, UP	B.Sc. Biotechnology	1	Dr. Shashi Bhushan	Studies on development of process for preparation of dietary fiber from fruits waste and their incorporation in RTS juices
41.	Ms. Sunyna	Shoolini University, Solan, HP	M.Sc. Biotechnology	1.5	Dr. Shashi Bhushan	Basic techniques in Plant Tissue Culture

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
42.	Ms. Subarna Deb	Banaras Hindu University, Varanasi, HP	M.Sc. Food & Science Technology	2	Dr. Shashi Bhushan	Preparation of fermented tea (Kombucha) from green and black tea and its quality evaluation
43.	Ms. Nitika	Maharaja Agrasen University, Kalujhanda, Baddi, HP	M.Sc. Biotechnology	3	Dr. Shashi Bhushan	Establishment of aseptic shoot culture of *Arnebia euchroma*
44.	Mr. Nikhil Rajput	Amity University, Noida	B.Tech Biotechnology	3	Dr. Shashi Bhushan	A report on tea cultivation and farm management
45.	Mr. Mohammad Sahil Khan	Amity University, Noida	B.Tech Biotechnology	3	Dr. Shashi Bhushan	A report on tea manufacture process
46.	Mr. Ankit Kumar Varun	Amity University, Noida	B.Tech Biotechnology	2	Dr. Shashi Bhushan	A report on tea production and tea based diversified products in global market
47.	Ms. Monika Devi	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Biotechnology	6	Dr. Shashi Bhushan	*In vitro* shoot cultures of *Arnebia euchroma*
48.	Mr. Dixit Chambial	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Chemistry	1.5	Dr. Pralay Das	Polystyrene supported rhodium (0) catalysed microwave assisted suzuki miyaura cross coupling reaction
49.	Ms. Uday Laxmi	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Chemistry	1.5	Dr. Pralay Das	Naturally occurring Himachalenes from *Cedrus deodara* oil to benzocycloheptene compound synthesis
50.	Mr. Pankaj Kumar	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Chemistry	1.5	Dr. Pralay Das	Rhodium Catalysed Suzuki Reaction of Aryl Halide with Aryl

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
						Boronic Acid for Biaryl Synthyesis
51.	Ms. Kriti Shakya	Indian Institute of Technology (IIT) Mandi, HP	M.Sc. Chemistry	1	Dr. Pralay Das	Polystyrene supported palladium nanoparticles catalyzed CO fixation reactions and its application in heterocycles synthesis
52.	Ms. Pooja Devi	Abhilashi University, Mandi (H.P.)	M. Pharmacy	3	Dr. Pralay Das	Oxalic and malonic acids as carbon building blocks for bioactive benzimidazole synthesis
53.	Mr. Shivam Chambyal	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Chemistry	1.5	Dr. Vijai Kant Agnihotri	Isolation and characterization of essential oil of *Dracocephalum heterophyllum* Benth.
54.	Mr. Deepank Bhardwaj	Amity University, Noida	M.Sc. Chemistry	1.5	Dr. Vijai Kant Agnihotri	Isolation and characterization of essential oil of *Tagetes minuta*
55.	Ms. Shubanjali Parashar	Amity University, Gwalior, MP	B.Tech Biotechnology	1.5	Dr. Ravi Shankar	Molecular characterization of DIS3-like exonuclease 2 - RNA interaction to reveal post transcriptional gene regulation
56.	Mr. Abhinav Dogra	Indian Institute of Science Education & Research (IISER) Mohali, PB	BS-MS	1	Dr. Ravi Shankar	Handling big data in bioinformatics and database creation using MongoDB
57.	Ms. Ananya Agnihotri	Guru Nanak Dev University, Amritsar, PB	M.Sc. Food Technology	1	Dr. Mahesh Gupta	Study on development of process for

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
						preparation of instant SEERA (Nishasta)
58.	Mr. Harshil Sharma	DAV College, Jalandhar, PB	Bachelor of Food Science & Technology (Hons.)	1	Dr. Mahesh Gupta	Process optimization of different parameters during canning
59.	Ms. Anuja Devi	IK Gujral PTU, Kapurthala, PB	M.Sc. Food Technology	1	Dr. Mahesh Gupta	Study the antimicrobial activity of Ginger and Bouganvale extracts and its edible coating
60.	Ms. Yogita Thakur	Banaras Hindu University (BHU), Varanasi, UP	M.Sc. Food Technology	3	Dr. Mahesh Gupta	Development of Mango based nutribar & analysis of its nutritional-functional properties
61.	Mr. Ankur	Himalayan Institute of Pharmacy & Research (HIP&R), Dehradun, UK	M. Pharmacy Pharmaceutical Chemistry	1.5	Dr. Rituraj Purohit	Interaction analysis between ATP synthase and In-house synthesized ligand molecules by Hex package
62.	Ms. Riya Dhiman	Jaypee University of Information Technology (JUIT) Waknaghat, Solan, HP	B.Tech Bioinformatics	1	Dr. Rituraj Purohit	Screening and evaluation of natural molecules against FATP2
63.	Mr. Yawar Ali Khan	Intergal University, Lucknow, UP	B.Tech Biotechnology	1	Dr. Rituraj Purohit	Computational modeling & structural exploration of Green Fluorescent Protein (GFP)
64.	Ms. Sadia Abrar	Intergal University, Lucknow, UP	B.Tech Biotechnology	1	Dr. Rituraj Purohit	Computational modeling & structural exploration of Green Fluorescent Protein (GFP)

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
65.	Mr. Ajay Kumar Sharma	Shoolini University, Solan, HP	M. Pharmacy Pharmacology	1	Dr. Rituraj Purohit	Binding site detection and interaction analysis of potential bio-active molecules
66.	Mr. Anchit Sharma	Shoolini University, Solan, HP	M. Pharmacy	1	Dr. Rituraj Purohit	Computational interaction analysis of potential bioactive molecules
67.	Ms. Monika Purohit	JECRC, Jaipur (RJ)	B.Sc. Biotechnology	2	Dr. Rituraj Purohit	Hands on experience on basic and molecular docking
68.	Ms. Namrata	HPU, Shimla	M.Sc. Biotechnology	6	Dr. Rituraj Purohit	Basics of heterologous protein expression and purification
69.	Mr. Sangam Sharma	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Chemistry	1.5	Dr. Sushil Kumar Maurya	Synthesis of amino acid based building blocks for total synthesis of bioactive natural products
70.	Ms. Ruchika	Lovely Professional University, Phagwara, PB	M.Sc. Zoology	1	Dr. Gireesh Nadda	Insect rearing, bioassay and basic techniques in biotechnology
71.	Ms. Venika Choudhary	JECRC, Jaipur, RJ	B.Sc. Microbiology	3	Dr. Gireesh Nadda	Isolation, culturing and molecular characterization of entomopathogenic fungi from soil
72.	Mr. Atul Mothia	National Institute of technology (NIT), Hamirpur, HP	B.Tech Chemical Engineering	1	Er. Mohit Sharma	Study on different methods of extraction & distillation techniques
73.	Ms. Simranpreet Kaur	DAV, University, Jalandhar, PB	B.Tech Chemical Engineering	1.5	Er. Mohit Sharma	Extraction, filtration, crystallization and distillation techniques

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
74.	Mr. Akash Patil	Savitribai Phule Pune University, Pune (MH)	M.Sc. Environmental Science	1	Dr. Amit Chawla	Ecological techniques for assessing bioresources
75.	Ms. Anchal	Shoolini University, Solan, HP	M.Sc. Botany	1	Dr. Amit Chawla	Isolation and quantification of total RNA from plant tissue
76.	Ms. Anisha Jain	Centre For Converging Technologies, University of Rajasthan, Jaipur, HP	B.Tech+ M.Tech Biotechnology	2	Dr. Amit Chawla	Laboratory and data analysis of primary and secondary data sets for modelling and phylogeny studies
77.	Ms. Monika Janghir	Centre For Converging Technologies, University of Rajasthan, Jaipur, HP	B.Tech+ M.Tech Biotechnology	2	Dr. Amit Chawla	Preliminary analysis of filed samples, distribution modelling of selected species and preparation of phylogenetic tree
78.	Mr. Sarthak Nakra	SHUATS, Allahabad, UP	B.Tech Agriculture Engineering	1	Dr. Amit Chawla	Understanding applications of remote sensing and GIS in bioresource management
79.	Ms. Tanvi Sharma	Govt. PG College, Dharamshala, HP	B.Sc. Biotechnology	1	Dr. Ashok Kumar	Micropropagation of Chrysanthemum
80.	Ms. Shagun Rana	Sri Sai University, Palampur, HP	M.Sc. Zoology	2	Dr. SG Eswara Reddy	Biology and life cycle of *Spodoptera litura* and *Plutella xylostella*
81.	Ms. Surbhi Singla	Panjab University, Chandigarh	M.Sc. Biotechnology	1	Dr. Dharam Singh	Basic molecular techniques for the characterization of microorganisms
82.	Ms. Sheetalpreet Kaur	Panjab University, Chandigarh	M.Sc. Microbiology	1	Dr. Dharam Singh	Hands on techniques of molecular microbiology

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
83.	Ms. Sukhvir Kaur	Panjab University, Chandigarh	M.Sc. Microbiology	1	Dr. Dharam Singh	Basics of protein expression and purification
84.	Ms. Nikhita Thakur	Chandigarh University, Gharuan, Mohali, PB	B.Sc. Biotechnology	2	Dr. Dharam Singh	Basic techniques of plant molecular biology
85.	Ms. Manmehar Kaur	Panjab University, Chandigarh	B.Sc. Biotechnology	1	Dr. Dharam Singh	Molecular and biochemical analysis of medicinal plants
86.	Ms. Shivani	Maharaja Agrasen University, Kalujhanda, Baddi, HP	M.Sc. Biotechnology	3	Dr. Dharam Singh	Identification of plant associated bacteria and their functional screening for hydrolytic enzymes
87.	Ms. Parika Sood	Guru Nanak Dev University, Amritsar, PB	M.Sc. Microbiology	3	Dr. Dharam Singh	Screening of thermostable superoxide dismutase from microorganisms using molecular biology techniques
88.	Ms. Sakshi Jain	Chandigarh University, Gharuan, Mohali, PB	B.Sc. Biotechnology	1	Dr. Dharam Singh	To learn the different techniques of protein engineering
89.	Mr. Rohan Pradhan	Graphic Era (Deemed to be University), Dehradun, UK	B.Sc. Biotechnology	1.5	Dr. Dharam Singh	Hands on basic techniques in molecular microbiology
90.	Ms. Shivangi Jaryal	Govt. PG College, Dharamshala, HP	B.Sc. Biotechnology	1	Dr. Dharam Singh	Introduction to basic microbiology & molecular biology techniques
91.	Ms. Tusha Chandra	Amity University, Noida	B.Tech Biotechnology	2	Dr. Dharam Singh	*Agrobacterium* mediated transformation for achieving higher expression of target gene in transgenic plants

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
92.	Ms. Arshdeep Kaur	Guru Nanak Dev University, Amritsar, PB	M.Sc. Biotechnology	1	Dr. Yogendra Shantaram Padwad	Introduction to experimental animals and techniques in Animal Cell Culture
93.	Ms. Shivani Devi	Shoolini University, Solan, HP	M.Sc. Zoology	3	Dr. Yogendra Shantaram Padwad	Training on molecular biology techniques and methodologies of *in-vitro* and *in-vivo* experimentation for preclinical assessment
94.	Mr. Satish Kumar	Central University of Punjab	AcSIR-Dr. APJ Abdul Kalam fellow	2	Dr. Yogendra Shantaram Padwad	To evaluate the role of Berberine in modulation of H2O2-induced premature senescence in murine preadipocytes
95.	Ms. Nancy Diwan	Chandigarh Group of Colleges (CGC), Landran, PB	M. Pharmacy Pharmacology	6	Dr. Yogendra Shantaram Padwad	Antidiabetic potential of PKE (Plant Extract) in ameliorating the insulin resistance in *in vitro* and *in vivo* model of type 2 Diabetes Mellitus
96.	Ms. Rashmi Bhamra	Chandigarh Group of Colleges (CGC), Landran, PB	M. Pharmacy Pharmacology	6	Dr. Yogendra Shantaram Padwad	Ameliorating effect of PFAP on western diet induced non-alcoholic fatty liver disease (NAFLD) in mice
97.	Mr. Prajnadipta Panda	Central University of Gujrat, Gandhinagar	M.Sc. Life Science	6	Dr. Yogendra Shantaram Padwad	Elucidation of the anti-cancer properties of semi-synthetic small molecules against head and neck

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
						squamous cell carcinoma
98.	Mr. Anurag Shukla	Amity University, Noida	M.Sc. Chemistry	1.5	Dr. Upendra Sharma	Extraction, qualitative and quantitative analysis of *Camellia sinensis* leaves
99.	Ms. Ankita Rana	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Chemistry	1.5	Dr. Upendra Sharma	Study towards oxidation of quinoline derivatives
100.	Dr. Naresh Kumar	Indian Institute of Technology (IIT), Indore, MP	PDF, BS&BE	6	Dr. Upendra Sharma	Organic synthesis and animal cell culture
101.	Ms. Pooja	SRM University, Delhi-NCR, Sonepat, HR	M.Sc. Chemistry	6	Dr. Upendra Sharma	Study on isolation and characterisation of secondary metabolites from medicinal plants
102.	Mr. Ayush Kumar	DAV University, Jalandhar, PB	M.Sc. Chemistry	1	Dr. Upendra Sharma	Basic training on working in organic synthesis
103.	Mr. Arpit Mahajan	Guru Nanak Dev University, Amritsar, PB	M.Sc. Applied Chemistry	4	Dr. Upendra Sharma	Protection of amino acids using phthalic anhydride
104.	Mr. Sahil Dhiman	Amity University, Noida	M.Sc. Chemistry	1.5	Dr. Pamita Bhandari	Extraction of terpenoids from *Emblica officinalis*
105.	Mr. Rishabh Kumar	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Chemistry	1.5	Dr. Pamita Bhandari	Extraction of green pigment from *Eupatorium adenophorum*
106.	Ms. Neha Katoch	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Chemistry	1.5	Dr. Pamita Bhandari	Extraction of Anthocyanin pigment from different rose species
107.	Ms. Nitika Sharma	Abhilashi University, Chail chowk, Mandi, HP	M. Pharmacy Pharmaceutical Chemistry	3	Dr. Pamita Bhandari	Design and synthesis of triterpenoid analogues

