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Annual Report
2021-22

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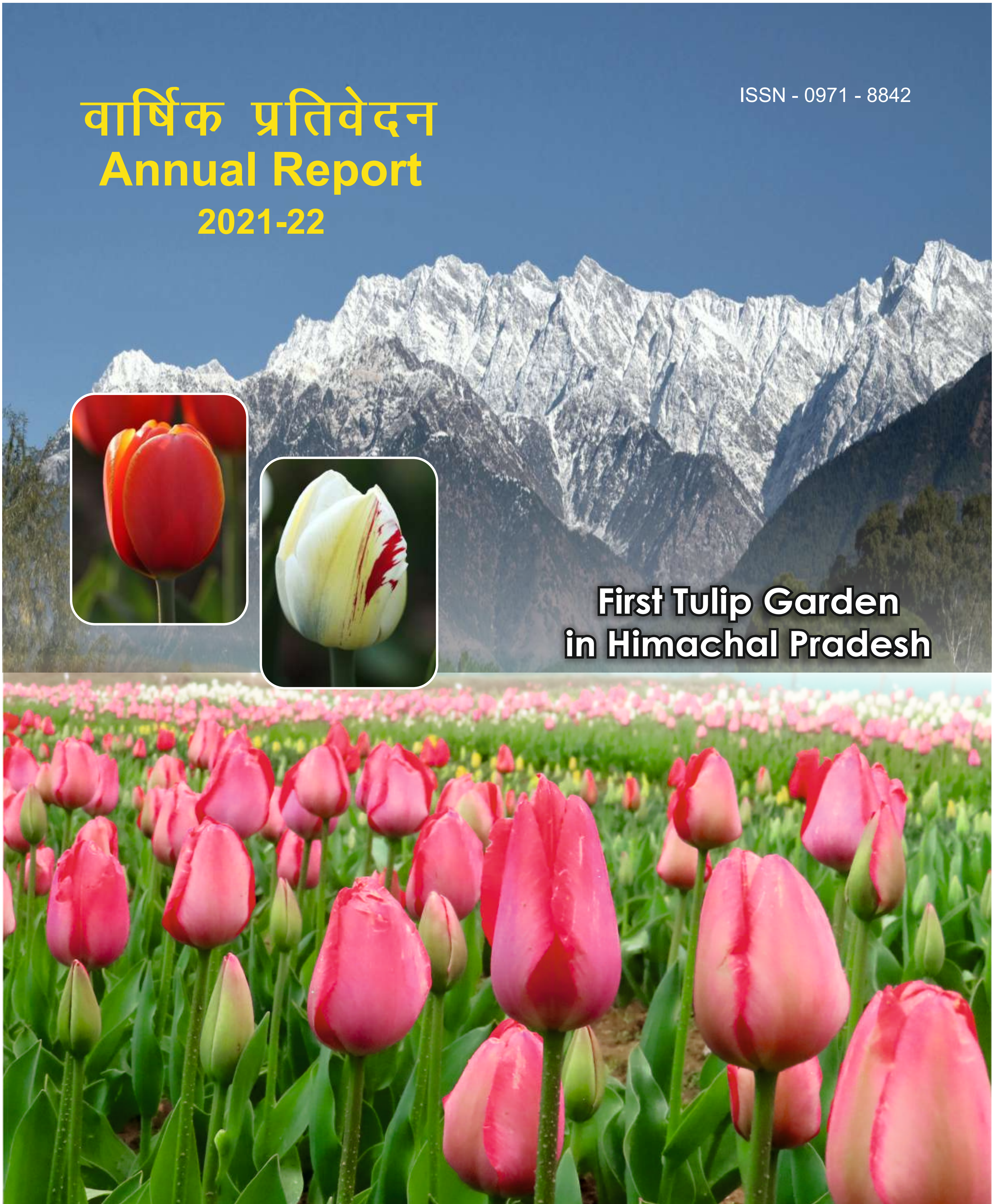

First Tulip Garden
in Himachal Pradesh

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।
जैवसंपदा को तेरी, सुरक्षित करते जाएंगे।
सुरक्षित करते जाएंगे।।

हिम आंचल से तेरे, प्रगति कर दिखलाएंगे।
ज्ञान से अज्ञान तिमिर, हम मिटाते जाएंगे।
हम मिटाते जाएंगे।।

प्रौद्योगिकी से देश को, स्वावलंबी बनाएंगे।
अनुसंधान से जग में, अर्थ विकास कराएंगे।
अर्थ विकास कराएंगे।।

मातृभूमि की भव्यता, विज्ञान से बढ़ाएंगे।
हो समर्पित हम सभी, जन उत्थान कराएंगे।

जन उत्थान कराएंगे।
जन उत्थान कराएंगे।
जन उत्थान कराएंगे।

संस्थान गान हेतु क्यूआर कोड को स्कैन करें

क्यूआर रीडर ऐप डाउनलोड करें

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Annual Report
2021-22

With Best Compliments from
Dr. Sanjay Kumar

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Palampur (HP)-176061

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CONTENTS

सीएसआईआर–आईएचबीटी का अवलोकन

परिकल्पनाः जैवार्थिकी के उन्नयन हेतु प्रौद्योगिकीय उद्भवता एवं विकास में हिमालयी जैवसंपदा के संपोषणीय उपयोग द्वारा विश्व स्तर पर अग्रणी होना।

उद्देश्यः सामाजिक, औद्योगिक, पर्यावरणीय और अकादमिक हित हेतु हिमालयी जैवसंपदा से प्रक्रमों, उत्पादों और प्रौद्योगिकियों की खोज, नवोन्मेश, विकास एवं प्रसार।

पश्चिमी हिमालय में धौलाधार पर्वतमाला की हिमच्छादित पर्वतमाला की तलहटी में बसे सीएसआईआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान (सीएसआईआर–आईएचबीटी) का इतिहास 1960 के दशक का है, जब जिला कांगड़ा पंजाब राज्य का एक भाग था। राज्य सरकार ने विज्ञान और प्रौद्योगिकी मंत्रालय, भारत सरकार के अंतर्गत एक स्वायत्त संगठन, वैज्ञानिक और औद्योगिक अनुसंधान परिषद (सीएसआईआर) की एक घटक प्रयोगशाला के रूप में पालमपुर में राष्ट्रीय जीवविज्ञान अनुसंधान संस्थान (एनबीआरआई) स्थापित करने पर विचार किया।

इस उद्देश्य के लिए जनवरी 1966 में, पंजाब सरकार के चिकित्सा और स्वास्थ्य विभाग द्वारा पालमपुर में होल्टा टी एस्टेट से लगभग 12396 करनाल भूमि अधिग्रहण की प्रक्रिया शुरू करने के लिए एक अधिसूचना जारी की गई। जिसमें सरकार द्वारा भूमि हस्तांतरण की प्रक्रिया में कुछ और समय लगा और सितंबर 1966 में पंजाब राज्य के पुनर्गठन के साथ जिला कांगड़ा का हिमाचल प्रदेश राज्य में विलय हो गया, और कम से कम आने वाले कुछ ओर समय में पालमपुर में एनबीआरआई की स्थापना का मुद्दा प्राथमिकता खोता गया।

समय बीतने के साथ, हिमाचल प्रदेश सरकार ने अन्य प्रतिष्ठानों के निर्माण के लिए एनबीआरआई की कुल चिह्नित भूमि का कुछ भाग उन्हें आवंटित कर दिया। परिणामस्वरुप, बनुरी और होल्टा में भूमि का एक छोटा टुकड़ा ही शेष रहा, जिसका इस संस्थान के निर्माण के लिए प्रारंभिक समय में अधिग्रहण किया गया था। 1970 के दशक शुरू में सीएसआईआर ने हिमाचल प्रदेश राज्य में अपनी उपस्थिति दर्ज की, जब क्षेत्रीय अनुसंधान प्रयोगशाला (आरआरएल) जम्मू ने पालमपुर में बंदला टी एस्टेट में किराए के भवन में अपना विस्तार केंद्र स्थापित किया। पालमपुर में एक स्वतंत्र सीएसआईआर प्रयोगशाला स्थापित करने के विचार ने एक बार फिर गति पकड़ी। पालमपुर में प्रस्तावित अनुसंधान संस्थान की स्थापना के उद्देश्य से एनबीआरआई के नाम से खाली पड़ी 186.2 एकड़ भूमि को आरआरएल, जम्मू के कब्जे में दे दिया गया।

इस प्रकार सीएसआईआर कएम्प्लेक्स पालमपुर की आधारशिला 2 जुलाई, 1983 को सीएसआईआर के उपाध्यक्ष और विज्ञान और प्रौद्योगिकी मंत्री, भारत सरकार प्रो. नूरुल हसन, द्वारा, हिमाचल प्रदेश के तत्कालीन मुख्यमंत्री, सीएसआईआर के महानिदेशक, डए. जी.एस. सिद्धू और अन्य गणमान्य व्यक्तियों की उपस्थिति में रखी। इसके अतिरिक्त, प्रौद्योगिकीय पहल के माध्यम से उच्च पर्वतीय क्षेत्रों की अर्थव्यवस्था को सुदृढ़ करने के लिए, अक्टूबर 2011 को रिब्लिंग (केलांग के पास 3450 मीटर), जिला लाहौल और स्पीति, हिमाचल प्रदेश में उच्च तुंगता जीवविज्ञान केंद्र (सीएब) की स्थापना की गई।

संस्थान आधारभूत और ट्रांसलेशनल अनुसंधान के लिए बहुआयामी अत्याधुनिक सुविधाओं के माध्यम से प्रक्रमों और उत्पादों को विकसित करने के लिए हिमालयी जैवसंपदा के संपोषणीय उपयोग के प्रति अग्रसर है। संस्थान के पास अत्याधुनिक विज्ञान पर आधारित एक मजबूत पेटेंट आधार और औद्योगिक विकास को बढ़ावा देने के लिए प्रौद्योगिकियों के सफल व्यावसायीकरण का व्यापक अनुभव है। संस्थान ने पुष्प, औषधीय और सगंध पौधों की खेती और मूल्यवर्धन के लिए स्थानीय संसाधनों के प्रसंस्करण के माध्यम से उच्च तुंगता वाले क्षेत्रों के जनजातीय और अन्य समुदायों के सशक्तिकरण और आजीविका को बढ़ाने के माध्यम से आर्थिकी को बढ़ावा देने में पहचान बनाई है।

OVERVIEW OF CSIR-IHBT

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

Mission: To discover, innovate, develop and disseminate the processes, products and technologies from Himalayan bioresources for society, industry, environment and academia

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, Government of India.

In January 1966, a notification was issued by the Medical and Health Department of the Government 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 Government 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. An area 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, Government of India, Prof. Nurul Hasan, in presence of the then Chief Minister of HP Sh. Virbhadra Singh, 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) in 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.

संस्थागत संरचना

श्री नरेन्द्र मोदी
माननीय प्रधानमंत्री भारत
अध्यक्ष, सीएसआईआर

डॉ जितेंद्र सिंह
विज्ञान और प्रौद्योगिकी मंत्रालय और पृथ्वी विज्ञान मंत्रालय के राज्य मंत्री और प्रधानमंत्री कार्यालय के राज्य मंत्री कार्मिक, लोक शिकायत और पेंशनय परमाणु ऊर्जा विभाग और अंतरिक्ष विभाग
उपाध्यक्ष, सीएसआईआर

डा. शेखर सी. माण्डे
सचिव, डीएसआईआर एवं महानिदेशक, सीएसआईआर

अनुसंधान परिषद → निदेशक ← प्रबन्ध परिषद

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Palampur– 176061 (HP)

IMPRESSIONS

10/04/2021 MOHD. ASLAM
Ex- Advisor, DBT and Ex- MD, BIRAC
9871935454

I visited IHBT after 5+ years and delighted to see a lot of improvement in the campus overall. The institute has really working on its real mandate for generating technology packages for converting rich genetic resources of this Himalayan Region in to economic wealth by generating entrepreneurship alongwith employment generation. Dr. Sanjay Kumar, Director, IHBT has made tremendous effort to give this institute a translational face. I hope the institute will continue its efforts for socio-economic development of this Region.
I wish all the success to everyone associated with IHBT.
Mohd. Asl

S. No.	Date	Name & Address	Phone	Comments
	19-06-21	वीरेन्द्र कंवर ग्रा० वि० पंचायती राज, कृषि, पशु पालन व मत्स्य पालन मन्त्री (हि० प्र०)	9418480444	आज मुझे जैव सम्पदा प्रौद्योगिकी संस्थान पालमपुर का दौरा किया, यहाँ के निदेशक डॉ० संजय कुमार जी ने हमें यहाँ चल रहे शोध कार्यों से अवगत करवाया। जैव विविधता में यह संस्थान बहुत ही सराहनीय कार्य कर रहा है। मैं आशा करता हूँ कि संस्थान राज्य में ग्रामीण विकास के साथ-2 किसानों की आय बढ़ाने तथा आत्मनिर्भर बनाने में अपना सक्रिय योगदान दे। 19/6

26/6/2021 Prof Satish Chandra
Director, CSIR-CRRI
New Delhi

This is my visit to the institute and was delighted to see the vibrant campus, and a highly motivated and dynamic group of scientists and technical staff. The institute has made several innovations under the leadership of Dr Sanjay Kumar. Its work on Asafoetida has caught attention at the highest level. Guesthouse facility and its staff are excellent.
Schandra 26/6/2021

17/10/2021 Prof J.P. Sharma
Vice-Chancellor
SKUAST- Jammu and Kashmir

9811721815

I had an opportunity to visit this CSIR institute for the first time and show various research and development initiatives under the able leadership of Dr Sanjay Kumar. Really impressed to see the various innovative initiatives taken by the institute in the area of speciality agriculture, Aromatic and medicinal Plant & their value addition having high potential for entrepreneurship development. Various start-ups taken by the youths under the guidance of Institute is worth appreciation. My all appreciation to able leadership

[signature]

18/02/22 Lok Nath Sharma
Cabinet Minister
Govt. of Sikkim.

I had opportunity to visit CSIR-IHBT palampur, Himachal pradesh on 17th Feb. 2022 with my department officers.
I congratulate the Renowned director Dr. Sanjay kumar & team to prove the institude as model. Through this institude our state is getting so many projects and research work. I had visited the whole Area and encourage to work togather in near future. we are sighing MOU for. Low chilling Asde. Aroma. Medicinal plants. during my stay at Guest house. on behalf of our HCM & myself congratulate & wishes for more research and give technology to the farmers of country & state.
Thank you.

[signature]
18/2/22
MINISTER
Agriculture, Horticulture, Animal Husbandry and Veterinary Services, Information and Public Relations, and Printing and Stationery Deptt
Government of Sikkim

FROM THE DIRECTOR'S DESK

I am delighted to present the salient achievements of the CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT) for the year 2021-2022. It was heartening to note that the institute continues to be among the top ten institutes of CSIR as per the SCImago rating.

CSIR-IHBT implemented three major mission mode projects this year. Under Aroma Mission Phase-II, the institute consolidated the area under aromatic crops to 1398 ha and extended cultivation in twelve states and two union territories. Nineteen lakh rooted plants and three tonnes of seeds of aromatic crops were generated and supplied to the farmers. Eight field distillation units were installed in the farmers' fields for the extraction of essential oils, while four more units are in the process of installation in remote Dodra Kwar (Himachal Pradesh), Kalimpong (West Bengal), Medina (Haryana) and Nawanshahr (Punjab). During the year, Himachal Pradesh maintained its position as the top producer of aromatic marigold oil in the country with a production of 7.3 tonnes of oil. Overall, ~29 tonnes of essential oil worth ₹15.66 crore was produced from the cultivation of aromatic crops by the farmers associated with our institute.

Under CSIR-Floriculture Mission, the area coverage of floriculture crops was extended to 350 ha benefitting 1004 farmers with a potential of generating revenue worth ₹15.68 crore. Fifteen lakh planting materials of floriculture crops in the form of corms and rooted plants were generated and supplied to the farmers of Himachal Pradesh, Uttarakhand, Punjab and union territories of Jammu & Kashmir and Ladakh as a part of the mission. One of the main attractions of the floriculture mission during the current year was the establishment of the Tulip Garden in Himachal Pradesh, which was inaugurated by the Hon'ble Governor of Himachal Pradesh, Shri Rajendra Vishwanath Arlekar on the occasion of National Science Day, 28 February, 2022, at CSIR-IHBT campus. This is the first Tulip garden in Himachal Pradesh where 30,000 tulip bulbs, raised by the institute in cold desert areas of Lahaul were used to develop it.

In order to boost additional income of farmers through honey production, apiculture is now being aggressively promoted under the floriculture mission. During this year, 2100 bee-boxes were supplied to the various farmer groups.

Considering the post COVID-19 health complications, CSIR launched a Mission on "Immunomodulatory Function of Nutritionals and Nutraceuticals for Health and Wellness" with the sole objective to provide an array of immunity-boosting and modulating nutraceuticals and health supplements. CSIR-IHBT is the nodal institute of the mission and has undertaken several projects of importance. A number of products using traditional herbs & spices and indigenous teas produced across India are being evaluated to produce health supplements to promote immunity. Furthermore, the Human Intervention Studies to validate the nutraceuticals to improve cartilage health, vitamin D deficiency, cardiac health and aged-linked neurodegeneration are in the final stage of evaluation. Under this mission, a digital portal is being developed to document the evidence-based immune-stimulatory capacity of native fruits and vegetables.

Based on the efforts by the institute, captive cultivation of stevia has been consolidated to 448 ha in Punjab, Himachal Pradesh, Chhattisgarh, Uttar Pradesh, Uttarakhand, Haryana, Andhra Pradesh, Manipur, Maharashtra and Odisha. Around 2 crores quality planting material of stevia was generated and supplied to the industry and farmers to promote the cultivation of stevia in different regions of the country. Similarly, the initiation of *Heeng* cultivation in the country was further strengthened in terms of the layout of nurseries (46000 plants raised), supply of planting material to farmers (33000 plants have been supplied covering 4 ha area at 214 locations), training of farmers (519 farmers) and capacity building of Agriculture Officers (53 officers) for better outreach in the states of Himachal Pradesh, Uttarakhand and Union Territories of Jammu & Kashmir and Ladakh. Under the joint collaboration programme of CSIR-IHBT and State Department of Agriculture, Himachal Pradesh for the cultivation of saffron, 6859 kg corms of saffron were supplied to farmers at 25 locations in Kinnaur, Mandi, Chamba, Kangra and Kullu districts to boost production of saffron.

Following the introduction of low-chilling varieties of apple in the North Eastern states by CSIR-IHBT in the year 2016, these varieties have further been extended this year in the states of Mizoram, Manipur, Meghalaya and Arunachal Pradesh. The total area under apples has now increased to 117.5 acres. Success of apple in the north east region was highlighted by the Hon'ble Prime Minister of India Shri Narendra Modi in *Mann Ki Baat* programme aired on 25 July 2021.

In a new initiative, CSIR-IHBT introduced organised cultivation and processing of cinnamon (*Cinnamomum verum*) in Himachal Pradesh. A pilot project was initiated with the background that India imports ~45,000 tonnes of cinnamon worth Rs. 900 crores annually from several countries including Sri Lanka and Vietnam. The first sapling of cinnamon in Himachal Pradesh was planted on September 29, 2021 by the Hon'ble Agriculture Minister of HP, Sh. Virender Kanwar at Kholin, District Una in a plantation drive organized by the institute. I am pleased to state that honourable Chief Minister of Himachal Pradesh Shri Jai Ram Thakur ji mentioned in his budget speech also on cultivation of cinnamon in the state with our institute.

Yet another new initative undertaken by the institute during the current year was to develop suitable methods on culturing and processing of freshwater pearl to enhance livelihood of rural communities.

Our scientists formulated several health-promoting food and nutraceutical products based on scientific evaluation, such as pearl millet based fermented products having increased availability of essential amino acids, and value-added soluble dietary fiber rich food products from mango and pomegranate peels. Phytochemicals extracted from Indian barberry (*Berberis lycium*) showed a novel activity in the prevention of joint articular damage during rheumatoid arthritis. Phloretin, a marker bioactive constituent present in apple was found to mitigate oxidative injury and alleviate hepatic inflammation and progression of liver fibrosis. The preclinical evaluation also revealed that consumption of catechin-rich green tea enhanced murine healthspan by regulating cellular senescence.

CSIR-IHBT is also working to develop novel therapeutics and nutraceuticals from Himalayan plants. In this context, a novel antidiabetic and antihypertensive bioactive peptide "ASGLCPEEAVPRR", having inhibitory activities against angiotensin-converting enzyme (ACE) and dipeptidyl peptidase-IV (DPP-IV), was identified from *Picrorhiza kurrooa*. Computational analysis identified several bioactive leads from Himalayan plants that could be developed as novel inhibitor against 11β-hydroxysteroid dehydrogenase type 1 (11β-HSD1), an enzyme responsible for metabolic changes including insulin resistance leading to Type II diabetes.

In the previous year, CSIR-IHBT launched "POSHAN Maitree" program under the "POSHAN Abhiyaan" in collaboration with the Directorate of Women and Child Development, Govt, of Himachal Pradesh for distribution and assessment of health impact of protein and micronutrient fortified food products developed at CSIR-IHBT. The study indicated that continuous supplementation of protein and micronutrient food products resulted in improved anthropometric parameters (growth, BMI and overall health) in malnourished children.

In addition, '*Seera*', a sweetened fermented cereal food product was launched for public consumption, and the technology for packaging of *Seera* in modified atmospheric condition has been transferred for its commercial production.

In value valorisation from waste, CSIR-IHBT scientists developed a process for utilization of agri-byproducts such as guar meal and microalgae biomass for the production of protein concentrates for food and feed applications. The process has been transferred to M/s. Shree Ram Gums India Pvt., Ltd., Jodhpur. The institute also developed a process for the cultivation of microalgae utilizing beverage industry waste (reverse osmosis reject salt) and extracted microalgae-based nutraceuticals such as C-phycocyanin, carotenoids and edible protein concentrates. The process know-how has been transferred to M/s. AlgaReal Nutraceuticals, Bengaluru.

Two scientifically validated technologies namely "Production and processing of Vitamin D_2 enriched *shiitake* mushroom" and "efficient psychrotrophic bacterial formulation for preparation of enriched compost/ vermicompost in the cold hilly region" have been used for the livelihood generation through five "Scheme of Fund for Regeneration of Traditional Industries (SFURTI)" clusters in rural areas of Sikkim and Himachal Pradesh. Further, the product "Compost Booster- Single solution for stabilization of night soil/kitchen waste" is being widely used in Lahaul valley for stabilization of human faeces into a compost-like soil amendment. Also, CSIR-IHBT installed anaerobic biogas plants with the capacity of treating 250 kg of organic waste per day at Nagar Panchayat Baijnath Paprola, Baijnath, Himachal Pradesh, and Gyalshing Nagar Panchayat, Gyalshing, West Sikkim.

In the area of agro-waste utilization for high-value chemicals, a comprehensive solution has been put forth for furfural, 5-hydroxymethylfurfural (5-HMF), lignin and bio-char production from Rice straw (*Oryza sativa* L.) biomass. Further, to reinforce the fundamental chemistry research, this year overall 16 synthetic methodologies have been published to enhance knowledge in the area of organic synthesis. The developed methodologies emphasize on nano-composite material as catalyst, C-H activation, green and sustainable chemistry, photo-catalysis, carbon monoxide fixation and redox reactions involving the synthesis of valuable azelaic acid, benzimidazoles, aryl esters, quinoline based heterocycles and macrocyclic molecules.

Considering the importance of bioactive phytochemicals, the commercially important medicinal plants (*Rhododendron arboreum*, *Aconitum heterophyllum*, *Thalictrum foliolosum*, *Trillium govanianum*, *Polygonatum verticillatum* and *Swertia chirayita*) have been explored for specialized bioactive metabolites and characterized for important metabolites. In the area of natural colors/dyes, the stabilizing additives have been optimized to stabilize anthocyanins. The retention of anthocyanins was studied against light, heat, oxygen, storage, and pH.

One of the many strategies in Himalayan plants to adapt to low temperature is by utilizing specialized proteins referred to as 'antifreeze proteins', which inhibit ice crystal growth and have applications in food and medical industries. Proteins from six Himalayan plant species were evaluated for antifreeze activities, where barley protein extract exhibited remarkable potential in cryopreservation in food and biomedical products.

Further, ornamental rose that represents an economically important floriculture crop, bears prickles on the stems, which hinders its harvesting and transportation. The institute elucidated the molecular basis of prickle morphogenesis in rose, which has implications in generating genetically stable prickle-less rose varieties.

The role and mechanism of action of endophytes towards enhancing plant productivity was also worked out. The institute now has a collection of >600 endophytes isolated from different parts Himalayan plants, including *Arnebia euchroma, Sinopodophyllum hexandrum, Picrorhiza kurrooa,* and *Fritillaria roylei.* These plant growth promoting endophytes are being tested as plant probiotics to enhance the production under different environmental stress, and biosynthesis of therapeutic metabolites. Evaluation of a yeast endophyte showed promising results in imparting cold stress tolerance in model plant Arabidopsis.

Researchers working in the area of Bioinformatics addressed some of the challenging fundamental research problems in modern biology including using artificial intelligence and machine-learning. At one side RBSpot to detect RNA-binding proteins interactions was developed with RNAs applying Deep-Learning, on the other side the group developed the first ever software, miRBiom, to detect miRNAs profile in any condition without needing miRNA profiling experiments. The group partnered with chemistry group to unravel natural lead molecules against SARS-CoV2. DBT, India has awarded the institute one of the few National Bioinformatics Research Centers (BIC) of the country.

One of the major thrust of the institute is to understand stress- and adaptation biology of Himalayan plants. In this context, institute reported first indigenously developed draft genome and an extensive organ and developmental stages specific proteomic description in *Picrorhiza kurrooa*.

Proteome-wide and post-translational modification analysis suggests the enrichment of RNA binding proteins and modifications such as phosphorylation and ADP-ribosylation, which seems to play important role in *Picrorhiza kurrooa*. adaptation to alpine environment.

Through genome wide analysis of TIR-NBS-LRR gene family in potato, a gene *StTNLC7G2* was identified that had a role in defense against early blight disease caused by *Alternaria solani*. In another study, a deep learning-based rice network model (DLNet) was developed by using a data set of rice-pathogen interactions to identify strategies used by rice immune system to evade contrasting pathogens.

In the area of plant-fungal interactions, characterization of evolutionarily distinct rice BAHD-acyltransferases in rice provided insights into their plausible role in susceptibility to *Rhizoctonia solani*.

Bioprospecting high-altitude microbial resource for industrially important extremozymes, we explored and tested lab-scale applications of efficient lignocellulolytic microbes and their enzymes (laccase, xylanase, endoglucanase, and β-galactosidase). Pilot-scale fermentation to produce efficient cellulase from a thermophilic *Bacillus* sp. PCH94 using agricultural waste was achieved.

Kluyveromyces marxianus PCH397 isolated from yak milk was found to be an efficient β-galactosidase producer and could be a potential probiotic yeast that has therapeutic potential against obesity, T2D, and colon cancer as revealed by cell lines studies.

In plant-viral interactions, viral protein 2b (suppressor of silencing) was found to exert its effect by associating with Homeobox 27 transcription factor during disease development and its specific overexpression lead to tolerance against the virus. Research on the transmission of apple scar skin viroid by whitefly *Trialeurodes vaporariorum*, revealed that viroid RNA binds to 20 kDa heat shock protein of host and utilize it for the transmission.

Biodiversity exploration and documentation of Himalayan flora is central to our institute, and four species viz. *Alangium alpinum* (C.B. Clarke) W.W. Sm. & Cave (Cornaceae), *Euphrasia officinalis* L. (Orobanchaceae), *Geranium refractum* Edgew. & Hook.f. (Geraniaceae) and *Sedum filipes* Hemsl. (Crassulaceae) were reported first time from Arunachal Pradesh. A highly fragrant zingiber i.e. *Hedychium flavescens* Carey ex Roscoe (Zingiberaceae) was also reported as a new distributional record for Himachal Pradesh. Continued research in the LTER sites in the timberline zone revealed important insights into the nutrient resorption strategy of *Betula utilis* species, a key treeline species of Himalaya.

Recognizing the importance of traditional knowledge and the trends of its decline, a CSIR-TKDL Point of Presence was established in the Institute. It has a focus on Sowa Rigpa (Tibetan System of Medicine) wherein the same is being documented and digitized. Also, patterns and processes of transhumance amongst the *Gaddis* of Himalaya revealed a declining trend of the same. Theft of livestock *en-route* and limiting fodder resource were recorded to be the prime reasons behind this. Work on community forests revealed that disturbance significantly alters forest composition and promotes invasive species.

Our institute is amongst few in the country in utilization of very high resolution modern remote sensing for monitoring and management of phytoresources. Drone based multispectral remote sensing was carried out for the determination of available biomass of *Stevia rebaudiana* at the time of harvesting and also estimation of requisite dose of nitrogen in their canopy. The hyperspectral remote sensing helped us in identification and discrimination of medicinal plants such as *Saussurea costus*, *Valeriana jatamansi* and *Picrorhiza kurrooa*, which otherwise would require taxonomic skills. Automated flower enumeration method was developed for the floriculture industries which provided automated approach for yield estimation of *Tagetes* flowers from its digital picture captured at the time of their harvesting stage.

The Air Pollution Tolerance Index of 15 commonly used indoor ornamental plant species were estimated which provided their air indoor pollution abatement abilities.

The field genebank at CSIR-Centre for High Altitude Biology (CeHAB) was enriched with 40 threatened plant species that include *Angelica glauca, Carum Carvi, Arnebia euchroma, Eremurus himalaicus, Polygonatum cirrihifolium, Aconitum heterophyllum, Sinopodophyllum hexandrum, Picrorhiza kurrooa,* and *Fritillaria roylei* .

Also, complete *in-vitro* protocols were developed for threatened medicinal species such as *Fritillaria roylei* and *Nardostachys jatamansi*, which have been optimised as low cost and with high survival rate of plants after hardening. Recognizing the demand of quality planting materials, the institute standardized the protocol for mass propagation high value species including *Ferula assafoetida* (*Heeng*), *Siraitia grosvenorii* (monk fruit), saffron, and bamboo.

To nurture scientific temperament in the next generation of scientists, CSIR-IHBT organized the 5th Student Seminar Series on 5th September 2021. The event was celebrated with great fervour and was themed "Scientific Innovation and Digital Transformation: Bridging Interdisciplinary Perspective". Also, the curtain raiser ceremony of the India International Science Festival was held on 6th December 2021 through hybrid mode. CSIR-IHBT organized the Swarn Jayanti Tea Fair on 14th December, 2021. The Hon'ble Minister of Rural Development, Panchayati Raj, Agriculture, Animal Husbandry & Fisheries, Govt. of Himachal Pradesh, Sh. Virender Kanwar laid the foundation for the Tea Policy in H.P.

Continuing her efforts toward establishing linkages between research, academia, industry and society, the institute participated and displayed research products and technologies in various national and international trade fairs and symposia. Our scientists published 159 research articles out of which 147 articles were published in SCI journals with an average impact factor of 4.609. The institute signed 316 agreements/MoUs with different farming-societies and academic R&D institutes/universities. Moreover, ten technology transfers, two hundred sixty-three material transfer agreements , and one consultancy service for the establishment of the shiitake mushroom cluster were carried out. To encourage youth for entrepreneurial ventures and self-employment opportunities, thirteen MoUs/Agreements were signed under the "Chief Minister's Start-up Scheme" for incubation and facility use at CSIR-IHBT.

Under Scientific Social Responsibility activities, ~2600 school students and teachers participated in a student-scientist connect programme, JIGYASA. Besides, educational visits were organized for ~400 college and university students and their faculty at out institute. This year, we have adopted 10 Kendriya Vidyalaya and Govt. schools in HP having Atal Tinkering Labs for their smooth functioning. Institute has established and further strengthened linkages with different schools and educational institutes for Jigyasa activities, establishment of gardens under CSIR-Floriculture Mission, research internship programmes and outreach activities.

Various skill development programmes were conducted under CSIR-Integrated Skill Initiative, Skill Vigyan Programme of The Department of Biotechnology, GoI (DBT) implemented by Himachal Pradesh Council for Science, Technology and Environment (HIMCOSTE) in H.P., and UGC-STRIDE Programme (Scheme for Trans-disciplinary Research for India's Developing Economy). This year, institute was registered as 'Training Provider' and 'Training Center' with National Skill Development Council. We conducted Life Sciences Sector Skill Development Council courses of Quality Control Biologist and Lab Technician/Assistant of 3 months' duration. Besides, students from different educational and research institutes were provided research internship at the Institute.

CSIR-headquarters, Management Council, various funding agencies and state government continued to support and motivate us for achieving scientific excellence, developing newer technologies and entrepreneurships, and discharging social/national responsibilities. I am happy to share that we are part of the Himalayan Bioresource Mission of The Department of Biotechnology, GoI (DBT). Also, the support of The Department of Science and Technology, GoI (DST) through SHRI scheme is acknowledged. We are grateful to the Research Council for their vital and positive role in guiding R&D programmes of the institute. We commit to devote ourselves for growth and development of the nation by offering scientific solutions on economic, scientific, industrial, societal and environmental issues.

Jai Hind !