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
108.	Ms. Divya	DAV, University, Jalandhar, PB	M.Sc. Chemistry	1	Dr. Pamita Bhandari	Quantitative analysis of *Terminalia bellirica* by HPLC
109.	Ms. Nitika Sharma	Abhilashi University, Chail chowk, Mandi, HP	M. Pharmacy Pharmaceutical Chemistry	3	Dr. Pamita Bhandari	Design and synthesis of triterpenoid analogues
110.	Ms. Bhasita Bharat	Amity University, Gwalior, MP	B.Tech Biotechnology	1.5	Dr. Amitabha Acharya	Synthesis and characterization of plant based metallic nanoparticals and their antibacterial activity
111.	Ms. Smriti Gupta	GGDSD College, Sec-32-C, Chandigarh	M.Sc. Biotechnology	3	Dr. Amitabha Acharya	Biosynthesis of gold nanoparticles from *Populus alba*: their characterization and antibacterial activity
112.	Mr. Anikesh Bhardwaj	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Chemistry	1.5	Dr. Dinesh Kumar	Isolation of components of *Saussurea lappa* from methanolic extract
113.	Ms. Riya Sharma	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Chemistry	1.5	Dr. Dinesh Kumar	Isolation of secondary metabolites from seed oil of *Hippophae rhamnoides*
114.	Ms. Ayushi Mahajan	DAV, University, Jalandhar, PB	M.Sc. Chemistry	1	Dr. Dinesh Kumar	Phenolics separation on ultra-pressure liquid chromatography (UPLC) and ultra-high pressure liquid chromatography-quadrupole-time of flight mass spectrometry

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
						(UHPLC-Q-TOF-MS/MS)
115.	Ms. Namrata	Guru Nanak Dev University, Amritsar, PB	M.Sc. Biotechnology	1	Dr. Vikram Patial	Training in basic and molecular techniques in *In-vivo* animal experimentation
116.	Ms. Anchal Rana	Guru Nanak Dev University, Amritsar, PB	M.Sc. Biotechnology	1	Dr. Vikram Patial	Basic and molecular techniques in animal pathology and toxicology
117.	Mr. Nitin Dhillon	Manipal College of Pharmaceutical Sciences, Manipal, Karnataka	B. Pharmacy	1	Dr. Damanpreet Singh	Testing the cardio protective activity of PPE-IHBT-01 in Isoproterenol induced Myocardial infarction on Zebrafish model
118.	Ms. Darshpreet Kaur	Maharaja Ranjit Singh Punjab Technical University, Bathinda, PB	Ph.D.	1	Dr. Damanpreet Singh	Basic techniques used in pharmacology, toxicology and molecular biology
119.	Ms. Sanmi Sharma	Beant College of Engineering and Technology (BCET), Gurdaspur, PB	B.Tech Biotechnology	1.5	Dr. Damanpreet Singh	Basic techniques used in pharmacology and toxicology laboratory
120.	Ms. Tanjot Kaur	Sri Guru Granth Sahib World University, Fatehgarh sahib, PB	B.Tech Biotechnology	1.5	Dr. Damanpreet Singh	Basic techniques in pharmacology and toxicology laboratory
121.	Ms. Mohnish Kaur	Sri Guru Granth Sahib World University, Fatehgarh sahib, PB	B.Tech Biotechnology	1.5	Dr. Damanpreet Singh	Basic techniques in pharmacology and toxicology laboratory
122.	Ms. Suryapriya Ulaganathan	Central University of Rajasthan	AcSIR- Dr. APJ Abdul Kalam fellow	2	Dr. Damanpreet Singh	Investigating the effect of FN01 in phenytoin-induced cognitive deficit in pentylenetetrazole mediated

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
						convulsions in zebrafish
123.	Mr. Nitin Goel	G.H.G. Khalsa College of Pharmacy, Gurusar Sudhar, PB	M. Pharmacy Pharmacognosy	6	Dr. Damanpreet Singh	*Nardostachys jatamansi* prevents Cardiotoxicity via inhibiting mTOR pathway in Zebrafish model
124.	Ms. Sakshi Kanotra	Goa University, Taleigao, Goa	M.Sc. Marine Biotechnology	2	Dr. Vishal Acharya	Comparative genomic analysis of psychrotolerant *Chryseobacterium polytrichastri ERMR 1:04* for cold-adaptation study
125.	Ms. Riya Sood	Shoolini University, Solan, HP	B.Tech Biotechnology	1.5	Dr. Vishal Acharya	Cold-adaptive traits revealed by the genome-wide comparison of *Chryseobacterium jeonii* with its mesophilic relatives for survival at extreme cold-conditions
126.	Mr. Pawan Kumar Sharma	CSKHPKV, Palampur	Post. Doc	1	Dr. Vishal Acharya	Identification of Differentially Expressed Genes and Network Construction in Rice through Bioinformatics tools
127.	Ms. Himani Sharma	Centre For Converging Technologies, University of Rajasthan, Jaipur, HP	B.Sc. Biotechnology	3	Dr. Vishal Acharya	Computational genome analysis of *Rhodococcus Sp.* JG-3 with its mesophilic relatives for understanding its survival at extreme cold-conditions

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
128.	Mr. Archit Sharma	Jaypee University of Information Technology (JUIT) Solan, HP	B.Tech CSE	1	Dr. Vishal Acharya	Optimization of Network Guided Forest (NGF) approach for discrimination of plant immune system
129.	Ms. lavisha	Kanya Maha Vidyalaya, Jalandhar, PB	B.Sc. Biotechnology	1	Dr. Bhavya Bhargava	Culturing of chrysanthemum and subculturing of orchids
130.	Ms. Nandini Kanwar	Kanya Maha Vidyalaya, Jalandhar, PB	B.Sc. Biotechnology	1	Dr. Bhavya Bhargava	Culturing of chrysanthemum and subculturing of orchids
131.	Ms. Mandeep Kaur	Sri Guru Granth Sahib World University, Fatehgarh sahib, PB	B.Tech Biotechnology	1.5	Dr. Bhavya Bhargava	Studies on *in-vitro* micropropagation and hardening of *Chrysanthemum morifolium*
132.	Ms. Usha Kumari	Maharaja Agrasen University, Kalujhanda, Baddi, HP	M.Sc. Biotechnology	3	Dr. Bhavya Bhargava	Culturing of Chrysanthemum and Subculturing of Orchids
133.	Ms. Nitika	Govt. PG College, Dharamshala, HP	B.Sc. Biotechnology	1	Dr. Bhavya Bhargava	*In vitro* micropropagation and multiplication of *Cymbidium orchid* and seeds inoculation of *Dracula simia*
134.	Ms. Anchal	Govt. PG College, Dharamshala, HP	B.Sc. Biotechnology	1	Dr. Bhavya Bhargava	*In vitro* culturing, multiplication and establishment of Lilium variety (Party Diamond)
135.	Ms. Surabhi Gaba	Amity University, Noida	B.Tech Biotechnology	2	Dr. Bhavya Bhargava	*In vitro* seed germination and seedling development of *Orchid Cymbidium* using plant tissue culture techniques

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
136.	Mr. Dewansh Mehta	Amity University, Noida	B.Tech Biotechnology	2	Dr. Jeremy Dkhar	Efficacy of bioactive compounds from the pitcher fluid of Nepenthes khasiana against pathogenic microbes
137.	Ms. Simran Katle	DY Patil University, MH	B.Tech Biotechnology	6	Dr. Rohit Joshi	Optimization of axillary shoot proliferation and biochemical characterization of giant bamboo, *Dendrocalamus giganteus* Wall. Ex Munro
138.	Ms. Anika Samyal	Himachal Pradesh University (HPU), Summer-Hill, Shimla, HP	M.Sc. Microbiology	1	Dr. Shiv Shanker Pandey	Culture techniques in microbiology
139.	Ms. Neha Carpentar	Balkavi Bairagi Mahavidyalaya, MP	M.Sc. Biotechnology	6	Dr. Shiv Shanker Pandey	Isolation of L-Asparaginase producing cold-tolerant microorganism
140.	Ms. Harkirat Kaur	Panjab University, Chandigarh	M.Sc. Biotechnology	1	Dr. Kunal Singh	Assessment of plant growth promoting traits in given bacterial strains isolated from cold region
141.	Ms. Meenakshi	Gautam College Hamirpur, HP	M.Sc. Microbiology	1	Dr. Kunal Singh	Cloning of 16srRNA gene of bacteria through PGEMT vector
142.	Ms. Vidushi Sharma	Guru Nanak Dev University, Amritsar, PB	M.Sc. Microbiology	3	Dr. Kunal Singh	Characterization and identification of efficient plant growth promoting Rhizobacteria isolated from multilocation of Himachal Pradesh

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
143.	Ms. Swati Dogra	GNDU, Amritsar, PB	M.Sc. Microbiology	1	Dr. Kunal Singh	Basic techniques in plant molecular biology
144.	Mr. Arush Kaushal	Jaypee University of Information Technology (JUIT) Waknaghat, Solan, HP	B.Tech Biotechnology	1.5	Dr. Ashish Rambhau Warghat	Basic of plant tissue culture and *in-vitro* propagation of *Podophyllum hexandrum* using embryo culture technique
145.	Ms. Parul	Hans Raj Mahila Maha Vidyalaya, Jalandhar, PB	B.Sc. Biotechnology	1	Dr. Ashish Rambhau Warghat	Basic of Plant Tissue Culture and embryo culture in *Podophyllum hexandrum*
146.	Ms. Bhanve Jain	Hans Raj Mahila Maha Vidyalaya, Jalandhar, PB	B.Sc. Biotechnology	1	Dr. Ashish Rambhau Warghat	Basic of Plant Tissue Culture and callus culture in *Stevia rebaudiana*
147.	Mr. Rahul	SUSECT, Mohali, PB	B.Tech Biotechnology	1	Dr. Ashish Rambhau Warghat	Basic techniques of plant tissue and organ culture
148.	Ms. Tanvi Sehgal	Jaypee University of Information Technology (JUIT) Waknaghat, Solan, HP	B.Tech Biotechnology	1.5	Dr. Ashish Rambhau Warghat	Basic in plant tissue culture
149.	Mr. Asheesh Kumar	Chandigarh University, Gharuan, Mohali, PB	B.Sc. Agriculture	2	Dr. Ashish Rambhau Warghat	Basic techniques of plant cell, tissue and organ culture
150.	Ms. Diksha	Maharaja Agrasen University, Kalujhanda, Baddi, HP	M.Sc. Biotechnology	3	Dr. Ashish Rambhau Warghat	Micropropagation, Callus induction and cell suspension culture of *Rhodiola imbricata*
151.	Ms. Mansi Rana	Govt. PG College, Dharamshala, HP	B.Sc. Biotechnology	1	Dr. Ashish Rambhau Warghat	Basic techniques of plant tissue with especial emphasis on micropropagation of Himalayan medicinal plants

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
152.	Ms. Diksha Thakur	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Biotechnology	6	Dr. Ashish Rambhau Warghat	Basic Techniques of Plant Cell, Tissue and Organ Culture in *Picrorhiza kurroa* Royle ex Benth. - A Medicinal Important herb of Himalayas
153.	Mr. Shivam Chaudhary	DUVASU, Mathura, UP	B.Sc. Biotechnology	3	Dr. Ashish Rambhau Warghat	Basic techniques in plant tissue culture
154.	Ms. Laveena Kaushal	Panjab University, Chandigarh	M.Sc. Biotechnology	1	Dr. Rajiv Kumar	Identification and characterization of protiens by mass spectrometry based proteomic analysis
155.	Ms. Sandeep Kaur	Maharaja Agrasen University, Kalujhanda, Baddi, HP	M.Sc. Biotechnology	3	Dr. Rajiv Kumar	Proteomic analysis of *Medicago sativa* using MALDI-TOF-TOF MS/MS
156.	Ms. Neha	Vellore Institute of Technology (VIT), Tamil Nadu	M.Sc. Biotechnology	6	Dr. Rajiv Kumar	Root and shoot specific proteomic dissection of *Picrorhiza kurroa*
157.	Mr. Devangna Paul	Amity University, Noida	B.Sc. Biotechnology	1	Dr. Rajiv Kumar	Biochemical assays of medicinal plant extracts
158.	Mr. Vishal Kumar Deb	Baba Farid Institute of Technology (BFIT), Dehradun, UK	M.Sc. Microbiology	1	Dr. Narendra Vijay Tirpude	Training on methodologies of molecular biology and preliminary toxicological screening
159.	Ms. Bhavya Arora	BBK DAV College for Women, Lawrence Road, Amritsar, PB	B.Sc. Biotechnology	1	Dr. Narendra Vijay Tirpude	Sensitization training on techniques involved in preclinical assessment of novel herbal formulations