(Sanjay Kumar)

निदेशकीय प्रतिवेदन

मुझे वर्ष 2021–2022 के लिए सीएसआईआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान (सीएसआईआर–आईएचबीटी) की प्रमुख उपलब्धियों को प्रस्तुत करते हुए हर्ष हो रहा है। उल्लेखनीय है कि इस वर्ष भी यह संस्थान एससीआईमैगो रेटिंग के अनुसार सीएसआईआर के शीर्ष दस संस्थानों में बना हुआ है।

सीएसआईआर–आईएचबीटी ने इस वर्ष तीन प्रमुख मिशन मोड परियोजनाओं को क्रियान्वित किया। अरोमा मिशन चरण– I I के अंतर्गत संस्थान ने 1398 हेक्टेयर क्षेत्र को सगंध फसलों अंतर्गत समाहित किया और बारह राज्यों तथा दो केंद्र शासित प्रदेशों में इसकी खेती का विस्तार किया। उन्नीस लाख जड़ युक्त पौधे तथा तीन टन सगंध फसलों के बीज तैयार कर किसानों को वितरित किए गए। सगंध तेलों के निष्कर्षण के लिए किसानों के प्रक्षेत्रों में आठ आसवन इकाइयां स्थापित की गईं, जबकि ऐसी चार अन्य इकाइयां दूरस्थ डोडरा क्वार (हिमाचल प्रदेश), कलिम्पोंग (पश्चिम बंगाल), मदीना (हरियाणा) और नवांशहर (पंजाब) में स्थापित करने की प्रक्रिया में है। वर्ष के दौरान, हिमाचल प्रदेश ने 7.3 टन तेल के उत्पादन के साथ देश में सगंध गेंदे के तेल के शीर्ष उत्पादक के रूप में अपना स्थान बनाए रखा है। कुल मिलाकर, हमारे संस्थान से जुड़े किसानों द्वारा सगंध फसलों की खेती से ₹15. 66 करोड़ मूल्य के ~29 टन सगंध तेल का उत्पादन किया गया।

सीएसआईआर–फ्लोरिकल्चर मिशन के अंतर्गत, पुष्प फसलों के क्षेत्र में 350 हेक्टेयर तक का विस्तार किया गया, जिससे 1004 किसानों लाभान्वित हुए तथा ₹15.68 करोड़ की आय संभव हुई। इस मिशन के अंतर्गत हिमाचल प्रदेश, उत्तराखंड, पंजाब और केंद्र शासित प्रदेशों जम्मू एवं कश्मीर और लद्दाख के किसानों को कॉर्म और जड़ वाले पौधों के रूप में पुष्प फसलों की पंद्रह लाख रोपण सामग्री तैयार कर वितरित की गई। इस वर्ष के दौरान फ्लोरिकल्चर मिशन के अंतर्गत के हिमाचल प्रदेश में ट्यूलिप गार्डन की स्थापना मुख्य आकर्षणों में से एक रही, जिसका उद्घाटन हिमाचल प्रदेश के माननीय राज्यपाल श्री राजेंद्र विश्वनाथ अर्लेकर ने सीएसआईआर–आईएचबीटी परिसर में 28 फरवरी 2022 को राष्ट्रीय विज्ञान दिवस के अवसर पर किया। यह हिमाचल प्रदेश का पहला ट्यूलिप गार्डन है जहां संस्थान द्वारा लाहौल के ठंडे रेगिस्तानी इलाकों में उगाए गए 30,000 ट्यूलिप बल्बों का उपयोग इसे विकसित करने के लिए किया गया।

शहद उत्पादन के माध्यम से किसानों की आर्थिकी को सुदृढ़ करने के लिए अब सीएसआईआर–फ्लोरिकल्चर मिशन के अंतर्गत मधुमक्खी पालन को अत्याधिक सक्रियता के साथ प्रोस्ताहित किया जा रहा है। इस वर्ष के दौरान विभिन्न किसान समूहों को 2,100 मधुमक्खी बक्से वितरित किए गए।

कोविड–19 के बाद की स्वास्थ्य संबन्धी समस्याओं को ध्यान में रखते हुए, सीएसआईआर ने 'स्वास्थ्य और कल्याण के लिए पोषण और न्यूट्रास्यूटिकल्स के इम्यूनोमॉड्यूलेटरी फंक्शन' पर एक मिशन शुरू किया, जिसका एकमात्र उद्देश्य प्रतिरक्षा बढ़ाना और न्यूट्रास्युटिकल्स एवं स्वास्थ्य की खुराक को व्यवस्थित करना है। सीएसआईआर–आईएचबीटी इस मिशन का नोडल संस्थान है और कई महत्वपूर्ण परियोजनाएं शुरू की गई हैं। प्रतिरक्षा को बढ़ावा देने के लिए, स्वास्थ्य की खुराक का मूल्यांकन करने के लिए पूरे भारत में उत्पादित पारंपरिक जड़ी–बूटियों एवं मसालों तथा स्वदेशी चाय का उपयोग करने वाले कई उत्पादों का मूल्यांकन किया जा रहा है। इसके अतिरिक्त, उपास्थि स्वास्थ्य, विटामिन डी की कमी, हृदय स्वास्थ्य और वृद्धों से जुड़े न्यूरोडीजेनेरेशन में सुधार के लिए न्यूट्रास्यूटिकल्स को मान्य करने के लिए मानव हस्तक्षेप अध्ययन मूल्यांकन के अंतिम चरण में हैं। इस मिशन के अन्तर्गत स्थानीय फलों और सब्जियों की साक्ष्य–आधारित प्रतिरक्षा–प्रेरित क्षमता का दस्तावेजीकरण करने के लिए एक डिजिटल पोर्टल भी विकसित किया जा रहा है।

संस्थान के प्रयासों के आधार पर पंजाब, हिमाचल प्रदेश, छत्तीसगढ़, उत्तर प्रदेश, उत्तराखंड, हरियाणा, आंध्र प्रदेश, मणिपुर, महाराष्ट्र और ओडिशा जैसे राज्यों में 448 हेक्टेयर क्षेत्र को स्टीविया की कैप्टिव खेती के अंतर्गत लाया गया। देश के विभिन्न क्षेत्रों में स्टीविया की खेती को बढ़ावा देने के लिए उद्योगों और किसानों को स्टीविया की लगभग 2 करोड़ गुणवत्ता युक्त रोपण सामग्री तैयार कर वितरित की गई। इसी प्रकार, देश में हींग की खेती को, पौधशाला तैयारी (46000 पौधे उगाए गए), किसानों को रोपण सामग्री के वितरण (214 स्थानों पर 4 हेक्टेयर क्षेत्र को खेती के अन्तर्गत लाते हुए

33000 पौधों का वितरण), हिमाचल प्रदेश, उत्तराखंड और केंद्र शासित प्रदेशों जम्मू और कश्मीर एवं लद्दाख में किसानों तक बेहतर पहुंच के लिए 519 किसानों और 53 कृषि अधिकारियों को प्रशिक्षण के माध्यम से क्षमता निर्माण करके आगे बढ़ाया जा रहा है। केसर की खेती के लिए सीएसआईआर–आईएचबीटी और राज्य कृषि विभाग, हिमाचल प्रदेश के संयुक्त सहयोग कार्यक्रम के अंतर्गत किन्नौर, मंडी, चंबा, कांगड़ा और कुल्लू जिलों में 25 स्थलों पर किसानों को 6859 किलो केसर के कंदों का वितरण किया गया ताकि केसर उत्पादन को बढ़ावा दिया जा सके।

वर्ष 2016 में सीएसआईआर–आईएचबीटी द्वारा उत्तर पूर्वी राज्यों में सेब की लो चिलिंग किस्मों की शुरुआत के बाद, इस वर्ष इन किस्मों का मिजोरम, मणिपुर, मेघालय और अरुणाचल प्रदेश राज्यों में आगे विस्तार किया गया है। सेब का कुल क्षेत्रफल अब बढ़कर 117.5 एकड़ हो गया है। भारत के माननीय प्रधान मंत्री श्री नरेंद्र मोदी द्वारा 25 जुलाई 2021 को प्रसारित 'मन की बात' कार्यक्रम में उत्तर पूर्व क्षेत्र में सेब के सफल उत्पादन का उल्लेख किया गया।

एक नई पहल के अंतर्गत, सीएसआईआर–आईएचबीटी ने हिमाचल प्रदेश में दालचीनी की संगठित खेती और प्रसंस्करण की शुरुआत की। हमारा देश श्रीलंका और वियतनाम सहित कई देशों से प्रति वर्ष ₹ 900 करोड़ से 45,000 टन दालचीनी का आयात करता है, इसे देखते हुए एक पायलट परियोजना को शुरू किया गया है। हिमाचल प्रदेश में दालचीनी का पहला पौधा 29 सितंबर 2021 को हिमाचल प्रदेश के माननीय कृषि मंत्री श्री वीरेंद्र कंवर द्वारा संस्थान द्वारा आयोजित वृक्षारोपण अभियान के दौरान जिला ऊना के खोली में लगाया गया। यह हर्ष का विषय है कि हिमाचल प्रदेश के माननीय मुख्यमंत्री श्री जय राम ठाकुर जी ने अपने बजट भाषण में हमारे संस्थान के साथ राज्य में दालचीनी की खेती का भी उल्लेख किया।

वर्ष के दौरान संस्थान द्वारा शुरू की गई एक और नई पहल ग्रामीण समुदायों की आजीविका बढ़ाने के लिए मोती की खेती एवं प्रसंस्करण पर उपयुक्त पद्धति विकसित करना रहा है।

हमारे वैज्ञानिकों ने वैज्ञानिक मूल्यांकन के आधार पर कई स्वास्थ्यवर्धक खाद्य और न्यूट्रास्यूटिकल उत्पाद तैयार किए, जैसे कि बाजरा आधारित किण्वित उत्पाद जिनमें आवश्यक अमीनो एसिड की उपलब्धता में वृद्धि हुई है एवं आम और अनार के छिलके से मूल्य वर्धित घुलनशील आहारीय फाइबर समृद्ध खाद्य उत्पाद प्रमुख हैं। भारतीय बार्बेरी (*बर्बेरिस लाइसियम*) से निकाले गए फाइटोकेमिकल्स ने रुमेटीइड गठिया के दौरान जोडों की क्षति की रोकथाम में एक नई गतिविधि दिखाई। सेब में मौजूद एक मार्कर बायोएक्टिव घटक फ्लोरेटिन ऑक्सीडेटिव चोट को कम करने और यकृत की सूजन तथा यकृत फाइब्रोसिस के बढ़ने को कम करने के लिए कारगर पाया गया है। प्रीक्लिनिकल मूल्यांकन से यह भी पता चला है कि कैटेकिन से भरपूर ग्रीन टी के सेवन से सेल्युलर सेनेसेंस को विनियमित करके म्यूरिन हेल्थस्पैन को बढ़ाया जाता है।

सीएसआईआर–आईएचबीटी हिमालयी पौधों से नई चिकित्सीय और न्यूट्रास्यूटिकल्स विकसित करने के लिए भी काम कर रहा है। इस संदर्भ में, एक नवीन एंटीडायबिटिक और एंटीहाइपरटेन्सिव बायोएक्टिव पेप्टाइड "ASGLCPEEAVPRR", जिसमें एंजियोटेंसिन–कनवर्टिंग एंजाइम (ACE) और डाइपेप्टिडाइल पेप्टिडेज-IV (DPP-IV) के खिलाफ निरोधात्मक गतिविधियाँ हैं, को *पिक्रोराइजा कुरोआ* में खोजा गया। कम्प्यूटेशनल विश्लेषण ने हिमालयी पौधों से कई बायोएक्टिव लीड्स की पहचान की, जिन्हें 11β–हाइड्रॉक्सीस्टेरॉइड डिहाइड्रोजनेज टाइप 1 (11β–HSD1) एक एंजाइम जो टाइप II मधुमेह के लिए इंसुलिन प्रतिरोध सहित मेटाबोलाइट परिवर्तनों के लिए उत्तरदायी है, के विरूद्ध नवीन अवरोधक के रूप में विकसित किया जा सकता है।

पिछले वर्ष, सीएसआईआर–आईएचबीटी ने महिला एवं बाल विकास निदेशालय, हिमाचल प्रदेश सरकार के सहयोग से 'पोषण अभियान' के अन्तर्गत 'पोषण मैत्री' कार्यक्रम शुरू किया गया जिसमें संस्थान द्वारा विकसित सूक्ष्म प्रोटीन और पोषक तत्वों से भरपूर खाद्य उत्पादों के स्वास्थ्य प्रभाव को जानने के लिए इनका वितरण और मूल्यांकन किया गया। अध्ययन से पाया गया कि प्रोटीन और सूक्ष्म पोषक खाद्य उत्पादों के निरंतर पूरकता के परिणामस्वरूप कुपोषित बच्चों में मानवशास्त्रीय मापदंडों (विकास, बीएमआई और समग्र स्वास्थ्य) में सुधार हुआ है।

इसके अतिरिक्त 'सीरा', एक मीठे किण्वित खाद्य उत्पाद को सार्वजनिक उपभोग के लिए प्रारंभ किया गया और संशोधित वायुमंडलीय स्थिति में सीरा की पैकेजिंग के लिए प्रौद्योगिकी को इसके व्यावसायिक उत्पादन के लिए हस्तांतरित कर दिया गया है। व्यर्थ से मूल्यवर्धन की दिशा में, सीएसआईआर–आईएचबीटी के वैज्ञानिकों ने खाद्य और आहारीय अनुप्रयोगों के लिए प्रोटीन कान्सन्ट्रेट के उत्पादन के लिए ग्वार मील और माइक्रोएल्गी बायोमास जैसे कृषि–उप उत्पादों के उपयोग के

लिए एक प्रक्रिया विकसित की। इस प्रक्रिया की तकनीक को मैसर्स श्री राम गम्स इंडिया प्राइवेट लिमिटेड, जोधपुर को स्थानांतरित कर दिया गया है। संस्थान ने पेय उद्योग के अपशिष्ट (रिवर्स ऑस्मोसिस रिजेक्ट सॉल्ट) का उपयोग करते हुए माइक्रोएल्गे की खेती के लिए एक प्रक्रिया भी विकसित की और सी–फाइकोसाइनिन, कैरोटेनॉयड्स और खाद्य प्रोटीन कान्सन्ट्रेट जैसे माइक्रोएल्गी–आधारित न्यूट्रास्यूटिकल्स को एक्स्ट्रैक्ट किया। इस प्रक्रिया की तकनीक को मैसर्स एलगारियल न्यूट्रास्यूटिकल्स, बंगलुरु को हस्तांतरित कर दिया गया है।

वैज्ञानिक रूप से दो मान्य तकनीकों 'विटामिन डी 2 समृद्ध शिटाके मशरूम का उत्पादन और प्रसंस्करण' और 'ठंडे पहाड़ी क्षेत्र में वर्मीकम्पोस्ट तैयार करने के लिए कुशल साइकोट्रॉफिक बैक्टीरियल फॉर्मूलेशन' को स्फूर्ति कार्यक्रम के अन्तर्गत सिक्किम और हिमाचल प्रदेश के ग्रामीण क्षेत्रों में पांच क्लस्टर के माध्यम से आजीविका सृजन के लिए प्रयुक्त किया गया है। इसके अतिरिक्त 'कम्पोस्ट बूस्टर' उत्पाद का व्यापक रूप से लाहौल घाटी में उपयोग किया जा रहा है ताकि मानव मल को खाद में परिवर्तित किया जा सके। इसके साथ ही, सीएसआईआर–आईएचबीटी ने नगर पंचायत बैजनाथ पपरोला, बैजनाथ, हिमाचल प्रदेश और ग्यालशिंग नगर पंचायत, ग्यालशिंग, पश्चिम सिक्किम में प्रति दिन 250 किलोग्राम जैविक कचरे को संसाधित करने की क्षमता वाले अवायवीय बायोगैस संयंत्र स्थापित किए हैं।

उच्च मूल्य वाले रसायनों के लिए कृषि–अपशिष्ट उपयोग के क्षेत्र में, चावल (*ओरिज़ा सैटिवा* एल.) के भूसे के बायोमास से फरफुरल, 5–हाइड्रॉक्सीमिथाइल फरफुरल (5–एचएमएफ), लिग्निन और बायो–चार उत्पादन के लिए एक व्यापक समाधान प्रस्तुत किया गया है। इसके अतिरिक्त, मौलिक रसायन विज्ञान अनुसंधान को सुदृढ़ करने के लिए, इस वर्ष कार्बनिक संश्लेषण के क्षेत्र में ज्ञान बढ़ाने के लिए कुल 16 सिंथेटिक पद्धतियों को प्रकाशित किया गया है। विकसित कार्यप्रणाली उत्प्रेरक, C-H सक्रियण, हरित एवं सतत रसायन विज्ञान, फोटो–उत्प्रेरण, कार्बन मोनोऑक्साइड निर्धारण और रेडॉक्स प्रतिक्रियाओं के रूप में नैनो–समग्र सामग्री पर आधारित हैं जिसमें मूल्यवान एजेलिक एसिड, बेंज़िमिडाज़ोल, एरिल एस्टर, क्विनोलिन आधारित हेटरोसायकलस और मैक्रोसाइक्लिक अणुओं का संश्लेषण शामिल है।

जैवसक्रिय पादप रसायन (बायोएक्टिव फाइटोकेमिकल्स) के महत्व को ध्यान में रखते हुए, व्यावसायिक रूप से महत्वपूर्ण औषधीय पौधों (*रोडोडेंड्रोन अर्बोरियम, एकोनिटम हेटरोफिलम, थैलिक्ट्रम फोलियोलोसम, ट्रिलियम गोवियनम, पॉलीगोनैटम वर्टिसिलैटम* और *स्वर्टिया चिरायता*) में विशेष बायोएक्टिव मेटाबोलाइट्स की खोज की गई है और महत्वपूर्ण मेटाबोलाइट्स के लिए लक्षणचित्रण किया गया। प्राकृतिक रंगों/रंजकों के क्षेत्र में, एंथोसायनिन को स्थिर करने के लिए योजकों को अनुकूलित किया गया है। एंथोसायनिन की अवधारणा का अध्ययन प्रकाश, गर्मी, ऑक्सीजन, भंडारण और पीएच के विरुद्ध किया गया।

हिमालयी पौधों में कम तापमान पर अनुकूलन के लिए कई रणनीतियों में से एक 'एंटीफ्रीज़ प्रोटीन' के रूप में संदर्भित विशेष प्रोटीन का उपयोग करना है, जो बर्फ के क्रिस्टल के विकास को रोकता है और इसका खाद्य और चिकित्सा उद्योगों में अनुप्रयोग होता है। हिमालयी पौधों की छह प्रजातियों के प्रोटीन का मूल्यांकन एंटीफ्रीज़ गतिविधियों के लिए किया गया, जहां बारले प्रोटीन के अर्क ने खाद्य और जैव चिकित्सा उत्पादों में क्रायोप्रेज़र्वेशन में उल्लेखनीय क्षमता प्रदर्शित की है।

इसके अतिरिक्त, सजावटी गुलाब, जो एक आर्थिक रूप से महत्वपूर्ण पुष्प फसल है, जिसके तनें पर कांटे होते है तथा इसकी कटाई और परिवहन में बाधा उत्पन्न करते हैं। इसे देखते हुए संस्थान ने गुलाब में प्रिकल मोर्फोजेनेसिस के आणविक आधार को स्पष्ट किया, जिसका आनुवंशिक रूप से स्थिर कांटा रहित गुलाब की किस्मों को उत्पन्न करने में भूमिका है।

पौधों की उत्पादकता बढ़ाने की दिशा में एंडोफाइट्स की क्रिया की भूमिका और प्रक्रिया पर भी कार्य किया गया है। संस्थान के पास अब हिमालयी पौधों *अर्नेबिया यूक्रोमा, सिनोपोडोफिलम हेक्सेंड्रम, पिक्रोराइजा कुरोआ* और *फ्रिटिलारिया रॉयली* के विभिन्न भागों से अलग किए गए > 600 एंडोफाइट्स का संग्रह है। इन एंडोफाइट्स का उत्पादन बढ़ाने के लिए प्लांट प्रोबायोटिक्स और चिकित्सीय मेटाबोलाइट्स के जैवसंश्लेषण के रूप में परीक्षण किया जा रहा है। एक यीस्ट एंडोफाइट के मूल्यांकन ने मॉडल प्लांट अरेबिडोप्सिस में कोल्ड स्ट्रेस टॉलरेंस प्रदान करने में आशाजनक परिणाम दिखाए हैं।

जैव सूचना विज्ञान के क्षेत्र में काम करने वाले शोधकर्ताओं ने आर्टिफिशयल इन्टेलिजेन्स और मशीन–लर्निंग का उपयोग करने के साथ आधुनिक जीव विज्ञान में कुछ चुनौतीपूर्ण

मौलिक अनुसंधान समस्याओं पर कार्य किया है। एक और आरएनए–बाइंडिंग प्रोटीन इंटरैक्शन का पता लगाने के लिए आरबीस्पॉट को डीप–लर्निंग लागू करने वाले आरएनए के साथ विकसित किया गया था, दूसरी तरफ समूह ने miRNAs प्रोफाइलिंग प्रयोगों की आवश्यकता के बिना किसी भी स्थिति में miRNAs प्रोफाइल का पता लगाने के लिए पहला सॉफ्टवेयर, miRBiom विकसित किया है। SARS-CoV2 के विरुद्ध प्राकृतिक लेड अणुओं को जानने के लिए समूह ने रसायन विज्ञान समूह के साथ सहयोग किया। जैवप्रौद्योगिकी विभाग, भारत सरकार ने इस संस्थान को देश के कुछ राष्ट्रीय जैव सूचना विज्ञान अनुसंधान केंद्रों (बीआईसी) में से एक के रूप से सम्मानित किया है।

संस्थान का एक प्रमुख क्षेत्र हिमालयी पौधों के तनाव और अनुकूलन जीव विज्ञान को समझना है। इस संदर्भ में, संस्थान ने पहले स्वदेशी रूप से विकसित ड्राफ्ट जीनोम और एक विस्तृत /व्यापक अंग और विकासात्मक चरणों के विशिष्ट प्रोटिओमिक विवरण को *पिक्रोराइजा कुरोआ* में रिपोर्ट किया। प्रोटिओम–वाइड और पोस्ट–ट्रांसलेशनल संशोधन विश्लेषण आरएनए बाइंडिंग प्रोटीन के संवर्धन और फॉस्फोराइलेशन और एडीपी–राइबोसाइलेशन जैसे संशोधनों के बारे में सुझाया है जो अल्पाइन पर्यावरण के लिए *पिक्रोराइजा कुरोआ* अनुकूलन में महत्वपूर्ण भूमिका निभाता प्रतीत होता है। आलू में टीआईआर–एनबीएस–एलआरआर जीन परिवार के जीनोम व्यापक विश्लेषण के माध्यम से, एक जीन StTNLC7G2 की पहचान की गई थी, जो *अल्टरनेरिया सोलानी* के कारण होने वाले अर्ली ब्लाइट रोग से बचाव में एक भूमिका रखता है।

एक अन्य अध्ययन में, चावल की प्रतिरक्षा प्रणाली द्वारा विपरीत रोगजनकों से बचने के लिए उपयोग की जाने वाली विधियों की पहचान करने के लिए चावल–रोगज़नक़ अंतः क्रिया के डेटा सेट का उपयोग करके एक गहन शिक्षण–आधारित चावल नेटवर्क मॉडल (डीएलनेट) विकसित किया गया था।

पादप–कवक अंतःक्रिया के क्षेत्र में, चावल में क्रमिक रूप से भिन्न BAHD-acyltransferases के लक्षण वर्णन ने *राइजोक्टोनिया सोलानी* के प्रति संवेदनशीलता में उनकी संभाव्य भूमिका को अन्तर्दृष्ट किया गया।

औद्योगिक रूप से महत्वपूर्ण एक्स्ट्रेमोजाइम के लिए उच्च–तुंगता वाले माइक्रोबियल संसाधन की बायोप्रोस्पेक्टिंग, हमने कुशल लिग्नोसेलुलोलिटिक रोगाणुओं और उनके एंजाइमों (लैकेस, जाइलानेज़, एंडोग्लुकैनेज़, और β–गैलेक्टोसिडेज़) के प्रयोगशाला–पैमाने पर अनुप्रयोगों का पता लगाया एवं परीक्षण किया। कृषि अपशिष्ट का उपयोग कर थर्मोफिलिक बेसिलस पीसीएच94 से कुशल सेल्युलेस का उत्पादन करने के लिए पायलट–स्केल किण्वन हासिल किया गया।

औद्योगिक रूप से महत्वपूर्ण एक्स्ट्रेमोजाइम के लिए उच्च–तुंगता वाले माइक्रोबियल संसाधन की बायोप्रोस्पेक्टिंग, हमने कुशल लिग्नोसेलुलोलिटिक रोगाणुओं और उनके एंजाइमों (लैकेस, जाइलानेज़, एंडोग्लुकैनेज़, और β–गैलेक्टोसिडेज़) के प्रयोगशाला–पैमाने पर अनुप्रयोगों का पता लगाया एवं परीक्षण किया। कृषि अपशिष्ट का उपयोग कर थर्मोफिलिक बेसिलस पीसीएच94 से कुशल सेल्युलेस का उत्पादन करने के लिए पायलट–स्केल किण्वन हासिल किया गया।

याक के दूध से अलग किया गया *क्ल्यूवेरोमाइसेस मास्कस्यानस* PCH397 एक कुशल β-galactosidase उत्पाद पाया गया, जो कि संभावित प्रोबायोटिक यीस्ट हो सकता है जिसमें मोटापा, T2D और पेट के कैंसर के खिलाफ चिकित्सीय क्षमता है जैसा कि सेल लाइनों के अध्ययन से पता चला है।

प्लांट–वायरल इंटरैक्शन में, वायरल प्रोटीन 2b (साइलेंसिंग का शमन) रोग के विकास के दौरान होमोबॉक्स 27 ट्रांसक्रिप्शन फैक्टर के साथ जुड़कर अपना प्रभाव डालता पाया गया और इसके विशिष्ट ओवरएक्प्रेशन से वायरस के प्रति सहिष्णुता पैदा हुई। व्हाइटफ्लाई *ट्रायलेरोड्स वेपोरिओरम* द्वारा एप्पल स्कार स्किन वायरोइड के संचरण पर शोध से पता चला है कि वाइराइड आरएनए होस्ट के 20 केडीए हीट शॉक प्रोटीन से संगलित होता है और इसे संचरण के लिए उपयोग करता है।

हिमालयी वनस्पतियों की जैव विविधता की खोज एवं प्रलेखन हमारे संस्थान के लिए महत्वपूर्ण है। इस संदर्भ में चार प्रजातियां *एलंजियम एल्पिनम* (सी.बी. क्लार्क) डब्ल्यू.डब्ल्यू. एस.एम. एवं केव (कॉर्नेसी), *यूफ्रेसिया ऑफिसिनैलिस* एल. (ओरोबैंचेसी), *जेरेनियम रिफ्रैक्टम* एज्यू और हुक.एफ. (जिरेनिएसी) और *सेडम फिलिप्स* हेम्स्ल (Crassulaceae) पहली बार अरुणाचल प्रदेश से रिपोर्ट किया गया। एक अत्यधिक सुगंधित जिंजिबर *हेडिचियम फ्लेवेसेंस* केरी एक्स रोस्को (ज़िंगिबेरेसी) को भी हिमाचल प्रदेश के लिए एक नया वितरण रिकॉर्ड दर्ज किया गया। प्रमुख वृक्षसीमा प्रजाति, *बेटुला यूटिलिस* प्रजाति के द्वारा पोषक तत्वों के पुनर्जीवन विधि में महत्वपूर्ण पहचान का पता चला।

पारंपरिक ज्ञान के महत्व और इसके ह्रास होने की प्रवृत्ति को देखते हुए, संस्थान में सीएसआईआर–टीकेडीएल प्वाइंट ऑफ प्रेजेंस की स्थापना की गई। इसमें सोवा रिग्पा (तिब्बती चिकित्सा पद्धति) केन्द्र बिन्दु पर है। जहां इसे प्रलेखित और डिजिटाइज़ किया जा रहा है। साथ ही रास्ते में पशुओं की चोरी और चारा संसाधनों की लगातार हो रही कमी के कारण गद्दियों की आजीविका में बदलाव देखे गए हैं। सामुदायिक वनों पर काम से पता चला है कि अत्याधिक प्रदोहन वन संरचना में परिवर्तन और आक्रामक प्रजातियों को बढ़ावा देने के लिए उतरदायी है।

अति उच्च विभेदन आधुनिक सुदूर संवेदन का उपयोग पादप संसाधनों के आकलन और प्रबंधन के लिए हमारा संस्थान एक महत्वपूर्ण भूमिका निभा रहा है। यह सुविधा देश में कुछ चुनिंदा संस्थानों में ही उपलब्ध है। खेतों में स्टीविया बायोमास के निर्धारण के लिए ड्रोन आधारित मल्टीस्पेक्ट्रल रिमोट सेंसिंग का प्रयोग किया गया और साथ ही केनोपी में नाइट्रोजन की आवश्यक खुराक का अनुमान लगाया गया। इसके साथ ही हाइपरस्पेक्ट्रल रिमोट सेंसिंग द्वारा *सौसुरिया कॉस्टस, वेलेरियाना जटामांसी* और *पिक्रोराइजा कुरोआ* जैसे औषधीय पौधों की पहचान स्थापित करने में सहायता मिली। जिसके लिए अन्यथा टैक्सोनोमिक कौशल की आवश्यकता होती है। पुष्प खेती के उद्योगों के लिए फूलों की गणना पद्धति विकसित की गई, जो गेंदे के फूलों की उपज के आकलन के लिए उनकी कटाई के चरण के समय ली गई डिजिटल तस्वीरों का उपयोग करती है।

आमतौर पर प्रयोग किए जाने वाले 15 इनडोर सजावटी पौधों की प्रजातियों के वायु प्रदूषण सहिष्णुता सूचकांक का अनुमान लगाया गया, जो उनकी इन्डोर वायु प्रदूषण कम करने की क्षमता दर्शाता है।

सीएसआईआर–उच्च तुंगता जीवविज्ञान केंद के प्रक्षेत्र जीनबैंक को 40 संकटग्रस्त पौधों की प्रजातियों से समृद्ध किया गया, जिनमें *एंजेलिका ग्लौका, कैरम कार्वी, अर्नेबिया यूक्रोमा, एरेमुरस हेलाइकस, पॉलीगोनैटम सिरिहिफोलियम, एकोनिटम हेटरोफैलम, सिनोपोडोफिलम हैग्जेड्रम, पिक्रोराइजा कुरोआ* और *फ्रिटिलारिया रॉयली* प्रमुख हैं।

इसके अतिरिक्त, संकटग्रस्त औषधीय प्रजातियों जैसे कि *फ्रिटिलारिया रॉयली* और *नार्डोस्टैकिस जटामांसी* के लिए पूर्ण इन–विट्रो प्रोटोकॉल विकसित किए गए, जिन्हें कम लागत के रूप में अनुकूलित किया गया है और दृढ़ीकरण उपरांत पौधों की उच्च जीवितता दर के साथ अनुकूलित किया गया है। गुणवत्तायुक्त रोपण सामग्री की मांग को देखते हुए, संस्थान ने *फेरुला* (हींग), *सिरैतिया ग्रोसवेनोरी* (मोंक फ्रूट), केसर और बांस सहित उच्च मूल्यवान प्रजातियों के बड़े पैमाने पर प्रसार के लिए प्रोटोकॉल का मानकीकरण किया है।

वैज्ञानिकों की अगली पीढ़ी में वैज्ञानिक जिज्ञासा को बढ़ाने के लिए, सीएसआईआर–आईएचबीटी ने 5 सितंबर 2021 को 5वीं छात्र संगोष्ठी श्रृंखला का आयोजन किया। आयोजन बड़े उत्साह के साथ किया गया, जिसका विषय 'सांइटिफिक इनोवेशन एण्ड डिजिटल ट्रांसफोरमेशनः ब्रिजिंग इंटरडिसिप्लिनरी पर्सपेक्टिव' था। साथ ही, 6 दिसंबर 2021 को हाइब्रिड मोड के माध्यम से इंडिया इंटरनेशनल साइंस फेस्टिवल का कर्टेन रेज़र समारोह भी आयोजित किया गया। सीएसआईआर–आईएचबीटी ने 14 दिसंबर, 2021 को स्वर्ण जयंती चाय मेले का आयोजन किया। माननीय ग्रामीण विकास मंत्री, पंचायती राज, कृषि, पशुपालन और मत्स्य पालन, हिमाचल प्रदेश सरकार श्री वीरेंद्र कंवर ने हिमाचल प्रदेश में चाय नीति की शुरूआत की।

अनुसंधान, शिक्षा, उद्योग और समाज के बीच संबंध स्थापित करने की दिशा में अपने प्रयासों को जारी रखते हुए, संस्थान ने विभिन्न राष्ट्रीय और अंतर्राष्ट्रीय व्यापार मेलों और संगोष्ठियों में प्रतिभागिता करते हुए अपने अनुसंधान उत्पादों की प्रौद्योगिकियों को प्रदर्शित किया। हमारे वैज्ञानिकों ने कुल 159 शोध लेख प्रकाशित किए जिसमें से 147 शोध लेख एससीआई जर्नल में प्रकाशित हुए जिनका औसत इंपेक्ट फैक्टर 4.609 रहा। संस्थान ने विभिन्न कृषि–संगठनों और शैक्षणिक अनुसंधान एवं विकास संस्थानों/विश्वविद्यालयों के साथ 316 समझौतों/एमओयू पर हस्ताक्षर किए। इसके साथ–साथ, दस प्रौद्योगिकी हस्तांतरण, 263 सामग्री हस्तांतरण समझौते और शिटाके मशरूम क्लस्टर की स्थापना के लिए एक परामर्श सेवा प्रदान की गई। उद्यमशीलता के उपक्रमों और स्वरोजगार के अवसरों के लिए युवाओं को प्रोत्साहित करने के लिए, सीएसआईआर–आईएचबीटी में इन्क्यूबेशन एवं सुविधाओं के उपयोग के लिए 'मुख्यमंत्री स्टार्ट–अप योजना' के अंतर्गत तेरह समझौतों पर हस्ताक्षर किए गए।

वैज्ञानिक सामाजिक उत्तरदायित्व गतिविधियों के अंतर्गत ~2,600 स्कूली छात्रों और शिक्षकों ने छात्र–वैज्ञानिक संपर्क कार्यक्रम 'जिज्ञासा' में प्रतिभागिता की। इसके साथ–साथ संस्थान के बाहर ~400 कॉलेज और विश्वविद्यालय के छात्रों और उनके संकाय के लिए शैक्षिक यात्राओं का आयोजन

किया गया। इस वर्ष हमने टिंकरिंग लैब सुविधा युक्त हिमाचल प्रदेश के 10 केंद्रीय विद्यालय एवं सरकारी विद्यालयों को अपनाया है, ताकि इन लेब के सुचारु कामकाज के लिए सहायता की जा सके। संस्थान ने जिज्ञासा गतिविधियों, सीएसआईआर–फ्लोरिकल्चर मिशन के अन्तर्गत उद्यानों की स्थापना, अनुसंधान इंटर्नशिप कार्यक्रमों और आउटरीच गतिविधियों के लिए विभिन्न स्कूलों और शैक्षणिक संस्थानों के साथ संबंधों को स्थापित और सुदढ़ किया है।

संस्थान ने सीएसआईआर–एकीकृत कौशल पहल, हि. प्र. विज्ञान, प्रौद्योगिकी एवं पर्यावरण परिषद (हिमकोस्ट) द्वारा जैवप्रौद्योगिकी विभाग, भारत सरकार के हिमाचल प्रदेश में क्रियान्वित के कौशल विज्ञान कार्यक्रम और यूजीसी–स्ट्राइड कार्यक्रम (भारत की विकासशील अर्थव्यवस्था के लिए ट्रांस–विषयी अनुसंधान योजना) के अन्तर्गत विभिन्न कौशल विकास कार्यक्रम आयोजित किए। इस वर्ष, संस्थान को राष्ट्रीय कौशल विकास परिषद के साथ 'प्रशिक्षण प्रदाता' और 'प्रशिक्षण केंद्र' के रूप में पंजीकृत किया गया। हमने जीव विज्ञान क्षेत्र कौशल विकास परिषद के गुणवत्ता नियंत्रण जीवविज्ञानी और लैब तकनीशियन /सहायक के लिए 3 माह की अवधि के पाठ्यक्रम संचालित किए हैं। इसके अतिरिक्त, विभिन्न शैक्षणिक और अनुसंधान संस्थानों के छात्रों को संस्थान में शोध इंटर्नशिप प्रदान की गई।

सीएसआईआर–मुख्यालय, प्रबंधन परिषद, विभिन्न वित्त पोषण एजेंसियों तथा राज्य सरकार ने हमें वैज्ञानिक उत्कृष्टता प्राप्त करने, नई प्रौद्योगिकियों एवं उद्यमिता विकास तथा सामाजिक/राष्ट्रीय दायित्वों का निर्वहन करने के लिए सहयोग और प्रेरणा के क्रम को लगातार जारी रखा। मुझे यह बताते हुए हर्ष हो रहा है कि हम जैवप्रौद्योगिकी विभाग, भारत सरकार के हिमालय जैवसंपदा मिशन में एक सहयोगी हैं। साथ ही हम 'श्री' योजना के माध्यम से सहयोग के लिए विज्ञान एवं प्रौद्योगिकी विभाग का आभार व्यक्त करते हैं। हम संस्थान के अनुसंधान एवं विकास कार्यक्रमों में मार्गदर्शन हेतु अनुसंधान परिषद की महत्वपूर्ण और सकारात्मक भूमिका के लिए आभारी हैं। हम आर्थिक, वैज्ञानिक, औद्योगिक, सामाजिक और पर्यावरणीय मुद्दों पर वैज्ञानिक समाधान प्रस्तुत करके राष्ट्र निर्माण और विकास के लिए खुद को समर्पित करने के लिए प्रतिबद्ध हैं।

जय हिंद!

(संजय कुमार)

TECHNOLOGIES AVAILABLE AND ROLLED OUT

TECHNOLOGY TRANSFER AGREEMENTS

S. No.	Title of agreement	Name of party	Date of signing
	BIOTECHNOLOGY		
1	Transfer the lab scale technology for cultivation and production of medicinal plants (Picrorhiza, Valeriana) under hydroponic system, tissue culture protocols and extraction of the produce	M/s Amar Exports, 6-3-1239/2, 2nd floor, Raj Bhavan Road, Somajiguda, Hyderabad, TG, IN 500 082	02.07.2021
2	Transfer the lab scale technology for ready to reconstitute oral formulations utilizing microalgae and carry out need based R&D project for development of Algae based nutraceuticals and derived food formulations	M/s Algareal Nutraceuticals, G3, Vaasthu Nirvaan, No. 26, Railway Parallel road, Nehru Nagar, Bangalore-560 020	11.08.2021
	CHEMICAL TECHNOLOGY		
3	Transfer the lab scale technology for making Herbal Soaps	Suhavi Producer Company Ltd., Village Kangar PO. Basali, Tehsil Anandpur Sahib, District Rupnagar, Punjab – 140 117	08.04.2021
4	Transfer the lab scale technology for making, manufacturing, designing and using the distillation units of different capacities	M/s Kontact Consortium India Pvt. Ltd., Sidco Nagar, Villivakkam, Chennai	16.12.2021
5	Transfer the lab scale technology for making travel/pocket perfumes (4-5 variants)	M/s The Fragrance, Ward No. 8, M C Palampur, Maranda, District Kangra (HP) 176 102	28.12.2021
	FOOD TECHNOLOGY		
6	Transfer the lab scale technology for manufacturing/ processing facility for manufacturing/ processing of (i) Granola bars - (millet and cereals based), and (ii) Spirulina peanut bar PRODUCTS	M/s Komal Innovation & Wellness Initiative, Shed No. 4, Industrial Area, Nagrota Bagwan, Kangra (HP) – 176 047	25.06.2021
7	Transfer the lab scale technology for cultivation of Shiitake mushroom to its implementation at large scale	M/s Gaurav Agro Foods, Plot no. 28, Industrial Area -2, Nagri, Palampur (HP) – 176 059	02.07.2021
8	Transfer the lab scale technology to make herbal Formulation for Immunity Modulation	M/s Ras Vaidyashala, Jobner, Jaipur (Rajasthan)- 303329	14.12.2021
9	Transfer the lab scale technology for Technology/ process for ready to eat instant seera in the convenience package	M/s Yuktika Biotech Pvt. Ltd., Bharmat Palampur (HP)	28.02.2022
10	Transfer the lab scale technology for making/ preparation of Tea Mouthwash	The Unati Cooperative Marketing-cum-Processing Society Ltd. Talwara, District Hoshiarpur, Punjab	28.02.2022

MATERIAL TRANSFER AGREEMENTS

S. No.	Title of agreement/ MoU/ MTA	Name of party	Date of signing
	AGROTECHNOLOGY		
1.	Material Transfer Agreement (MTA) to take up 3 plants of *Ginkgo biloba* in each Anganwadi Centers in Bharmour & Pangi Development Blocks of Aspirational District Chamba	RCFC NR1, RIISM, Joginder Nagar, Distt. Mandi (HP)	01.04.2021

2.	MTA to take up 60 kg seed of wild marigold (*Tagetes minuta*) variety Him Swarnima for cultivation under "CSIR Aroma Mission –II"	Bhuja Rishi Kisan Vikas Committee Shilhibagi, Village & PO Shilhibagi Tehsil Thunag, District Mandi (HP)	19.04.2021
3.	MTA to take up stevia seeds	Mr. Vijay Ambati, 405, JMJ Hieghts, Maruthi Hills Colony, Bandhamkommu, Ameenpur Road, Sangareddy, Telangana	22.04.2021
4.	MTA to take up flower bulbs, plant saplings suitable for UT Ladakh	Directorate of Industries & Commerce, UT Ladakh, Director Industries and Commerce Office, Near Court Complex, Leh, Ladakh	31.05.2021
5.	MTA to take up 100 plants of Hing (*Ferula assa-foetida*)	Sher-e-Kashmir University of Agricultural Sciences & Technology, (SKUAST-J), Chatha, Jammu, J&K	16.06.2021
6.	MTA to take up 13,000 plants of lavender for cultivation at the Kalhel Tissa Block in Chamba District under "CSIR Aroma Mission Phase II"	Sh. Ranjan Kumar C/o Alps Resort Upper Bakrota Hills, Dalhousie District Chamba (HP)	28.06.2021
7.	MTA to take up Lilium bulbs and Calla lily plants for promotion and demonstration purposes under Lahaul conditions	Mahadev Floriculture Society, Village Madgram PO. Udaipur, Tehsil Udaipur, District Lahaul Spiti (HP)	02.07.2021
8.	MTA to take up Lilium bulbs under "CSIR Floriculture Mission"	Tinan White Mountain Floriculture Fruit & Veg. Grower Co-Op Ltd., Lahaul & Spiti (HP)	02.07.2021
9.	MTA to take up Lilium bulbs under "CSIR Floriculture Mission"	The Rattan Jot Chandra Valley Cooperative Marketing & Processing Society Ltd., Lahaul & Spiti (HP)	02.07.2021
10.	MTA for cultivation of Hing (*Ferula assa-foetida*) plants for research and development trials in Chamoli district of Uttarakhand	Sh. Puran Singh Bisht, VPO Mundoli, Distt. Chamoli (Uttarakhand)	02.07.2021
11.	MTA to take up 50 plants of Monk fruit for field trial	Sh. Manav Khulker, VPO Raison, Distt. Kullu (HP)	12.07.2021
12.	MTA to take up rosemary, lavender, *Valeriana jatamansi* and *Tagetes erecta*	Himalayan Phytochemical & Growers Association, Baggi, Tehsil Sadar District Mandi (HP)	22.07.2021
13.	MTA to take up carnation plants (10,000 plants)	Mr. Satish Kumar S/o Karam Chand, Tehsil Barsar, Chakmoh, Hamirpur (HP)	26.07.2021
14.	MTA to take up carnation plants (7,000 plants)	Mr. Atul Kumar S/o Rajinder Kumar, Post Office Fatepur (HP), Tehsil Nadaun, Ranghar, Hamirpur (HP)	26.07.2021
15.	MTA to take up carnation plants (23,000 plants)	Mr. Krishan Chand, S/o Shalo Ram, Village Bahal Arjun, Tehsil Barsar, PO. Chakmoh, Hamirpur (HP)	26.07.2021
16.	MTA to take up carnation plants (12,500 plants)	Mr. Sanjeev Kumar, S/o Sh. Man Singh Village Shakog PO Jhaja Tehsil Kandaghat Distt. Solan (HP)	28.07.2021
17.	MTA to take up carnation plants (12,500 plants)	Mr. Ramesh Chand, Village Jethna Tehsil Kandaghat Distt. Solan (HP)	28.07.2021
18.	MTA to take up 50 plants of Monk fruit for field trial	Mr. Nishant Thakur, Member Secretary, (HP) Council for Science, Technology & Environment, Village Bharhka	29.07.2021

		(Near Sarsai), Tehsil and District Kullu (HP)	
19.	MTA to take up Limonium plants (4,500 plants)	Sh. Shri Ram, Tehsil Sadar, Sai Kanaitan (265), Chharol, Bilaspur (HP)	29.07.2021
20.	MTA to take up Limonium plants (5,400 plants)	Mr. Rajesh Kumar at S/o Nikka Ram, Village Bahal Arjun, 34/5 Chakmoh, Hamirpur (HP)	29.07.2021
21.	MTA to take up Agapanthus (30 plants), Hydrangea (40 plants), Marigold (200 seedlings), Calla Lilly (100 plants)	Mr. Sandeep Malhotra, Village Dehrian, PO Shamirpur, Tehsil and District Kangra (HP)	03.08.2021
22.	MTA to take up carnation plants (7,500 plants)	Mr. Kuldeep Kumar, S/o Sh. Dharam Singh Village Bahal Arjun PO Chakmoh Tehsil Dhatwal Distt. Hamirpur (HP)	06.08.2021
23.	MTA to take up carnation plants (5,000 plants)	Mr. Durga Singh S/o Sh. Jalam Singh, D.P.F Sunas (131), Bagsaid, Mandi, Thunag (HP)	06.08.2021
24.	MTA to take up carnation plants (12,500 plants)	Mr. Narender Singh S/o Sh. Ajeet Singh Tehsil Barsar, Samaila, Maharal, Hamirpur (HP)	06.08.2021
25.	MTA to take up carnation plants (12,500 plants)	Mr. Kartar Thakur S/o Sh. Balwant Singh, Post Office Chakmoh, Bahal Thakru, Hamirpur (HP)	06.08.2021
26.	MTA to take up Gladiolus corms (50,000 plants).	Mr. Naresh Sharma, S/o Sher Singh Sharma, 236/7 National street upper samkhetar, post office mandi, Tehsil Sadar Mandi (HP)	09.08.2021
27.	MTA to take up Gladiolus corms (40,000 plants)	Mr. Rajnesh Sharma, Address: - House number-19, Harkrishan enclave, near kali mata mandir, Dhakauli, SAS Nagar, Punjab	09.08.2021
28.	MTA to take Gladiolus corms (4,000 plants)	Mr. Raman Kumar S/o Sh. Dharam Singh, Village Ansoli, PO. Matour Tehsil and Distt. Kangra (HP)	10.08.2021
29.	MTA to take up chrysanthemum plants (20,000 plants)	Mr. Karnail Singh S/o Sh. Vikram Singh Village Karari, PO Gwal Pathar, Tehsil Nadaun, Hamirpur (HP)	11.08.2021
30.	MTA to take up chrysanthemum plants (30,000 plants)	Mr. Gurpreet Singh S/o Sh. Baldev Singh, Majal Khurad, Patiala, Punjab	11.08.2021
31.	MTA to take up chrysanthemum plants (15,000 plants)	Mr. Karanbir Singh S/o Sh. Bhupinder Singh, H. No. E.H.196-A, Civil Lines, Jalandhar City, Jalandhar, Punjab	12.08.2021
32.	MTA to take up planting material of *Ginkgo biloba* for cultivation at selected areas of district Chamba	Mr. Anoop Sharma S/o Rishi Dev Sharma, Village Patruma, Post Office Tikroo, Tehsil Salooni, District Chamba (HP)	18.08.2021
33.	MTA to take up gladiolus corms (10,000 corms)	Mr. Jahnvi Shekhar Ward No.6 Tika Redi, PO Thakurdwara, Teh Palampur, Distt. Kangra (HP)	19.08.2021
34.	MTA to take up gladiolus corms (10,000 corms)	Mr. Mukesh Kumar, VPO Sungal Tea Estate, Palampur (HP)	19.08.2021
35.	MTA to take up 2,000 rooted plants of Damask rose	Institute of Medicinal & Aromatic Plants, Uttarakhand University of Horticulture & Forestry	23.08.2021

		Mehalchori, Gaisain, Chamoli (U.K)	
36.	MTA to take up marigold seedlings (6,200 nos.)	Mr. Madan Gopal Jamwal S/o Sh. Chaman Singh, House No. 32, Ward No. 5, Village Barshogi, Shillihar (35/83) Kullu (H.P)	24.08.2021
37.	MTA to take up marigold seedlings (5,000 nos.)	Mr. Surjeet Singh S/o Balbir Singh, No 4 Post Office Kharat Khas Teh Baroh, Ganyadu, Kangra (HP)	25.08.2021
38.	MTA to take up marigold seedlings (5,000 nos.)	Sh. Mahinder Vill Ambdoli PO Amb Pathiar Teh. Jawalamukhi District Kangra (HP)	25.08.2021
39.	MTA to take up marigold seedlings (2,800 nos.)	Sh. Avtar singh Address: VPO Gummer Teh Jawalamukhi (HP)	25.08.2021
40.	MTA to take up gladiolus (60,000 nos.)	Mr. Balbir Singh Kamboj S/o Kishan Chandra, Nayagaon, Chandan Singh, Kaladhungi, Kamola, Nainital, Uttarakhand	25.08.2021
41.	MTA to take up marigold seedlings (70,000 nos.) and limonium plants (380 nos.)	Mr. Baldev Raj, S/o Harbans Lal, Jogipura, Udham Singh Nagar, Uttarakhand	25.08.2021
42.	MTA to take up marigold seedlings 3,100 nos.)	Ms Ruveena Kumari, VPO Bankhandi District Kangra (HP)	25.08.2021
43.	MTA to take up marigold seedlings 2,100 nos.)	Sh. Ravinder Village Indira colony PO Hazipur Teh. Dehra, Kangra (HP)	25.08.2021
44.	MTA to Take up Gypsophila plants (7100 nos.)	Mr. Kanta Ballabh S/o Mohgan Chandra, Bajoon, Nanital, Uttarakhand	25.08.2021
45.	MTA to take up marigold seedlings 1,800 nos.)	Sh. Rajesh S/o Bishan Dass VPO Ghallour Teh. Jawalamukhi Distt. Kangra (HP)	25.08.2021
46.	MTA to take up marigold seedlings (2,000 nos.), calla lily plants (40 nos.) and agapanthus plant (40 nos.)	Mr. Pardeep Kumar S/o Dalel Singh, Ward No 5 Village Amb Doli Tehsil Jwalamukhi Kangra (HP)	31.08.2021
47.	MTA to take up marigold seedlings (2,000 nos.)	Mr. Parveen Kumar S/o Prem Chand, Village garni, Tehsil Jwalamukhi, PO Fakloh District Kangra (HP)	31.08.2021
48.	MTA to take up heeng for research and Development purpose	Keladi Shivapa Nayaka University of Agricultural and Horticultural Sciences (KSNUAHS), Navile, Shivamogga	13.09.2021
49.	MTA to take up heeng plants for trial in Mukteshwar, District Nainital, Uttarakhand	M/s Dharampal Satyapal Ltd., C6-10, Noida	15.09.2021
50.	MTA to take up heeng for research and Development purpose	The Spiti Farmer's Society, PO Kibber, District Lahaul & Spiti (HP)	18.09.2021
51.	MTA to take up cultivation of damask rose, *valariana jatamansi* and lavender	Mr. Rakesh Handa, Village Beera, Panchayat Saran, Block Mahila, Tehsil Chamba (HP)	21.09.2021
52.	MTA to take up cultivation of heeng free of cost for field trials	ICICI Foundation for Inclusive Growth, ICICI Bank, Sheri Bazar, Opposite Indira Market, Mandi (HP)	23.09.2021

51.	MTA to take up cultivation of damask rose, *valariana jatamansi* and lavender	Mr. Rakesh Handa, Village Beera, Panchayat Saran, Block Mahila, Tehsil Chamba (HP)	21.09.2021
52.	MTA to take up cultivation of heeng free of cost for field trials	ICICI Foundation for Inclusive Growth, ICICI Bank, Sheri Bazar, Opposite Indira Market, Mandi (HP)	23.09.2021
53.	MTA for cultivation of floriculture plants for conservation and socio environmental of Parashar Area and promote livelihood in adjacent villages	ICICI Foundation for Inclusive Growth, ICICI Bank, ICICI Bank Towers, Bandra Kurla Complex, Bandra East Mumbai	26.09.2021
54.	MTA to take up 100 gm seeds of Stevia for research purpose	Mr. Naveen K. Tiwari, Department of Botany, University of Allahabad (U.P.)	28.09.2021
55.	MTA to take up Gypsophila plants (5000 Nos.)	Mr. Surjit Singh, S/o Late Dharam Singh, PO Chakmoh Tehsil Barsar, Bahal Arjun, Hamirpur (HP)	11.10.2021
56.	MTA to take up marigold plants (10,000 Nos.) and tulips bulbs (500 Nos.)	Ms. Sudesh Kaur W/o Balbir Singh Kamboj, 103, Nayagaon Chandan Singh, Kaladhungi, Kamola, Nanital, Uttarakhand	11.10.2021
57.	MTA to take up planting material of aromatic crops from CSIR-IHBT, Palampur	Dr. Sukhbir Singh, Mehar Singh Foundation, Village Kukhar, Tehsil Rakkar, Distt. Kangra (HP)	29.10.2021
58.	MTA to take up to take up 2000 samplings of Sugandhbala for Pipalkoti Joshimath Cluster	Alaknanda Ghati Shilpi Federation (AAGAAS Federation), Pipalkoti,Distt-Chamoli, Uttarakhand	22.11.2021
59.	MTA to take up gladiolus (20,000 No. of corms)	Sh. Yudhvir Sharma, S/o Mohinder Kumar Sharma, Lasara, Phillaur Jalandhar, Punjab	24.11.2021
60.	MTA to take up carnation (20,000 No. of rooted cuttings)	Sh. Satbir Singh S/o Chunhu Ram, Village Bhambla, Tehsil Sarkaghat, Mandi (HP)	24.11.2021
61.	MTA to take up gladiolus (26,000 No. of corms)	Sh. Sarabjit Singh, S/o Amarjit Singh, Tehsil Gurdaspur, Punjab, Alawalpur, Bhumbli, Gurdaspur, Punjab	24.11.2021
62.	MTA to take up Gladiolus (2000 No. of corms) and Gerbera (2000 No. of plants)	Smt. Ravinder Pal Kaur W/o Late Rasal Singh, House No. 595, E Block, Ranjit Avenue, Amritsar, G.PO Amritsar Punjab	24.11.2021
63.	MTA to take up gladiolus (2,000 No. of corms)	Sh. Prem Lal Yoterpa, S/o Chhewang, Tehsil Lahaul, Ropsang, Lahaul & Spiti (HP)	24.11.2021
64.	MTA to take up gladiolus (50,000 No. of corms)	Mr. Jashanpreet Singh, House No. 60, Gali No. 3, Green Enclave, New Sular, Patiala Punjab	24.11.2021
65.	MTA to take up gladiolus (8,000 No. of corms) and rose plants (500 No. of plants)	Sh. Narinder Singh, S/o Hazura Singh, Raipur Araian, Dayalpur, Jalandhar, Phillaur, Punjab	24.11.2021
66.	MTA to take up carnation (10,000 No. of rooted cuttings)	Sh. Jasdev Thakur S/o Lekh Ram, Village Tanaji, Tehsil Kandaghat, Solan (HP)	24.11.2021
67.	MTA to take up carnation (10,000 No. of rooted cuttings)	Sh. Jagdish Chand S/o Chandu Ram, Tehsil Barsar, Reli, Raili Jajri, Hamirpur (HP)	24.11.2021

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54.	MTA to take up 100 gm seeds of Stevia for research purpose	Mr. Naveen K. Tiwari, Department of Botany, University of Allahabad (U.P.)	28.09.2021
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56.	MTA to take up marigold plants (10,000 Nos.) and tulips bulbs (500 Nos.)	Ms. Sudesh Kaur W/o Balbir Singh Kamboj, 103, Nayagaon Chandan Singh, Kaladhungi, Kamola, Nanital, Uttarakhand	11.10.2021
57.	MTA to take up planting material of aromatic crops from CSIR-IHBT, Palampur	Dr. Sukhbir Singh, Mehar Singh Foundation, Village Kukhar, Tehsil Rakkar, Distt. Kangra (HP)	29.10.2021
58.	MTA to take up to take up 2000 samplings of Sugandhbala for Pipalkoti Joshimath Cluster	Alaknanda Ghati Shilpi Federation (AAGAAS Federation), Pipalkoti,Distt-Chamoli, Uttarakhand	22.11.2021
59.	MTA to take up gladiolus (20,000 No. of corms)	Sh. Yudhvir Sharma, S/o Mohinder Kumar Sharma, Lasara, Phillaur Jalandhar, Punjab	24.11.2021
60.	MTA to take up carnation (20,000 No. of rooted cuttings)	Sh. Satbir Singh S/o Chunhu Ram, Village Bhambla, Tehsil Sarkaghat, Mandi (HP)	24.11.2021
61.	MTA to take up gladiolus (26,000 No. of corms)	Sh. Sarabjit Singh, S/o Amarjit Singh, Tehsil Gurdaspur, Punjab, Alawalpur, Bhumbli, Gurdaspur, Punjab	24.11.2021
62.	MTA to take up Gladiolus (2000 No. of corms) and Gerbera (2000 No. of plants)	Smt. Ravinder Pal Kaur W/o Late Rasal Singh, House No. 595, E Block, Ranjit Avenue, Amritsar, G.PO Amritsar Punjab	24.11.2021
63.	MTA to take up gladiolus (2,000 No. of corms)	Sh. Prem Lal Yoterpa, S/o Chhewang, Tehsil Lahaul, Ropsang, Lahaul & Spiti (HP)	24.11.2021
64.	MTA to take up gladiolus (50,000 No. of corms)	Mr. Jashanpreet Singh, House No. 60, Gali No. 3, Green Enclave, New Sular, Patiala Punjab	24.11.2021
65.	MTA to take up gladiolus (8,000 No. of corms) and rose plants (500 No. of plants)	Sh. Narinder Singh, S/o Hazura Singh, Raipur Araian, Dayalpur, Jalandhar, Phillaur, Punjab	24.11.2021
66.	MTA to take up carnation (10,000 No. of rooted cuttings)	Sh. Jasdev Thakur S/o Lekh Ram, Village Tanaji, Tehsil Kandaghat, Solan (HP)	24.11.2021
67.	MTA to take up carnation (10,000 No. of rooted cuttings)	Sh. Jagdish Chand S/o Chandu Ram, Tehsil Barsar, Reli, Raili Jajri, Hamirpur (HP)	24.11.2021
68.	MTA to take up carnation (5000 No. of rooted cuttings)	Sh. Chet Ram S/o Alamu Ram, Tehsil Thunag, Bagsaid, Mandi (HP)	24.11.2021
69.	MTA to take up carnation (15,000 no. of rooted cuttings)	Sh. Jitender Singh Kashyap, Tikka Lehsar Chungi, No. 2, Village Post Office Yol Cantt, Tehsil Dharamshala, Kangra (HP)	24.11.2021
70.	MTA to take up gladiolus (30,000 no of corms)	Mr. Harinderpal Singh, S/o Sh. Amrik Singh, Madoka, Amritsar Punjab	25.11.2021

71.	MTA to take up gladiolus (50,000 no of corms)	Sh. Karamjit, H.No. 07 Vill. Majhal Khurd, PO – Panjola, Patiala, Punjab	25.11.2021
72.	MTA to take up gladiolus (50,000 no of corms)	Mrs. Anmol Kumar Shergill C/o Gurpreet Singh Shergill, Majal Khurd, Patiala, Punjab	25.11.2021
73.	MTA to take up Loose Rose plants (40,000 No.), Lilium Asiatic Bulbs (5600 No.), Lilium Oriental Bulbs (2400 No.) and Gladiolus corms (1,60,000 No.)	Mr. Pankaj Kamboj, S/o Hukum Chandra, Naya Gaon, Nanital, Uttarakhand	29.11.2021
74.	MTA to take up gladiolus (80,000 No. of corms), Cut Roses plants (6000 No.)	Mr. Rajender Singh, S/o Mangat Ram, Jogipura, Udham Singh Nagar, Uttarakhand	29.11.2021
75.	MTA to take up gladiolus (50,000 No. of corms)	Mr. Paramvir Singh Rai, S/o Jasbir Singh, Tehsil – Garhshankar, Moranwali, Hoshiarpur, Punjab	29.11.2021
76.	MTA to take up gladiolus (80,000 no of corms)	Mr. Ram Kishan, S/o Mangat Ram, Jogipura, Udham Singh Nagar, Uttarakhand	29.11.2021
77.	MTA to take up Gerbera (4500 No.) Cut Roses (12,000 No.)	Mr. Balwant Raj, S/o Mangat Ram, Jogipura, Udham Singh Nagar, Uttarakhand	29.11.2021
78.	MTA to take up gladiolus (80,000 no of corms)	Mr. Ajeet Singh S/o Hariom, Chakarpur, Udham Singh Nagar, Uttarakhand	29.11.2021
79.	MTA to take up Gypsophilla plants (11,000 No.), Gerbera plants (4500 No.) and Gladiolus corms 16,000 No.	Mr. Harbansh Lal, S/o Jeevan Ram, Vill. – Jogipura Bazpur, Udham Singh Nagar, Uttarakhand	29.11.2021
80.	MTA to take up Loose Rose plants (40,000 No.), Lilium Asiatic Bulbs (5600 No.), Lilium Oriental Bulbs (2400 No.)	Mr. Jasvinder Kamboj, S/o Mangat Ram, Jogipura, Udham Singh Nagar, Uttarakhand	29.11.2021
81.	MTA to take up gladiolus (1,60,000 Nos.), gerbera plants (4,500 Nos.), lilium asiatic bulbs (5,600 Nos.) and lilium oriental bulbs (2,400 Nos.)	Mr. Baldev Singh, S/o Visawa Singh, Chanakpur, Udham Singh Nagar, Uttarakhand	02.12.2021
82.	MTA to take up gerbera plants (5,000 Nos.)	Mr. Pankaj Kumar, S/o Dharam Chand, Vill. – Kalohan, PO Bumbaloo, Tehsil- Barsar, Hamirpur (HP)	02.12.2021
83.	MTA to take up gladiolus (1,50,000 Nos. of corms), marigold plants (20,000 Nos.) and cut roses plants (21,000 Nos.)	Mr. Kishan Chandra Kamboj, S/o Ujagar Ram, Nayagoan Chandan Singh, Kaladhungi, Kamola, Nainital, Uttarakhand	02.12.2021
84.	MTA to take up up gladiolus (80,000 Nos. of corms)	Smt. Damodi Devi, w/o Jogipura, Udham Singh Nagar, Jogipura, Uttarakhand – 262401, Naya Gaon, Nanital, Uttarakhand	08.12.2021
85.	MTA to take up gladiolus (50,000 No. of corms)	Mr. Rajeev Rajput, S/o Jaghardip Rajput, Tehsil Palampur, Ghaghru, Btahral, Kangra (HP)	08.12.2021
86.	MTA to take up gladiolus (15,000 Nos. of corms) and chrysanthemum plants (500 Nos.)	Mr. Prem Nath Bubber, S/o Karam Chand Bubber, H. No 1665, St. Raj Bhawan ISTRI Bhawan, Fazilka Punjab	08.12.2021
87.	MTA to take up gypsophila plants (7,000 Nos.), gerbera plants (7,500 Nos.) and carnation plants (15,000 Nos.)	Mr. Raman Malhotra, S/o Shiv Charan Malhotra Ward no 6, Kotwali bazar Dharamshala Tehsil, Dharamshala Kangra, (HP)	08.12.2021