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
160.	Ms. Naaz Bansal	Panjab University, Chandigarh	B.Sc. Biochemistry	2	Dr. Narendra Vijay Tirpude	Studies on biochemical and genomic information in plants
161.	Ms. Gunjan Thakur	Himachal Pradesh University (HPU), Summer-Hill, Shimla, HP	M.Sc. Biotechnology	3	Dr. Narendra Vijay Tirpude	Training on molecular techniques involved *in vitro* and *in vivo* evaluation for preclinical assessment and methodologies of nutraceutical formulation development
162.	Ms. Ruchika	Lovely Professional University, Phagwara, PB	M.Sc. Zoology	1	Dr. Narendra Vijay Tirpude	Training on preclinical experimentation techniques involved in herbal formulation efficacy validation
163.	Ms. Ashu Devi	Lovely Professional University, Phagwara, PB	M.Sc. Zoology	1	Dr. Narendra Vijay Tirpude	Sensitization training on methodologies for *in vivo* toxicological screening of nutraceuticals
164.	Ms. Amarpreet Kour	SUSCET, Mohali, PB	B.Tech Biotechnology	6	Dr. Narendra Vijay Tirpude	Efficacy evaluation of novel herbal powder formulation on Monosodium iodoacetate (MIA) induced osteoarthritis
165.	Ms. Tanvi Sharma	DAV University, Jalandhar, PB	M.Sc. Zoology	6	Dr. Narendra Vijay Tirpude	Evaluation of synergistic effect of novel herbal powder and cream formulation

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
						on Monosodium iodoacetate (MIA) induced osteoarthritis
166.	Ms. Bhasita Bharat	Amity University, MP	B.Tech Biotechnology	2	Dr. Narendra Vijay Tirpude	Sensitization training on molecular techniques involved *in vitro* and *in vivo* evaluation for preclinical assessment of herbal nutraceutical formulations
167.	Ms. Megha Chatterjee	Guru Nanak Dev University, Amritsar, PB	M.Sc. Biotechnology	1	Dr. Rakshak Kumar	Taxonomic resolution of Pseudomonas strains from alpine region using multilocus sequence analysis (MLSA)
168.	Ms. Astha	SHUATS, Allahabad, UP	B.Sc. Biotechnology	1	Dr. Rakshak Kumar	Basic tools and software used in Bioinformatics
169.	Mr. Sarthak Upadhyay	Jaypee University of Information Technology (JUIT) Waknaghat, Solan, HP	B.Tech Biotechnology	1	Dr. Rakshak Kumar	Basic tools and software used in Bioinformatics
170.	Ms. Shagun Sharma	JECRC, Jaipur, RJ	B.Sc. Microbiology	3	Dr. Rakshak Kumar	Isolation, screening and characterization of psychrotrophic bacteria from high altitude compost sample
171.	Ms. Himani Bhushan	Amity University, Noida	M.Sc. Microbiology	5	Dr. Rakshak Kumar	Isolation and phylogenetic analysis of halophilic bacteria from the alpine

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
						regions of Western Himalayas
172.	Ms. Anchita Lalhall	Shoolini University, Solan, HP	B.Tech Food Technology	1	Dr. Vidyashankar Srivatsan	Characterization of functional and nutritional properties of traditional Indian cereal food (Sattu)
173.	Ms. Anugya Jaiswal	SHUATS, Allahabad, UP	B.Sc. Biotechnology	1	Dr. Vidyashankar Srivatsan	Studies on outdoor open pond cultivation of *Spirulina platensis* for nutraceutical applications
174.	Ms. Parul Narwal	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Biotechnology	2	Dr. Vidyashankar Srivatsan	Basic techniques in molecular biology
175.	Ms. Smriti Kumari	Banaras Hindu University (BHU), Varanasi, UP	M.Sc. Food Science &Technology	2	Dr. Vidyashankar Srivatsan	Extraction of phycocyanin from *Spirulina platensis* and evaluation of its stability
176.	Ms. Neha	Himachal Pradesh University, Shimla, HP	M.Sc. Microbiology	3	Dr. Vidyashankar Srivatsan	Cultivation and Biochemical composition analysis of industrially important Microalgae
177.	Ms. Bhavya Sharma	Kanya Gurukul Campus, haridwar, UK	M.Sc. Microbiology	3	Dr. Vidyashankar Srivatsan	Isolation and characterisation of microalgae for nutraceutical applications
178.	Ms. Vibha	C.T. Group of Institute, Jalandhar, PB	M.Sc. Biotechnology	6	Dr. Vidyashankar Srivatsan	Development of microalgae based iron enriched functional foods
179.	Ms. Nitika Kumari	Shoolini Institute of Life Sciences & Business Management (SILB), Solan, HP	M.Sc. Biotechnology	1	Dr. Poonam Kumari	Micropropagation studies on Calla lily

S. No.	Student Name	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
180.	Ms. Sheetal	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Biotechnology	6	Dr. Poonam Kumari	*In vitro* propagation of calla lily (*Zantedeschia ellotiana* cv. Him *Sumukh*)
181.	Ms. Deepika Shekhawat	Balkavi Bairagi Mahavidyalaya, Neemuch, MP	M.Sc. Biotechnology	6	Dr. Vandana Jaiswal	Development of molecular marker for some important genes in rose
182.	Mr. Harshal Sunil Vinchurkar	Savitribai Phule Pune University, Pune, MH	M.Sc. Environmental Science	1	Dr. Manoj Kumar	Effect of different crops on soil carbon density at Palampur, Himachal Pradesh
183.	Ms. Unnati Gusain	Shri Guru Ram Rai University, Dehradun, UK	M.Sc. Biotechnology	6	Dr. Kunal Singh	Re-isolation of *Bacillus siamensis* from applied soil and characterization for Plant growth promoting activities
184.	Ms. Sayali Asole	DY Patil University, MH	B.Tech Biotechnology	6	Dr. Amita Bhattacharya	Development of cell suspension system in saffron for biochemical analysis
185.	Dr. H.K. Jha	Aditya Herbal &Electrohomeopathy Research Centre, Godda, Jharkhand	Ph.D	5 days	Dr.Vijai Kant Agnihotri	Completed lab work training
186.	Dr. Vishal Paliwal	Arogyam's Herbal &Electrohomeopathy Research Centre, Chopda, Jalgaon, Maharashtra	Ph.D	5 days	Dr.Vijai Kant Agnihotri	Completed lab work training
187.	Dr. Ranjit Srishti	Begusarai, Bihar	Ph.D	5 days	Dr.Vijai Kant Agnihotri	Completed lab work training

Conference/ Training/ Workshop/ Symposium presentations

Pal PK (2019) Medicinal Plants for Higher Income & Health Care in a Meeting of Stakeholders of Medicinal Plants of Northern Region-I, Dharamshala, HP; Organized by NMPB, Ministry of AYUSH, May 3.

Guliani A and Acharya A (2019) Invited lecture on "Nanoemulsion of essential oils: physico-chemical characterization and their antimicrobial applications" International Conference on Electron Microscopy & Allied Analytical Techniques, Organized by HP University, Shimla and EMSI, June 5-9.

Reddy SGE and Dolma SK (2019) Effect of different nitrogen sources, water and pH in apple pomace medium for spore production of biocontrol agent, *Trichoderma harzianum*. International Conference on Agriculture, Horticulture and Plant Science, pp 17, Dharamshala (H.P.), June 27-28.

Dhiman AK and Sharma U (2019) Microwave-Assisted Metal-Free Three Component Reaction for Direct Synthesis of 2-Anilinoquinolines and 3-Hydroxyquinolines. In 25th CRSI National Symposium in Chemistry and CRSI-ACS, IIT Kanpur, July 18-21.

Kumar R and Sharma U (2019) Cobalt(III)-Catalyzed Alkylation of C(sp^3)-H Bonds of 8-Alkylquinolines with Maleimides. In 25th CRSI National Symposium in Chemistry and CRSI-ACS, IIT Kanpur, July 18-21.

Chandra D and Sharma U (2019) Rapid Synthesis of Quinoline by Organic Acid Mediated Povarov Type Multicomponent Reaction. In 25th CRSI National Symposium in Chemistry and CRSI-ACS, IIT Kanpur, July 18-21.

Reddy SGE and Dolma SK (2019) Insecticidal properties of essential oils for the control of diamondback moth (*Plutella xylostella*). International Conference on Plant Protection in Horticulture (ICPPH-2019), pp.81. Organized by Association for Advancement of Pest Management in Horticulture, ICAR-IIHR, Hessaraghatta, Bangalore, July 24-27.

Jayaram CS, Chauhan N, Dolma SK and Reddy SGE (2019) Ovicidal and ovipositional deterrence activity of essential oils against two spotted spider mites (*Tetranychus urticae*): a major pest of horticultural crops in protected cultivation. International Conference on Plant Protection in Horticulture (ICPPH-2019), pp. 96. Organized by Association for Advancement of Pest Management in Horticulture, ICAR-IIHR, Hessaraghatta, Bangalore, July 24-27.

Dolma SK and Reddy SGE (2019) Toxicity of essential oils for the control of two spotted spider mite (*Tetranychus urticae*) in horticultural crops. International Conference on Plant Protection in Horticulture (ICPPH-2019), pp. 94. Organized by Association for Advancement of Pest Management in Horticulture, ICAR-IIHR, Hessaraghatta, Bangalore, July 24-27.

Singh D (2019) Delivered a lectureon "Zebrafish as an Experimental Model in Biomedical Research: Focus on Preclinical Epilepsy Research" in IBRO-APRC MLSU School of Neuroscience, Mohanlal Sukhadia University, Udaipur. August 7.

Singh D (2019) Delivered a lecture on "Agro-Technology of MAP and Commercially Important Medicinal Plants and Therapeutic Potential of Traditional Medicinal Herbs of Western Himalayas" in a Refresher Training Course for Indian Forest Service (IFS) Officers on Conservation and Development of Medicinal Plants and Benefit Sharing with Local Communities at Himalayan Forest Research Institute (HFRI), Shimla, August 30.

Rana AK, Sharma S and Singh D (2019) Hormone replacement therapy: A double edge sword in taming neurobehavioral impairments after menopause. In: IBRO-APRC Sponsored Neuroscience School on Molecular Basis of Neuroinflammation Mediated Neurodegeneration, Department of Biochemistry, Institute of Science, Banaras Hindu University, September 1-14.

Bhattacharya A (2019) Conducted training on 'Basic training in plant tissue culture. CSIR-IHBT, Palampur, September 12-21.

Singh D (2019) Delivered a lecture on "Traditional Herbs as a Source of Medicine" in 2019 Joint Forum for Traditional Medicine under the New Southbound Policy-The Application and Translation of Traditional Medicine Resources at National Research Institute of Chinese Medicine, Taipei, Taiwan, October 22.

Pal PK (2019) "The Joint Forum for Traditional Medicine under the New Southbound Policy: Application and Translation of Traditional Resources", Taipei city, Taiwan, October 22-23.

Pal PK (2019) 9th Stevia Global Summit 2019. Stevia Global Forum. Noida, November 9.

Bhattacharya A (2019) Conducted 7 days training on 'Basic training in plant tissue culture'. CSIR-IHBT, Palampur, November 13-20.

Kumar R and Sharma U (2019) New Bioactive Molecules through C-H Bond Functionalization and [3+2] Cyclization of N-Heterocyclic Compounds in New Frontiers in Chemistry - From Fundamentals to Applications (NFCFA2019), (Third Prize for this Poster) Department of Chemistry, BITS Pilani, KK Birla, Goa Campus, December 20-22.

Kumar R and Sharma U (2019) Employing C-H activation for the synthesis of quinoline containing antimalarials in New Frontiers in Chemistry from Fundamentals to Applications (NFCFA2019), Department of Chemistry, BITS Pilani, KK Birla Goa Campus, December 20-22.

Gupta SS and Sharma U (2019) Derivatization of N-Heterocyclic Scaffolds to Bioactive Molecules Through C-H Activation Strategy in New Frontiers in Chemistry - From Fundamentals to Applications (NFCFA2019), Department of Chemistry, BITS Pilani, KK Birla Goa Campus, December 20-22.

Dhiman AK and Sharma U (2019) Design and Synthesis of Quinoline based Bioactive Heterocyclic Molecules through C-H Functionalization in New Frontiers in Chemistry - From Fundamentals to Applications (NFCFA2019), Department of Chemistry, BITS Pilani, KK Birla Goa Campus, December 20-22.

Kumar I and Sharma U (2019) Photocatalyzed Metal/Oxidant-free ipso-Hydroxylation of Boronic Acids: Direct Synthesis of Phenols in New Frontiers in Chemistry-From Fundamentals to Applications (NFCFA2019), Department of Chemistry, BITS Pilani, KK Birla Goa Campus, December 20-22.

Patil S, Singh P and Sharma U (2020) Steroidal Saponins from *Trillium govanianum*: Isolation and Characterization. Gyantarang 2020, CSIR-NEIST, Jorhat Assam, January 23-25.

Singh D (2020) Delivered a lecture on "Basic Concept of Pharmacology" for PG students at Ayurveda at Rajiv Gandhi Govt. Post Graduate

Ayurvedic College and Hospital, Paprola, January 28.

Joshi R (2020) Plant stress physiology: Paving the way of life for abiotic stress tolerance. National Symposium on Trends in Plant Biotechnology & Agriculture and 41st Annual Meeting of Plant Tissue Culture Association of India. Thapar institute of Engineering and Technology, Patiala, Punjab, Pp 26-27, February 6-8.

Singh D (2020) Delivered a lecture on "Structure activity relationship and drug discovery" for PG students at Ayurveda at Rajiv Gandhi Govt. Post Graduate Ayurvedic College and Hospital, Paprola, February 11.