88.	MTA to take up gladiolus (20,000 Nos. of corms)	Mr. Sukhdeep Singh, S/o Gurmel Singh, Dhaliwal patti, Tehsil -Dhuri, Sangrur, Punjab	08.12.2021
89.	MTA to take up gladiolus (2,000 Nos. of corms), chrysanthemum plants (100 Nos.) and cut roses plants (500 Nos.)	Mr. Anil Sood, S/o Ram Kishan House number B-4/202, Hoshiarpur, Punjab	08.12.2021
90.	MTA to take up gladiolus (30,000 Nos. of corms)	Mr. Anjeev Kumar, S/o Pancham Chand, Village Post office - Ghanetta, Brankar (56) Ghaneta, Kangra (HP)	08.12.2021
91.	MTA to take up gladiolus (30,000 Nos. of corms)	Mr. Yash Paul Singh, S/o Sappo Singh, Tehsil Palampur, Mahadev, Ghaneta, Kangra (HP)	08.12.2021
92.	MTA to take up lilium oriental plants (8,000 Nos.)	Mr. Bhupender Pal, S/o Kunden Lal, Village Salahar, PO - Devdhar, Mandi, Chachyot (HP)	08.12.2021
93.	MTA to take up gladiolus (50,000 Nos. of corms)	Mr. Pusinder Ohri, S/o Boota Ram, Dholbaha Road, Ward No. 02 PO. Hariana, Hoshiarpur, Punjab	08.12.2021
94.	MTA to take up rooted plants of lavender (2,000 nos.), rooted plants of lavandin (2,000 nos.) and rooted plants of rosemary (5,000 nos.)	Deputy Director of Horticulture, Chamba, District Chamba (HP)	09.12.2021
95.	MTA to take up damask rose rooted plants "Jwala variety" (1,000 nos.) out of which 500 damask rose rooted plant will be provided @ 18/plant and 500 rooted plants & Matricaria seed (1 kg)	Ms. Foram Pandya at Sky Studio, G2, Vasant Vaibhav, Gulmohar Lane, Sion, Mumbai	16.12.2021
96.	MTA to take up 500 rooted plants of Damask rose “Jwala variety”	M/s Shri Bajrang Commodity, Kh. No. 70/4, Ring Road No. 2, Gogoan, Raipur (C.G.)	17.12.2021
97.	MTA to take up lilium asiatic (1,550 Nos.) and lilium oriental (1,000 Nos.)	Mr. Inder Singh, S/o Saran Das, Tehsil Thunag, Kandhi, (95), Mandi (HP)	20.12.2021
98.	MTA to take up lilium asiatic (2,400 Nos.) and lilium oriental (600 Nos.)	Mr. Dimple Thakur S/o Devinder Singh, Village - Sunas Kandhi (95), Mandi (HP)	20.12.2021
99.	MTA to take up lilium asiatic (1,250 Nos.) and lilium oriental (1,000 Nos.)	Mr. Inder Singh S/o Mohan Singh, Tehsil - Thunag, Bagsiad, Mandi (HP)	20.12.2021
100.	MTA to take up lilium asiatic (3,400 Nos.) and lilium oriental (1,600 Nos.)	Mr. Anil Kumar, S/o Brij Lal, Tehsil - Chachyot, Gadhiman (123) Devdhar, Mandi (HP)	20.12.2021
101.	MTA to take up lilium asiatic (1,450 Nos.) and lilium oriental (800 Nos.)	Mr. Chaman Lal S/o Kundan, Kandhi, Sharan, Bagsaid, Mandi (HP)	20.12.2021
102.	MTA to take up lilium asiatic (1,450 Nos.), lilium oriental (1,000 Nos.) and calla lily (50 Nos.)	Mr. Dola Ram, S/o Jai Singh, Tehsil - Thunag, Sharan (96), Mandi (HP)	20.12.2021
103.	MTA to take up gladiolus corms (1,60,000), gerbera (4,500 Nos.), lilium asiatic (5,600 Nos.) and lilium oriental (2,400 Nos.)	Mr. Gurabaksh Singh S/o Basava Ram, village – Chanakpur, Post – Barheni, Bazpur Udham Singh Nagar, Uttarakhand	20.12.2021
104.	MTA to take up gladiolus corms (20,000 Nos.)	Mr. Hitender Prakash S/o Gurdayal, 35/1 Dalana PO. – Khatnol, Thana Dhali, Shimla (HP)	20.12.2021
105.	MTA to take up lilium asiatic (1,450 Nos.) and lilium oriental (800 Nos.)	Mr. Kundan Lal,Tehsil - Chachyot, Bah, Kandha, Mandi (HP)	20.12.2021

106.	MTA to take up gladiolus corms (30,000 Nos.)	Mr. Parlad Singh S/o Mohinder Singh, Vill. – Namoli, Hoshiarpur, Datarpur, Punjab	20.12.2021
107.	MTA to take up lilium asiatic (1,300 Nos.) and lilium oriental (800 Nos.)	Mr. Prem Singh S/o Bal Krishan, Tehsil - Thunag, Badin, Mandi (HP)	20.12.2021
108.	MTA to take up lilium asiatic (1,450 Nos.) and lilium oriental (1,000 Nos.)	Mr. Pushap Raj, S/o Ramesh Kumar, Rahi Dhar (129), Bagsaid, Mandi (HP)	20.12.2021
109.	MTA to take up Roses (cut) (5000 Nos.) and Gypsophila plants (1750 Nos.)	Mr. Het Ram Verma S/o Sh. Himat Ram, Post Office Rajgarh Tehsil Sadar, Near Panchyat Bhawan, Kehar, Mandi (HP)	20.12.2021
110.	MTA to take up Cut Roses (16,000 Nos.) and Gerbera (5000 Nos.)	Mr. Santvir Singh S/o Sh. Jatiner Singh Bajwa, Bajwa Farm, Bhagal Singh Nagar, Hoshiarpur, Punjab	20.12.2021
111.	MTA to take up Gypsophila plants (1800 Nos.)	Mr. Sunil Kumar S/o Sh. Balwant Singh, Village Bari Darolan, tehsil Jhandutta, Beri Darola, Bilaspur (HP)	20.12.2021
112.	MTA to take up Lilium (Asiatic) bulbs (5600 Nos.) and Lilium (Oriental) bulbs (2400 Nos.)	Mr. Amit Kharwal S/o Sh. Mohinder Singh Kharwal, Masal (653), Kangra (HP)	20.12.2021
113.	MTA to take up carnation plants (11,000 Nos.) and Gypsophila plants (1,200 Nos.)	Smt. Vibha Kumar, W/o Sanjay Kumar, Adarsh Cottage, Ward No. 7, Kotwali Bazar, Dharamshala (HP)	10.01.2022
114.	MTA for establishment of floriculture garden in their campus	Tehsil Office, Palampur, Palampur Distrct Kangra (HP)	13.01.2022
115.	MTA for cultivation of Hing plants for research and development trials in Rajasthan	Sh. Vinod Kumar Jat, Village Soniyana, PO. Reavaliya Khurd Vaya Ghosunda, Tehsil Bhadesar, District Chittorgarh, Rajasthan	17.01.2022
116.	MTA to take up stevia seeds	Sh. Rajiv Bhuria, VPO Darang. Tehsil Palampur, District Kangra (HP)	18.01.2022
117.	MTA to take up aromatic and Industrial Crops	M/s Tanishka Natural Agro Products Pvt. Ltd., 19th Floor, South Patel Nagar, New Delhi	18.01.2022
118.	MTA to take up clary sage seeds (300 gm) on Free of Cost (FOC) basis under “CSIR-Aroma mission-II”.	Kishan Sahayata Samuh Siyun, Ghoghardhar Village Siyun, PO and Tehsil Padhar, District Mandi (HP)	27.01.2022
119.	MTA to take up Rosemary rooted plants (3,000 nos.), Damask rose rooted plants "Jwala variety” (50 nos.), Lemon balm plants (20 nos.) and Marjorum seedling (5 nos.)	Jagriti CBO, Village Badah, Post Office Mohal, District Kullu (HP)	27.01.2022
120.	MTA to take up up carnation plants (5,000 Nos.)	Mr. Manohar Lal S/o Daya Ram, Tehsil – Thunag, Kandhi, Bagsaid, Mandi (HP)	04.02.2022
121.	MTA to take up carnation plants (5,000 Nos.)	Mr. Jai Prakash S/o Naresh Sharma, Tehsil – Nagwain, Mandi (HP)	04.02.2022
122.	MTA to take up up carnation plants (1,000 Nos.)	Mr. Bhop Singh, S/o Dhyan Singh, Tehsil - Thunag, Bagsaid, Mandi (HP)	04.02.2022
123.	MTA to take up carnation plants (5,000 Nos.)	Mr. Aas Mohammad S/o Shahid, Palri, Muzaffarnagar Uttar Pradesh	04.02.2022
124.	MTA to take up lilium bulbs (1,000 Nos.) and tulip bulbs (2,000 Nos.)	Mr. Parvin Chander Sarin, S/o Narender Nath Sarin, PO. – Chandpur, Tehsil – Palampur, Kangra (HP)	04.02.2022

125.	MTA to take up carnation plants (10,000 Nos.)	Mr. Rajesh Kumar, S/o Sant Ram, Vill. – Sakred, PO. – Namhol, Bilaspur (HP)	04.02.2022
126.	MTA to take up carnation plants (2,000 Nos.)	Mr. Pushap Raj, S/o Lajju, 44/1 Khanyari, Kandha, Mandi (HP)	04.02.2022
127.	MTA to take up carnation plants (10,000 Nos.)	Mr. Suresh Kumar S/o Krishnu Ram, Vill. – Vijaypur, Tehsil - Jhandutta, Bilaspur (HP)	04.02.2022
128.	MTA to take up carnation plants (2,000 Nos.)	Mr. Tej Singh S/o Shyamu, Village - Khanyari, Tehsil – Chachyot, PO. - Kandha, Mandi (HP)	04.02.2022
129.	MTA to take up gladiolus corms (10,000 Nos.) and gerbera seedlings (1,300 Nos.)	Mr. Yogesh Sen S/o Avatar Singh Sen, 230/9 Tehsil –Sundar Nagar, Bhojpuri, Mandi (HP)	04.02.2022
130.	MTA to take up carnation plants (10,000 Nos.)	Smt. Hansika Sen w/o Yogesh Sen, Tehsil – Sunder Nagar, Bhojpur, Mandi (HP)	04.02.2022
131.	MTA to take up gladiolus corms (50,000 Nos.)	Mr. Arvind Setia S/o Ved Raj Setia, house no. 1345/A, Street no. 25, circular road, Abohar, Fazika Punjab	04.02.2022
132.	MTA to take up gladiolus corms (50,000 Nos.))	Mr. Sharad Setia S/o Ashwani Setia, house no. 1345/A Street no. 7, Six crossings, ward number 25, Abohar, Fazika Punjab	04.02.2022
133.	MTA to take up carnation plants (10,000 Nos.)	Mr. Rajeev Thakur S/o Amar Singh, Dangri, Solan (HP)	04.02.2022
134.	MTA to take up gladiolus corms (25,000 Nos.)	Mr. Ranjeet Singh S/o Lal Singh, Village Balla, PO. Rakh Balah (662) Rakh, Kangra (HP)	04.02.2022
135.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Amar Singh S/o Ram Singh, Tehsil Thunag, Rahi, Dhar (129), Bagsaid, Mandi (HP)	10.02.2022
136.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Ami Chand S/o Lajju Ram, Tehsil Chachyot, Bah, Kandhe, Mandi (HP)	10.02.2022
137.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Dharmender Singh S/o Jagjeet Singh, Sharan (96) Bagsaid, Mandi, Thunag (HP)	10.02.2022
138.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Jaiverdhan Singh S/o Jai singh, Tehsil Thunag, Banashi (126), Mandi (HP)	10.02.2022
139.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Kamal Dev S/o Bhim Singh, Tehsil Thunag, Rahi Dhar (129) Mandi (HP)	10.02.2022
140.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Khushal Singh S/o Hardev Singh, Tehsil Thunag, Village Sunas, Bagsiad, Mandi (HP)	10.02.2022
141.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Kishan Chand S/o Jhabe Ram, Tehsil, Thunag, Kandhi, 95 Bagsaid, Mandi (HP)	10.02.2022
142.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Komal Chand S/o Ram Singh, Kandhi (95), Mandi (HP)	10.02.2022
143.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Kundan Lal S/o Dilu Ram, Tehsil, Chachyot, Kandha, Mandi (HP)	10.02.2022
144.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Narender Pal S/o Han Singh, Tehsil, Thunag, Rahi Dhar (129), Bagsaid, Mandi (HP)	10.02.2022

145.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Naval Kishor S/o Besar ram Village Rahi dhar, PO. Bagsaid, Tehsil Thunag, Rahi Dhar (129) Bagsaid, Mandi (HP)	10.02.2022
146.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Ram Lal S/o Hardev Singh (95) Bagsaid, Mandi (HP)	10.02.2022
147.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Tej Singh C/o Shyamu, Village Khanyari, Tehsil Chachyot, PO. Kandha (125), Mandi (HP)	10.02.2022
148.	MTA to take up gladiolus corms (8,000 Nos.)	Mr. Topender Kumar S/o Mohan Singh, Rahi Dhar (129), Bagsaid, Mandi (HP)	10.02.2022
149.	MTA to take up carnation rooted cuttings (7,000 Nos.)	Mr. Pankaj Kumar S/o Pritam chand, Village Chakmoh Tehsil, Chhakmoh (34/8) Hamirpur, Dhatwal (HP)	10.02.2022
150.	MTA to take up carnation rooted cuttings (7,000 Nos.)	Mr. Parmodh Singh S/o Bali ram, Village Loharli, (34/30) Hamirpur (HP)	10.02.2022
151.	MTA to take up carnation rooted cuttings (7,000 Nos.)	Mr. Som Dutt S/o Duni Chand, Village Chakmoh Tehsil, Chhakmoh (34/8) Hamirpur Dhatwal	10.02.2022
152.	MTA to take up gladiolus corms (50,000 Nos.)	Mr. Surjeet Singh S/o Lal Singh, Dhalwan (423), Mandi (HP)	10.02.2022
153.	MTA to take up carnation rooted cuttings (4,800 Nos.)	Mr. Vipan Kumar S/o Purshotem Singh, Village - Jajiri post office - rail Jajri,Tehsil barsar, Jajri (34/47), Raili Jajri, Hmripur (HP)	10.02.2022
154.	MTA for establishment of Floriculture gardens to create awareness about flower crops under “CSIR Floriculture Mission”	Executive Engineer, (HP)PWD, Palampur District Kangra (HP)	10.02.2022
155.	MTA for establishment of Floriculture gardens to create awareness among school children and college students under “CSIR Floriculture Mission”.	Deputy Commissioner Office, Hamirpur 1st Floor, Mini Secretariat, Hamirpur (HP)	14.02.2022
156.	MTA to take up carnation plant (1,500 Nos.)	Mr. Nihal Singh S/o Late Sh. Ganesh Das, Rahi Dhar (129), Bagsaid, Mandi (HP)	16.02.2022
157.	MTA to take up carnation plant (1,500 Nos.)	Mr. Naresh Kumar S/o Surat Ram, Tehsil Thunag, Kandhi, Bagsaid, Mandi (HP)	16.02.2022
158.	MTA to take up carnation plant (1,500 Nos.)	Mr. Nanak Chand S/o Dagu Ram, Tehsil Thunag, Rahi Dhar, Bagsaid, Mandi (HP)	16.02.2022
159.	MTA to take up carnation plant (1,500 Nos.)	Mr. Vanit Kumar S/o Sunder Singh Tehsil Thunag, Kandhi, Bagsaid, Mandi (HP)	16.02.2022
160.	MTA to take up carnation plant (1,500 Nos.)	Mr. Mahesh Kumar S/o Som Prakash, Rahi Dhar (129), Bagsaid, Mandi (HP)	16.02.2022
161.	MTA to take up carnation plant (1,500 Nos.)	Mr. Manoj Kumar S/o Surat Ram, Teh Thunag, Surah, Mandi (HP)	16.02.2022
162.	MTA to take up carnation plant (1,500 Nos.)	Mr. Daulat Ram, S/o Shankar Das, Tehsil Thunag, Kandhi, Bagsaid Mandi (HP)	16.02.2022
163.	MTA to take up carnation plant (1,500 Nos.)	Mr. Netar Singh S/o Jhabe Ram, Tehsil Thunag, Kandhi, Mandi (HP)	16.02.2022
164.	MTA to take up carnation plant (1,500 Nos.)	Mr. Dalmi Ram S/o Karam Singh, Village Dhar, Kandhi, Mandi (HP)	16.02.2022

165.	MTA to take up carnation plant (1,500 Nos.)	Mr. Mohan Singh S/o Khem Singh, Marutha, Bagsaid, Mandi (HP)	16.02.2022
166.	MTA to take up carnation plant (1,500 Nos.)	Mr. Sangat Ram S/o Nand Lal, Tehsil Thunag, Surah (85), Bagsaid, Mandi (HP)	16.02.2022
167.	MTA to take up carnation plant (1,500 Nos.)	Mr. Khem Singh S/o Parama Nand Tehsil Thunag, Surah, Bagsaid, Mandi (HP)	16.02.2022
168.	MTA to take up carnation plant (1,500 Nos.)	Mr. Rajneesh Thakur S/o Balak Ram, Rahi Dhar, Bagsaid, Mandi (HP)	16.02.2022
169.	MTA agrees to take up carnation plant (1,500 Nos.)	Mr. Khem Singh S/o Narayan Singh Tehsil Thunag, Kandhi, Bagsaid, Mandi (HP)	16.02.2022
170.	MTA to take up carnation plant (1,500 Nos.)	Mr. Jaivardhan Singh S/o Jai Singh, Tehsil Thunag, Banaishi, Mandi (HP)	16.02.2022
171.	MTA to take up carnation plant (1,500 Nos.)	Mr. Ramesh Chand S/o Jai Singh, Tehsil Thunag, Ahun (94), Bagsaid, Mandi (HP)	16.02.2022
172.	MTA to take up carnation plant (1,500 Nos.)	Mr. Kishore Kumar S/o Narender Kumar, Village Sular, Bagsiad, Mandi (HP)	16.02.2022
173.	MTA to take up carnation plant (1,500 Nos.)	Mr. Puran Chand S/o Dhayan Singh, Dhar, Tehsil Thunag, Bagsaid, Mandi (HP)	16.02.2022
174.	MTA to take up carnation plant (1,500 Nos.)	Mr. Nek Ram S/o Shankar Das, Kandhi, Bagsiad, Mandi (HP)	16.02.2022
175.	MTA to take up carnation plant (1,500 Nos.)	Mr. Prem Lal S/o Brij Lal, Village Majwass, PO Devdhar Mandi (HP)	16.02.2022
176.	MTA to take up carnation plant (1,500 Nos.)	Mr. Umesh Kumar S/o Hukam Singh, post office kot tehsil chachyot, Dughal, Mandi (HP)	16.02.2022
177.	MTA to take up carnation plant (1,500 Nos.)	Mr. Brij Lal S/o Balak Ram, Gadhiman, Mandi (HP)	16.02.2022
178.	MTA to take up carnation plant (1,500 Nos.)	Mr. Tikam Singh S/o Om Chand, Tehsil Chachyot, Salahar, Devdhar, Mandi (HP)	16.02.2022
179.	MTA to take up carnation plant (1,500 Nos.)	Mr. Mohan Lal S/o Brij Lal Sharma, Tehsil Chachyot, Devdhar, Mandi (HP)	16.02.2022
180.	MTA to take up carnation plant (1,500 Nos.)	Mr. Nagendar Pal S/o Leela Ram, Tehsil Chachyot, Gandhiman(123), Devdhar, Mandi (HP)	16.02.2022
181.	MTA to take up gypsophila plant (1,000 Nos.)	Mr. Nihal Singh S/o Khem Singh Teh Thunag, Sharan, Mandi (HP)	16.02.2022
182.	MTA to take up gypsophila plant (1,000 Nos.)	Mr. Dola Ram S/o Jai Singh Teh Thunag, Sharan, Mandi (HP)	16.02.2022
183.	MTA to take up gypsophila plant (1,000 Nos.)	Mr. Devinder Singh S/o Kundan Lal, Tehsil Thunag, Kandhi, Bagsaid, Mandi (HP)	16.02.2022
184.	MTA to take up gypsophila plant (1,000 Nos.)	Mr. Hem Raj S/o Mohan Singh, Tehsil Chachyot, Musrani (103), Kandha, Mandi (HP)	16.02.2022
185.	MTA to take up gladiolus plant (20,000 Nos.)	Mr. Prem Singh Village Kandhi, PO Bagsiad, Tehsil Thunag, District Mandi ((HP)	16.02.2022

186.	MTA to take up gypsophila plant (1,000 Nos.)	Mr. Nagender Pal S/o Het Ram, Village Mandap, Tehsil Chachyot, Bassi, Mandi (HP)	16.02.2022
187.	MTA to take up 1 kg stevia seeds for cultivation near Hardoi (U.P.)	M/s Roman Eatery, 25 Central Lane, Bengali Market, New Delhi	18.02.2022
188.	MTA to take up 1 kg stevia seeds for cultivation in Maduari (T.N.)	M/s Maka Foods,19 LL Road, Lakshmipuram, Madurai Tamilnadu	21.02.2022
189.	MTA to take up gladiolus corms (10,000 Nos.)	Mr. Raj Kumar S/o Vir Singh PO. Khanda, Thunag. Mandi (HP)	21.02.2022
190.	MTA to take up gladiolus corms (10,000 Nos.)	Mr. Bhag Chand S/o Charan Das, Charkha, Mandi (HP)	21.02.2022
191.	MTA to take up gladiolus corms (10,000 Nos.)	Mr. Manohar Singh S/o Dhani Ram, Lot (24) Mandi (HP)	21.02.2022
192.	MTA to take up gladiolus corms (10,000 Nos.)	Mr. Piteshwar Kumar S/o Jhabe Ram, tehsil Chachyot, Lot (24) Mandi (HP)	21.02.2022
193.	MTA to take up gladiolus corms (10,000 Nos.)	Mr. Tupender Kumar S/o Niranjan Singh, Lot (24), Mandi (HP)	21.02.2022
194.	MTA to take up gladiolus corms (10,000 Nos.)	Mr. Lal Singh S/o Nand Lal, Lot (24), Mandi (HP)	21.02.2022
195.	MTA to take up gladiolus corms (10,000 Nos.)	Mr. Dikender Pal S/o Bir Singh, Chachyot, Lot (24), Mandi (HP)	21.02.2022
196.	MTA to take up Marigold seedlings (15,000 Nos.)	Mr. Sukhjeet Singh S/o Harbans Singh, Diwala, Ludhiana, Punjab	21.02.2022
197.	MTA to take up gladiolus corms (50,000 Nos.) and Marigold (25,000 Nos.)	Mr. Gurjeet Singh S/o Gurbachan Singh, House Number 74/13, Village Doraha, Jaipura, Ludhiana, Punjab	21.02.2022
198.	MTA to take up gladiolus (20,000 no. of corms),	Mr. Anand Bharadwaj S/o Jaininder Sharma, Ward Number 3 Post Office Nerti Teh. Shahpur, Nerti (137), Kangra (HP)	21.02.2022
199.	MTA to take up Cut roses (4,500 Nos.)	Mr. Sham Singh S/o Tarveej Singh, Kathet (237), Chamba (H.P)	21.02.2022
200.	MTA to take up Cut roses (5,000 Nos.)	Mr. Rishabh S/o Nikku Ram, VPO Rakkar Teh Dharamshala, Rakar (379), Kangra (HP)	21.02.2022
201.	MTA to take up Cut roses (15,000 Nos.)	Mr. Ajay Kumar Joshi S/o Narayan Dutt Joshi, Umagarh, Ramgarh, Nainital Uttarakhand	21.02.2022
202.	MTA to take up gladiolus corms (40,000 no. of corms),	Mr. Pankaj Singh S/o Tej Singh, bajoon, Bajoon, Nainital, Uttarakhand	21.02.2022
203.	MTA for establishment of vertical garden	Govt. (Girls) Sr. Secondary School, Palampur, Kangra (HP)	02.03.2022
204.	MTA to take up 6300 rooted plants of damask rose "Jwala" variety and Mentha Suckers (1000kg) under CSIR Aroma Mission –II	M/s Social Action for People also known as SAP Sanyasipali, PO-Kolabira, P.S.- Kolabira, Dist. Jharsuguda, Odhisa- 768213	03.03.2022
205.	MTA to take up gerbera (14,000 Nos.) and chrysanthemum plants (39,000 Nos.)	Mr. Chhtrapal Singh S/o Dhan Singh, Rajpura No. 2, Jogipura, Udham Singh Nagar, Jogipura Uttarakhand	07.03.2022
206.	MTA to take up chrysanthemum plants (39,000 Nos.)	Mr. Deepak Kumar S/o Munna Lal, Ward No-2, Kaladhungi, Kala Dhungi Range, Nainital Uttarakhand	07.03.2022

207.	MTA to take up chrysanthemum plants (39,000 Nos.), gladiolus bulbs (70,000 Nos.) and rose cuttings (15,000 Nos.)	Mr. Pankaj Singh S/o Tej Singh, Bajoon, Nainital, Uttarakhand	07.03.2022
208.	MTA for establishment of vertical garden	Municipal Corporation Dharamshala, Near Fire Station, Dharamshala, Distt Kangra (HP)	07.03.2022
209.	MTA to take up loose rose (30,000 Nos.), tuberose (9,000 Nos.) and gladiolus (20,000 Nos. of corms)	Mr. Jasdev Singh S/o Pritam Singh, Ward No. 13, Doraha, Ludhiana, Punjab	08.03.2022
210.	MTA to take up Gerbera plants (4,000 Nos.), cut rose plant (300 Nos.)	Mr. Sansar ChandS/o Jaindu Ram katnorya, Ward no. 5, Kuriala, Una (HP)	11.03.2022
211.	MTA for establishment of vertical garden	JNV Paprola, District Kangra (HP)	11.03.2022
212.	MTA for establishment of vertical garden	Govt. Sr. Sec. School Paprola District Kangra (HP)	11.03.2022
213.	MTA for establishment of vertical garden	Govt Girls Sr. Sec. School Paprola District Kangra (HP)	11.03.2022
214.	MTA to take up Carnation rooted cuttings (1,500 Nos.)	Mr. Prem Singh S/o Bal Krishan, Tehsil Tuunag, Badin (127) Mandi (HP)	11.03.2022
215.	MTA to take up Chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Krishan Lal Thakur S/o Shri Sant Ram Thakur, Teh Sadar, Sakred, Bilaspur (HP)	11.03.2022
216.	MTA to take up Chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Lalit Kumar S/o Daulat Ram, Kandhi, Bagsiad, Mandi (HP)	11.03.2022
217.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Khub Ram S/o Sadhu Ram, Village Khunagi, Surah (85), Shikawari, Mandi (HP)	11.03.2022
218.	MTA to take up Marigold seedlings (4,000 Nos.) and gladiolus corms (3,000 Nos.)	Mr. Shakti Dev S/o Jagat Raj, Ward No. 2, Tika Diktu vill. Jhoel post The Dharamshala, Kangra (HP)	11.03.2022
219.	MTA agrees to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Yadav Singh S/o Suraj singh Vill.dhayas, po bagsaid, Mandi (HP)	11.03.2022
220.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Chetan Kumar S/o Karam Singh, The. Thunag, Surah (85), Bagsaid, Mandi (HP)	11.03.2022
221.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Jai Singh S/o Maan Daas, Teh Thunag, Surah (85), Mandi (HP)	11.03.2022
222.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Narender Kumar S/o Maya Ram, Village Khunagi, Surah, Bagsiad, Mandi (HP)	11.03.2022
223.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Humesh Kumar S/o Lesr Singh Tehsil Thunag, Kandhi (HP)	11.03.2022
224.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Dhameshwar Singh S/o Almu Ram, Kandhi, Mandi (HP)	11.03.2022
225.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Om Parkash S/o Daya Ram, Tehsil Thunag, Kandhi, Bagsiad, Mandi (HP)	11.03.2022
226.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Kuldeep Singh S/o Prem Singh, Kandhi, Mandi (HP)	11.03.2022
227.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Maya Ram S/o Alamu Ram, Village Khunagi, Bagsiad, Mandi (HP)	11.03.2022
228.	MTA to take up Loose rose cuttings (20,000 Nos.)	Mr. Kamaldeep S/o Puran Chand, House No. 116, Near Hunaman Mindir, Sukhera Khera, Sirsa, Haryana	11.03.2022
229.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Smt. Hansa Kumari W/o Rejender Singh, Tehsil Thunag, Mandi (HP)	11.03. 2022

230.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Bal Krishan S/o Devi Ram, Teh Thunag, Badin (127), Bagsaid, Mandi (HP)	11.03. 2022
231.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Seva Singh S/o Kanshi Ram, Tehsil Thunag, Surah, Mandi (HP)	11.03. 2022
232.	MTA to take up Marigold seedlings (1,000 Nos.)	Smt. Sunita Sharma W/o Dwarka Dhish, Ward No 07, Banuri Khas (231), Banuri Kangra (HP)	11.03. 2022
233.	MTA to take up Marigold seedlings (1,000 Nos.)	Mr. Sanjay Kumar S/o Kishor Chand, Gujrehra (292), Kangra (HP)	11.03. 2022
234.	MTA take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Bhushan Kumar S/o Uttam Singh, Kandhi, Mandi (HP)	11.03. 2022
235.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Jai Parkash S/o Molak Ram Tehsil Thunag, Bagsiad, Mandi (HP)	11.03. 2022
236.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Smt. Manorma D/o Late sh. Khem Singh Vill Shamsher, Thunag, Mandi (HP)	11.03.2022
237.	MTA to take up Rose cuttings (1,200 Nos.)	Mr. Milap Chand, Vill Kaseti, Paisa Khas (605), Kangra (HP)	11.03.2022
238.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Bhupender Singh S/o Ludded Singh, Kandhi (95), Bagsaid, Mandi, (HP)	11.03.2022
239.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Harnam Singh S/o Lal Man, Tehsil, Thunag, Ahun, Bagsiad, Mandi (HP)	11.03.2022
240.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Dola Ram S/o Tule Ram, Tehsil Thunag, Badin, Mandi (HP)	11.03.2022
241.	MTA agrees to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Narender Kumar S/o Het Ram Village Sular PO. Bagsaid Teh Thunag Distt. Mandi (HP)	11.03.2022
242.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Khem Raj S/o Lal Singh, Village Khunagi, Bagsiad, Mandi (HP)	11.03.2022
243.	MTA to take up chrysanthemum rooted cuttings (15,000 Nos.)	Mr. Prem Lal S/o Hari Singh, Tehsil Thunag, Bagsiad, Mandi (HP)	11.03.2022
244.	MTA to take up marigold seedlings (5,000 Nos.)	Mr. Manohar Lal S/o Chandi Prasad, Vill Kothi, Teh Baijnath, Kothi (543), Chadhiar, Kangra (HP)	11.03.2022
245.	MTA to take up gladiolus corms (50,000 Nos.)	Mr. Harpal Singh S/o Gormukh Singh, Bharapur (157), Dhaulula kuan, Sirmaur, Paonta Sahib (HP)	11.03.2022
246.	MTA to take up marigold seedlings (2,000 Nos.)	Mr. Ajay Kumar S/o Ratan Chand, No. 5, Bheth Jhikli (817), Taragarh, Kangra (HP)	11.03.2022
247.	MTA to take up marigold seedlings (5,000 Nos.)	Mr. Rajesh Rana S/o Chamel Singh Rana, Vill Daleep nagar, Post Chobin, Teh Baijnath, Kangra (HP)	11.03.2022
248.	MTA to take up gladiolus corms (16,000 Nos.)	Mr. Kabil Ghhogra S/o Satish Kumar, Vill. Phata Rani Sidpur, Brindaban (208), Palampur, Kangra (HP)	11.03.2022
249.	MTA with take up gladiolus corms (15,000 Nos.)	Mr. Balwinder Singh S/o Bahadur Singh, Teh Bhoranj, Naili (42/113), Mundkhar, Hamirpur (HP)	11.03.2022
250.	MTA to take up marigold seedlings (15,000 Nos.)	Mr. Sukhjit Singh S/o Harbans Singh, Diwala, Ludhiana, Punjab	11.03.2022
251.	MTA to take up chrysanthemum rooted cuttings (23,750 Nos.)	Mr. Tilak Raj S/o Kaur Chand, Teh Dehra, Vill. Dreak Lahar, Post Kathog, Badoli (664), Kangra (HP)	11.03.2022

252.	MTA to take up Lemongrass (10,00,000 slips) and Wild Marigold (75 kg seed) provided free of cost (FOC) basis under "CSIR Aroma Mission –II".	Dev Surya Himalayan Organic Pvt. Ltd. (FPO) Ltd. Hotel Suryadev, Palampur (HP)	24.03.2022
253.	MTA for integration of apiculture in floriculture/fruit orchards for pollination and livelihood promotions	Bee keeping Cluster, Ghorab, Village Ghorab, PO. Bathrer, Tehsil Nagrota Bagwan, District Kangra (HP)	31.03.2022
254.	MTA for integration of apiculture in floriculture/fruit orchards for pollination and livelihood promotions	Bee keeping Cluster, Samma, Village Samma, PO. Khel, Tehsil Nurpur, District Kangra (HP)	31.03.2022
255.	MTA for integration of apiculture in floriculture/fruit orchards for pollination and livelihood promotions	Bee keeping Cluster, Samlara, having its registered address at Village Samlara, Tehsil Bangana, District Una (HP)	31.03.2022
256.	MTA for integration of apiculture in floriculture/fruit orchards for pollination and livelihood promotions	Bee keeping Cluster, Ghurkari, Village Ghurkari, Tehsil and District Kangra (HP)	31.03.2022
BIOTECHNOLOGY/AGROTECHNOLOGY			
257.	MTA to take up rooted cuttings of chrysanthemum and culture flasks of Gerbera"	M/s Neva Plantations LLP, Village Gopalpur, tehsil Palampur, Distt. Kangra (HP)	02.07.2021
258.	MTA to take up planting material of tissue culture of Him Stevia raised through plant tissue culture in flasks/bottles	M/s Relsus India Pvt. Ltd. Ltd., TG-6/6A Orchid Garden, Suncity, Sector-54, Gurugram (Haryana)	27.08.2021
259.	MTA to take up compost booster for winter season to solve the problem of dry toilets	Gram Panchayat Tandi, Village Tandi, Block Lahaul, District Lahaul & Spiti (HP)	26.09.2021
260.	MTA to take up compost booster for winter season to solve the problem of dry toilets	Krishi Seva Sehkari Sabha Society, Village Gaushal, District Lahaul & Spiti (HP)	26.09.2021
261.	MTA to take up compost booster for winter season to solve the problem of dry toilets	Mahila Mandal Mooling, Village Mooling, Distict Lahaul & Spiti (HP)	26.09.2021
262.	MTA to taking compost booster to solve the problem of dry toilets in winter season	Lahol Life and Heritage of Lahul, Keylong, District Lahaul & Spiti (HP)	10.02.2022
263.	MTA to provide 800 Kg or more compost boosters, and 50L EM solution per month	Station Headquarters, Holta Camp, Palampur (HP)	16.02.2022
MISCELLANEOUS MoUs			
AGROTECHNOLOGY			
1.	MoU for collaborate in humanitarian activity pertaining to economic upliftment, environmental stewardship and sustainable development in hilly regions	Rise Up Foundation Mandi and Rotary Club of Mandi, First Floor, Near M.C. Office (opposite Police Chowki), Mandi (HP)	13.08.2021
2.	MoU to undertake joint collaboration in the area of saffron	M/s Riser Saffron, 110/7 Nanda Nagar, Indore (M.P.)	29.09.2021
3.	MoU to collaborate and complement each other common goals	NMPB, Ministry of Ayush, Government of India at IRCS, Annexe Building, 1 Red Cross Road, New Delhi	04.10.2021
4.	MoU signed join hands for the purpose of increasing farm income, livelihood promotion and rural development in (HP) through transfer of innovations by means of research, mass propagation, capacity building, and skill development activities in the area of Dalchini (*Cinnamomum verum*) cultivation	ICAR Indian Institute of Spices Research (IISR), PB No. 1702, Marikunnu, PO. Kozhikode	22.10.2021

5.	MoU for increasing farm income, livelihood promotion and rural development in Himachal Pradesh through transfer of innovations by means of research, mass propagation, capacity building, and skill development activities in the area of Dalchini (*Cinnamomum verum*) cultivation	Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth (DBSKKV), Tal. Dapoli, Dist. Ratnagiri (Maharashtra)	07.12.2021
6.	MoU to undertake joint collaboration in the area of floriculture	M/s Join Flora Pvt. Ltd., 313, 3rd Floor, Udyog Mandir, Industrial Estate No. 1, Bhagoji Keer Marg, Mahim West, Mumbai	22.12.2021
7.	MoU to join hands for strategic partnership for the purpose of livelihood promotion and rural development in Himachal Pradesh through Innovations by means of capacity building, Skill development and other extension services in the area of aromatic plants and other allied plant species cultivation.	Himachal Pradesh Forest Department (HPFD), Society for improvement of Forest Ecosystem management and Livelihoods in H.P, Potters Hill Shimla (HP)	23.12.2021
8.	MoU to undertake joint collaboration in the area of floriculture	M/s Manish Flowers, A-28, Gazipur Flower Market, New Delhi	08.03.2022
BIOTECHNOLOGY			
9.	Joint research project entitled “Role of viral and host factors in circulative transmission of *tomato begomo* viruses by the whitefly *Bemisia tabaci*	Plant Health Institute of Montpellier, Montpellier, France	28.12.2021
AGROTECHNOLOGY AND CHEMICAL TECHNOLOGY			
10.	MoU to undertake joint collaboration in the area of essential oils	M/s Gan Eden Biotic, 20/371/A, Ottaplackal, Nedumgadu, Panacheppally Post, Kottayam, Kerala	25.06.2021
11.	MoU to undertake joint collaboration in the area of essential oils	M/s Maf India Pharmaceuticals,194, New rattan Garh Colony, Jalbhera Road, Ambala City, Haryana	01.07.2021
12.	MoU to undertake joint collaboration in the area of essential oils	Innoveo Exports, B-92, Chitrakut Society, Sanand Ahmedabad, Gujrat	21.07.2021
13.	MoU to install distillation unit at Kalimpoong, West Bengal as per technical know-how and guidelines of CSIR-IHBT	Mani Trust, Mani Bhawan, Relli Road, Kalimpong, West Bengal	06.09.2021
14.	MoU to undertake join collaboration in the area of essential oil	M/s farm Grocer Products Pvt. Ltd., 58, Sarswati Nagar, Ambala City, Haryana	10.01.2022
15.	MoU to undertake joint collaboration in the area of essential oils	M/s Mount leaf, Ghurkari khas, Kangra (HP)	21.01.2022
16.	MoU to install the distillation unit under CSIR Aroma Mission-II	Vishavpujita Gram Sangathan, Chameti, PO. Kuhna Block Pragpur, Tehsil Rakkar, District Kangra (HP)	02.03.2022
17.	MoU to install the distillation unit under CSIR Aroma Mission-II	The Jakh Devta Kisan Cooperative Society, Dodra, Gopan Niwas, Dodra, Tehsil Dodra Kawar, Shimla (HP)	07.03.2022
18.	MoU for installation of distillation unit under CSIR Aroma Mission-II	Own War Farmer Producer Company Limited, Khasra No. 23/24, Village Mubarakpur, Nawashahr to Garhshankar Road, Adjoining Royal Marriage Palace, Tehsil Nawanshahr, District	29.03.2022

		Shaheed Bhagat Singh Nagar, Punjab	
19.	MoU for installation of distillation unit under CSIR Aroma Mission-II	The Laughing Flower Co-operative Multipurpose Society Ltd. Madina, Village Madina, House No. 881, Madina Gindhran District Rohtak Haryana	29.03.2022
AGROTECHNOLOGY, BIOTECHNOLOGY AND FOOD TECHNOLOGY			
20.	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 Lahaul & Spiti District	Deputy Commissioner, Lahaul & Spiti, Himachal Pradesh, Deputy Commissioner Office Keylong, Lahaul & Spiti (HP)	05.01.2022
21.	MoU signed for the purpose of livelihood promotion and rural development in selected / targeted Areas / Districts of Himachal Pradesh	(HP) Agro Industries Corporation Limited (HPAIC), Nigam Vihar, Shimla (HP)	5.10.2021
22.	MoU to join hands for the purpose of livelihood promotion and rural development of Sikkim	Department of Horticulture, Govt. of Sikkim, Horticulture Department Krishi Bhawan, East Sikkim	18.02.2022
ACADEMICS			
23.	MoU to collaborate for research and teaching	Indian Institute of Technology, Kamand, District Mandi (HP)	13.04.2021
24.	MoU for Close cooperation for the benefit of the students and teacher	Jawahar Navodaya Vidyalaya Petrol Pump, The – Baijnath, District Kangra (HP)	02.07.2021
25.	MoU to undertake joint research work in the areas of mutual interest	Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu, J&K	16.10.2021
26.	MoU for academic and R&D collaboration	Hemvati Nandan Bahuguna Garh wal University (Central University), Srinagar- 246174, Dist. Garhwal (Uttrakhand)	12.11.2021
27.	MoU to jointly perform the research on Nanotechnology	JSS College of Pharmacy, Post Box No.20, Rocklands, Ooty – 643 001, The Nilgiris, Tamil Nadu	01.12.2021
28.	MoU for collaborative research and academic activities of mutual interest	Career Point University Tikker-Kharwarian, PO Kharwar, Tehsil Bhoranj, District Hamirpur (HP)	22.02.2022
29.	MoU for academic and R&D collaboration	ICAR CPRI, Shimla	31.03.2022
AGREEMENTS WITH INCUBATEES/ STAR-UPS			
BIOTECHNOLOGY			
1.	Incubation facility under CM Startup scheme for establishment of plant tissue culture lab for planting material of blueberry, apple and saffron	Mr. Ankit Shandil, Jahri, PO Naswal, Tehsil Ghumarwin District Bilaspur (HP)	01.04.2021
	Availing Incubation Facility for production/enrichment/drying of Vitamin D2 enriched Shiitake Mushroom at CSIR-IHBT	Innotech AgroPostikam Pvt Ltd, Indigram Labs, B1, Mohan Cooperative, Industrial Estate, Badarpur, New Delhi	02.07.2021
3.	Availing Incubation Facility for production/enrichment/drying of Vitamin D2 enriched Shiitake Mushroom at CSIR-IHBT	M/s Gaurav Agro Foods, Plot no. 28, Industrial Area -2, Nagri, Palampur (HP)	02.07.2021
4.	Incubation facility under CM Startup scheme for establishment of facility	Mr. Tanmay Sharma, C/o Sh. Devi Sharma, VPO Khaira,	19.07.2021

	organic incense sticks with/without bamboo sticks	Tehsil Palampur, District Kangra (HP)	
5.	Availing incubation facility for development of pine charcoal from pine needle (*Pinus roxburghii*) and its essential oil for Mosquito /Insect repellent formulation	Mr. Ajay Kumar Thakur,C/o Shri Sarbjeet Singh VPO Biara Tehsil Palampur, District Kangra (HP)	26.07.2021
6.	Availing incubation facility to develop packaging material from Mushroom Mycelium	Mr. Rohit Kalia, Plot no. 28, Industrial Area -2, Nagri, Palampur (HP)	26.07.2021
7.	Incubation facility under CM Startup scheme for establishment of plant tissue culture lab for growing *Cordyceps militaris* along with Oyester mushrooms used for health and wellness	Mr. Abhishek Gautam, Block No. 18, Flat No. 4, Phase No. 3, New Shimla (HP)	15.11.2021
8.	Incubation facility under CM Startup scheme for Hydroponic production of Picrorhiza Kurroa (kutki) and Valeriana jatamansi (Muskbala)".	Mr. Akash Deep Rehan,Rehan Niwas, 1st Floor, Near Yamini Hotel, Palampur, District Kangra (HP)	18.11.2021
CHEMICAL TECHNOLOGY			
9.	Incubation facility under CM Startup scheme for establishment of facility for various types of value added products from *Tinospora cordifolia* (Giloe)	Ms. Nitika Bhandari C/o Khadi Gramoudhyog Sansthan, Nagrota Bagwan Distt. Kangra (HP)	19.07.2021
10.	Facility use agreement making stevia liquid drops for its commercial sale by using processing facility at CSIR-IHBT, Palampur	M/s USAS natural and herbal products Pvt. Ltd., Village Pantehar, Post office Patti, Tehsil Palampur District Kangra (HP)	29.07.21
11.	Facility use agreement making stevia liquid drops for its commercial sale by using processing facility at CSIR-IHBT, Palampur	M/s Agri Natural India, 107, New Model Town, Ludhiana	05.08.21
12.	Facility use agreement making stevia liquid drops for its commercial sale by using processing facility at CSIR-IHBT, Palampur	M/s Relsus India Pvt. Ltd. Ltd., TG-6/6A Orchid Garden, Suncity, Sector-54, Gurugram, Haryana	27.08.21
13.	Incubation facility under CM Startup scheme for Aromatherapies: Plants healing properties to promote good health and lifestyle without any physical contact with skin	Mrs. Aditi Sharma, A-2491, Ground floor, Green Field Colony, Faridabad, Haryana	22.11.2021

PRODUCTS DEVELOPED AND LAUNCHED UNDER CM START-UP SCHEME

Name of the Start-up	Product	Product's Photographs
Mr. Rajan Minhas M/s. The Fragrance Ward No. 8, Maranda Palampur, HP	Aromatherapy Candles	
Mr. Kushal Kumar Village Bharmat, PO Banuri, Palampur, HP	Natural Perfumes	
Mr. Tanmay Sharma and Mr. Abhinav M/s. The Bamboo Connection Village Kahira, Teh. Palampur Palampur, HP	Incense Sticks	
Dr Ishan Kashyap M/s. Petsby, Distt. Mandi H.P	Herbal Skin Care Cream	
Mr. Bharat Mohan, Baggi, Sundernagar 175027, Distt-Mandi (H.P.)	Cedar Hydrosol, Herbal floor cleaner, Herbal Toilet cleaner, and Himalayan essential oils	

MISSION MODE PROJECTS

CSIR– AROMA MISSION (PHASE-II)

Nodal: Dr. Sanatsujat Singh

Co-Nodal: Dr. Rakesh Kumar

Principal Investigators: Dr. Ram Kumar Sharma, Dr. Vijai Kant Agnihotari

Dr. Probir, Dr. Sushil, Er. Mohit Sharma, Dr. Ashok Kumar, Dr. SGE Reddy, Dr. Upendra, Dr. Dinesh, Dr. Satbeer, Dr. Ramesh, Er. Amit, Dr. Robin Joshi, Dr. Kiran, Mr. Ramjeelal Meena, Dr. Arvind Verma, Kuldeep Singh and Mr. Ramdeen Prasad

Generation of quality planting material

Quality planting materials of targeted aromatic crops were generated within the institute and supplied to the farmers to bring the degraded and waste land under aromatic crops cultivation. More than 1,04,050, 2,55,000 and 2,17,000 number of stem cuttings of damask rose, scented geranium and lavender were generated. Given below are the complete details of the planting material of the targeted aromatic crops generated and supplied during the year (Table 1).

Training and awareness programmes for skill development

Thirty four awareness cum training programs for farmers on cultivation and process technologies of aromatic crops were conducted during April, 2021 to March, 2022 (Table 2). 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 program the farmers were inculcated for the cultivation of aromatic crops namely damask rose, aromatic marigold, chamomile, lavender, scented geranium, lemongrass, Indian velerian, tulsi and rosemary.

Table 1 Generation of planting material under CSIR-Aroma Mission Phase II

S. No.	Crop Name	Planting material generated & supplied
1	Aromatic marigold	1165 kg seeds
2	Damask rose	104050 plants
3	Lemongrass	10 lakhs slips
4	Spear and pepper mints	5 quintal
5	Mint (*M. arvensis*)	30 quintal
6	Rosemary	1.0 lakh plants
7	Ocimum	100 kg seeds
8	Palmarosa	100 kg seeds
9	Geranium	2.55 lakhs
10	Indian valerian	5 lakh plants
11	Salvia	5 kg seeds
12	Chamomile	100 kg seeds
13	Lavender	217000 plants
14	Artemisia	40 kg seeds
15	White dragonhead	3 kg seeds

Table 2 Awareness cum training programs conducted during April, 2021 to March, 2022 on cultivation and process technologies of aromatic crops						
S. No	**State/Union territory**	**District**	**Program Location**	**Program Date**	**Total Partici-Pants**	**Women Partici-pants**
1	Himachal Pradesh	Kangra	Palampur	04/06/2021	18	0
2	Himachal Pradesh	Kangra	Palampur	04/13/2021	6	3
3	Himachal Pradesh	Kangra	Palampur	04/11/2021 to 04/13/2021	2	1
4	Himachal Pradesh	Kangra	Palampur	04/19/2021	4	1
5	Himachal Pradesh	Kangra	Palampur	07/29/2021	9	2
6	Himachal Pradesh	Kangra	Palampur	07/30/2021	30	11
7	Himachal Pradesh	Chamba	Parwai	08/04/2021	18	9
8	Ladakh	Leh	Leh	08/07/2021	53	23
9	Himachal Pradesh	Kangra	Palampur	08/24/2021	16	5
10	Himachal Pradesh	Kangra	Palampur	08/31/2021	7	1
11	Himachal Pradesh	Kangra	Lag baliyana	09/01/2021	19	12
12	Himachal Pradesh	Kangra	Palampur	09/09/2021 to 09/10/2021	2	0
13	Himachal Pradesh	Kangra	Palampur	09/10/2021	6	0
14	Himachal Pradesh	Kangra	Palampur	09/13/2021	4	0
15	Uttarakhand	Champawat	Garasari	09/25/2021	27	18
16	Uttarakhand	Champawat	Mara	09/26/2021	16	9
17	Uttarakhand	Champawat	Tyarshu	09/27/2021	6	2
18	Uttarakhand	Champawat	Tapnipal	10/05/2021	78	29
19	Himachal Pradesh	Kangra	Ghallour	10/06/2021 to 10/07/2021	09	03
20	Himachal Pradesh	Hamirpur	Bhatera	10/14/2021	12	04
21	Himachal Pradesh	Una	Gondpur	11/14/2021	170	68
22	Himachal Pradesh	Kangra	Palampur	11/18/2021	81	07
23	Himachal Pradesh	Bilaspur	Ghumarwin	11/24/2021	13	03
24	Himachal Pradesh	Kangra	Palampur	11/25/20	09	03
25	Himachal Pradesh	Kangra	Sukairi	12/06/2021	28	09
26	Himachal Pradesh	Kangra	Palampur	12/30/2021	142	17

27	Himachal Pradesh	Kangra	Palampur	01/04/2017	11	0
28	Himachal Pradesh	Chamba	Bhattiyat	02/24/2022	60	09
29	Himachal Pradesh	Kangra	Palampur	03/07/2022	33	19
30	Himachal Pradesh	Kangra	Patari	03/09/2022	14	14
31	Himachal Pradesh	Kangra	Khowa	03/09/2022	48	38
32	Himachal Pradesh	Kangra	Palampur	03/10/2022	23	3
33	Himachal Pradesh	Chamba	Salooni	03/21/2022	139	6
34	Himachal Pradesh	Kangra	Palampur	03/23/2022 03/24/2022	26	18
				Total	**1139**	**347**


An awareness cum training programme on aromatic plants cultivation at Mara Champawat, Uttarakhand

Distribution of quality planting material of lemongrass to farmers of Distt. Una, HP.

Training programme on aromatic plant cultivation at CSIR-IHBT.

CSIR FLORICULTURE MISSION

Nodal: Dr. Bhavya Bhargava
Co-Nodal: Dr. Poonam Kumari
Research group: Dr. Sanatsujat Singh, Dr. Ashok Kumar, Dr. Pamita Bhandari, Dr. Mahesh Gupta, Dr. Vidyashankar, Er. Amit Kumari, Dr. Robin Joshi, Dr. Dinesh Kumar, Dr. SGE Reddy, Dr. Girish Nadda and Dr. Sukhjinder Singh

CSIR-Floriculture Mission was launched on 4th March 2021 by the then Hon'ble Vice President, CSIR, Dr. Harsh Vardhan to enhance farmers' income and promote entrepreneurship through high value floriculture utilizing CSIR technologies. The mission has seven verticals viz., (A) Development of new floral varieties; (B) Expansion of area under floriculture crops; (C) Urban floriculture; (D) Development of post-harvest and value addition technologies; (E) Integration of Apiculture and Floriculture; (F) National level registration and release of existing and new floral varieties; and (G) Establishing effective domestic and international market linkage.

Area extension and generation of quality planting material

During 2021-22, 249.90 ha area were brought under the floriculture crops. Area covered under different crops were: Marigold (200 ha), Gladiolus (20.59 ha), Chrysanthemum (6.60 ha), Gerbera (1.37 ha), Carnation (2.56 ha), Lilium (0.84 ha), Tuberose (3.60 ha), Rose loose (2.18 ha), Calla lily (1.43 ha), Limonium (0.61 ha), Gypsophila (1.23 ha), Tulip (0.04 ha) and Cymbidium orchids (0.08 ha). Bringing a large area under floriculture requires propagules, hence the Institute generated planting material for the same (Table 1). Under CSIR-Floriculture Mission, around 102.74 lakh quality planting materials of floricultural crops were distributed to the farmers (Table 2).

Table 1 Crop-wise area extension, number of farmers and planting material distributed to the farmers under floriculture mission

S. No.	Crop	Total area (ha)	No. of farmers	Planting material (Nos.)
1.	Marigold	200.00	511	40,40,000 seedlings
2.	Gladiolus	20.59	114	40,68,641 bulbs
3.	Chrysanthemum	6.60	22	5,94,614 rooted cuttings
4.	Gerbera	1.37	24	1,24,000 plants
5.	Carnation	2.56	119	5,12,589 plants
6.	Lilium	0.84	26	1,68,400 bulbs
7.	Tuberose	3.60	32	3,56,032 bulbs
8.	Cut-rose	2.18	30	1,31,650 cuttings
9.	Loose rose	8.77	20	1,31,650 cuttings
10.	Calla lily	1.43	5	15,000 plants
11.	Limonium	0.61	19	36,780 plants
12.	Gypsophila	1.23	29	73,900 plants
13.	Tulip	0.04	3	16,700 bulbs
14.	Cymbidium orchids	0.08	50	5,000 seedlings
	Total	**249.90**	**1004**	**1,02,74,306**

Table 2 Crop-wise details of planting material distributed to the farmers of different states under floriculture mission			
S. No.	**Crop**	**Planting material (Nos.)**	**Places**
1.	Marigold	40,40,000 seedlings	Chamunda, Paraur, Tanda, Dehra, Jawalamukhi, Kangra, Thakurdwara, Bhuntar, Bhawarna, Dharamshala, Mandi (HP); Nanital (Uttarakhand); Pathankot, Sangrur, Jalandhar, Bhatinda, Abohar, Zirakpur (Punjab); Khairpur (Haryana); Indore (Madhya Pradesh); J&K
2.	Gladiolus	40,68,641 bulbs	Barot, Mandi, Chamunda, Gondhla, Aut, Dehra, Mataur, Sungal, Thakurdwara (HP); Roorkee, Nanital (Uttarakhand); Zirakpur (Punjab)
3.	Chrysanthemum	5,94,614 rooted cuttings	Salooni, Rajgarh, Chakmoh, Nadaun, Aut (HP); (Uttarakhand); Mohali, Patiala, Jalandhar (Punjab)
4.	Gerbera	1,24,000 plants	Salooni, Kullu, Dharamshala, Fatehpur (HP)
5.	Carnation	5,12,589 plants	Harmirpur, Nadaun, Solan, Chakmoh, Mohral, Thunag, Baijnath, Bijad (HP); Jogipura, Nanital (Uttarakhand)
6.	Lilium	1,68,400 bulbs	Dalang, Gondhla, Madgran, Ribbling, Kullu (Himachal Pradesh); Kargil, Sankoo, Kurbathang of Kargil district and Ranbirpur, Stakna, Sankar, and Tukcha of Leh district, Ladakh)
7.	Tuberose	3,56,032 bulbs	Panchrukhi, Tanda (HP); Roorkee, Champawat (Uttarakhand)
8.	Cut-rose	1,31,650 cuttings	
9.	Loose rose	1,31,650 cuttings	Bhawarna, Mandi (HP); Champawat (Uttarakhand)
10.	Calla lily	15,000 plant	Madgran (HP); Nanital (Uttarakhand)
11.	Limonium	36,780 plants	Chakmoh, Bilaspur (HP); Nanital (Uttarakhand)
12.	Gypsophila	73,900 plants	Dharamshala, Chakmoh (HP); Bajun, Nanital (Uttarakhand)
13.	Tulip	16,700 bulbs	Lahaul, L&S, HP
14.	Cymbidium orchids	5,000 seedlings	Darjeeling, West Bengal
	Total	**1,02,74,306**	

Training and awareness programmes for skill development

Twenty-eight awareness cum training programmes on cultivation and value addition technologies of floricultural crops were conducted from June 2021 to March 2022 for unemployed youth, rural women and farmers (Table 3).

Table 3 Training programs conducted under the CSIR-Floriculture Mission				
S. No.	**Event**	**Date**	**Place**	**Number of participants**
1	Hands on training on Beekeeping	28/03/2022	CSIR-IHBT, Palampur (HP)	15
2	Farmers training and marigold seed distribution	26/03/2022	CSIR-IIIM, Jammu (J&K)	250

19	One day awareness cum training programme on cultivation and post-harvest management of floriculture crops	04/10/2021	Village Turuk, Sittong, Darjeeling (West Bengal)	18
20	Training cum awareness program on lilium bulb production through tissue culture	08/09/2021	Centre for High Altitude Biology, Ribling, Lahaul (HP)	16
21	Training to Ladakh farmer's on Lilium flower and bulb production	23/08/2021	Khinning, Lahaul (HP)	32
22	Practical demonstration for Agrotechnology and post-harvest management of lilium flowers	08/08/2021	Leh, Ladakh (UT)	25
23	One day awareness cum training program on agro and post -harvest management technology of floriculture crops in association with Ladakh based Organic Farmers Foundation Society	07/08/2021	Leh, Ladakh (UT)	36
24	Training in Agro technologies in Lilium and Tulips for Ladakh Farmers	23/08/2021	Lahual and Spiti (HP)	35
25	Agro technologies for flower Crops in Maharashtra	29/07/2021	Pune, Maharashtra	16
26	Training on Commercial Floriculture	24/06/2021	Dadi, Dharamshala, District Kangra (HP)	12
27	Training program on Agro-technologies of cut -flowers suitable for Kangra region, HP	20/06/2021	Dehra, Kangra (HP)	22
28	Prospects of crops like carnation, marigold, gladiolus, lily and gerbera	11/06/2021	Jhandutta, district Bilaspur (HP)	10
	Total			**1159**

Integration of apiculture in floriculture with the following objectives:

Establishment of apiculture clusters targeting existing fruit orchards and new nectar yielding floral crop fields

- Eleven bee keeping clusters (20 farmers/clusters in 10 clusters and 10 farmers in one cluster) were formed in Himachal Pradesh and Uttarakhand.
- Two thousand and one hundred (2100) bee hive boxes with colonies and 210 bee keeping kits (Bee veil, Bee smoker, Hive tool, uncapping knife) were distributed to the farmers.
- Eleven honey extractors were distributed in 11 bee keeping clusters.
- The crops targeted in different bee keeping clusters are marigold, rose, litchi, apple, mango, guava, citrus, pear, peach, papaya, mulberry etc.
- Material transfer agreements (MTA) were signed between CSIR-IHBT and bee keeping clusters.

Development and deployment of technologies to improve quality and yield of honey

- Improved bee hives have been fabricated (100 No.) and will be distributed to different clusters.

Awareness and training programme/skill development

- Twelve awareness and training programme were conducted in Maryari (Kangra), Saloh (Kangra), Ghorab (Kangra), Gurkari (Kangra), Samlara (Una) and Samma (Kangra).
- One skill development programme on apiculture was conducted for the students/faculty/orchardists of HIMCOSTE, Shimla (H.P.).
- Altogether 164 farmers attended the training and awareness programme including 60 female and 104 male farmers.

Urban floriculture and vertical gardens

Establishment of floriculture garden in schools and colleges

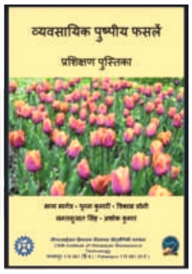
- Established eight vertical gardens in different state government offices and public places in Kangra and Hamirpur, district of HP

S. No.	Name of the Institute	Place
1	Combined Office Building Tehsil Office	Palampur, HP
2	Deputy Commissioner Office	Hamirpur, HP
3	Govt. Civil hospital	Ghumarwin, Bilaspur, HP
4	Municipal Corporation	Palampur, HP
5	Municipal Corporation	Dharamshala, HP
6	PWD Guest House	Palampur, HP
7	Chaina Ram Sant Ram Filling Station	Palampur, HP
8	Herbal Garden	Bilaspur, HP

- 19 gardens have been established in the various schools and colleges of Himachal Pradesh

S. No.	Name of the Institute	Place
1	National Institute of Technology	Hamirpur, H.P.
2	Jawahar Navodaya Vidyalaya	Paprola, HP
3	Govt. Senior Secondary School	Paprola HP
4	Govt. Senior Secondary School	Thandol, HP
5	Netaji Subhash College	Palampur, HP
6	Govt. Girls School	Palampur, HP
7	St. Pauls School	Palampur, HP
8	Govt. Girls School	Paprola, HP
9	Govt. Senior secondary School	Bharari, HP
10	Govt. Senior secondary School	Choru, HP
11	Govt. Girls Senior secondary School	Nadaun, HP
12	Govt. Senior Secondary School	Manoh, HP
13	Govt. Senior Secondary School	Ladarur, HP
14	Govt. Senior Secondary School	Mundukhar, HP
15	Govt. Senior Secondary School	Bhagwara, HP
16	Govt. Senior Secondary School	Balduhak, HP
17	Govt. middle school	Putriyal, HP
18	Govt Senior secondary school	Didwin, HP
19	Delhi Public School	Palampur, HP

As a part of the mission, Hindi training manual on "व्यवसायिक पुष्पीय फसलें: प्रशिक्षण पुस्तिका' written by Bhavya Bhargava, Poonam Kumari, Vikas Soni, Sanatsujat Singh and Ashok Kumar was released by Hon'ble Governor of HP, Shri Rajendra Vishwanath Arlekar on National Science Day dated 28th February, 2022.



Tulip Garden

Under the Floriculture Mission, a Tulip Garden was established. This is the first 'Tulip Garden' of HP and was inaugurated by Hon'ble Governor, Himachal Pradesh, Shri Rajendra Vishwanath Arlekar on National Science Day, 28th February, 2022. Around 5,000 nos. of students, tourists, researchers, farmers and public visited Tulip Garden this year.

General public visiting the Tulip Garden

Inauguration of Tulip Garden

Hon'ble Governor, Himachal Pradesh, Shri Rajendra Vishwanath Arlekar with Dr. Sanjay Kumar, Director of the institute

Cold storage facility

CSIR-IHBT, Palampur, HP signed two memorandum of understanding for cold storage facility with M/s Flower Grower Social Welfare Trust Kaladhungi, Kamola, Nainital, Uttarakhand. The cold storage facility has been provided to around 80 farmers who are cultivating ten different floral crops namely gladiolus, rose, gerbera, carnation, lilium, tuberose, chrysanthemum, gypsophila, limonium and calla lily. This will help the farmers to enhance their livelihood.

Value added products developed

Five dry flower products (frames, greeting cards, arrangements, floral candles and potpourris) have been developed.

Developed value added products

IMMUNO MODULATORY FUNCTION OF NUTRITIONALS AND NUTRACEUTICALS FOR HEALTH AND WELLNESS (CSIR IMMUNITY MISSION)

Mission Director: Dr. Sanjay Kumar
Principal Investigators: Dr. Sanjay Kr. Uniyal, Dr. Shashi Bhushan, Dr. Mahesh Gupta, Dr. Yogendra Padwad, Dr. Vikram Patial, Dr. Damanpreet Singh, Dr. Narendra Tirpude and Dr. Rakshak Kumar
Team members: Dr. Yogendra Padwad, Dr. Upendra sharma, Dr. Pamita Bhandari, Dr. Dinesh Kumar, Dr. Vikram Patial, Dr. Damanpreet Singh, Dr. Vidyashankar Srivatsan and Dr. Rakesh Pandey

CSIR Mission on **"Immuno-modulatory Function of Nutritionals and Nutraceuticals for Health and Wellness"** has been initiated with an aim to explore, identify and develop evidence based nutraceuticals and nutritionals that can boost immunity. The following is the key objective of the mission:

- Explore, identify and develop nutraceuticals and nutritionals that boost immunity to fight microbial and viral infections

Under the mission, there is networking of different CSIR institutions (Fig. 1) with budgetary allocation of around Rs. 18.00 Crores.

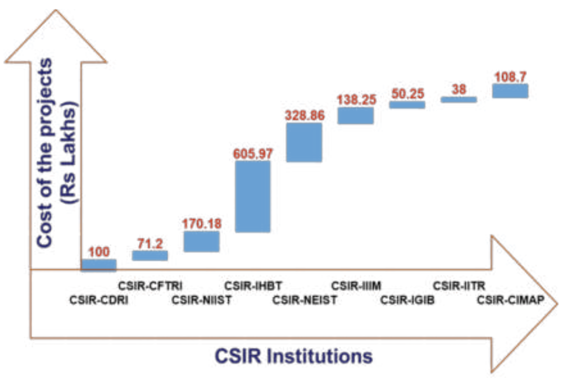


Fig. 1 Networking of CSIR institutions under the mission and budget allocation.

Key targets proposed by CSIR-IHBT under the mission projects are:

- Polyherbal immunomodulatory supplements containing potent plant extracts
- Development of nutraceutical formulation for renal health
- Regional tea based nutraceuticals for boosting immunity
- Development of spice based immunomodulatory nutraceuticals
- Monograph on Indian fruits and vegetables with immune boosting properties
- Scientific validation by human intervention studies of nutraceuticals developed in previous mission

In addition, the mission also integrate traditionally known spices, a basic ingredient of food in every Indian household for their immunity boosting properties. Chemical profiling/ finger printing and *in vitro* studies employing different cell lines for screening against various markers of immune response is under progress. Polyherbal formulation based on *Phyllanthus amarus*, *Solanum trilobatum*, *Cardiospermum halicacabum*, *Adhatoda vasica*, *Vitex negundo*, *Talinum triangulare*, *Moringa oleifera* and *Piper longum* extracts are being developed for improving immunity (Fig. 2). The activity of different combinations of *Tinospora cordifolia*, *Hippophae rhamnoides* and *Picrorhiza kurrooa* against renal cell lines, while *Illicium griffithii*, *Piper mullesua* and *Pyrus pashia* with significant cytoprotective effect, ROS inhibition and antiglycation activity.

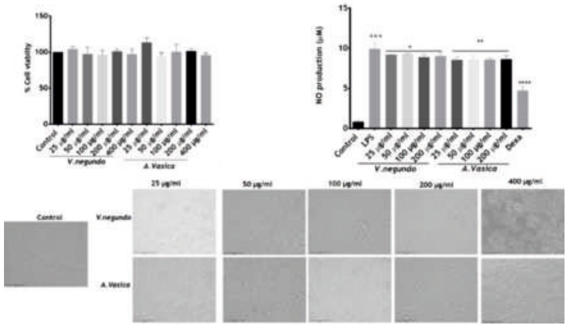


Fig. 2 *V. negundo* and *A. vasica* showed cytocompatibility and NO inhibition in macrophages.

Regional teas (Kangra, Assam and Munnar) from different part of India is also being assessed along with their relative efficacies and mode of action using appropriate model of immunity dysfunction (Fig 3.). Native plants such as *Carum carvi* & *Bunium persicum* (Himachal Pradesh); *Brassica juncea* (Jammu and Kashmir); *Capsicum chinense* & *Cinnamomum tamala* (North Eastern region) and *Buchanania lanzan* or Priyala (Central India) have also been evaluated for their marker metabolites and possible role in immunity modulation.