Selvaraj V, Chhimwal J, Padwad Y and Hallan V (2020) Cross Kingdom transfection of Apple scar skin viroid, a plant pathogen in animal cells. International conference of Virology on the theme "Evolution of viruses and viral diseases". Organized by Indian Virological society, Indian National Science Academy, New Delhi, February 18-20.

Chaudhary S, Selvaraj V, Bhuria S, Purohit R and Hallan V (2020) Plant mediated silencing of Trialeurodes vaporariorum small heat shock protein gene and its role in Apple Scar Skin Viroid transmission. International conference of Virology on the theme "Evolution of viruses and viral diseases". Organized by Indian Virological society, Indian National Science Academy, New Delhi, February 18-20.

Pal PK (2019) Agro-Technology of MAP and Commercially Important Medicinal Plants and Therapeutic Potential of Traditional Medicinal Herbs of Western Himalayas in a Refresher Training Course for Indian Forest Service (IFS) Officers on "Conservation and Development of Medicinal Plants and Benefit Sharing with Local Communities" at Himalayan Forest Research Institute (HFRI), Shimla, August 30.

Sharma A, Ranout AS and Nadda G (2020) Molecular tools for the identification of insects. National Seminar on Science as a tool for Skill Enhancement Among Entrepreneurs-2020", SVGC, Ghumarwin (HP), 7-8 February.

Kumar R and Sharma M (2020) organized a training programme on improved cultivation of low chilling varieties of apple at Champhai, Mizoram, January 26.

Kumar R (2020) organized a training programme on Improved Agro and process technology of Damask rose for the industrialist from Maharashtra, February 24-25.

Kumar R, Bhargav B and Asish (2020) organized two Training programmes on hydroponics and aeroponics cultivation at CSIR IHBT Palampur, December 16-19, 2019 and February 5-8.

Ishu, Kumar A, Bhattacharya A and Singh KK (2020) Large scale production of juvenile planting material of *Phyllostachys pubescens* (Moso bamboo) and applications in making agarbatti and broom sticks, National Symposium on Trends in Biotechnology & Agriculture and 41st Annual meeting of Plant Tissue Culture Association of India at Thapar University, Patiala (Punjab), Vol. NSTPB 2020/ 0025, pp.94.

Conference/ Training/ Workshop/ Meeting attended

Kumar R and Singh S (2019) Attended Second Monitoring Committee meeting and Steering Committee meeting of CSIR-Aroma Mission project at CSIR Headquarter New Delhi, April 15-16.

Kumar R and Hallan V (2019) Attended brainstorming workshop on Precision Agriculture at CSIR-Science centre, New Delhi, July 23.

Kumar R and Singh S (2019) Attended Steering Committee Meeting of CSIR-Aroma mission at CSIR-Headquarter, New Delhi, August 20.

Kumar R, Sharma M, Kumar D and Joshi R (2020) Attended Research Institute of Fragrance Materials INFOX meeting at The Leela Palace, New Delhi, India, January 23.

Singh D (2019) Demonstration on Zebrafish as an experimental animal model on National Technology Day, May 11.

Kumar P (2019) Awarded with Excellence in Research Award -2019 by Agro Environmental Development Society, India during 2nd International conference on Recent Advances in Agricultural, Environmental & Applied Sciences for Global Development (RAAEASGD-2019) held at Dr. Yashwant Singh Parmar University of Horticulture and Forestry, Nauni, Solan, Himachal Pradesh, India, September 27-29.

Kumar P (2019) Awarded with Young Scientist Award -2019 by the Society of Tropical Agriculture, New Delhi, India during 9th International Conference on Agriculture, Horticulture and Plant Science, organized by The Society of Tropical Agriculture at ANGEL'S INN RESORT, Dharamshala, June 27-28.

Singh D (2019) Attended “Train the Educator” course for educators/trainers on “Developing and Sustaining India's Capacity for Preclinical Drug Discovery” under MSDE-UKIERI skills thematic Institutional Partnership Program at National Institute of Nutrition, Hyderabad, July 8-12.

Singh S (2019) Attended Five days “NBM Technology Transfer Training Program” DBT-NBM, Pune, September 8-12.

Kumar R and Gupta M (2020) Attended a meeting in DBT office, New Delhi, for establishing Inter Institutional Centre on Bioresources in Mizoram, February 18.

Kumari A (2020) Attended one workshop on “Downstream Bioprocess Development” organised by KIIT-Technology Business Incubator and sponsored by National Biopharma Mission, Bhubaneswar, Orissa, January 20-24.

Singh A (2020) Attended 2 days training programme on the topic "*Institutionalizing Capacities on Climate Change*", Hotel Holi-Day Home Shimla, organized by Department of, Science, Technology & Environment Government of Himachal Pradesh, February 20–21.

Kumar P (2020) Attended and participated in the 41st Annual Meeting of Plant Tissue Culture Association of India and National Symposium on Trends in Plant Biotechnology & Agriculture" held at Thapar Institute of Engineering & Technology, Patiala, India, February 6-8.

Conference/ Training/ Workshop/ Meeting organized

Sharma M (2019) One-day demonstration cum training of rose oil distillation was imparted to 5 farmers of Sainj, Distt. Kullu HP, April 26.

Sharma M (2019) Training cum demonstration on rose oil distillation was imparted to 2 faculty members and 2 students of IIT, Mandi, under Mission Aroma April 27.

Sharma M (2019) Training cum demonstration on rose oil distillation was imparted to 25 farmers of Mandi, Shimla and Chamba districts under Mission Aroma, April, 29.

Kumar R (2019) Coordinated a meeting of MSME official to CSIR-IHBT Palampur during May 16-17. MSME Director Mercy Epao along with three officers from MSME participated in the meeting, May 16-17.

Kumar R (2019) Coordinated a Meeting of National Research Institute of Taiwanese Medicine Taiwan at CSIR-IHBT. The meeting was attended by Professor Fang-Rong Chang Director, NRICM; Dr Lie-Chwen Lin, Research Fellow/Director Division of Chinese Medicine Literature & Informatics; Dr Mayeesha Yu-Hwei Tseng and Dr Chang-Chang Chen, Assistant Research Fellows and CSIR-IHBT Scientist, July 1-4.

Sharma M (2019) Training cum demonstration was given to 4 representatives of INDCOSERVE, Tamilnadu for the extraction of tea catechins. July 31 to August 2.

Kumar S (2019) Inaugurated the CSIR-HRDC Training Programme on CSIR Manual on Procurement of Goods 2019. Seventy-two participants from CSIO, IHBT, IIIM, and IMTECH attended the training program during September 2-6.

Dahal N (2019) Attended an informal discussion held at the Princeton University between Indian scientists and Princeton faculty and students on ecology and conservation of biodiversity in the Himalaya. The program was funded by University's Global Collaborative Network program, November 14-15.

Warghat A (2019) Training cum demonstration on hydroponic and aeroponic cultivations to farmers, students and entrepreneurs to around 43 farmers & students participated, held at CSIR-IHBT, Palampur, December 16-19.

Agnihotri VK (2019) A Training programme entitled "Standardization and analytical investigation of Electrohomeopathic medicines" was organized for the doctors of Electrohomeopathy, December 23-27.

Agnihotri VK (2019) Chief Minister Startup Scheme of the Directorate of Industries, Himachal Pradesh for development of products from *Curcuma longa* growing at HP.

Warghat A (2020) Training cum demonstration on hydroponic and aeroponic cultivations to farmers, students and entrepreneurs to around 33 farmers & students participated, held at CSIR-IHBT, Palampur, February 5-8.

Kumari P (2020) Training cum demonstration on hydroponic and aeroponic cultivations to farmers, students and entrepreneurs to around 33 farmers & students participated, held at CSIR-IHBT, Palampur, February 5-8.

Sharma M (2020) Training on essential oil distillation was imparted to around 50 farmers of Rourkela district, February 14.

Sharma M (2020) Training cum demonstration of essential oil distillation was imparted to 2 entrepreneurs of Maharashtra, February 25.

Lectures Invited/delivered

Dr. Vijai Kant Agnihotri (2019) Aroma@Himalayas: Status and Future Direction of R & D in Essential Oil & Fragrance Sector. Delivered in "Flavours & Fragrances Expo 2019", held at Bombey Exhibition Centre, Goregaon (E), Mumbai, India, April 16.

Dr. Sanjay Kumar (2019) Rural Upliftment Through Science & Technology Interventions at HESCO, Dehradun (UK), April 19.

Dr. Shashi Bhushan (2019) Delivered a talk during Regional Stakeholders Meet on Medicinal Plants at Dharamshala, Himachal Pradesh, May 03.

Dr. Ashok Singh (2019) Delivered a lecture on the topic "*a value chain on Seabuckthorn*" at Gymnasium Hall Keylong, organized by GBPNIHE Himachal Regional Centre, Mohal-Kullu under the NMHS funded project, June 6.

Dr. Rakesh Kumar (2019) Delivered an invited lecture in "Innovations in rural technologies" for the senior officers of NABARD at Hotel Nature Bloom, Nagari, Palampur HP. June 24.

Dr. Rakesh Kumar (2019) Delivered an invited talk on the topic entitled "High Altitude Medicinal Plants of Himalayas and Their Therapeutics Uses" in National Yang Ming University, Taipei City, Taiwan, on July 13.

Dr. Upendra Sharma (2019) "Remote C-H Activation: Direct Access to C8-Functionalized Quinolines International Conference" in Catalysis and Organic Synthesis (ICCOS-2019), Moscow, Russia, September 15-20.

Dr. Sanjay Kumar (2019) Foundation Day lecture on Technological Needs for Plant Biologist at CSIR-CEERI, Pilani, September 21.

Dr. Ashok Singh (2019) Delivered a lecture on the topic "*Scope of medicinal plants in the Lahaul-Spiti*" organized by KVK Kukumseri, October.

Dr. Ashok Singh (2019) Delivered a lecture on the topic "*Cold desert biodiversity*" One-day workshop program on "*SECURE Himalaya UNDP & GEF project*" DC Office Keylong, October.

Dr. Shashi Bhushan (2019) Delivered a talk at CIAB, Mohali in a workshop on Functional Food and Process Engineering, Mohali, October 15.

Dr. Rohit Joshi (2019) Delivered lectures on "plant tissue culture" Himalayan Action Research Centre, Dehradun in a training programme entitled 'Basic training in plant tissue culture , November 13-20.

Dr. Ashok Singh (2019) Lecture delivered as an expert member in the brain storming workshop "*Improving Livelihoods in High-altitude Himalaya*" organized by UNDP & GEF India, Habitat Centre, Lodhi Road, New Delhi, December 2.

Dr. Sanjay Kumar (2019) Chief Guest and delivered a lecture on "Himalayan Bioresources for Human Health and Wellness" ITC 2019 at IITR Lucknow, December 5.

Dr. Upendra Sharma (2019) "Don't forget the Past: Traditional Knowledge Derived Discovery of Novel Bioactive Molecules" in National Conference on Innovation in Bioprocess Technology (IBT-2019), CIAB, Mohali, Punjab, December 11-13.

Dr. Poonam Kumari (2019) Delivered a lecture on "Hydroponic Substrates" around 43 farmers & students participated, CSIR-IHBT, Palampur, December 18.

Dr. Poonam Kumari (2019) Delivered a lecture on "Basic principles of plant nutrition, nutrient solutions" around 43 farmers & students participated, CSIR-IHBT, Palampur, December 18.

Dr. Rakesh Kumar (2019) Delivered an invited talk on the topic entitled "Medicinal plants of Himalaya and their use in traditional system of medicine" at IHBT-NRICM Forum on Research and Development of Traditional Medicine on December 21.

Dr. R.K. Sharma (2019) Delivered a lecture on Next-generation genomics to expedite genetic improvement efforts in seabuckthorn. National Conference on Recent Development in Plant

Stress Biology: Translating 3rd National Conference of Seabuckthorn Association of India on Seabuckthorn: Translating research into sustainable utilization and conservation, organised by Department of Botany, University of Delhi, Delhi, December 19-20.

Dr. Pralay Das (2020) Delivered lecture on "Oxalic acid as a bench stable C1 surrogate for CO/CO_2 fixation reactions" in International Conference on Chemistry for Human Development, jointly organized by Prof. Asima Chatterjee Foundation, Heritage Institute of Technology (HIT), Kolkata, January 9-11.

Dr. Sanjay Kumar (2020) lead lecture on Fermentation technology shaping the global bioeconomy landscape National Workshop on "Fundamentals of Fermentation Process Development" at CSIR-IMTECH, Chandigarh, January 13.

Dr. Sanjay Kumar (2020) Medicinal and Aromatic Plants - Production Challenges and Processing Opportunities "National Seminar on Medicinal and Aromatic Plants Production Challenges and processing Opportunities- Way Forward, PHD House, New Delhi, January 15.

Dr. Sushil K. Maurya (2020) Diversity oriented synthesis approach for macrocycles, 26th ISCB International Conference (ISCBC-NIPiCON 2020), Institute of Pharmacy, Nirma University, Ahmedabad, January 22-24.

Dr. R. K. Sharma (2020) Delivered a lecture on GENOMIC ERA - Shift from Laboratory Model Plant Systems to Non-Model Plants. Plant Genetics and Genomics Conference, T. P. Ganesan Auditorium, Mini Hall 2 SRM IST, Kattankulathur, Tamil Nadu, January 23-24.

Dr. Sanjay Kumar (2020) "Young researchers: champions of innovation, and national growth & development "AcSIR Gyantarang 2020" January 23-25.