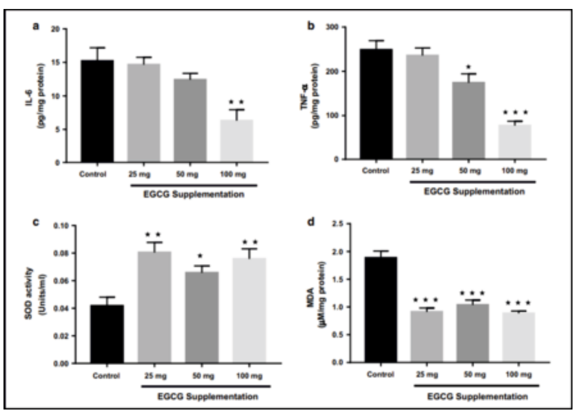


Fig. 3 Epigallocatechin gallate (EGCG) alleviates oxi-inflammatory stress.

The mission also envisaged development of digital portal on plants, fruits and vegetables, especially with a focus on providing data on immunity enhancing properties. Development of portal for immune boosting compounds from plant materials is carried out by compilation of data from various literature and databases. Chemical classification, and virtual screening of phytochemicals with selected targets along with the draft web portal has been developed. As of now, the library containing 11285 phytochemicals from different databases and literature. Chemical classification, scaffold identification of FSSAI listed nutraceuticals are compared with phytochemical library by computing physicochemical properties, ADME/toxicity analysis along with the molecular docking against pro-inflammatory cytokines (IL-6, TNF-alpha, IL-1β). Some of the identified compounds (Alpha-D-Glucopyranose, 7-Methoxyflavone, SanguiinH10, Lambertianin D) exhibits probable immunomodulatory properties. CSIR-Immunity-Mission web portal is in progress for plants, fruits and vegetables.

Furthermore, a facility for allergenic testing exist with CSIR-IGIB is strengthened to evaluate nutritionals and nutraceuticals being developed under the mission. Shiitake mushroom allergenicity evaluation has been done previously, whereas allergenic testing for some of the plants is underway.

Human Intervention Studies for GMP formulations or nutraceuticals (Vitamin D2 from enriched Shiitake mushroom, Cartilage health improvement, Cardio-protection, Neurodegeneration, Triphala and sleep improvement) based on leads of CSIR Mission on Nutraceuticals and Nutritionals are in progress as ethical clearance, selection of CRO and other prerequisite has already been completed.

AGRI NUTRI BIOTECH THEME

AGRI NUTRI BIOTECH THEME

Deciphering the mechanism(s) of host-endophytes' coevaluation, enhanced secondary metabolite production and crop productivity (IHBT, NBRI, CIMAP, IIIM, IMTECH, NEIST, CFTRI, CCMB) MLP-0171

Principal Investigators: Dr. Shiv Shanker Pandey

Under this project, CSIR-IHBT is working on endophytes of *Valeriana jatamansi* and *Podophyllum hexandrum*. Here the endophytes of selected Himalayan medicinal plants are being explored to promote plant growth and enhance therapeutically important secondary metabolite production and the associated mechanism is also being investigated. First the selected plants were collected from their natural habitats. *V. jatamansi* plant samples were collected from nine different natural locations in Himachal Pradesh including Nashala, Sainj, Barot, Sural Bhatori, Seema Dhar, Vindhyavasini, Billing, Prasahar and Palampur. Endophytes were isolated from different parts of *V. jatamansi* plants (root, rhizome, leaf, seeds) and a total of 190 endophytes (97 Bacterial and 93 fungal endophytes) were isolated (Fig. 1). Molecular characterization of isolated endophytes is in progress and 52 endophytes have been molecularly identified. Testing of the presence of important plant growth promotion activities such as phosphate solubilization, siderophore production, production of 1-Aminocyclopropane-1-carboxylate deaminase (ACCD), production of IAA (3-indoleacetic acid) in the isolated endophytes from *V. jatamansi* has been also done. Efficacy of selected endophytes to promote plant growth and secondary metabolite production of *V. jatamansi* is also being tested on endophyte-free *V. jatamansi* plants. Preliminary study demonstrated that some of the selected endophytes inoculation could improve photosynthesis of *V. jatamansi* plants and promoted plant growth (Fig. 2).

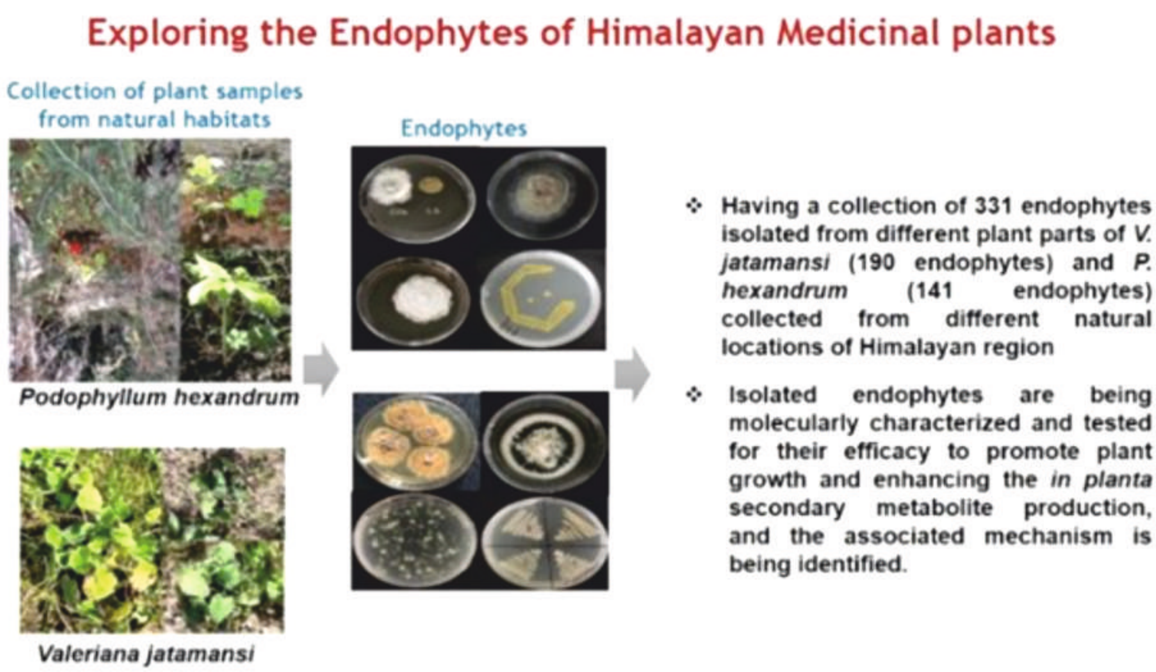


Fig. 1 Isolation of endophytes from selected test crop.

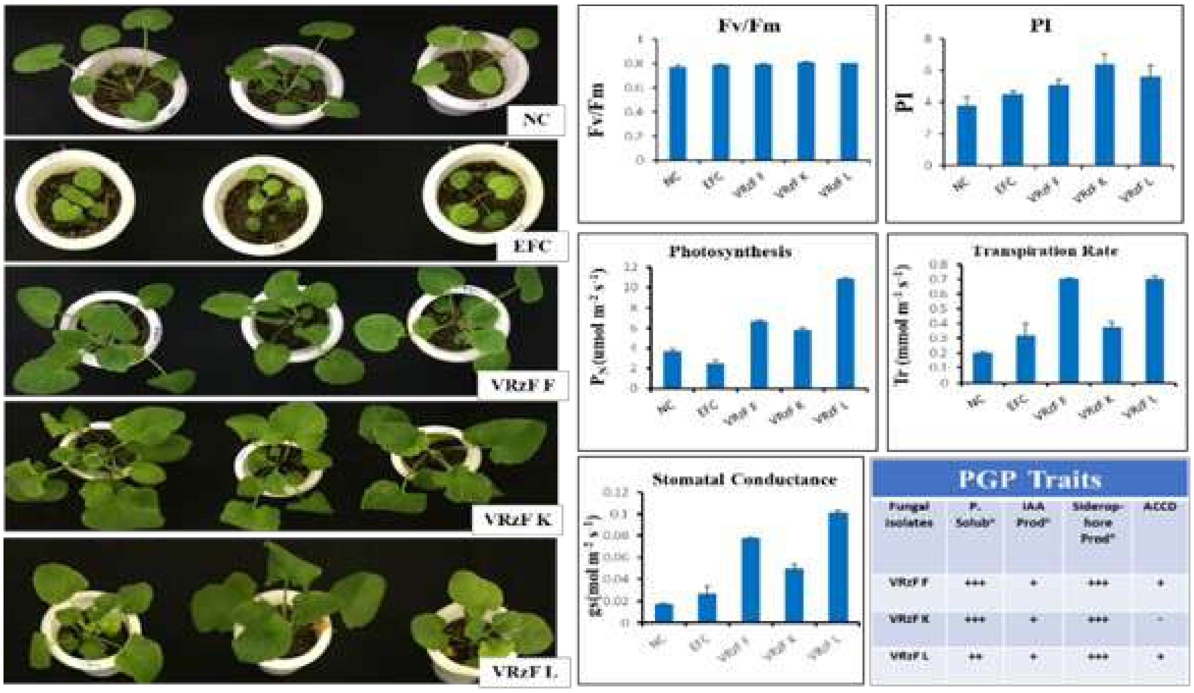


Fig. 2 Effect of selected endophytes inoculation on growth of *Valeriana jatamansi* plant. (NC: Natural control plants, EFC: Endophyte free control plants, VRzFF, VRzFK and VRzFL are the selected endophytic strains treated plants).

In the case of *Podophyllum hexandrum*, the plant samples were collected from five different natural locations including Triloknath, Lahaul, Kardang, Shansha and Supa. Endophytes were isolated from different parts of plants (root, rhizome, leaf, stem, fruit, seeds) collected from different locations and a total of 141 endophytes (109 Bacterial and 32 fungal endophytes) were isolated from *P. hexandrum* (Fig. 3). Molecular identification of isolated endophytes is in progress, and 49

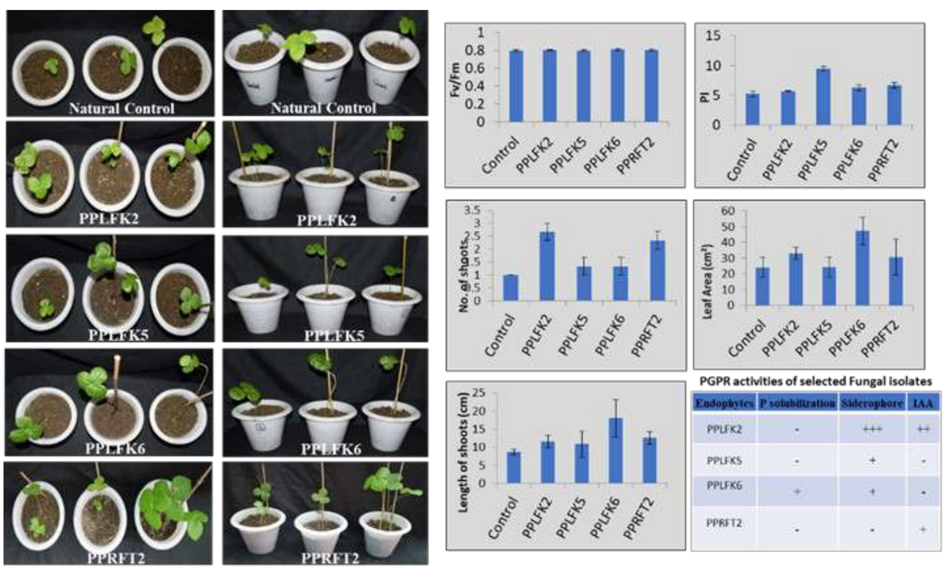
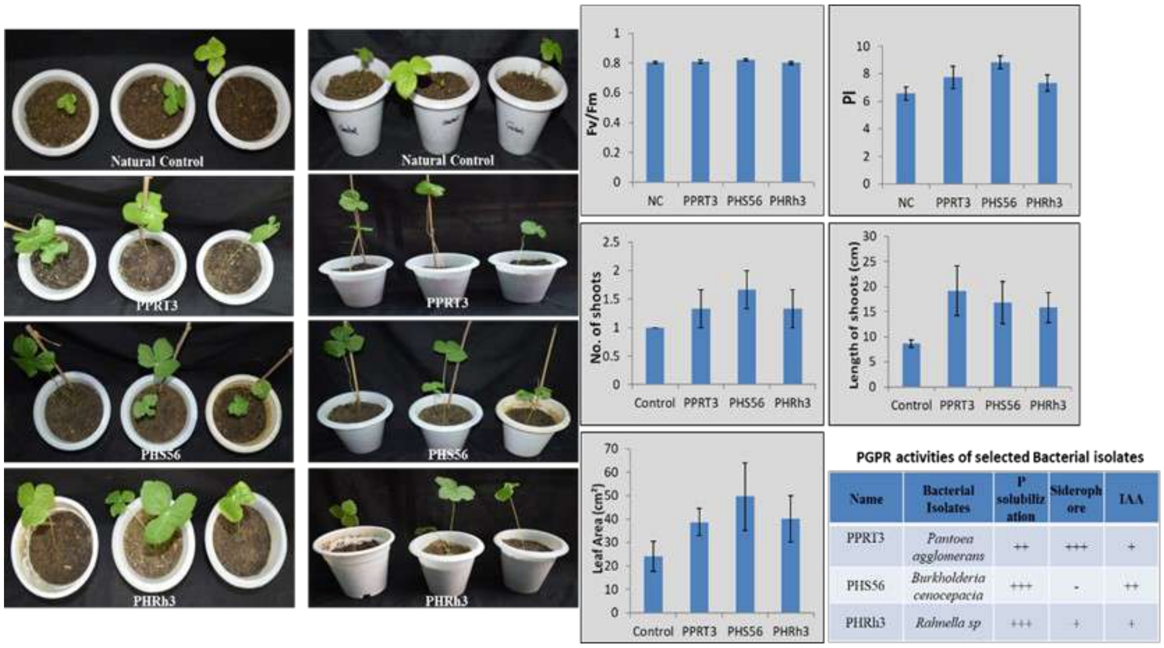


Fig. 3 Effect of selected fungal endophytes inoculation on growth of *Podophyllum hexandrum* plant (PPLFK2, PPLFK5, PPLFK6, PPRFT2 are the selected endophytic strains treated plants).



Name	Bacterial Isolates	P solubilization	Siderophore	IAA
PPRT3	*Pantoea agglomerans*	++	+++	+
PHS56	*Burkholderia cenocepacia*	+++	-	++
PHRh3	*Rahnella sp*	+++	+	+

Fig. 4 Effect of selected bacterial endophytes inoculation on growth of *Podophyllum hexandrum* plant. (PPRT3, PHS56 and RHRh3 are the selected endophytic strains treated plants).

endophytes have been molecularly identified. Isolated endophytes from *P. hexandrum* are being tested for the presence of plant growth promotion activities such as phosphate solubilization, siderophore production, production of 1-Aminocyclopropane-1-carboxylate deaminase (ACCD) and production of IAA (3-indoleacetic acid). Efficacy of selected endophytes to promote plant growth and secondary metabolite production of *P. hexandrum* is also being tested. Preliminary results demonstrated that some of the selected fungal (Fig. 3) and bacterial (Fig. 4) endophytes inoculation could improve the growth of *P. hexandrum* plants.

Genome-editing for crop improvement (CIMAP, IHBT, NBRI, IIIM, NEIST, NCL, CFTRI, CCMB) MLP-0170

Under this project, CSIR-IHBT is working on genome-editing of *Camellia sinensis*. The long period of juvenility (6-10 years), self-incompatibility, high inbreeding depression, differences in time of flowering and fruit-bearing capability, and the low success rate of hand pollination in *C. sinensis* limited the application of the conventional breeding approach for the improvement of quality of tea. Therefore, genome editing using CRISPR/Cas9 is a promising and effective approach for tea quality improvement. Silencing of genes encoding polyphenol oxidase (*PPO*) regulate browning during tea processing, and caffeine synthase (*TCS*) responsible for caffeine content in tea are targeted. Bioinformatic analysis of the targeted genes revealed the presence of multiple genes encoding caffeine synthase and polyphenol oxidase in *C. sinensis*. Therefore, primers were designed using the available sequences in nucleotide database, and PCR amplification of the *TCS* (~1100 bp) and *PPO* (~1800 bp) genes from the selected tea cultivars (Him Sphurti, UPASI-9, TV23, Kangra Asha) were performed. The amplified *PPO* and *TCS* genes were cloned into the pGEM-T Easy vector, and PCR and restriction digestion confirmation were performed. The cloned genes were further sequenced and the obtained sequences were analysed using the Bioinformatics tools. The obtained sequences of the *TCS* and *PPO* genes were further used for designing the gRNA to silence the target genes in the selected *C. sinensis* cultivars. The obtained sequences were further analysed using the CHOPCHOP web tool to identify the optimum gRNAs for our study. The selected gRNAs were further analysed using the Cas-OFFinderalgorithm to find out any possible off-targets. A total of three gRNAs were selected to silence the *TCS* gene and three gRNAs were selected for the *PPO* gene. The selected gRNAs were synthesized and cloned into the CRISPR/Cas9 binary vector pKSE401. These CRISPR/Cas9 constructs were transformed in to the *Agrobacterium* strain GV3101 that are being further used for the transformation of the selected tea cultivars. Transformation of selected tea cultivars (Him Sphurti, UPASI-9, TV23, Kangra Asha) is in progress (Fig. 5).

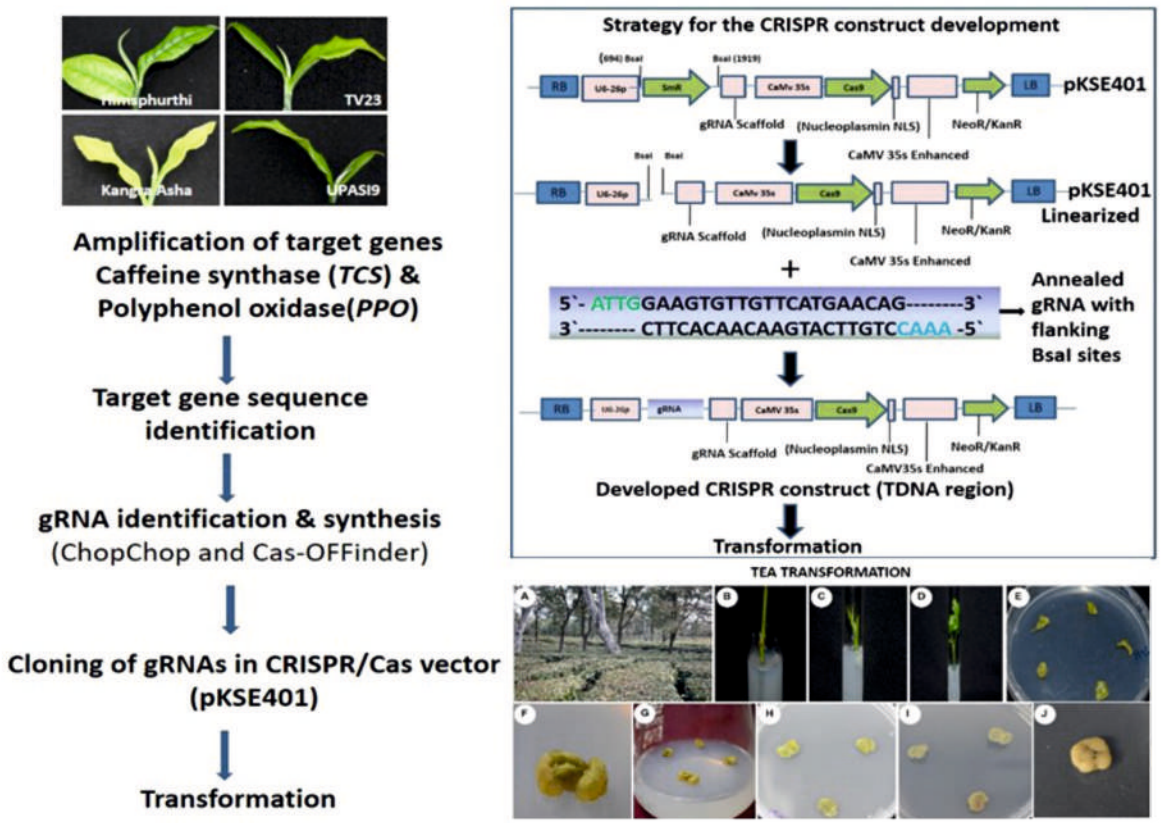


Fig. 5 Strategy for silencing of targeted genes using CRISPR/Cas approach in *Camellia sinensis*.

STATE GOVERNMENT SPONSORED PROJECTS

PRODUCTION OF HEENG IN HIMACHAL PRADESH - A NEW APPROACH (RNS)

Principal Investigators: Dr. Ashok Kumar
Co-Principal Investigators: Dr. Sanatsujat Singh, Dr. Ramesh and Dr. Rohit Joshi
Project Associate: Mr. Ravi Kumar

Cultivation of *Heeng* in Himachal Pradesh- A new approach

F. assa-foetida (*Heeng*) is one of the medicinal and spice plants for which India is completely dependent on imports. Recognizing its importance, sixty more accessions of *Heeng* were introduced through ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi. After overcoming the seed dormancy, seedlings were raised in the controlled conditions at CSIR-IHBT, Palampur. Further during this year, field trials were conducted in two new districts *i.e.* Kullu and Chamba of Himachal Pradesh along with Lahaul & Spiti, Mandi, Kangra, Kinnaur district in collaboration with State Department of Agriculture, Himachal Pradesh. A total of 10 seed production centers were established at Lahaul & Spiti (2), Kangra (CSIR- IHBT, Palampur) (1), Mandi (2), Kinnaur (2) and Chamba (2) and Chamoli (1). A total of 28603 *Heeng* plants were distributed in Lahaul & Spiti (12801 plants), Mandi (4800 plants), Kinnaur (6252), Kullu (2350), Chamba (2400 plants) districts of Himachal Pradesh. The cover an area of 4.29 ha under *Heeng* cultivation.

A capacity-building program was organized for officers of the State Department of Agriculture from 20-24 September 2021. Additionally, a total of 17 training program on *Heeng* cultivation were organized during the session and 290 farmers were trained. The first "*Heeng* Germplasm Resource Centre" of the country established at CSIR-IHBT, Palampur, was inaugurated by Dr. Shekhar C. Mande, Secretary DSIR & Director General, CSIR, Govt. of India on 5th March 2022.

Vehicle loaded with *Heeng* saplings for Kinnaur (H.P.)

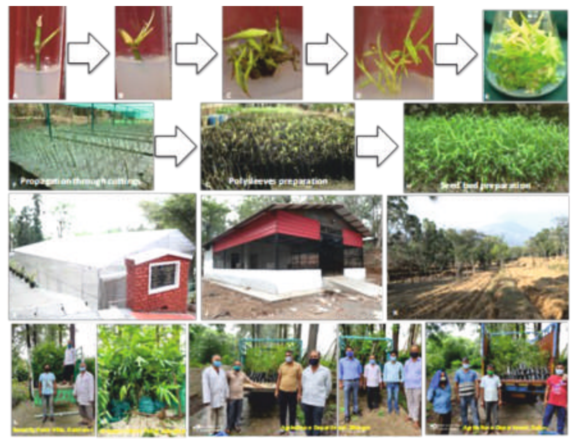
Capacity building program at CSIR-IHBT, Palampur

ESTABLISHMENT OF SMALL AND HI-TECH NURSERIES OF BAMBOOS AT CSIR-IHBT, PALAMPUR UNDER RESTRUCTURED NATIONAL BAMBOO MISSION IN HIMACHAL PRADESH

Principal Investigator: Dr. Gireesh Nadda
Co-Principal Investigators: Dr. Amita Bhattacharya, Er. K.K. Singh, Dr. Rohit Joshi and Dr. Jeremy Dkhar

Bamboos are evergreen, inexpensive and renewable material, which can be used as a substitute for expensive timber or wood, and hence is termed as "the green gold of India". Under National Bamboo Mission, department of Agriculture, Himachal Pradesh has sanctioned a project (amount = 64.80 lakhs) entitled "Establishment of Small and Hi-Tech Nurseries of Bamboos at CSIR-IHBT, Palampur". In this project we have developed a small nursery (area= 0.5ha) with potting shed and Hi-Tech nursery (area=2.0 ha) at CSIR-IHBT. Further, we are commercially propagating different bamboo species i.e., *Dendrocalamus hamiltonii, Dendrocalamus strictus, Dendrocalamus asper, Dendrocalamus balcoa, Dendrocalamus giganteous, Bambusa nutans, Bambusa multiplex* and *Phyllostachya aurea* through cuttings, layering and seeds under National Bamboo Mission. In addition, we are standardizing protocols for commercial propagation of *Bambusa tulda, Dendrocalamus giganteus* and *Phyllostachys edulis*. Moreover, we have generated an ECF amounting to Rs. 4.8 lakhs through the supply of 12000 vegetatively propagated bamboo plants and 250 tissue culture developed flasks (each flask contains approximately 10-15 plantlets) to different agencies under National Bamboo Mission.

We also signed Material Transfer Agreements on supply of bamboo plants with Punjab Agriculture University, Ludhiana; KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Kerela and M/s Future Grapes Plantech Pvt. Ltd. Further,



Commercial scale propagation of bamboos through tissue culture (A-E), Cuttings (F), Seedlings (G) and Seeds (H). Development of Hi-Tech Green House, Potting shed and 2.0 ha land preparation under National Bamboo Mission. Supply of bamboo plants to government agencies and other planters (L-O).

CSIR-IHBT has published two books on bamboo resources available at the Institute. These books entitled "Bamboo Resources of CSIR-IHBT-Volume I" and "सीएसआईआर-आईएचबीटी की बाँस संपदा" contain descriptions of various bamboo species available at CSIR-IHBT, information details on scientific names, vernacular names, habitat, origin, and their economic uses. In addition, this book provides brief information on some interesting facts and folklores related to bamboos. Both of these volumes are expected to provide valuable information to students, scientists, teachers, foresters, visitors, tourists, and entrepreneurs interested in bamboo.

TECHNICAL AND HAND HOLDING SUPPORT BY CSIR-IHBT PALAMPUR FOR SAFFRON PRODUCTION

Principal Investigator: Dr Rakesh Kumar
Co-Principal Investigator: Dr Rohit Joshi
Research group: Dr Robin Joshi, Mr. Deepak Kothari and Ms. Neha Chaudhary

Saffron (*Crocus sativus* L.), an important spice for Indian cuisines mainly grown in parts of Jammu and Kashmir. The country has an annual domestic demand of 100 tonnes of it, but produces only 13.2 tonnes per year. Year on year the import of saffron in India grew by 88.53% during 2014 to 2018. A major constraint in large scale cultivation of saffron is the scarcity of disease-free planting material; considering the constraints, CSIR-IHBT developed a tissue culture protocol for production of disease-free corms.

The institute's efforts in promoting cultivation of saffron in the state to enhance the livelihood of farming communities have been widely acclaimed at the state level. Hon'ble Chief Minister of Himachal Pradesh, Shri Jai Ram Thakur, in his budget speech, on March 6, 2020, highlighted the efforts of CSIR-IHBT on introduction and cultivation of saffron in the state. Consequently, two megaprojects have been funded in the form of "Technical and hand holding support by CSIR-IHBT, Palampur for saffron and heeng production". In this context, MoU was signed on June 6, 2020 between CSIR-IHBT and Department of Agriculture, HP for saffron corm production, and establishment of seed production chain for cultivation of heeng at commercial scale within the state. The progress made under these projects has been summarized hereunder.

Quality planting material (3581 kg corms) was supplied to the agriculture department for distribution among the farmers of 6 districts *viz.*, Mandi, Chamba, Kullu, Kinnaur, Kangra, and Lahaul & Spiti (Table 1&2). A total of two ha area have been covered till date under saffron cultivation at the villages under the above mentioned districts. Time to time monitoring of the crop at different growth stages is being done by the agricultural officers of department of agriculture. The saffron samples obtained from different locations were analyzed for quality evaluation (Table 3). Picrocrocin and crocin contents were highest in Holi, Chamba, while safranal content was higher in Kalpa, Kinnaur.

Table 1 Detail of saffron corms (seed) distribution to Agriculture Department, Govt. of HP during 2021 under the saffron project

S.No	District	Saffron corms (kg)	Date
1	Kinnaur	840	28.08.2021
2	Chamba	840	13.09.2021
3	Kangra	140	28.09.2021
4	Mandi	840	01.10.2021
5	Kullu	691	15.09.2021 & 01.10.2021
6	Lahaul &Spiti	230	30.09.2021
	Total	3581	

Table 2 List of the blocks and villages of various districts of Himachal Pradesh where corms have been distributed by agriculture department for saffron plantation in 2021.

Sr. No.	District	Block	Number of Farmer
1.	Kinnaur	Nichar Kalpa	22
2.	Chamba	Bharmour Salooni Tissa	14
3.	Kullu	Sarahan Tharla Chamarna	7
4.	Mandi	Seraj	6
5.	Kangra	Nalhota Kothi Kohar Chougan	12
6.	Lahaul & Spiti	Darcha Koksar Udaipur	17

Corm plantation of saffron and flowering at Kinnaur and Bharmour

Table 3 Chemical analysis of saffron cultivated in different locations of HP

Locations	Picrocrocin (µg/100mg)	Crocin (µg/100mg)	Safranal (µg/100mg)
Sangla, Kinnaur	143.669	7128.385	8.578
Kalpa, Kinnaur	232.586	6250.153	10.039
Nirmand, Kullu	231.657	5406.741	9.904
Seraj, Mandi	170.057	2740.680	4.782
Tyari, Holi, Chamba	253.224	7561.072	9.213
Chota Bhangal, Kangra	148.075	4651.367	8.937

On farm training of progressive farmers

Training cum capacity building programmes for the progressive farmers of district Kullu, Kinnaur, Mandi and Chamba were conducted by team CSIR IHBT along with Department of Agriculture, H.P. Government (Table 4).

Table 4 Detail of training cum capacity building programs for the progressive farmers

Sr. No.	Date	Village	Distt.	Number of Farmers
1	23.06.21	Nirmand	Kullu	25
2	25.06.21	Sangla	Kinnaur	20
3	26.06.21	Reckongpeo	Kinnaur	16
4	30.11.21	Bagsiad	Mandi	56
5	22.02.22	Holi	Chamba	48
6	23.02.22	Chamba	Chamba	24
			Total	**189**

Training program at Nirmand, Kullu

Training program at Sangla, Kinnaur

Training program at Reckongpeo

Training program at Bagsiad, Mandi

Field visit by scientist CSIR-IHBT and agriculture department officials at Holi, Chamba

Training program at Chamba

Saffron (corms) planting material

Production and distribution of saffron corms to different districts of HP

Training of agriculture officers at CSIR-IHBT

Five days' capacity building programmes for the agricultural officers on production technology of saffron was organised in IHBT from July 20-24, 2021. Twelve officers (AEO, ADO, SMS) from district Chamba, Kinnaur, Kullu, Kangra and Lahaul& Spiti participated in the program. In this program, the emphasis was given on agro techniques right from sowing, site selection, soil sampling, plantation, plantation techniques, nutrient management, weed management, insect pest management, harvesting, storage, packaging, and post-harvest management of saffron.

Practical exposure of agriculture officers to saffron farming

Visit of Sh. Virender Kanwar, Minister of Agriculture, Rural Development, Panchayati Raj, Animal Husbandry & Fisheries, H.P Government to review the progress of saffron and Heeng projects at CSIR-IHBT

Review meeting of saffron and Heeng projects by The Director, CSIR-IHBT and Director of Agriculture, Govt. of HP on August 23, 2021

INTRODUCTION OF APPLE CROP IN NORTH EAST PROJECT IN COLLABORATION WITH NERCORMP

PROMOTION OF LOW CHILLING APPLE PLANTATION IN NORTH EASTERN REGION OF INDIA

Principal Investigator: Dr. Rakesh Kumar
Research group: Dr. Kiran Singh Saini

Apple (*Malus x domestica* Borkh.) is a deciduous tree of Rosaceae family that originated in western Asia and is now one of the most widely cultivated fruit tree. World apple production is mainly located in temperate areas in which medium to high chill cultivars are widely growing. Low-chilling apple cultivars have high adaptation and adequate productivity in warm-winter areas, where traditional cultivars fail to produce a regular annual yield. In continuation to the previous year's activity, to promote apple cultivation in North Eastern states, this year CSIR-IHBT supplied 35,000 rooted plants of six low chilling varieties of apple.

North East Council funded a project to CSIR-IHBT for bringing 55 acres of area under low chilling varieties in Arunachal Pradesh and Meghalaya. A consultancy project entitled **"Promotion of low chilling apple plantation in North Eastern Region of India"** by CSIR-Institute of Himalayan Bioresource Technology, Palampur for North Eastern Region Community Resource Management Society (NERCRMS) was initiated during September 2021. Six low chilling varieties *viz.*, Anna (400 h), Dorsett Golden (350 h), Red Fuji (500-600 h), Gale Gala (600 h), Scarlet Gala (600 h) and Granny Smith (400 h) were supplied to North East region as per the detail given in the Table 1. The virus free root stocks (MM 793, MM111, MM106, and M7) of these varieties were raised though tissue culture technique and then grafted with the suitable variety. Root stock has been used for raising the plant. Glimpses of project activities are shown in Fig. 1.