Dr. Sukhjinder Singh (2020) Technology pool, techno-economic viability & transfer agreements. workshop on IPR commercialization and technology transfer organized by technology innovation support centre, Punjab state council for science & technology in collaboration with cell for IPR promotion and management, DPIIT, GoI & Dr. BR Ambedkar National Institute of Technology, Jalandhar at NIT, Jalandhar, February 11.

Dr. Sukhjinder Singh (2020) Technology pool, techno-economic viability & transfer agreements. workshop on IPR commercialization and technology transfer organized by technology innovation support centre, Punjab state council for science & technology in collaboration with cell for IPR promotion and management, DPIIT, GoI & Indian Institute of Technology, IIT, Ropar, February 12.

Dr. Poonam Kumari (2020) Delivered a lecture on Potentials of wild rose species and their utilization in India In National Conference on Climate Change: Agriculture, Biodiversity and Human Health. CSIR-National Botanical Research Institute (NBRI) Lucknow, February 22-23.

Dr. Vijai Kant Agnihotri (2020) Quality of rose volatile and its evaluation. Delivered in "TWO DAY (Feb 24-25, 2020)" on "Skill Development Programme on Improved agro and process technologies of damask rose (*Rosa damascena*Mill.), CSIR-IHBT, Palampur. February 24.

Dr. Sushil K. Maurya (2020) Development of methods for value-added products from sustainable natural resources, International Conference on Smart Materials for Sustainable Technology (SMST-2020), Bagmallo Beach Resort, GOA, India, February 22-25.

Dr. Upendra Sharma (2020) "Regioselective C(sp^3)-Methylation, Alkylation and Arylation *via* C(sp^3)-H Activation" in International conference on organometallics and Catalysis-II (ICOC-II, 2020), Holiday Inn Resort, Goa, India, March 07-10.

Dr. R.K. Jain (2020) "Innovative Solutions and New opportunities for sustainable use of Biomass- Bioeconomy / Biorefinery Approach" during the RC meeting at CSIR-IHBT, Palampur, March 13, 2020.

Visits abroad

Dr. Sanjay Kumar and Dr. Rakesh Kumar (2019) Visited Taiwan to attend Southeast Asia Symposium of Traditional Medicine-Experience Sharing & Future Cooperation in National Yang Ming University, Taipei City, Taiwan, Taiwan July 12-14.

Dr. Probir Kumar Pal visited Taipei city, Taiwan During. Short-term visiting program aiming to provide scientists at NRICM (National Research Institute of Chinese Medicine) and from overseas sufficient space to brainstorm, understand in a holistic manner research activity in the areas of common, and look out for collaborative opportunities, October, 21-29.

Foreign delegations

Delegation from Taiwan led by Professor Fang-Rong Chang, Director, NRICM, Dr Lie -Chwen Lin, Research Fellow/Director, Dr Mayeesha Yu-Hwei Tseng, Assistant Research Fellow, Dr Chang-Chang Chen, Assistant Research Fellow, NRICM, Taiwan, visited CSIR-IHBT during July 1-4.

Delegation from Taiwan led by Dr Henry Chen, Director, TECC, Professor Fang-Rong Chang, Director, NRICM, Dr Wen-chi Wei and Dr Mayeesha Yu-Hwei Tseng, Assistant Research Fellows, NRICM; visited CSIR-IHBT during December 22-23.

Distinguished visitors

IPH officers, Keylang visited CeHAB Ribling, Lahaul-Spiti HP, September, 2019.

Dr. Ram Lal Markanda, Minister of Himachal Pradesh, visited CeHAB Ribling, Lahaul-Spiti HP, on the occasion of "*State Level Tribal Fair Keylong*", Lahaul-Spiti, and >500 people interacted of our R&D works, 14-16 August 2019.

Dr. Ram Lal Markanda, Minister of Himachal Pradesh, visited CeHAB Ribling, Lahaul-Spiti HP, on the occasion of "*State Level Ladarcha Fair at Kaza*", Lahaul-Spiti, and almost >400 people interacted of our R&D works,17-19 August 2019.

Prof. GB Mangla, Ex. Tagore National Fellow (Gov. of India, Ministry of Culture) & Ex. Prof., HOD, Dean, University of Delhi, 03 July 2019.

Dr. Nagendra Kumar Singh, National Prof. ICAR-National Institute for Plant Biotechnology, New Delhi, 03 July 2019.

Dr. Kuldeep Singh, Director ICAR, NBPGR, New Delhi, 03 July 2019.

Prof. Pinak Chakrabati, Bose Institute, Kolkatta, 03 July 2019.

Prof. Cletus J. M. D'Souza, Emeritus Professor, Department of Biochemistry, University of Mysore, Mysore, 03 July 2019.

Dr. Vidya Gupta, CSIR Emeritus Scientist, Biochemical Sciences Division, CSIR-NCL, Pune, 03 July 2019.

Prof. Wazahat Hussain, Prof. and Chairman (Ret.) Botany Department AMU, Aligarh, 04 July 2019.

Mr. Jayant Modak, Deputy Director, IISC Bangalore, 04 July 2019.

Dr. Vikram Saha, (Ex. IIT Delhi) Gurgaon, 04 July 2019.

Mr. Abdul Rehman, CSIR-IIIM, Jammu, 05 July 2019.

Dr. Ajay Kumar Dixit, Life Science & Technology Centre, ITC Limited, Bangalore, 11 September 2019.

Prof. S.C. Bhatla, Department of Botany University of Delhi North Campus Delhi-110007, 18 September 2019.

RADIO TALK

Dr Rakesh Kumar (2019) "Aushdhiye faslon ki kheti" on All India Radio Dharamshala, HP, aired on May 31, at 6:30 to 7:40 pm.

TV TALK

Dr Rakesh Kumar (2019) highlighted the CSIR-Aroma mission and contribution of CSIR-IHBT Palampur in Divya Himachal TV News network on June 29.

Dr Rakesh Kumar (2019) and highlighted appeared in DD News Saffron cultivation in non traditional areas aired on November 18.

Poster presented

Kumar A, Chauhan SA and Das P (2019) 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.

Agarwal H, Joshi R and Gupta M (2019) Effect on functional and physicochemical properties during *in vitro* enzymatic hydrolysis of protein isolates from three different Indian millets, at 2nd Food Chemistry Conference, at Seville, Spain organized by Elsevier, September 17-19.

Anand P, Padwad Y and Das P (2019) Therapeutic Implication of MAPKAPK2 in the management of Head and Neck Squamous Cell Carcinoma. 7th Summer School in Translational Cancer Research, Albufeira, Portugal, October 7.

Thakur M, Bhatt V and Kumar, R (2019) Influence of light intensity and mulch on photosynthesis, yield and essential oil composition of damask rose (*Rosa damascena* Mill.) under acidic conditions of Western Himalayas. Oral Presentation in Sixth World Congress on Medicinal and aromatic Plants held at Famagusta North Cyprus, Turkey. November 13-17.

Rattan, S and Warghat A (2019) *In vitro* propagation of *Rhodiola imbricata* (Edgew.): a high value rare medicinal herb presented in International conference on conservation and sustainable use of high altitude medicinal and aromatic plants for the socio-economic development at Dehradun, November 29-30.

Sharma AK, Ram S and Das P (2020) Heterogeneous nano-catalysts for CO/CO_2 fixation reactions, International Conference on Emerging Trends in Catalysis- 2020 (ETC-2020), VIT Vellore, Chennai, India, January 6-8.

Chauhan AS and Das P (2020) Conversion of cellulosic biomass into furan based biochemical, International Conference on Chemistry for Human Development (ICCHD-2020), Heritage Institute of Technology, Kolkata, January 9-11.

Sood A, Upadhyay R, Rana R and Maurya SK (2020) Eco-friendly and rapid Antimarkonikov hydrothiolation of styrenes using Formic acid, 26th ISCB International Conference (ISCBC-NIPiCON 2020), Institute of Pharmacy, Nirma University, Ahmedabad, January 22-24.

Walia S and Kumar R (2020) Variability in chemical composition of wild marigold (*Tagetes minuta* L.) essential oil from Indian Himalayas. In the AcSIR Gayantarang 2020 held in CSIR-NEIST, Jorhat, Assam, January 23-25.

Rathore S and Kumar R (2020) Seasonal variation in essential oil content and composition of rosemary (*Rosmarinus officinalis* L.) in the western Himalaya. In the AcSIR Gayantarang 2020 held in CSIR-NEIST, Jorhat, Assam, January 23-25.

Kumari A, Maurya SK and Gulati A (2020) Secondary metabolite profiles of two species of Camellia flowers growing in Kangra region of India and their comparative study, 26th ISCB International Conference (ISCBC-NIPiCON 2020), Institute of Pharmacy, Nirma University, Ahmedabad, January 22-24.

Shaifali, Yamini and Das P (2020) Development of heterogeneous nano-catalyst and its applications for valorisation of CO/CO2 through greener and sustainable approaches, 26th ISCB International Conference (ISCBC-2020), Nirma University, Ahmedabad, India, January 22-24.

Kumar A and Das P (2020) Development of polystyrene stabilized nano-catalyst and its applications for CO/CO_2 fixation reactions, AcSIR GYANTARANG 2020, CSIR-NEIST, Jorhat, Assam, India, January 23-25.

Daswal V, Joshi R and Gupta M (2020) Extraction optimization of phenolic acids and bio-flavonoid from *citrus reticulate*. L peel using LC-MS/MS AcSIR Gyantarang-2020, CSIR-NEIST, Jorhat, Assam, January 23-25.

Maurya AK and Agnihotri VK (2020) Enhancement of the essential oil recovery of *Valeriana jatamansi* by using hydrodistillation adsorption (HDA) apparatus. AcSIR Gyantarang 2020. Jointly organized by "Academy of Scientific and Innovative Research & CSIR-North East Institute of Science and Technology", January 23-25.

Chander R andAgnihotri VK (2020) Variation in essential oil yield and composition of *Dracocephalum heterophyllum* from different geographical regions of western Himalayas. AcSIR Gyantarang2020. Jointly organized by "Academy of Scientific and Innovative Research & CSIR-North East Institute of Science and Technology", January 23-25.

Bhatt S and Gupta M (2020) Extraction, Physico-chemical Evaluation and Characterization of Soluble Dietary Fiber from Mango Peel, at the 27th Indian Convention of Food Science and Technology (ICFOST)organized by AFST (I), Tezpur University, Assam. January 30- February 01.

Kumari R and Gupta M (2020) Morphological, nutritional, functional and sensory attributes of functional noodle prepared by utilizing black pea, at the 27th Indian Convention of Food Science and Technology (ICFOST)organized by AFST (I), Tezpur University, Assam. January 30-February 01.

Ashrita and Warghat A (2020) Enhancement of steviol glycosides using elicitors in tissue culture raised plants of *Stevia rebaudiana*, Bertoni presented in 41st annual meeting of the plant tissue culture association of India NSTPB, Patiala, February, 6-8.

Joshi R, Singla-Pareek SL and Pareek A (2020) Rice MATH domain containing protein (MDCP) functions as a positive regulator of biotic and abiotic stress response. National Symposium on Trends in Plant Biotechnology & Agriculture and 41st Annual Meeting of Plant Tissue Culture Association of India, Thapar Institute of Engineering & Technology, Patiala, Punjab, February 6-8.

Gautam N and Bhattacharya A (2020) Biochemical studies on saffronbulb development. National symposium on Trends in Plant Biotechnology & Agriculture & 41st Annual Meeting of the Plant Tissue Culture Association of India, Thapar Institute of Engineering & Technology, Thapar, Patiala, India, February 6-8.

Ishu, Bhattacharya A and Singh KK (2020) Large scale production of juvenile planting material of *Phyllostachys pubescens* and its application in making aggarbatti and broom sticks. National symposium on Trends in Plant Biotechnology & Agriculture & 41st Annual Meeting of the Plant Tissue Culture Association of India, Thapar Institute of Engineering & Technology, Thapar, Patiala, India, February 6-8.

Sethy P, Thapa P, Sood A and Bhattacharya A (2020) *Ex situ* conservation of *Dactylorhiza hatagirea* by raising *in vitro* plants from seeds of different regions and their rehabilitation in natural habitat. National symposium on Trends in Plant Biotechnology & Agriculture & 41st Annual Meeting of the Plant Tissue Culture Association of India, Thapar Institute of Engineering & Technology, Thapar, Patiala, India, February 6-8.

Rana R, Upadhyay R, Maurya SK (2020) Diversity Oriented Synthesis Approach towards the Synthesis of Hybrid Macrocycles, International Conference on Smart Materials for Sustainable Technology (SMST-2020) Bagmallo Beach Resort, GOA, India, February 22-25.

Sharma A, Sharma S, Sushil K. Maurya SK (2020) An Efficient Tin (II) triflate Catalyzed Synthetic Methodology for 3-Methyleneisoindolin-1-Ones Synthesis, International Conference on Smart Materials for Sustainable Technology (SMST-2020), Bagmallo Beach Resort, GOA, India, February 22-25.

Maheshwari Y, Thakur D, Selvaraj V and Hallan V (2020) Complete genome sequence and molecular diagnosis of *Papaya ringspot virus* from Palampur, Himachal Pradesh. Poster presentation in an International Conference VIROCON 2020, Indian National Science Academy, New Delhi, February 18-20.

Maheshwari Y, Selvaraj V, Yokomi R and Hallan V (2020) Rapid and on-site diagnosis of *Citrus tristeza virus*. Poster presentation in International Conference VIROCON 2020. Indian National Science Academy, New Delhi. February, 18-20.

Abstracts

Kumari P, Bhargava B and Singh S (2020) Potentials of wild rose species and their utilization in India. In: National Conference on Climate Change: Agriculture, Biodiversity and Human Health. CSIR-National Botanical Research Institute (NBRI) Lucknow, February 22-23.

Bhargava B, Kumari P and Singh S (2020) Utilization of temperate flora for urban landscaping. In: In National Conference on Climate Change: Agriculture, Biodiversity and Human Health. CSIR-National Botanical Research Institute (NBRI) Lucknow, February 22-23.

Participation in exhibition

Dr. Mahesh Gupta (2019) Organized Exhibition of Technologies in Food Processing, at Constitution Club of India, New Delhi, November 13.

Dr Rakesh Kumar, Dr Gireesh Nadda, Er Mohit Sharma, Dr SGE Reddy, Dr Rohit Joshi ((2019) participated and exhibited the technologies and products of CSIR-IHBT in Global Investor Meet at Dharamshala, HP, November 7-9.

Dr. Mahesh Gupta (2019) Participated in "Rising Himachal Global Investors' Meet 2019" organized by Government of Himachal Pradesh, Dharamshala Distt. Kangra, November 7-8.

Dr. Mahesh Gupta (2019) Participated in Annual Tribal Fair, Keylong (Lahaul & Spiti), August14-16.

Dr. Mahesh Gupta (2020) Participated in Food Tech Conclave-2020, Dibrugarh, Assam, February 12.

Dr. Mahesh Gupta (2019) Participated in Food and Agritech expo, Pragati Maiden, New Delhi, August 1-3.

Dr. S.G. Eswara Reddy (2019) Participated in Global Investors Meet 2019, Dharamshala (Distt. Kangra), Organized by Government of Himachal Pradesh, November 7-8.

Dr. Mahesh Gupta (2020) Participated in National Organic Festival for Women Entrepreneur, New Delhi, February 21-23.

Dr. Mahesh Gupta (2020) Participated in Holi Mela Exhibition, Palampur, March 9-10.

Dr. Mahesh Gupta (2020) Participated in CSIR Food Processing Technology Industry meet, Imphal, January 22-26.

Dr. Mahesh Gupta (2019) Exhibited at 8th Bhopal Vigyan Mela, Bhopal, September13-16.

Dr. Mahesh Gupta (2019) Attended Tech 4th Seva, IIT, Delhi, August 9-13.

Dr. Mahesh Gupta (2019) Participated in The North East Innovators Meet and Technology Innovation entrepreneurship (TIE) expo, Shillong (Meghalaya), February 28-March 1.

Dr. Ramesh (2019) Participated in "Rising Himachal Global Investors' Meet 2019" organized by Government of Himachal Pradesh, Dharamshala Distt. Kangra, November 7-8.

Dr. Rohit Joshi (2019) Participated in "Rising Himachal Global Investors' Meet 2019" organized by Government of Himachal Pradesh, Dharamshala Distt. Kangra, November 7-9.

Prizes/ awards/ recognitions

Sharma C and Acharya A (2019) "Rapid one pot synthesis of carbon dots from citrus peel with enhanced fluorescence property" International Conference on Electron Microscopy & Allied Analytical Techniques, Organized by HP University, Shimla and EMSI, June 5-9.

Uniyal S (2020) Delivered an invited talk titled "*Communities for conservation: let the water flow*" at the 107th Indian Science Congress held at Bengaluru, Environmental Sciences Section, January 3-7.

Uniyal S (2020) Participated in the "Carbon Neutral Ladakh: A New Beginning" held at Leh, March 2-5.

Kumari A, Maurya SK and Gulati A (2020) Best Poster Award to Ms. Amita Kumari for poster "Secondary metabolite profiles of two species of Camellia flowers growing in Kangra region of India and their comparative study" 26th ISCB International Conference (ISCBC-NIPiCON 2020), Institute of Pharmacy, Nirma University, Ahmedabad, India. January 22-24.

Das P (2019-20) Bentham Ambassador, Bentham Science Publishers.

Joshi R (2019) Observer for online CSIR-NET exam at Himachal Institute of Engineering and Technology, Shahpur, Kangra, December 15.

Sharma U (2020) Early Career Advisory Board of *Asian Journal of Organic Chemistry*.

Sharma U (2019) Chaired a poster session in National Conference on Innovation in Bioprocess Technology (IBT-2019), CIAB, Mohali, Punjab, India, December 11-13.

Kumar R and Sharma U (2020) Third Prize for this Poster entitled "New Bioactive Molecules through C-H Bond Functionalization and [3+2] Cyclization of N-Heterocyclic Compounds in New Frontiers in Chemistry-From Fundamentals to Applications (NFCFA2019), presented at Department of Chemistry, BITS Pilani, KK Birla, Goa Campus, 20-22 December.

Gautam N and Bhattacharya A (2020) was awarded second prize at National symposium on 'Trends in Plant Biotechnology & Agriculture', Thapar Institute of Engineering & Technology, Thapar, Patiala, India, for her poster entitled 'Biochemical studies on saffronbulb development', February 6-8.

Bhattacharya A (2019) Joined as Associate Editor in the Editorial Board of the international journal 'Plant Cell Tissue and Organ Culture'

Bhattacharya A (2019) Work on transgenic tea was featured in the article 'Engineering a Better Beverage' by Dolgin E in the international journal 'Nature Outlook', 2019, volume 566 and page S12 to S13.

Damanpreet Singh (2019) Visiting scientist under the New Southbound Partnership Program at National Research Institute of Chinese Medicine Taipei, Taiwan, October 21-29.

Damanpreet Singh (2019) Served as an external examiner for thesis evaluation and conduct dissertation viva-voce of two M. Sc. students at Department of Food Science and Technology, Punjab Technical University, Main Campus, Kapurthala, Punjab, November 08.

Damanpreet Singh (2019) Served as an external examiner conduct of viva-voce of M. Pharm. (Pharmacology) students at G.H.G. Khalsa College of Pharmacy, Gurusar Sadhar, Ludhiana, Punjab, December 23. Research Institute (NBRI) Lucknow, February 22-23.

LINKAGES ESTABLISHED DURING 2019-20

1. International Linkages:

- National Research Institute of Chinese Medicine (NRICM), Taiwan, 155-1, Section 2, Linong Street, 11221 Taipei, Taiwan

2. Government Organisation/Institution (10 numbers):

- MSME-Technology Centre (FFDC Kannauj), Food Park, Nilakuthi, Imphal East, Manipur
- CIAB, NABI, Mohali
- Khadi & Village Industries Commission, Gramodaya, 3, Irla Road, Vile Parle (West), Mumbai
- SCVB Government College, Palampur
- Rajendra Prasad Govt. Medical College and Hospital (RPGMCH), Tanda, Kangra (H.P.)
- Deputy Commissioner-cum- Commissioner Trilokpur Temple Trust, Nahan, District Sirmour (H.P.)
- Medicinal Plant Lab, IIT Mandi -EWOK, Kamand District Mandi (H.P.)
- Chaudhary Sarwan Kumar Himachal Pradesh Krishi Vidyalaya (CSKHPKV), Palampur (H.P.)
- Department of Forest Products, COF-UHF, Nauni, District Solan (H.P.)
- School of Life Sciences, Department of Plant Sciences, University of Hyderabad, Gachibowl, Hyderabad

3. Private Industries (22 numbers):

- M/s A B Scientific Solutions, Green Vally Lohna, Palampur, District Kangra (H.P.)
- M/s A Qube Inc., 29, NRI Block, Carlton Woods, South City, Ludhiana
- M/s. Mother India Organics and Naturals Pvt Ltd, 801, 8th Floor, Brigade Rubix, No. 20, Watch Factory Main Road, Peenya, Bangalore 560013
- M/s Innotech AgroPostikum Pvt. Ltd., Biotech Park, IIT Guwahati, Guwahati, Assam
- M/s Anodyne Bio Spagyric, Delhi Darwaza, Sambhal, (U.P)
- M/s Camelia Beverages Pvt. Ltd., K-8, Ground Floor, Jangpura Extension, New Delhi
- M/s Sashanka Agro Tech. Pvt., Ranchi (Jharkhand)
- Ana Bioenergy, 255/9, Krishna Colony, Ladwa-Kurukshetra
- M/s Baijnath Pharmaceuticals Pvt. Ltd., VPO Paprola, Tehsil Baijnath Distt. Kangra (H.P.)
- SS Sujalam Sukhalam Foundation and Affiliates, Y C Co working Space, 3rd Floor, plot No. 94 Sector 13 Dwarka, Delhi
- Dev Bhoomi Flower Nursery, House No. 123, Housing Board Colony, Bindravan, Tehsil Kangra (H.P.)
- Thapasu Centre, Marhi Near ICAR Research Farm, Naggar Kullu (H.P.)
- M/s Sandeep Kumar & Company, VPO Nadaun, Jwalaji Road, Tehsil Nadaun District Hamirpur
- M/s Beejsheetal Research Private Limited Jalna, Maharashtra
- Aman Van Vatika Pvt. Ltd, Maidalpur Distt. Nabrangpur (Odisha)
- M/s Yujo Agriculture & Aquaculture Farm Society, 354 (S), Green Heights, A 2 Z Colony, Pallavapuram, Meerut (U.P.)

- M/s Pratyaksha Agrotech Private Limited, Pratyaksha House Bagbahar Part- II, P.O. Bagbahar District Cachar Assam
- Resham Ayurvedic Nursery, Kartarpur, District Jalandhar, Punjab
- M/s IoTechWorld Avigation Pvt. Ltd., Plot 1643, Sector 52, Gurgaon (Haryana)
- The Unati cooperative Marketing- cum Processing Society Ltd., Talwara, Punjab
- M/s Sirimiri Nutrition Food Products Pvt. Ltd. 134/A, 3rd Floor, Yeshwanthpur, Bangalore
- M/s Nano Tech Chemical Brothers Pvt. Ltd. Village Mangarh, Post Office Kohara, Chandigarh Road, Ludhiana

4. Farmer Societies and NGO (36 numbers):

- Social Action for People, Sanyashipali, P.O. Kolabira, Dist.-Jharsuguda Odisha
- Progressive Aroma Crop Farmers Welfare Association, Chohan, P.O. Gharota, Tehsil and District Pathankot, Punjab
- Shiv Aushdhiya Paudh Utpadan Society, Rajgardh (Gumna), Gram Panchayat Todsa, Tehsil Chirgaon, District. Shimla (H.P.)
- Satohar Kalyan Samiti, Tur, V.P.O. Darbhala Sub-Tehsil Darbhala, District Chamba
- Chamunda Kisan Samiti Village Kathiyari, Gram Panchyat Dharoon, Tehsil Sihunta Distt. Chamba (H.P.)
- Sugandhit Krishi Vikas Samooh, Village Kaamla. Gram Panchyat Kaamla, Tehsil Sihunta, District Chamba (H.P.)
- The Shivdass Ramdass Medicinal & Aromatic Plant Growers Cooperative Marketing Society Ltd. VPO Udaipur, Tehsil Keylong, Distt. Lahul & Spiti (H.P.)
- Green Himalaya Herb Process Committee, Village and P.O. Sarahan Pargna-Sahoo Tehsil and District Chamba (H.P.)
- Gandhinagar Dist. Co-op. Society for Flower Production and Selling, Krishi Vigyan Kendra, Village Randheja Tehsil & Distt. Gandhinagar
- Shakti Ajibika NRLM Gram Sangthan Vill. Jhudgaon Tulla, Block Okhalkanda Distt. Nainital (U.K.)
- Manav Jiwan Sudhar Evam Kshamata Nirman Samiti, Daragaon, Soreng, West Sikkim
- Association for Peoples Advancement and Action Research (APAAR) 7/12/Ramashram, Tekana Road, Pithoragarh (Uttrakhand)
- Jai Bhawani Krishi Vikas Sangh Chala Dochi, Village Chala Dochi, P.O. Sanora, Sub-Tehsil Pajhota at Nohri, Distt. Sirmour (H.P.)
- Kartik Krishak Society Guwad, Village Tipri, P.O. Sarahan, Tehsil & Distt. Chamba (H.P.)
- Shiv Aushdhiya Paudh Utpadan Society, Rajgardh (Gumna), Gram Panchayat Todsa, Tehsil Chirgaon, District. Shimla (H.P.)
- Ladakh Farmer's & Products Cooperative Ltd., Post Box No. 240, Leh, Ladakh
- Nagsen Kissan Club Trust, Galhar Tehsil Nagsen Distt. Kishtwar J&K
- Krishi & Van Sudhar Sabha Khani-Gareema Village Khani, Tehsil Bharmour Distt. Chamba (H.P.)
- Lemon Grass Farmer Produce Committee, Village Ghagwal, Tehsil Mukerian, District Hoshiarpur, Punjab
- Bhuja Rishi Kisan Vikas Committee Shilhibagi, VPO Shilhibagi, Tehsil Thunag Distt. Mandi (H.P.)
- Danpur Himalayan Rural and Agriculture Society, Dani Bhavan, Mukhani Choraha, Haldwani, Nainital (UK)
- The Eco Friendly society of Farmers (Regd.) Rureke Kalan, Barnala Punjab