Table 1 Detail of low chilling varieties of apple supplied to North East

S. N.	Variety Name	Root Stock	No. of Plants	Plant Total
1	Anna	MM111	4000	12000
2	Anna	MM111	500	
3	Anna	M7	2200	
4	Anna	M7	1300	
5	Anna	M793	1000	
6	Anna	M793	3000	
7	Dorsett Golden	MM111	3400	9000
8	Dorsett Golden	MM111	600	
9	Dorsett Golden	M7	1200	
10	Dorsett Golden	M7	800	
11	Dorsett Golden	M793	3000	
12	Red Fuji	MM111	2000	6000
13	Red Fuji	MM106	1400	
14	Red Fuji	MM106	100	
15	Red Fuji	M793	2400	
16	Red Fuji	M793	100	
17	Gale Gala	MM111	400	1000
18	Gale Gala	MM111	100	
19	Gale Gala	M793	400	
20	Gale Gala	M793	100	
21	Scarlet Gala	MM111	2000	4000
22	Scarlet Gala	M793	1400	
23	Scarlet Gala	M793	600	
24	Granny Smith	MM111	1600	3000
25	Granny Smith	MM111	400	
26	Granny Smith	M793	1000	
Total				**35000**

Packaging and forwarding of planting material

Loading of planting material

Flagging off of planting material to North East by The Director, CSIR-IHBT, Palampur

Fig. 1 Packaging and supply of low chilling varieties of apple to North East

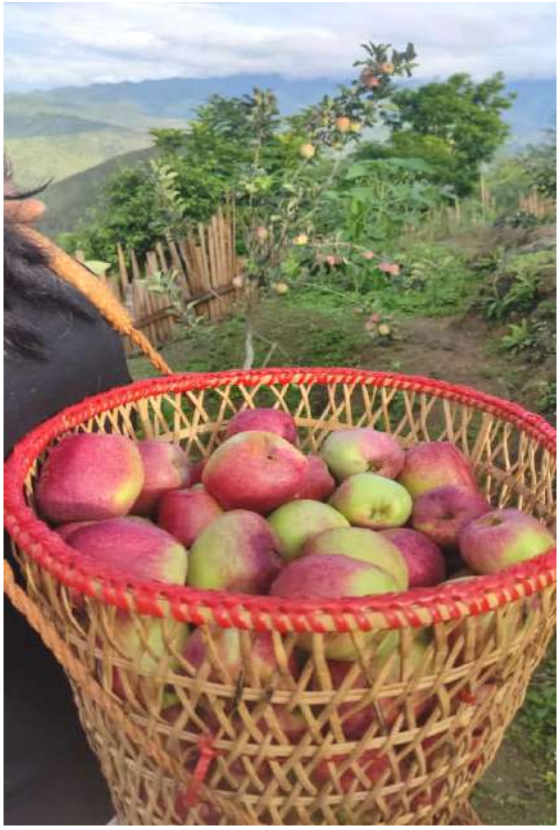
Apple success story in North East applauded by Hon'ble PM, India and CM of Manipur

Apple plants planted earlier during 2016 to 2021 have started bearing fruits in different states *viz.*, Mizoram, Manipur, Meghalaya. One of our apple beneficiary farmer Ms Awungshi Shimray Augustina received recognition and award from Hon'ble CM of Manipur, Sh. N. Biren Singh on June 29, 2021. Hon'ble Prime Minister Narendra Modi in his 'Mann Ki Baat' on July 25, 2021 address praised the agricultural innovations that have taken place in the North-East states over the passage of time. He said, "Nowadays, apple cultivation is gaining traction in Ukhrul, Manipur. Farmers here are now cultivating apples in orchards. He said that "Filled with the zeal to do something new, the youth of Manipur has accomplished this deed. The farmers here are now cultivating apples in orchards. These people also went to Himachal to take proper training for apple farming. One of them is Ringphami Thingshung, an aeronautical engineer by profession. He along with his wife Angel Thingshung has cultivated the apples. Prime Minister Modi further added, "Similarly, Awungshi Shimray Augustina has also cultivated apple orchard. Awungshi was having a job in Delhi but left her job and returned to her village and started apple cultivation. There are many such apple cultivators in Manipur who have accomplished something different and new."

Mizoram

Happy farmers with harvested fruits

Apple in Champhai, Mizoram



Apple in Ukhrul, Mizoram

Apple in Meghalaya

Apple farmer in Manipur

Presentation of apple to Hon'ble CM of Manipur by one of apple beneficiary from Ukhrul district.

PROJECT FROM SCHEME OF FUND FOR REGENERATION OF TRADITIONAL INDUSTRIES (SFURTI) CLUSTERS UNDER THE MINISTRY OF MICRO SMALL & MEDIUM ENTERPRISES (MoMSME)

DISSEMINATION OF SCIENTIFICALLY VALIDATED TECHNOLOGIES THROUGH MSME CLUSTERS TO GENERATE SUSTAINABLE EMPLOYMENT IN RURAL SECTOR

Principal Investigators: Dr. Bhavya Bhargava and Dr. Rakshak Kumar

Gondhla & Shansha Cut Flower Cluster

Under Ministry of Micro Small & Medium Enterprises (MoMSME) Scheme of Fund for Regeneration of Traditional Industries (SFURTI) scheme two cut-flower clusters in Lahual & Spiti district of Himachal Pradesh has been approved by the ministry. A total of 350 farmers will be benefited from these clusters. To strengthening the cool chain of lilium bulbs and flowers, both clusters will play a vital role in the economy of tribal region. In the cluster CSIR-IHBT and Foundation for MSME clusters (FMC) are the Technical Nodal agency. Whereas the Lahaul Fruits and Vegetables Growers Co-operative Marketing Society Limited and The Rattan Jot Chandra Valley Seabuckthorn, Floriculture, Aromatic, Fruit & Vegetables, Medicinal Plants, Milk and Milk Producers Cooperative Marketing & Processing Society Ltd., Lahaul are registered as Implementing agency. The clusters were formed with the objective to promote Lilium cultivation in 34 villages in Keylong block of the Lahual & Spiti district of Himachal Pradesh. Gondhla cluster will be operational in May 2022 while Shansha cluster will be operational in August 2022. The following objectives will be met through these clusters:

- To make lilium growers more competitive, productive and profitable with development of cool chain system for regulation of lilium bulbs and cut-flower production
- Introduction of new techniques in grading, washing, storing and packing for improved productivity and quality
- To build up innovated skills, market intelligence and new models of public-private partnerships
- To upgrade the skill sets of farmers related to cut flower, whose market demand is ever increasing so as to match the requirements of major retail chains, exporters and changing tastes of customers.

Common Facility Centre (Gondhla Cut-flower cluster)

CFC Construction site of Shansha cut-flower cluster

Washing, grading and sorting conveyors

Cold Storage facility

Launch workshop of Shansha cut-flower cluster

Training program at Khinning, Lahaul

PROJECT SPONSORED BY
NATIONAL MISSION
ON HIMALAYAN STUDIES

PROMOTING CONSERVATION OF DECLINING LIFE SUPPORT FOREST TREE SPECIES IN HIMACHAL PRADESH

Co-ordinator: Dr. Sanjay Kumar
Principal Investigators: Dr. Sanjay Kr. Uniyal and Dr. Vikas Kumar
Research group: Ms. Aradhana Bharti and Mr. Rishabh Sharma

Promoting Conservation of Declining Life Support Forest Tree Species in Himachal Pradesh

Recognizing the importance of trees in ecological sustenance and human livelihood, and their declining status; the institute is coordinating a project titled "Promoting Conservation of Declining Life Support Forest Tree Species in Himachal Pradesh". Through this coordinated project, efforts are on the revival of prioritized multipurpose tree species viz., *Corylus jacquemontii, Juglans regia, Taxus wallichiana* and *Ulmus wallichina*. The project is being funded by the National Mission on Himalayan Studies being implemented by the Gobind Ballabh Pant National Institute of Himalayan Environment, Almora.

The project involves four partner institutes/organizations namely the State Forest Department, HP; Himalayan Forest Research Institute, Shimla; Dr. YS Parmar University of Horticulture and Forestry, Solan; and CSIR-IHBT. The latter being the overall coordinator.

It primarily aims at documenting current status of the prioritized species, establishing nurseries of the species, greening of landscape through plantations, and awareness creation and outreach. For this, primary field surveys have been carried out in Kangra, Mandi, Chamba, and Lahaul & Spiti districts. Also, plant nurseries have been established in Mandi and Solan districts. Distribution of the species have been recorded along with their uses (Fig. 1 & 2).

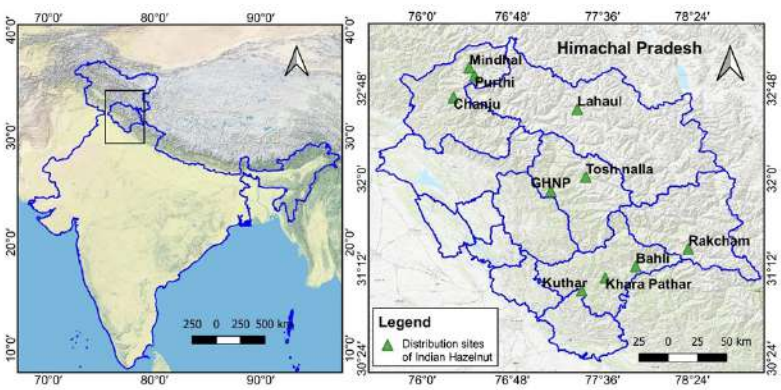


Fig. 1 Distribution sites of *Corylus jacquemontii* in Himachal Pradesh.

Fig. 2 Fruits of *Ulmus wallichiana*.

INDIAN HIMALAYAN CENTRAL UNIVERSITIES CONSORTIUM AS APPROVED BY THE NITI AAYOG

AGRO-ECOLOGY IN HIMALAYAN STATES WITH SPECIAL EMPHASIS ON MARKETING

Co-ordinator: Dr. Sanjay Kumar
Principal Investigators: Dr. Sanjay Kr. Uniyal, Dr. Sanat Sujat Singh and Dr. Sukhjinder Singh

Agro-ecology in Himalayan states with special emphasis on marketing

The "Indian Himalayan Central Universities Consortium" (IHCUC) was formed and supported by the NITI Aayog. The IHCUC focussed on the Indian Himalayan Region (IHR) wherein the following five thematic areas were identified for prioritized studies:

- Enumeration and valuation of the economic impact of Female labour in the Hills
- Agro-ecology in Himalayan states with special emphasis on marketing
- Development of eco-friendly and cost effective tourism in hills
- Opportunities of livelihood to check migration from hills
- Water conservation and harvesting strategies

The IHCUC comprised of the Central Universities located in the IHR, namely Assam University, Silchar, Central University of Himachal Pradesh, Central University of Jammu, Central University of Kashmir, HNB Garhwal University, Manipur University, Mizoram University, Nagaland University, North Eastern Hill University, Rajiv Gandhi University, Itanagar, Sikkim University, Gangtok, Tezpur University, Tripura University. Herein the CSIR-IHBT was identified as the technology partner (Fig. 1) and co-ordinated the thematic area "Agro-ecology in Himalayan states with special emphasis on marketing".

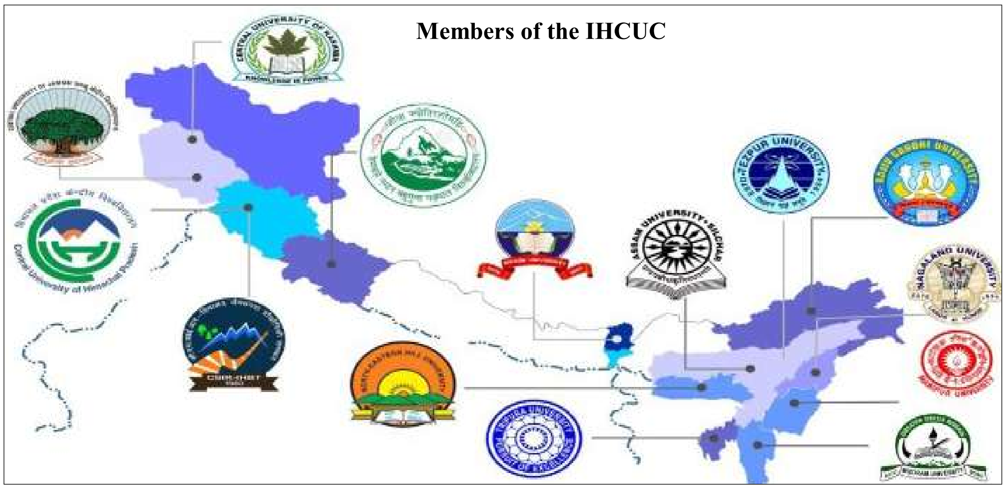


Fig. 1 Members of the IHCUC.

The CSIR-IHBT provided technological interventions for societal development in the IHR and made detailed presentations on the technologies available with it and their relevance to the IHCUC. Through this, niche Himalayan products, their markets, and value chains were identified. CSIR-IHBT prioritized activity flow (Fig. 2) towards the promotion of same and presented it to the IHCUC (Fig. 3).

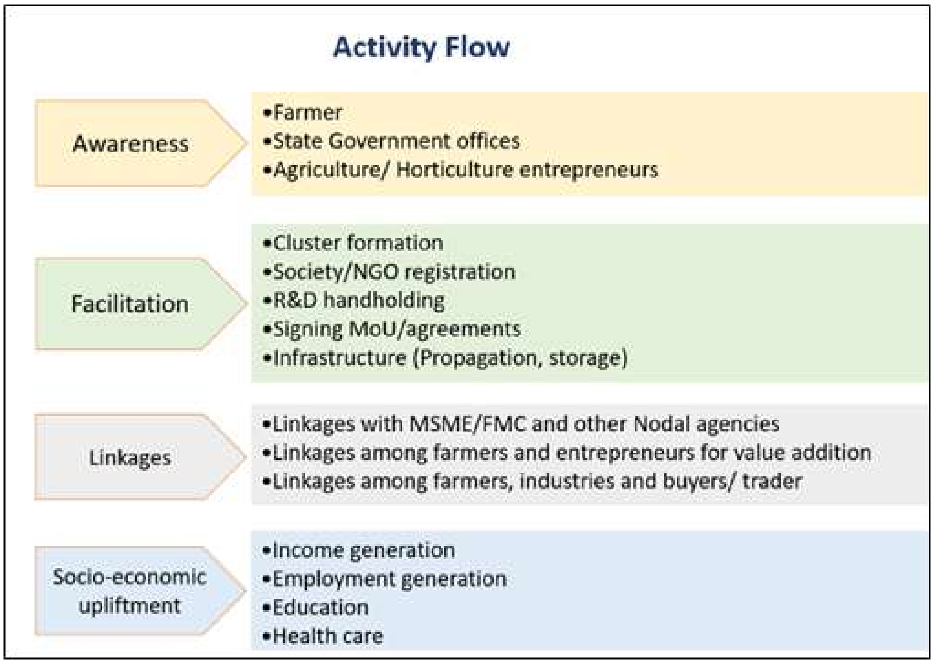


Fig. 2 The proposed flow of activities suggested by the Institute.

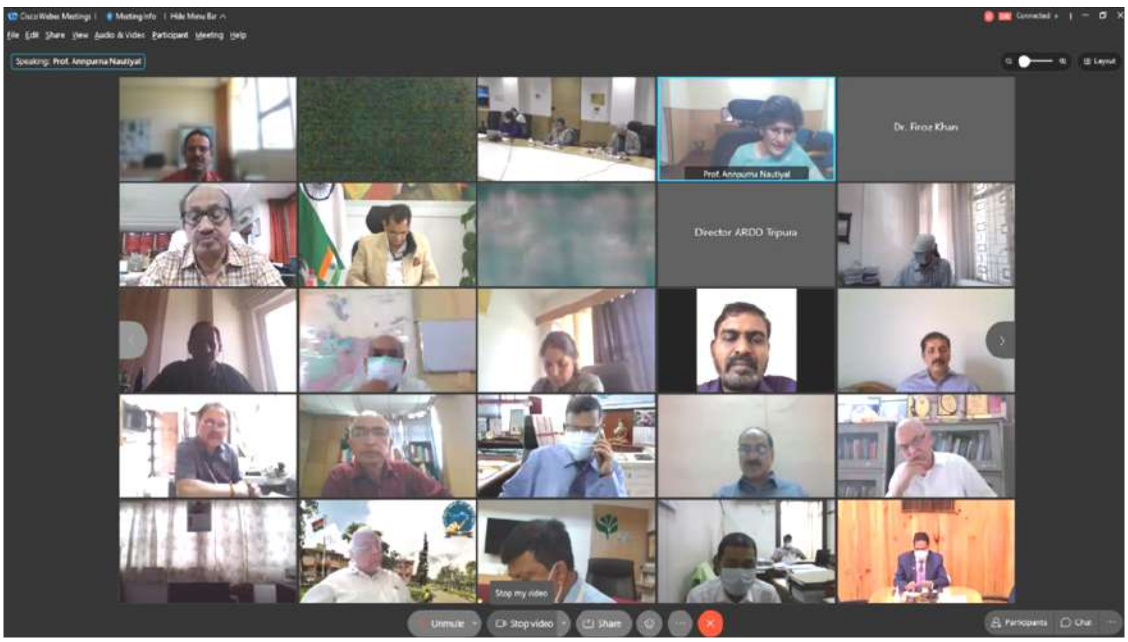


Fig. 3 Group meeting of the IHCUC.

EFFORTS TOWARDS MANAGEMENT OF COVID-19

COVID-19 TESTING FACILITY

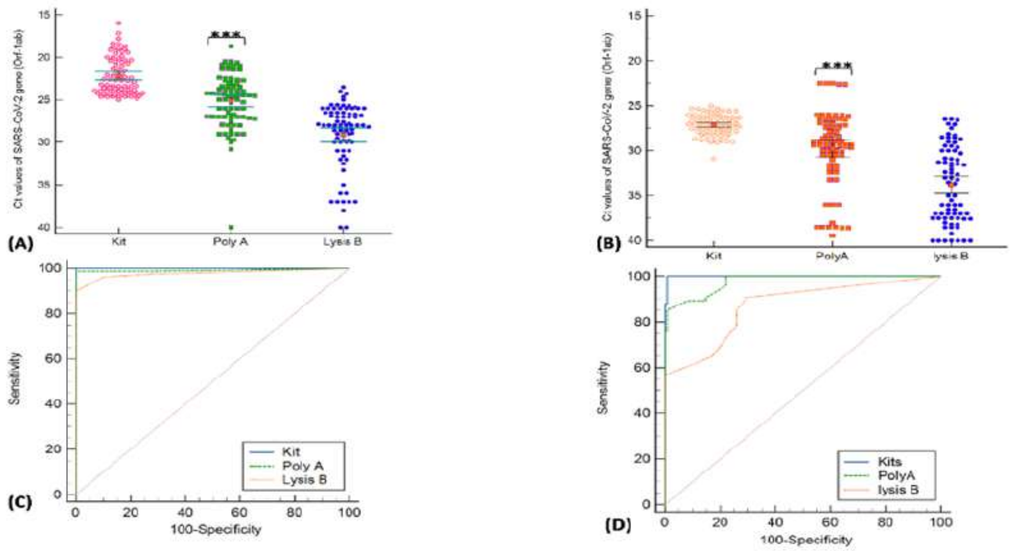
Principal Investigator: Dr. Yogendra Padwad
Co- Principal Investigators: Dr. Vipin Hallan and Dr. Narendra Vijay Tirpude
Research group: Arun Kumar, Dr. Anish Kaachra, Mr. Girja Nand, Dr. Arbind Kumar, Dr. Varun Chauhan, Dr. Sharad Thakur, Dr. Aashish Sharma, Mr. Naveen Prakash Bokolia, Mr. Sahdev Chaudhary, Mr. Lal Chand Pal, Mr. Suresh Kumar, Miss. Kumari Anu, Ms. Priti, Mr. Pardeep Kumar and Mr. Shakeel Ahmad Tantary

To meet the requirements of testing for the state of Himachal Pradesh and to fulfil the requirements of accurate and faster diagnosis, institute created Indian Council of Medical Research recognised RT-PCR based COVID-19 testing facility in its premises that started working from 22 April 2020. Later institute upgraded its facility for even COVID 19 sequencing and related basic and applied research. In the year 2021-2022, second and third waves of COVID-19 were highly transmissible and fatal, and during that time the facility tested approximately 97000 samples from different blocks of Kangra and Una districts of Himachal Pradesh, that helped to contain and mitigate the risk of pandemic.

To help state identify continuously mutating strains of COVID-19 virus, CSIR IHBT also contributed to sequencing of SARS CoV-2. CSIR IHBT utilised high throughput sequencing facility (Illumina NOVASEQ 6000) and portable DNA sequencer, MinION of Oxford Nanopore Technologies Limited. CSIR-IHBT sequenced more than 400 samples from first and second wave of the pandemic.

Development of a rapid, one step real time RT-PCR test to detect the SARS-CoV-2

Real-time reverse transcription polymerase chain reaction detection of COVID-19 disease typically relies on RNA extraction steps. The goal of this study was to develop a method for a one-step real-time PCR test that



Variable	AUC	SE [a]	95% CI [b]
Kit	1.000	0.000	0.980 to 1.000
Poly_A	0.992	0.00798	0.965 to 0.999
Lysis_B	0.978	0.0116	0.945 to 0.994

[a] DeLong et al., 1988
[b] Binomial exact

Variable	AUC	SE [a]	95% CI [b]
Kits	0.999	0.000944	0.981 to 1.000
PolyA	0.976	0.00819	0.946 to 0.992
lysis_B	0.870	0.0258	0.817 to 0.913

[a] DeLong et al., 1988
[b] Binomial exact

Fig. 1 Comparative analysis of lysis alone with Poly A and developed direct to lysis solution for RT-PCR detection of SARS CoV-2.

avoids the routine RNA isolation steps. For the preparation of direct and rapid one-step real time RT-PCR lysis solutions, neutral detergents were used. To achieve optimal sensitivity and specificity, the conditions were optimized using different concentrations of carrier molecules. Diagnostic potential of this method was demonstrated using large sample size, and the sensitivity of the RT-PCR diagnostic test was estimated to be 0.986 (95%CI; 0.986±0.026, $p<0.005$) for group 1; CT =25 and 0.87 (95%CI; 0.872±0.070, $p<0.005$) for group 2; CT =25-30, with excellent accuracy (0.9 < AUC < 1.0), whereas, the specificity was 100% in both cases (Fig. 1). This strategy is feasible, and it could aid in the development of a quick, less time-consuming, cost-effective and allow a massive screening of samples in a minimum time.

Direct detection of SARS-CoV-2 variants located in the RBD domain region through real time-RT-PCR

A study was carried out to evaluate the utility of melt curve analysis for the rapid and direct detection of SARS-CoV-2 variantsin swab samples. The assay was validated in 70 clinically positive patient's swab samples. Variants were discriminated from the wild type by comparing melting-curve patterns, which was further confirmed by sanger sequencing.

Potent bioactive molecules from tea plant

A total of 65 bioactive molecules of Tea plant were screened, followed by exploration of the vast conformational space of protein-ligand complexes by long term molecular dynamics (MD) simulations to find the potential lead molecules against the Mpro (Membrane proteases) of SARS-CoV-2. Our studies corroborated that the interaction profiles were significantly higher with some of the selected molecules, showing higher MM-PBSA binding energy when compared to repurposed drug molecules. *In vitro* efficacy of theaflavin 3-gallate was evaluated and showed reduced viral count in dose dependent manner inhibition after incubation of SARS-CoV-2 (Fig. 2). *In vitro* efficacy evaluation was carried out at CSIR-Centre for Cellular and Molecular Biology, Hyderabad.

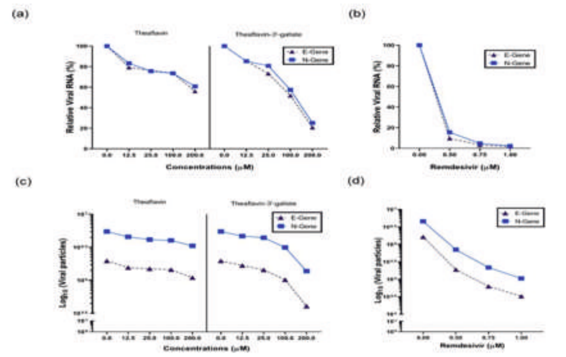


Fig. 2 Effect of theaflavin 3-gallate on the inhibition of SARS-CoV-2. Response to theaflavin (positive control), theaflavin 3-gallate and remdesivir (positive control) in Vero cells.

Pharmaco-immunomodulatory interventions forcytokine storm-linked disease severity inCoV-2 infection

Despite emergency vaccine approvals and subsequent global immunisation programmes in some countries, COVID-19 hospitalizations will continue to occur due to the SARS-CoV-2 virus's proclivity for mutation. Control and resolution of infectious diseases are dependent on the immune response. In many disorders, however, an aberrant immune response is the cause for the degree of respiratory discomfort. A cytokine storm triggered by a severe COVID-19 infection has been related to acute respiratory distress syndrome (ARDS), which leads to vital organ failure and death. Thus, safe and effective therapeutics to treat hospitalised patients remains a significant unmet clinical need. In that state, any clue of possible treatments, which save patient's life, can be treasured for this time point. Several cohorts and clinical trial studies showed that the timely administration of immunomodulatory drugs resulted in decrease risk of disease severity, hospital stay and mortality. This article addresses the severity and risk factors of cytokine syndrome linked with COVID-19 patients, with special emphasis on prospective immunomodulatory therapies (Fig. 3).

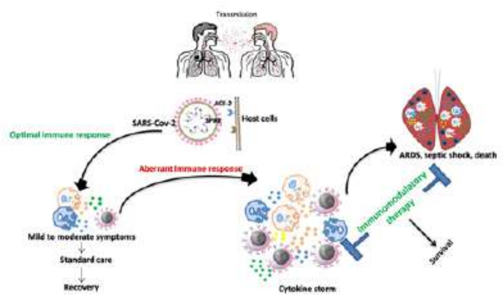


Fig. 3 Schematic representation of the pathological progression of COVID-19 towards ARDS and possible reinforcement of immunomodulatory therapy to combat COVID-CSS.

Combating the Progression of Novel Coronavirus SARS-CoV-2 Infectious Disease: Current State and Future Prospects in Molecular Diagnostics and Drug Discovery

The first case of SARS-CoV-2 infection was reported in animal market, Wuhan China in late 2019, causes a disease known as COVID-19. SAR-CoV-2 infection is linked with a severe acute respiratory syndrome, a respiratory illness. Asymptomatic patients silently spread the infections, therefore, massive screening is required to reduce the epidemic transmission of disease, and to identify and mitigate the risk associated with the COVID-19. The two most common methods for COVID-19 detection are real-time PCR, which depends on detecting viral genetic material (Fig. 4), and serological, which relies on detecting antiviral antibodies. To date, there are no effective COVID-19 prophylactics or therapies available. However, a few drugs have shown promising antiviral activity, got Emergency Use Authorization (EUA) by FDA for the emergency use for the treatment of SARS-CoV-2 infection. In this review, attempts were made to address the current progress, challenges and future prospects of laboratory detection methods of COVID-19, and highlights the clinical stage of the major evidence-based drugs/vaccines recommended against the novel SARS-CoV-2 pandemic virus.

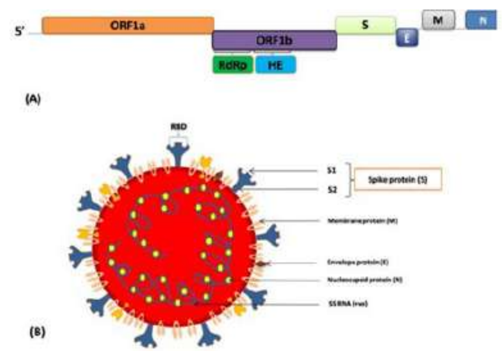
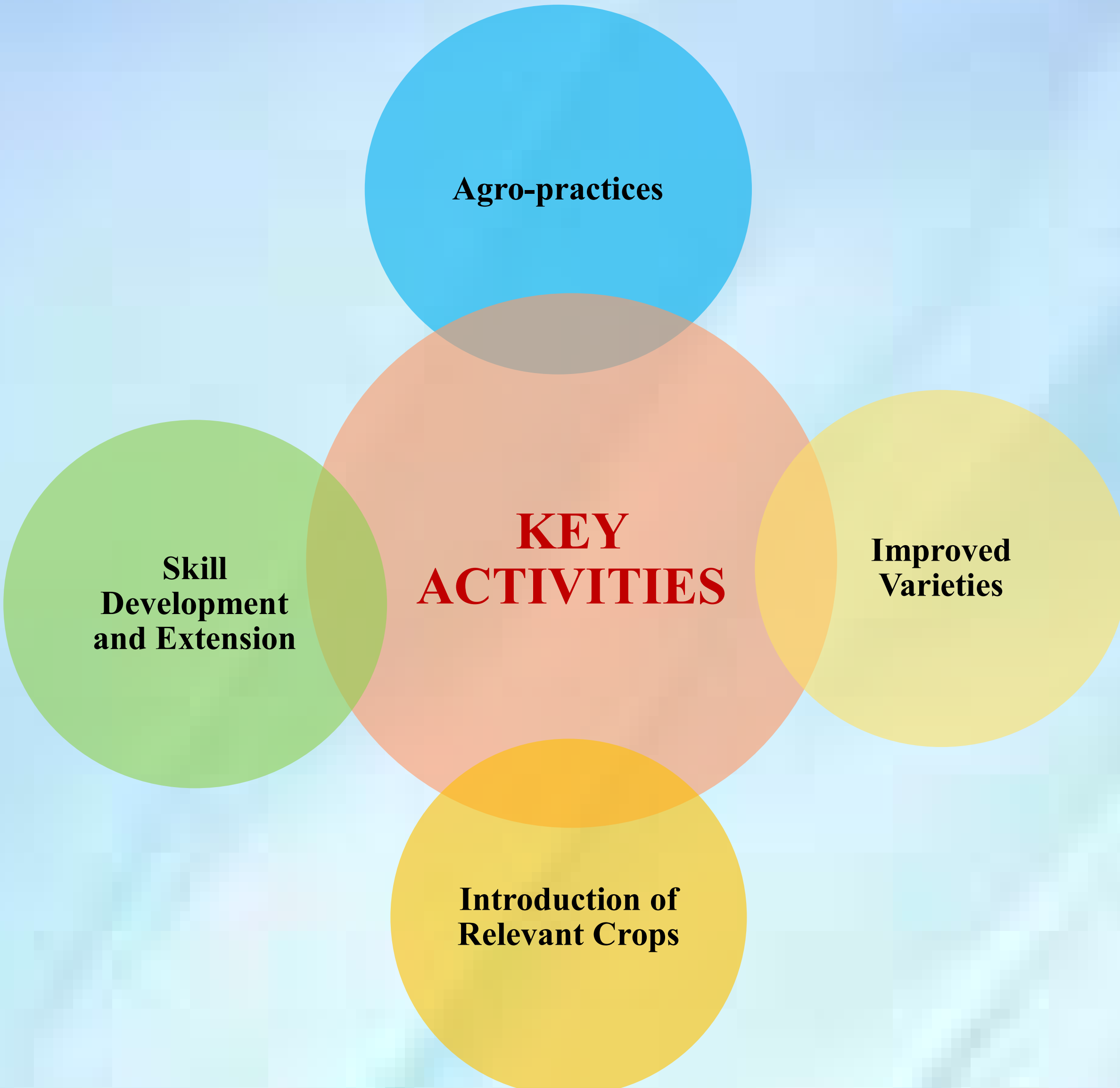


Fig. 4 (A) The genomic organization of SARS-CoV-2: (B) Cartoon Structure of SARS-CoV 2 Virus representing structural and non structural parts.

AGROTECHNOLOGY DIVISION



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Agrotechnology, Advisory and Extension,
Planning, Project Monitoring and Evaluation

TEA SCIENCE

Artificial intelligence based methodology for automatic grading of machine harvested tea leaves (Joint project with CSIR-CMERI)

Tea (*Camellia sinensis*) leaves harvested mechanically were studied in terms of thier shoot composition and grades. The various leaf samples of different grades of tea such as one leaf and a bud (1L+Bud), two leaves and a bud (2L+Bud), three leaves and a bud (3L+Bud), four leaves and a bud (4L+Bud) and five leaves and one bud (5L+Bud) were picked up from the mechanized tea harvesting plots at Banuri Tea Experimental Farm of the institute. These leaves were scanned using the prototype of tea leaves scanning system designed and developed by CSIR-CMEERI under this project (Fig. 1). These leaves were scanned considering different dimensions of leaves such as size, shapes, angles, etc., to simulate real time scenarios which might exist during the actual operation of the scanning system in the field condition.

A drill was made with the actual leaf samples and the real time conditions were simulated for factory conditions in which tea leaves are received from the tea growers and require segregations in its various grades. This visualisation was made in order to simulate the actual output as we expect from the tea leaves segregation AI model output. Leaves were simulated in such a way that they are

Fig. 1 Scanning of tea leaves using CSIR-CMEERI designed prototype scanning system.

Fig. 2 Simulation of tea leaves grading output of AI model.

being sorted through a segregation machine developed through an AI model (Fig. 2). The studies are underway.

Extension and Advisory serves for small tea growers in Himachal Pradesh

Extension activities were continued during this year also on the dissemination of improved agro-technology package from planting of improved clones to pruning, skiffing, plucking, spraying, etc. by both mechanical as well as manual means for achieving better productivity, quality and returns for the small tea growers in Himachal Pradesh. The detailed description of the activities undertaken has been given hereunder (Table 1).