- The Energy & Resources Institute, 6 C Darbari Seth Block India Habitat Centre Complex, Lodhi road, New Delhi
- Aromatic Medicinal and Herbal Farmers Society, Jalauli, Tehil Panchkula Haryana
- Mizoram Rural and Development Society, Zotlang, Aizawl Mizoram
- Helping Hands Welfare Society, 339 Bagh, Khinni Mahal, Taj Nagari Phase 2, Fatehabad Road, Taj Ganj Agra, Uttar Pradesh
- SAMPDA (Samagra Adivasi Medicinal Plants Development Association),in front of Telephone exchange, Post Office Kondagaon, DNK Colony Tehsil Kondagaon, Chhattisgarh
- Himalayan Phytochemical & Growers Association, Baggi Tehsil Sadar District Mandi (H.P.)
- Om Shanti Vishav Jagriti Mission, 761/7 Gali No. 7, Govind Puri, Kalka Ji, Delhi
- Neel Kanth India, VPO Lag Baliana Tehsil Dehra District Kangra (H.P.)
- Rural Development Farming Society, Village Kaltri, P.O. Kothuwan, Tehsil Sandhol, District Mandi (H.P.)
- Suhavi Producer Company Ltd., Village Kangar, P.O. Basali, Nurpur Bedi, District Ropar (Rupnagar) Punjab
- Shiva Kisan Samiti Kangra, Village Bhatera, P.O. Jol Lambri, Tehsil Sujanpur, District Hamirpur (H.P.)
- Kisan Bagwan Samiti, Village Deol, Sub Tehsil, Holi, Tehsil Bhhwarna, Distt Chamba
- Jan Shakti Committee, Gram Panchayat Mangli, Tehsil Churah, District Chamba (H.P.)
- All Mizoram Farmers' Union (AMFU), General Headquarter Office, Treasury Square, Aizawl, Mizoram

5. Start-up Incubation (10 numbers)

- Mrs. Sudershna Kumari, V.P.O Rait, Tehsil Shahpur, District Kangra (H.P.)
- Mr. Udhey Singh S/o Sh Kuldeep Singh House No. 41, V.P.O Dehan Khas, Tehsil Palampur, District Kangra, (H.P.)Mrs. Reena Chandel, Village Gagal P.O. Bharmoti, Tehsil Nadaun Distt. Hamirpur (H.P.)
- Dr. Ankita Rana, V.P.O Ghati Bilwan Tehsil Kotla Jaswan Distt. Kangra (H.P.)
- Mr. Vipan Kumar Village Magroo Suryala P.O. Aloh, Tehsil Rakkar Distt. Kangra (H.P.)
- Mrs. Mona Singh, V.P.O Bharmat, Palampur (H.P.)
- Mr. Satish Kumar S/O Sh. Kishori Lal VPO Ghurkari Khash Tehsil & Distt. Kangra (H.P.)
- Amshu C.R, Thapasu Centre, Marhi Near ICAR Research Farm, Naggar Kullu (H.P.)
- Mr. Sandeep Bhatia C/o Sh. Surender Pal, V.P.O Nadaun, Ward no. 6, Tehsil Nadaun, District Hamirpur (H.P.)
- Mr. Subodh Thakur, Village & Post office Saloh, Tehsil Palampur, District Kangra (H.P.)
- Mr. Jaiveeer Singh, Village Jandera, P.O. Rajpur, Tehsil Palampur (H.P.)

Staffs

STAFF LIST

Director
Dr. Sanjay Kumar
Director CSIO (Additional Charge)
w.e.f. 28.02.2020

Sr. Principal Scientist
Dr. R.K. Sud
Er. K.K. Singh
Dr. Aparna Maitra Pati
Dr. Amita Bhattacharya
Dr. Vipin Hallan
Dr. Sanjay Kumar Uniyal
Dr. Ram Kumar Sharma
Dr. Amit Kumar

Principal Scientist
Dr. Sanatsujat Singh
Dr. Rakesh Kumar
Dr. Shashi Bhushan
Dr. Pralay Das
Dr. Vijay Kant Agnihotri
Dr. Ravi Shankar
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Dr. Gireesh Nadda

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Dr. Robin Joshi

Senior Technical Officer (2)
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Sh. Mukesh Gautam
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Sh. Rakesh Chand

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Sh. Shamsher Singh

Lab Attendant (2)
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Sh. Balak Ram

Sh. Kuldip Singh
Sh. Balwant Raj
Sh. Girja Nand
Sh. Deepak Sood

Administration Officer

Sh. Alok Sharma

Finance & Accounts Officer

Sh. S. N. Gulia

Controller of Store and Purchase

Sh. S. Gnanaprakasam
(joined on 29.07.2019)

Section Officer (Gen.)

Sh. S.D. Rishi
(Up to 08-07-2019)
Sh. Amarjeet

Section Officer (F&A)

Sh. Yash Pal
(joined on 04.09.2019)

Section Officer (S&P)

Sh. Ram Singh

Hindi Officer

Sh. Sanjay Kumar

Sr. Steno (MACP)

Sh. Didar Singh Patial

Assistant Section Officer

Sh. Parveen Singh
Sh. Ved Prakash
Sh. Keerti Raj
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Sh. Baldev

Assistant Section Officer (F&A)

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 (Gen.)

Sh. Praveen Kumar
Sh. Sandeep Kumar
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Sh. Karan Singh

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Sh. Nitesh Bhardwaj

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Gr. "C" (Non- Technical)

Sh. Thaman Bahadur

Chowkidar

Sh. Baleshwar Prasad
Sh. Devender Kumar

Tea Maker

Sh. Bipan Gurang

Frash

Smt. Rujala Devi

Joined CSIR-IHBT between 01.04.2019-31.03.2020

Sr. No.	Name	Designation	Date of Joining
1.	Sh. S. Gnanaprakasam	COSP (MACP)	29.07.2019
2.	Sh. Yash Pal	Section Officer (F&A)	04.09.2019
3	Dr. Sukhjinder Singh	Senior Scientist	06.09.2019
4.	Dr. Ankit Saneja	Scientist	12.09.2019
5.	Dr. Poonam Kumari	Scientist	16.09.2019
6.	Dr. Vandana Jaiswal	Scientist	19.09.2019
7.	Ms. Amit Kumari	Scientist	20.09.2019
8.	Dr. Satbeer Singh	Scientist	23.09.2019
9.	Dr. Jeremy Dkhar	Sr. Scientist	24.09.2019
10.	Dr. Rohit Joshi	Sr. Scientist	01.10.2019
11.	Dr. Ramesh	Scientist	03.10.2019
12.	Dr. Vikas Kumar	Scientist	11.10.2019
13.	Dr. Shiv Shankar Pandey	Sr. Scientist	14.10.2019
14.	Dr. Sarita Devi	Scientist	20.11.2019
15.	Dr. Arun Kumar	Sr. Scientist	27.02.2020

Transfer

Sh. S.D. Rishi tranferred to CSIR - HRDG, New Delhi, as Under Secretary on 08-07-2019

Staff Superannuated

Sh. Raj Kumar
Assistant Section Officer (Gen.) MACP 31.05.2019

Sh. Darshan Singh
Finance & Accounts Officer 30.06.2019

Sh. Om Prakash
Principal Technical Officer 30.09.2019

Sh. Manoj Kumar Sood
Assistant Section Officer (F&A)
MACP 29.02.2020

Emeritus Scientists
Dr. Bikram Singh
Dr. Surender Kumar Vats

Field Assistant
Sh. Jagdeep Singh
Mr. Sunny Kumar
Mr. Kishan Kharka
Mr. Umesh
Mr. Hariom Kapoor
Mr. Puneet Sharma

NSPIRE Faculty
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NPDF
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Dr. Rahul Jain

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Ms. Shweta Thakur
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Project Assistant-I
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Ms. Garima Dadhich

Project Assistant-III

Mr. Sanjeet Kumar

Project Associate

Ms. Kanika Kiran
Mr. Chirag Sharma
Mr. Anil Kumar

Project Fellow

Ms. Neha Chilwal

Mr. Anirudh Verma

Project Scientist

Dr. Heena Gupta

Dr. Ajay Rana

Research Associate

Dr. Shalika Rana

Dr. Prakriti Kashyap

Dr. Deepali Katoch

Dr. Heena Gupta

Mr. Antim Kumar Maurya

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Dr. Kumari Sita

Research Fellow

Mr. Sourav Kumar

SRA

Dr. Paromik Bhattacharya

Women Scientist

Ms. Ritu Sharma

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आइएचबीटी की तकनीकों को निवेशकों ने सराहा

धर्मशाला में इन्वेस्टर्स मीट में आइएचबीटी के स्टाल को देखते प्रधानमंत्री नरेंद्र मोदी • जागरण

जागरण संवाददाता, पालमपुर : धर्मशाला में ग्लोबल इन्वेस्टर्स मीट में हिमालय जैवसंपदा प्रौद्योगिकी संस्थान (आइएचबीटी) पालमपुर की टेक्नोलॉजी को निवेशकों ने काफी सराहा। वहीं प्रधानमंत्री नरेंद्र मोदी ने भी जहां संस्थान के बारे में जानकारी प्राप्त कर उसे सराहा वहीं मुख्यमंत्री जयराम ठाकुर, राज्यपाल बंडारू दत्तात्रेय और केंद्रीय मंत्री प्रह्लाद पटेल ने भी ... निदेशक डॉ. संजय कुमार ने बताया कि आइएचबीटी ने नवीनतम तकनीकों को प्रदर्शित करते हुए स्टॉल लगाए थे। यहां पर कई निवेशकों ने संस्थान की तकनीकों में रुचि भी दिखाई। आइएचबीटी की टीम ने कई निवेशकों से मुलाकात की। उन्होंने बताया कि मुख्य के निवेशकों और केंद्रीय रेल मंत्री पीयूष गोयल, केंद्रीय राज्य मंत्री अनुराग ठाकुर, मुख्य सचिव डॉ. श्रीकांत ...

IHBT develops new natural flavoured sanitiser

आई.एच.बी.टी. ने एन.ए.बी.आई. एवं सी.आई.ए.बी. के साथ किया समझौता

पालमपुर, 1 अक्तूबर (भृगु): अनुसंधान एवं शैक्षणिक विकास के साथ छात्रों और शिक्षाविदों सहित आदान-प्रदान के सहयोग के लिए सी.एस.आई.आर. हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर ने राष्ट्रीय कृषि खाद्य जैव प्रौद्योगिकी संस्थान मोहाली और नवोन्मेषी एवं अनुप्रयुक्त जैव प्रसंस्करण केंद्र सी.आई.ए.बी. के साथ संयुक्त रूप से एक समझौते पर हस्ताक्षर किए। सी.एस.आई.आर. आई.एच.बी.टी. के निदेशक डा. संजय कुमार तथा डा. टी.आर. शर्मा, कार्यकारी निदेशक, एन.ए.बी.आई. एवं सी.आई.ए.बी. के मुख्य कार्यकारी अधिकारी के अनुसार ये तीनों संस्थान वैज्ञानिक, तकनीकी और शैक्षणिक गतिविधियों को बढ़ावा देने और सुविधा प्रदान करने के लिए कृषि जैव प्रौद्योगिकी, खाद्य और न्यूट्रास्यूटिकल्स और उद्योग अकादमिक सहभागिता के क्षेत्र में सहयोग करेंगे। संस्थानों के बीच समग्र वैज्ञानिक सहयोग को बढ़ावा देने के लिए पारस्परिक हित के क्षेत्रों के ज्ञान और छात्रों और शिक्षाविदों के आदान-प्रदान और सहयोगी परियोजनाओं को विकसित करने पर भी सहमति हुई।

पंजाब केसरी ई-पेपर Wed, 02 October 2019 https://epaper.punjabkesari.in

धर्मशाला में आयोजित इन्वेस्टर्स मीट के दौरान हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर के निदेशक डॉ. संजय कुमार ... • जागरण

प्रधानमंत्री मोदी ने देखे आइएचबीटी के स्टॉल

जागरण संवाददाता, पालमपुर : धर्मशाला में आयोजित ग्लोबल इन्वेस्टर्स मीट में हिमालय जैवसंपदा प्रौद्योगिकी संस्थान (आइएचबीटी) पालमपुर ने प्रदेश व विकास में तैयार प्रौद्योगिकियों को प्रदर्शित किया। ...

अप्रैल में चाय की पत्तियों की अपनी महक

टीएमसी-आईएचबीटी में एमओयू

पालमपुर। सीएसआईआर-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान में राष्ट्रीय विज्ञान दिवस के अवसर पर संस्थान द्वारा विकसित औषधि के नैदानिक अध्ययन को आंकने के लिए डा. राजेंद्र प्रसाद मेडिकल कालेज, टांडा के साथ एक समझौता ज्ञापन किया गया। डा. मंजु शर्मा, भारत सरकार की पूर्व सचिव, जैवप्रौद्योगिकी विभाग तथा प्रतिष्ठित महिला वैज्ञानिक चेयर नासी, इलाहाबाद राष्ट्रीय विज्ञान दिवस समारोह की मुख्य अतिथि थीं। ऑनलाइन संबोधित करते हुए उन्होंने राष्ट्रीय विज्ञान दिवस के उद्देश्य विज्ञान लोकप्रियकरण एवं समाज में वैज्ञानिक जागरूकता लाना के बारे में बताया उन्होंने संस्थान से आह्वान किया कि वे जैवसंपदा संरक्षण और जैवआर्थिकी को बढ़ाने की दिशा में सक्रिय भूमिका निभाएं। डा. मंजु शर्मा ने संस्थान की भवनों एवं सुविधाओं का पूर्व निदेशकों के योगदान एवं नेतृत्व प्रदान करने के लिए उनके नाम पर संस्थान के भवनों के नामकरण को भी समर्पित किया। उन्होंने खाद्य प्रसंस्करण इकाई का भी उद्घाटन किया। झालीवी दुग्धालय के भारत स्थित सीएसआईआर कार्यालय के निदेशक डा. श्रीनिवास वी कावेरी ने "समाज पर पर्यावरण का प्रभाव और हमारा दायित्व: विज्ञान की भूमिका" विषय पर राष्ट्रीय विज्ञान दिवस संभाषण दिया। डा. कावेरी ने बताया कि हमारी प्रतिरक्षा प्रणाली पर पर्यावरण का गहरा प्रभाव होता है।

दिव्य हिमाचल Sat, 29 February 2020 https://epaper.divyahim...

बिलासपुर की फिजाओं में महकेगी फूलों की खुशबू

आइएचबीटी के वैज्ञानिकों ने किसानों को अरोमा मिशन के अंतर्गत सुगंधित पौधों की खेती के लिए किया प्रोत्साहित

वैरीकोज वेन के लिए अब ऑप्रेशन नहीं, वनखौड़ देगा उपचार

खराब कार्टिलेज ठीक करेंगी जड़ी-बूटियां, नी-रिप्लेसमैंट से मिलेगी राहत

हिमाचल में खराब कार्टिलेज ठीक-अलाईट करने के लिए जड़ी है दवा उपलब्ध, आई.एच.बी.टी. के वैज्ञानिकों ने प्राप्त की सफलता

Scientists develop technique to introduce fruits as snacks

https://timesofindia.indiatimes.com/home/education/news/scientists-develop-technique-to-introduce-fruits-as-snacks/articleshow/69312364.cms

जैविक कचरे के क्षरण के लिए अब जीवाणु युक्त जैविक डस्टबिन

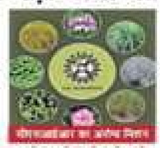
आई.एच.बी.टी. पालमपुर के वैज्ञानिकों को मिली बड़ी सफलता, लाहौल-स्पीति जैसे ठंडे कई क्षेत्रों में मिलेगी समस्या से राहत

पंजाब केसरी ई-पेपर Wed, 10 July 2019 https://epaper.punjabkesari.in/c/41254118

जंजैहली में ट्रायल के तौर पर लगाए गए हींग के पौधे

आईएचबीटी पालमपुर ने तैयार की है हींग की पौध

हिमाचल में उजड़ी खेती को बचाएंगे फूल



दिव्य हिमाचल

Mizoram farmers learn about aromatic crops

RAVINDER SOOD

PALAMPUR, DECEMBER 7

A group of farmers from the Mizoram Rural and Agriculture Development Society, Zotlang, Aizwal, visited the CSIR-IHBT, Palampur, to learn about aromatic crops, which are widely cultivated around the world for their high-value essential oils, use in perfumery, food, flavouring, pharmaceutical and agrochemical industry.

The group was exposed to the potential aromatic crops and improved agro-technologies developed by the institute. Later, the CSIR-IHBT signed an MoU with the society for the promotion of aromatic crops such as chamomile, damask rose, rosemary, muskbala, wild marigold, lemongrass and citronella.

Mizoram is one of the fastest growing economies in the country with a per capita income of Rs 36,021.

Despite the fact that agriculture is the mainstay of about 60 per cent of the population of the state, a lack of irrigation facilities and value addition to agriculture are major deterrents.

Longtlai district is also deprived of irrigation facilities and most of the agricultural fields are rain-fed. The cultivation of high-value aromatic crops offers a viable solution as the water requirement for these crops is low. The seeds of chamomile crop were provided to farmers along with a complete package of agro technologies.

Dr Sanjay Kumar, director, CSIR-IHBT, Palampur, said the institute had started the aroma mission programme throughout the country to promote aromatic crops and bring additional area of 5,500 hectares under their cultivation to generate employment.

The processing unit is indispensable for value addition of aromatic plants and the establishment of this facility will benefit the farmers of Longtlai district.

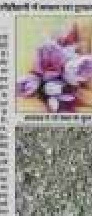
This year, the institute has signed agreements with 20 farmer societies and installed processing units in different regions of the country.

The Tribune Sun, 08 December 2019 https://epaper.tribuneindia

हिमाचल के इस मीठे फल में नहीं शुगर की चिंता

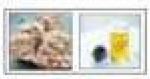
World's costliest spice set to bloom in HP, Ladakh after promising trials

कश्मीरी केसर की खुशबू से महके मंडी के खेत



हिमाचल की पहचान बनेगा आईएचबीटी का हींग-केसर

जयदीप रिहान – पालमपुर



सीएसआईआर-आईएचबीटी के वैज्ञानिकों द्वारा देश में पहली बार हींग का उत्पादन करने को लेकर किए जा रहे प्रयासों को प्रदेश सरकार से भी प्रोत्साहन मिलेगा। इसके साथ ही आईएचबीटी द्वारा केसर की खेती को लेकर किए जा रहे प्रयास को भी बढ़ावा दिया जाएगा। मुख्यमंत्री ने बाकायदा अपने बजट भाषण में इसका विशेष रूप से उल्लेख करते हुए हींग व केसर उत्पादन को बढ़ावा देने के लिए योजना की घोषणा की है। गौर रहे कि विश्व में प्रति व्यक्ति हींग की खपत भारत में सबसे अधिक होने के बावजूद देश में अभी तक इसका उत्पादन नहीं होता है और हींग का आयात किया जाता है। सीएसआईआर के हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर के निदेशक डा. संजय कुमार के अनुसार पहली बार देश में नेशनल ब्यूरो ऑफ प्लांट जेनेटिक के माध्यम से संस्थान को हींग के बीज उपलब्ध हुए हैं। हींग लाहुल-स्पीति, जम्मू-कश्मीर के लद्दाख तथा शीत मरुस्थल के क्षेत्र की आर्थिकी को बदलने का सामर्थ्य रखता है।

The Indian EXPRESS

Humble heeng is all imported, CSIR institute to grow it in India

'flowering started within 58 days'

अब सुगंध फूलों का गुरु मंत्र देंगे हिमाचल के वैज्ञानिक

राष्ट्रीय सहारा

जैवसंपदा संरक्षण व जैवआर्थिकी को बढ़ाने की दिशा में सक्रिय भूमिका निभाएं वैज्ञानिक : डा. मंजू शर्मा

https://www.etvbharat.com/hindi/himachal-pradesh/state/kangra/himachal-becomes-first-state-to-start-asafoetida-cultivation/hp20200127213515221

e-platform for auction of Kangra tea

Arun Kumar Ray, Deputy Chairman of the Tea Board India, Kolkata, at the CSIR-IHBT on Monday.

OUR CORRESPONDENT

PALAMPUR, OCTOBER 14

Deputy chairman of the Tea Board India, Kolkata, Arun Kumar Ray, visited the CSIR-IHBT today. He interacted with scientists for strengthening the Kangra tea industry.

Ray said an e-platform would be created for auctioning Kangra tea so that it could be sold from Dharamsala without being transported to Kolkata to avoid transportation cost.

For the assessment of tea quality, artificial intelligence would be used throughout the country so that the complaints of growers and the factory management on accurate leaf grade could be addressed. He also asked the institute to assess the cold-flavour quality of the first flush tea, which was gaining popularity in Darjeeling. The board had planned to promote Himachal tea brands through its GI, which had been awarded due to the scientific data of CSIR-IHBT.

Setting up of tea nurseries of quality tea clones was also discussed and it was suggested that entrepreneurship would be promoted for raising tea nurseries of high-yielding varieties. Ray appreciated the efforts of the institute for supporting the tea industry and invited them to participate in the proposed tea exhibition to be held in Kolkata.

"A comprehensive integrated programme on tea mechanisation is the only solution to cope with labour shortage, boost profitability of tea growers and strengthen the industry," Dr Sanjay Kumar, director, CSIR-IHBT.

The Tribune Tue, 15 October 2019

सुगंधित लैमन घास से किसान होंगे मालामाल

घास से निकलेगा तेल, 1100 रुपये प्रतिलीटर है कीमत

क्या है यह सुगंधित घास

बीज के लिए पालमपुर करें संपर्क

औषधीय गुणों वाली टी वाइन

चाय की गुणवत्ता में सुधार लाकर बढ़ाएं आर्थिकी

आयोजन

लैमन ग्रास से बंजर जमीन में उगल रही सोना

लैमन ग्रास उगाकर वंड करडियां के 22 किसानों ने सुधारी आर्थिकी

घास से निकलने वाले तेल की कीमत है लगभग 1500 रुपए प्रति किलो

उजड़े चाय बागानों का विकास

प्रदेश में 2300 हेक्टेयर रकबा बीज

अपनी माटी

नागछतरी का टिश्यू कल्चर तैयार

पालमपुर में आईएचबीटी के वैज्ञानिकों को मिली बड़ी कामयाबी

कैंसर से लड़ेगी चाय की पत्तियों से बनी दवा

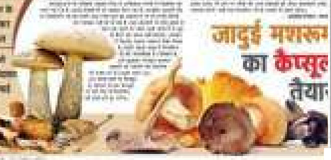
इनसे बनता है कैटेचिन्स

मिजोरम में पालमपुर की मदद से महकेंगे फूल

https://www.etvbharat.com//hindi/himachal-pradesh/state/kangra/shiitake-mushroom-rich-source-of-vitamin-d/hp20191221174643166

दिव्य हिमाचल

अपनी माटी



जादुई मशरूम का कैप्सूल तैयार

सिरमौर प्रशासन मंदिर में चढ़ने वाले फूलों से बनाएगा अगरबत्ती

Scientists to explore commercial values of Himalayan crops

बच्चों में आयरन की कमी दू[र] कर रही पालमपुर की कैंडी

आई.एच.बी.टी. पालमपुर ने हाईड्रोपोनिक खेती पर दिया 4 दिवसीय प्रशिक्षण

43 प्रतिशत किसानों ने लिया भाग

अगरबत्ती में महकेंगे श्रद्धा के फूल

दिव्य हिमाचल

एक बक्से से मिलेगा 40 किलो शहद

वज़न 7 किलो, मधुमक्खी भी सेफ

महिलाओं की खूबसूरती में चार चांद लगाएगी सब्जियों से तैयार लिपस्टिक

एक लाख मीट्रिक टन शहद का उत्पादन

दिव्य हिमाचल

DownToEarth

Himachal farmers have an affair with flowers

https://www.downtoearth.org.in/news/agriculture/himachal-farmers-have-an-affair-with-flowers-67544

The pioneer

Aromatic plants perk up Leh-Ladakh farmers

https://www.dailypioneer.com/2019/pioneer-exclusive/aromatic-plants-perk-up-leh-ladakh-farmers.html

ताईवानी वैज्ञानिकों ने जानीं आईएचबीटी की गतिविधियां

दिव्य हिमाचल Sun, 07 July 2019

अरुणाचल के किसानों ने सीखे सुगंधित फसलों की खेती के गुर

सुगंधित तेल निकालने की ली जानकारी

Science Day celebrated

The Tribune

आईएचबीटी और टीएमसी मिलकर तैयार करेंगे घुटनों के दर्द की दवा

सी.एस.आई.आर. की टीम बनी विजेता

CSIR-IHBT celebrates 77th foundation day

The Tribune

विद्यार्थियों ने विज्ञान की ओर आकर्षित किए विद्यार्थी

दिव्य हिमाचल

प्रवासी श्रमिकों के लिए आई.एच.बी.टी. ने उपलब्ध करवाया रैडी टू ईट फूड

सैनिटाइजर राज्य और बाहरी विभिन्न एजेंसियों एवं अधिकारियों को वितरित किया

पंजाब केसरी Mon, 30 March 2020

वनस्पतियों तथा पौध से विकसित उत्पादों की मैडीकल साइंस के मानदंडों पर होगी परख

पंजाब केसरी

अब सगंध फूलों का गुरु मंत्र देंगे हिमाचल के वैज्ञानिक

प्रकृति के जितने निकट, उतने ही स्वस्थ : डॉ. कावेरी

Sirmaur admn to tie up with CSIR for medicinal, aromatic crops

The Tribune

लेह-लद्दाख में लहलहाएंगी सगंधित फसलें

सीएसआईआर-आईएचबीटी और लद्दाख फार्मर्स एंड प्रोड्यूसर्स को-आपरेटिव के बीच करार

खराब कार्टिलेज ठीक करेंगी जड़ी-बूटियां, नी-रिप्लेसमैंट से मिलेगी राहत

Urban Himalaya running dry

Study warns of water insecurity, calls for timely action

IHBT develops sanitiser with natural flavours

PALAMPUR, MARCH 19

The CSIR-Institute of Himalayan Bioresource Technology (IHBT) has developed a hand sanitiser that contains natural flavours, active tea constituents and alcohol content as per WHO guidelines. The product is free from parabens, triclosan, synthetic fragrance and phthalates.

The technology will be transferred to a private unit through an agreement between the institute and AB Scientific Solutions.

The firm, that has a strong marketing network, will establish a facility at Palampur and market hand sanitisers and other disinfectants in all major cities across the country. — OC

पीएम ने निहारे सीएसआईआर आईएचबीटी पालमपुर के स्टाल

पालमपुर के हींग से चोखा निकलेगा रंग

सीएसआईआर आईएचबीटी में राष्ट्रीय प्रौद्योगिकी दिवस समारोह मनाया

आयरन व कैल्शियम की कमी दूर करेगा पापड़

बस एक 'सुपर फूड' चॉकलेट खाओ, लंच भूल जाओ

हिमालय जैवसंपदा प्रौद्योगिकी संस्थान, पालमपुर ने तैयार की बेहद पौष्टिक चॉकलेट

बस एक 'सुपर फूड' चॉकलेट खाओ, लंच भूल जाओ

कुपोषण दूर करने के लिए विकसित किए जाएंगे खाद्य उत्पाद : डॉ. संजय

आईएचबीटी पालमपुर में मनाया गया राष्ट्रीय विज्ञान दिवस

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