Table 1. Advisory visits, field demonstrations & training on improved tea agro-technologies

Date	Tea Garden/Location	Details of the activity
02/04/2021	Tea Planters Association meeting at Technical Officer (Tea) campus, Palampur	Advisory on management of First tea flush to the tea growers of Kangra and Mandi area
06/04/2021	Darang Tea Estate, Kangra Distt.	Management of scale insects
03/05/2021	Tea Planters Association meeting, Palampur	Foliar application of the nutrients in the mechanized gardens
04/05/2021	Thandole, Palampur, Messarna tea area, Kangra Distt.	Management of scale insects and red spider mite
15/05/2021	Bhawarna tea area, Kangra Distt.	--do--
28/05/2021	Chauntra tea area, Mandi Distt.	Plucking management, drought management and mite control
02/06/2021	Kangra Valley Small Tea Planters Association Meeting, Kangra Distt.	IPM particularly red spider mite, plucking strategies and dormancy management
24/06/2021	Chambi TE and Kangra valley TE, Kangra Distt.	Plucking management and foliar sprays
29/06/2021	Dharmshala tea area, Kangra Distt.	Mite and other pest management
02/07/2021	Kangra Valley Small Tea Planters Association Meeting, Kangra Distt.	IPM & INM particularly in drought period and foliar application of nutrients
13/07/2021	Sullah and Bhadal Devi tea area, Kangra Distt.	Advisory visits for mechanized plucking management
02/08/2021	Kangra Valley Small Tea Planters Association Meeting, Kangra Distt.	Drainage & shade management, vacancy infilling etc.
04/08/2021	Thandole & Bhawarna tea area, Kangra Distt.	Vacancy infilling and shade management
02/09/2021	Kangra Valley Small Tea Planters Association Meeting, Kangra Distt.	Management of back-end tea flush
18/09/2021	Thandole area, Kangra Distt.	Management of young tea plantation
29/09/2021	Dharamshala TE, Towa TE area, Kangra Distt.	Management of back-end tea flush
02/10/2021	Kangra Valley Small Tea Planters Association Meeting, Kangra Distt.	Foliar application of nutrients, and importance of maintaining mother leaf at plucking table
05/10/2021	Chambi TE and Gopalpur area, Kangra Distt	Preparation of pruning cycle plan
06/10/2021	Sullah area, Kangra Distt.	Plucking demonstration
02/11/2021	Kangra Valley Small Tea Planters Association Meeting, Kangra Distt.	Preparation of pruning cycle plan
05/11/2021	Thandole and Masserna area, Kangra Distt.	Pruning cycle planning
08/11/2021	Saliana & Sullah area, Kangra Distt.	--do--
12/11/2021	Chambi & KV tea plantations area, Kangra Distt.	--do--

Date	Tea Garden/Location	Details of the activity
15/11/2021	Towa & Dharamshala tea area, Kangra Distt.	--do-
02/12/2021	Kangra Valley Small Tea Planters Association Meeting, Kangra Distt.	Planning of organising Kangra tea Fair at CSIR-IHBT with State Agriculture Deptt. & KVSTPA. Also awareness on pruning cycle & winter operation and use of mechanized pruners
09/12/2021	Banuri Tea Experimental Farm, CSIR-IHBT, Palampur	Demonstration of new planting using one man & two men earth auger machine
17/12/2021	Khalet Tea Estate, Kangra Distt	Plantation of 3000 young plants in newly developed tea sections, using improved clones.
03/01/2022	Kangra Valley Small Tea Planters Association Meeting, Kangra Distt.	Shade tree lopping & soil test procedure
21/01/2022	Thandole TE, Kangra Distt.	Advisory on winter operations
02/02/2022	Kangra Valley Small Tea Planters Association Meeting, Kangra Distt..	Mechanized skiffing operations – light skiff, medium skiff and Deep skiff, and scale insect management
15/02/2022	Darang tea area, Kangra Distt.	Mechanized skiffing demonstration
02/03/2022	Kangra Valley Small Tea Planters Association Meeting, Kangra Distt.	Fertilizer recommendation, calculation of fertilizer dosages and application methods

Planting of improved tea clones with better quality and return

Advisory services were extended for planting of improved tea at Khalet area, done after testing the soil for its suitability. About 3000 tea plants were planted with proper planting distance amenable for mechanical plucking in due course of time.

Celebration of Swarn Jayanti Tea Fair

CSIR-IHBT organized "Swaran Jayanti Tea Fair" with financial support from Govt. of H.P. at the institute's campus on 14th December 2021. The function was presided over by Hon'ble Minister Rural Development, Panchayati Raj, Agriculture, Fisheries and Animal Husbandry, Shri Virendra Kanwar, Govt. of H.P. In his address, Shri Kanwar assured to make provision for grants for equipment, machinery, etc. to the tea growers to give a new direction to Kangra tea. He appreciated the growers and institutes to promote Kangra tea, which is the heritage of the state. He assured to increase tea acreage, tea quality, and promote tea tourism. He also thanked CSIR-IHBT for its continuous R&D support for promoting this industry in terms of production, productivity, value addition and introducing high-value new crops viz. asafoetida, saffron, and daalchini in different agroclimatic zones. The Minister also assured to formulate a Tea Policy for strengthening the tea industry in the state. Dr. Ajay Kumar Sharma, (Secretary, Agriculture), Dr. Sanjay Kumar, (Director CSIR-IHBT), Sh. Rajender Thakur (Chairman, Co-operative Tea Factory Palampur) and Smt. Veena Srivastava (Member, Tea Board of India) also shared their views and opinion for the development of Kangra tea industry.

On this occasion technology of “Tea Based Herbal Formulation for Immunity Modulation” was transferred by the institute to M/s Ras Vaidyashala, Jobner, Jaipur (Rajasthan), under an agreement.

Honour/Other Activities

- Expert member for appointment of Head of Deptt., Tea Science in CSK HP Krishi Vishvavidyalaya, Palampur
- Chairman for the Selection Committee Group III staff of CSIR-IIIM, Jammu.
- Expert member for the assessment of technical staff of CSIR-CMCRI, Bhavnagar
- Expert member in the meetings of Kangra Valley Tea Planters Association
- Expert member in the meeting of Tea Office (Tea) of State Agriculture Department
- Member, Annual Review Meeting of Tea Board of India

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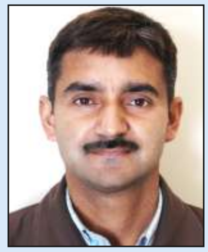
Plant Breeding



The present research work is focused on breeding efforts for the improved new varieties of aromatic crops under the CSIR-Aroma mission.

Evaluation of breeding lines of aromatic plants in multi-location trials *Salvia sclarea*

S. sclarea is popularly known as Clary sage, and is endemic to Himalayan region. In order to improve biomass yield and essential oil content in the flowers, a breeding programme has been undertaken to identify promising selections for commercial cultivation. Using half-sib progeny selection approach ten accessions of clary sage were evaluated in multi-location trials for flower yield and essential oil content at four locations for two years in comparison to population mean (μ) as control. Experiments were laid out in Randomized Block Design (RBD) with three replications. Results showed, CSIR-IHBT-SS-07 was significantly superior to control for flower yield and essential oil (Table 1).

Table 1. Mean variations for flower yield and essential oil content in *S. sclarea* accessions at different locations

Accessions	Flower yield (kg/plot)				Essential oil content (g/kg)			
	Sihunta	Bajaura	Palampur	Ribling	Sihunta	Bajaura	Palampur	Ribling
CSIR-IHBT-SS-01	6.21	6.29	5.53	5.04	1.82	1.41	1.37	1.33
CSIR-IHBT-SS-02	4.85	4.65	4.20	3.99	2.35*	2.45*	2.52*	2.47*
CSIR-IHBT-SS-03	4.28	4.12	3.80	3.25	1.28	1.39	1.58	1.54
CSIR-IHBT-SS-04	2.73	3.09	2.80	2.43	2.08	2.15	2.07	2.09
CSIR-IHBT-SS-05	3.65	3.74	3.18	3.00	2.12	2.16	2.34	2.14
CSIR-IHBT-SS-06	8.65	8.24	6.30	5.94	1.32	1.41	1.53	1.47
CSIR-IHBT-SS-07	10.26*	10.36*	10.26*	10.58*	2.27*	2.34*	2.32*	2.36*
CSIR-IHBT-SS-08	9.85	9.14	8.65	9.17	1.54	1.29	1.42	1.36
CSIR-IHBT-SS-09	7.94	7.84	5.82	5.41	1.35	1.34	1.45	1.39
CSIR-IHBT-SS-10	5.76	5.55	4.43	4.72	1.63	1.25	1.40	1.36
Control (μ)	6.41	6.30	5.49	5.35	1.77	1.71	1.79	1.75
S. E. (d)	0.049	0.255	0.083	0.093	0.073	0.079	0.077	0.082
C. D. (P=0.05)	0.104	0.536	0.174	0.195	0.154	0.166	0.161	0.173

*Significant

Pelargonium graveolens

P. graveolens is an aromatic plant which has high demand globally in manufacture of perfumes, colognes and cosmetics. To access productivity, eight clones with check (Bourbon) were evaluated for biomass yield and essential oil content for two years. Accessions were evaluated in RBD with three replications. Results showed that, CSIR-IHBT-PG-05 was significantly superior to check with respect to biomass yield and essential oil content (Table 2).

Rosmarinus officinalis

R. officinalis is an important essential oil bearing plant and to improve productivity, eight clones with check parent lines (CSIR-IHBT-RO-P1 and CSIR-IHBT-RO-P2) were evaluated for fresh biomass yield and essential oil content for two years. Accessions were evaluated in RBD with three replications. Results showed that CSIR-IHBT-RO-04 was significantly superior to

Table 2. Mean variations for biomass yield and essential oil content in *P. graveolens* accessions over different locations

Accessions	Biomass yield (kg/plot)				Essential oil content (g/kg)			
	Sihunta	Bajaura	Palampur	Ghumarwin	Sihunta	Bajaura	Palampur	Ghumarwin
CSIR-IHBT-PG-01	5.59	5.41	5.47	5.53	0.83	0.91	1.00	1.09
CSIR-IHBT-PG-02	5.01	5.00	5.16	5.31	0.83	0.88	0.93	0.98
CSIR-IHBT-PG-03	3.08	3.17	3.25	3.33	0.92	1.07	1.22	1.37
CSIR-IHBT-PG-04	4.47	4.46	4.43	4.39	0.92	0.85	0.77	0.70
CSIR-IHBT-PG-05	6.69*	7.74*	6.80*	7.46*	1.48*	1.62*	1.44*	1.26*
CSIR-IHBT-PG-06	3.35	3.35	3.25	3.15	0.79	0.90	1.00	1.11
CSIR-IHBT-PG-07	5.08	5.08	4.63	4.19	0.84	0.83	0.81	0.79
CSIR-IHBT-PG-08	5.05	5.05	5.36	5.68	1.02	1.07	1.11	1.16
Control	6.07	6.14	6.22	6.30	1.19	1.03	1.15	1.03
S. E. (d)	0.139	0.070	0.075	0.056	0.057	0.031	0.030	0.030
C. D. (P=0.05)	0.294	0.149	0.159	0.119	0.120	0.067	0.064	0.064

*Significant

checks with respect to biomass yield and essential oil content (Table 3).

Lilium hybrid

Hybridization was done among asiatic lily cultivars London (yellow) and Machete (red) to generate new flower colour and flower shapes in lilium. Among 71 hybrids developed through this particular cross, CSIR-IHBT-LH-3-4 was selected for large size, attractive color and better vigor compared to the parental lines (Fig. 1). Clonal propagation of CSIR-IHBT-LH-3-4 is being done through *in vitro* cultures, scales and bulbs for multiplication of the plants. The selection CSIR-IHBT-LH-3-4 was characterized morphologically and evaluated for field performance at four locations along with parents. Plantation was done in Randomized Block Design with ten plants per genotype replicated three times. Data recording was done on five plants per replication for plant height (cm), flower diameter (cm), and number of flowers per flowering shoot at four locations in 2020-21.

Table 3. Mean variations for biomass yield and essential oil content in *R. officinalis* accessions at different locations

Accessions	Biomass yield (kg/plot)				Essential oil content (g/kg)			
	Sihunta	Bajaura	Palampur	Talla	Sihunta	Bajaura	Palampur	Talla
CSIR-IHBT-RO-01	5.46	5.43	5.37	5.70	1.27	1.13	1.23	1.87
CSIR-IHBT-RO-02	6.28	6.18	6.15	6.38	1.39	1.39	1.33	1.45
CSIR-IHBT-RO-03	6.53	6.54	6.50	6.72	1.89	1.89	2.01	1.82
CSIR-IHBT-RO-04	3.99	3.68	3.75	3.35	2.42	2.42	2.46	2.34
CSIR-IHBT-RO-05	4.32	4.16	4.09	4.63	1.01	1.07	1.09	1.10
CSIR-IHBT-RO-06	7.37*	7.28*	7.22*	7.55*	2.69	2.57	2.61*	2.49*
CSIR-IHBT-RO-07	4.58	4.47	4.43	4.68	1.30	1.30	1.34	1.26
CSIR-IHBT-RO-08	6.79	6.65	6.60	6.89	1.80	1.80	1.70	1.61
CSIR-IHBT-RO-P1	5.69	5.57	5.51	5.80	2.54	2.54	2.34	2.13
CSIR-IHBT-RO-P2	5.03	4.36	4.94	4.39	1.51	1.51	1.59	1.32
S. E. (d)	0.114	0.161	0.059	0.089	0.096	0.048	0.106	0.071
C. D. (P=0.05)	0.241	0.339	0.125	0.185	0.202	0.101	0.224	0.150

*Significant

Fig. 1 Flowers of lilium hybrid CSIR IHBT-LH-3-4

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Development of Agrotechnologies

Our group is developing agro-technologies and is involved in generation of quality planting materials of *Rosa damascena, Tagetes minuta, Cymbopogon* spp., *Crocus sativus, Ocimum basilicum, Pelargonium graveolens, Salvia sclera*, and *Hypericum perforatum.* We are also involved in providing technical and handholding support to farmers for saffron production in non-traditional areas and promoting low chilling apple plantations in the North Eastern Region of India.

Development of agrotechnologies

- **Nutrient management effect on biomass and essential oil yield of *Tagetes minuta* L.**

Aromatic marigold (*Tagetes minuta* L.: Asteraceae) is an annual aromatic herb which has been cultivated around the world for its essential oil obtained from leaves and flowers. A field experiment was conducted to study the effect of phosphorus levels (0, 40, 80, 120, 160 kg P_2O_5/ha) and potassium (0, 30, 60 kg K_2O/ha) on growth, yield characters and essential oil composition of aromatic marigold during 2021. The analyzed results revealed that significantly higher biomass yield (25.52% higher) was recorded with the

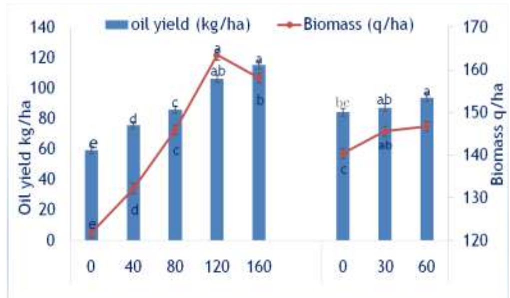

Fig. 1 Experimental field view of *T. minuta* and effect of phosphorus and potassium on biomass and essential oil yield of *Tagetes minuta.*

application of 120kg P_2O_5/ha and (4.33 %) 60 kg K_2O/ha compared with control (Fig. 1). Similarly, 42.86 and 4.74 % higher essential oil was obtained with the application of 160kg P_2O_5/ha and 60kg K_2O/ha, respectively, which was significantly higher compared to the control.

Standardization of post-harvest processing of aromatic grasses

Aromatic perennial grasses *viz.*, Palmarosa {*Cymbopogon martini* (Roxb.) W. Watson}, Java citronella (*Cymbopogon winterianus* Jowisstt ex Bor) and Lemongrass (*Cymbopogon citratus)* belong to the family Poaceae. Field experiments were conducted to study the effect of harvesting time, varietal effect and post-harvest processing time on the essential oil yield and composition in these grasses. In palmarosa, essential oil content (%) was significantly higher in H4 (25 November 2021) harvesting time compared to H1 (12 October, 2021) harvesting time, while essential oil content (%) was significantly higher in V1 selection of lemongrass compared to V3 selection. In citronella, essential oil content (%) was significantly higher in V3 selection compared to V1 selection. The drying time of 48 hrs recorded significantly higher essential oil content in aromatic grasses (Fig. 2)

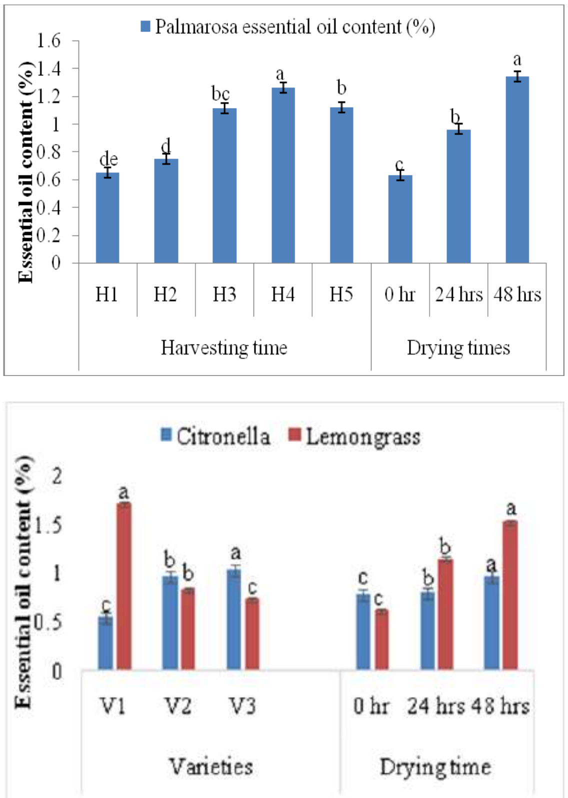

Fig. 2 Effect of harvesting time and processing time on the essential oil content of aromatic grasses

- **·Standardization of application of seaweed extract on saffron (*Crocus sativus* L.)**

Saffron (*Crocus sativus* L.) is an important spice for Indian cuisines and is mainly grown in parts of Jammu and Kashmir in India. A field experiment was initiated during 2020-2021 with five treatments [T1- control; T2 - corm dipping in seaweed solution (5% concentration); T3 - foliar spray @ 5% (30, 45, 60, 75 DAS); T4 – drenching @ 5% in the soil after corm sowing; T5 – corm dipping + foliar spray (@5% seaweed)] and three replications to evaluate the effect of application method of seaweed QAU-ICSP (80% K+ 20% S; where K= *Kappaphycus* sp., S= *Sargassum* sp.) for optimum growth, yield, quality and flowering size corm production in saffron. Seaweeds extracts are the organic biostimulants extracted from marine flora and contain macro and micronutrients, amino acids, and other growth-promoting substances. The total number of flowering size corm production was significantly higher in the T2 treatment than the other treatments. The number of corms produced in <5 g, 5-8 g and 8-12g categories were higher in T4 treatment than in other treatments. Similarly, the number of corms produced in the>12g category was significantly higher in T2 treatment than in other treatments (Fig. 3).

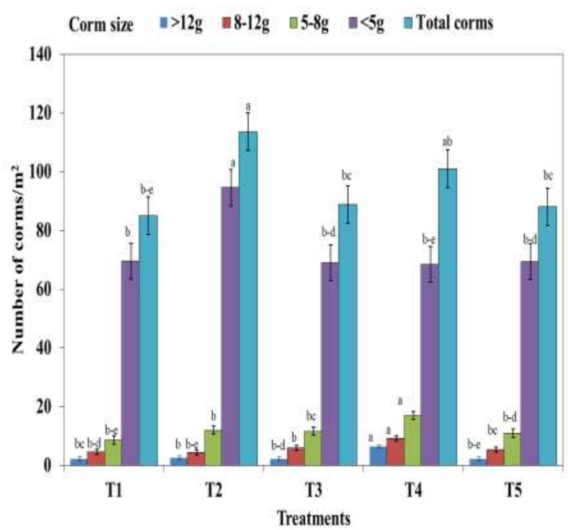

Fig. 3 Effect of seaweed extract on flowering size corm production in *Crocus sativus* L.

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Agronomy

The medicinal and aromatic plants (MAPs) are well known for the production of various bioactive compounds and essential oils. These properties create a huge demand of MAPs in phytopharmaceutical, food and cosmetic industries, but also become the major cause for their over-extraction from the nature. The yield and accumulation of bioactive compounds largely depends on agronomic practices, quality planting materials, and agro-ecology. In spite of massive global demand and availability of suitable agro-ecology India, the MAPs sector is suffering due to dearth of good agricultural practices (GAP), non-availability of quality planting materials, and poor market linkage. Therefore, the main focus of our group is towards development of agronomic practices (*i.e.* plant nutrition, site-specific management, water management, plant population and geometry, management strategy under abiotic conditions) and generation of quality planting materials.

Tagetes minuta L. is extensively used in perfumery and flavour industries. The essential oil of *T. minuta* also has various medicinal properties and health benefits. Since it is a relatively new crop in the western Himalayan region, it is a pressing need to understand the sowing method and seeding rate to improve yields and quality. Productivity of a crop is largely governed by the population density and even distribution. Likewise, seeding rate and sowing method are the major factors to determine crop vigour and eventually the yield. Thus, a field experiment was carried out to understand how the individual and interaction effects of sowing method and seeding rate influence the biomass yield, essential oil yield, and profiling of essential oil of *T. minuta*.

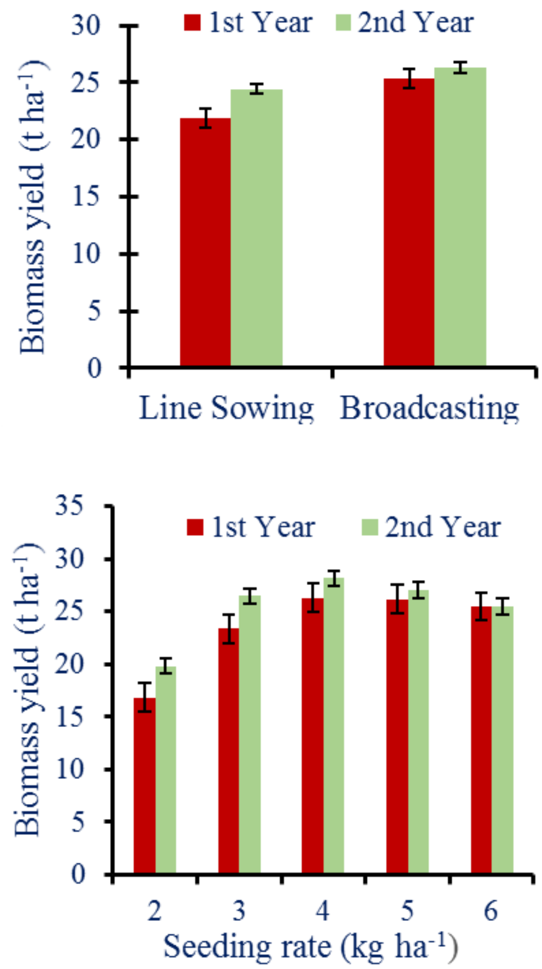

Fig. 1 Effect of sowing method (a) and seeding rate (b) on biomass yield (t ha^{-1}) of *Tagetes minuta.*

Fresh biomass yield (t ha^{-1}) of *T. minuta* was significantly (p = 0.05) affected by the sowing method and seeding rate during both the years (Fig. 1a, b), and the trend of results was consistence over the years.

Broadcasting sowing method produced significantly (p = 0.05) higher biomass yield compared with line sowing method by about 15.8 and 7.6% during first and second cropping seasons, respectively. The sowing method and seeding rate did not alter the concentration of essential oil in the aboveground fresh biomass of *T. minuta* in the present study, and the trend was consistent over the years. However, the effect of seeding rate on essential oil yield was significant (p = 0.05) in both the years, and the utmost values were recorded with seeding rate of 4 kg ha^{-1} in both the years.

Another experiment was conducted on stevia (Stevia rebaudiana), which is a perennial herb belonging to the family of Asteraceae. The plant leaves produce diterpnes, commonly known as steviol glycosides (SGs), which are low caloric and about 300 times sweeter than sucrose.

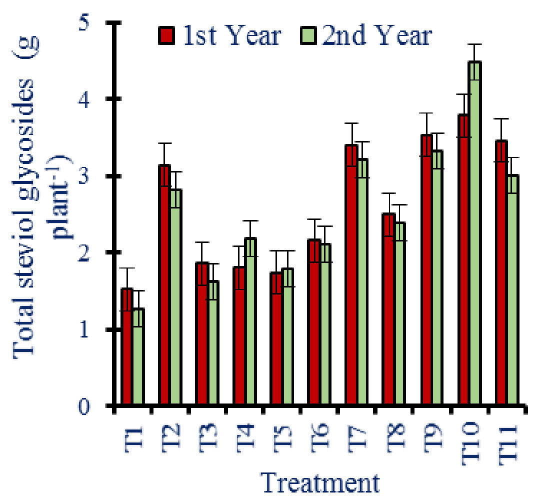

Fig. 2 Accumulation of total steviol glycosides under different nutritional treatments.

The objective of this study was to evaluate the sole effect of biochar and in combination with N fertilizer on growth, yield and biochemical parameters of Stevia as well as physico-chemical properties of acidic soil. The analyzed data revealed that application of biochar (at 8 t ha-1) in combination with recommended dose of N (T10) produced significantly (p = 0.05) higher dry leaf yield compared with control (T1) and recommended dose of N (T2). Moreover, application of biochar (at 8 t ha-1) in combination with 50% recommended dose of N (T7) produced statistically at par (p = 0.05) dry leaf compared with 100% recommended dose of N (T2). Accumulation of total steviol glycosides (TSGs) was also significantly (p = 0.05) affected by the nutritional treatments (fig. 2). The maximum TSGs was recorded with the integrated application of biochar (at 8 t ha^{-1}) 100% recommended dose of N followed by integrated application of biochar (at 4 t ha^{-1}) 100% recommended dose of N followed (T9).

Our group is also interested in developing agrotechnology of *Rosa damascena*, *Valeriana jatamansi* and *Mentha* Species, which are essential-oil-bearing plants. Field experiment were initiated to understand the role of growth regulators, biostimulants, and integrated nutrient management approaches on yield and composition of essential oil.

Our group is also working on new crop like monk fruit (*Siraitia grosvenorii*), which is used as a non-caloric natural sweetener in some countries. The sweet taste of monk fruit is attributed to cucurbitane-type triterpene glycosides known as mogrosides, which is about 300 times sweeter than su-sucrose or

Fig. 3 Beginning of monk fruit cultivation program in Himachal Pradesh by planting its seedlings in a progressive farmer's field at Raison, Kullu on 12th July 2021.

cane sugar. Since it is a new crop, the multilocation trials has initiated for identification of suitable locations in

Himachal Pradesh.

The first field trial for 'monk fruit' cultivation has been initiated in the field of a progressive farmer Manav Khullar at Raisonin Kullu Himachal Pradesh (Fig. 3).

Extension Activities/ Rural development: About 300 acres of land has been brought under stevia, medicinal, aromatic crops cultivation in Punjab, Himachal Pradesh, Chhattisgarh, Uttar Pradesh, Assam, Odisha and Maharashtra. Besides, large numbers of quality planting materials of stevia, *Valeriana jatamansi*, Mentha, and other MAPs have been generated to support the farmers under CSIR – Aroma Mission and other projects funded by DST, Govt. of India, National Medicinal Plant Board (NMPB), Ministry of AYUSH. The planting materials have been supplied to the industry and farmers to promote the cultivation of MAPs in different parts of the country. Moreover, plantation of *Ginkgo biloba* has also been promoted in Aspirational District Chamba in collaboration with Regional-cum-Facilitation Centre, Northern Region-1, Research Institute in Indian Systems of Medicine (RIISM), Ministry of AYUSH, Joginder Nagar, Himachal Pradesh (Fig. 4-8).

Fig. 4 Signing MoU with Regional-cum-Facilitation Centre, Northern Region-1, Research Institute in Indian Systems of Medicine (RIISM) for Promotion of Ginkgo biloba plantation in Himachal Pradesh.

Fig. 5 Distributing planting material of *Ginkgo biloba* for plantation in Chamba, H.P.

Fig. 6 Planting material of *Mentha arvensis* was sent to the tribal area in Odisha through transport during COVID period.

Fig. 7 Plantation of *Valeriana jatamansi* to utilize the forest land at Chamba, H.P.

Fig. 8 Plantation of *Stevia rebaudiana* in Ludhiana, Punjab, for crop diversification.

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Entomology and Pest Management

Development of Biopesticides

In the direction of developing biopesticides, evaluated plant extracts, essential oils and their fractions to identify leads. Samples IHBT-TO-1 and IHBT-TF-1 showed promising insecticidal activity against mosquito larvae under laboratory conditions.

Medicinal Mushrooms

Ophiocordyceps samples collected from Himachal Pradesh and Uttarakhand, India, showed promising antioxidant activities.

Identified and cultured one fungal isolate (IHBT-2020-13) of nutraceutical importance.

Fresh water pearl cultivation

In a new initiative, started R&D activities on freshwater pearl culturing at CSIR-IHBT. Standardized methods for molecular identification of freshwater mussels.

Freshwater pearl culturing at CSIR-IHBT

JIGYASA Programme

Coordinated JIGYASA-a student-scientist connect programme at CSIR-IHBT under Scientific Social Responsibility (SSR) of Scientific Community and Institutions. During 2021-22, a total of 2607 school students and their teachers from different schools (JNVs, Govt. and Public Schools) participated in this programme, through offline/ online activities.

Organized "Curtain Raiser Ceremony" of the 7th IISF 2021, in which Prof. Anupama Nautial, Vice-Chancellor ,HNB Garhwal University, Garhwal, Uttarakhand delivered a lecture through online mode. Details of these activities are at: https://www.youtube.com/channel/UCYD6c5wvsCqSlPomn5PVUVg/videos.

Coordinated making of short educational movies under CSIR Jigyasa 2.0 Programme: Virtual Lab Integration.

Adoption of Atal Tinkering Lab Schools (ATLs)

The institute adopted 10 ATLs schools (KVs and Govt. schools of HP) for smooth functioning of ATLs.

Coordinated the educational visits of students and teachers from different Universities, Institutes and Colleges at CSIR-IHBT.

Skill Development Programmes

This year, CSIR-IHBT, Palampur is registered as "Training Provider" (TP) and Training Center (TC) at National Skill Development Council (NSDC). Besides, CeHAB, Keylong is registered as another Training Center (TC) of the Institute.

Coordinated CSIR-Integrated Skill Initiative and Skill programmes of the Institute.

Coordinated a 5 days' capacity building programme for Ph.D. students and faculty members of MDU, Rohtak, Haryana under UGC-STRIDE Programme (Scheme for Tran-disciplinary Research for India's Developing Economy).

Training/ Internship of students

Coordinated training/ internship activities of 55 UG/ PG/ Ph.D. students from different educational and research institutes of Pan India. Besides, 48 trainees were enrolled and are continuing their training.

Skill Vigyan Program of DBT-HIMCOSTE

During this year, two LSSSDC courses *viz.* Quality Control Biologist (QCB) and Lab Technician/ Assistant (LTA) of 3 months' duration, were conducted under "Skill Vigyan Progam". All the 22 persons of first batch, have successfully completed these courses.

The second batch of QCB (15 no.) and LTA (09 no.) is in progress.

Restructured National Bamboo Mission (R-NBM)

Coordinated ongoing activities of (R-NBM) at CSIR-IHBT for generation and supply of quality planting material. During this year, Institute has generated more than 22,000 bamboo plants and supplied about 14,000 plants to different stakeholders.

Research group: Ms. Aakriti Sharma, Mr. Aditya Singh Ranout, Ms. Rupinder Kaur, Mr. Rahul Kumar, Mr. Vivek Awasthi, Mr. Sahil Sharma, Mr. Pankaj Kumar

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Plant Breeding

Our team is working on genetic improvement of aromatic, medicinal, floricultural and other commercially important plants/crops for the development of new germplasm and varieties.

***Heeng* (*Ferula assa-foetida* L.)**

Sixty six accessions of *Heeng* were introduced in the country through ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi. For conservation and evaluation of these accessions, the first "*Heeng* Germplasm Resource Centre" of the country established at CSIR-IHBT, Palampur, was inaugurated by Dr. Shekhar C. Mande, Secretary DSIR & Director General, CSIR, Govt. of India on 5th March 2022 (Fig. 1). Other than Himachal Pradesh, field trials were also extended to Jammu & Kashmir, Ladakh, and Uttarakhand.

Fig. 1 Inauguration of "*Heeng* Germplasm Resource Centre" by Dr. Shekhar C. Mande, Secretary DSIR & Director General, CSIR, Govt. of India.

Breeding of Palmarosa (*Cymbopogon martini*)

A total of two hundred sixty diverse germplasm lines were screened for morphological traits and essential oil content. Ten breeding lines (Table 1) were selected on the basis of morphological traits for multi-location trials at Palampur (L1), Bajaura (L2), Sihunta (L3), and Madeena (L4) for evaluation and selection of promising lines. Results of showed that PR-04 had maximum plant height as well as highest number of tillers/plant at all the locations. While, five lines i.e. PR-03, PR-04, PR-11, PR-38 and PR-40 had significantly higher plant height; Line PR-03, PR-04, PR-11 and PR-41 had significantly higher number of tillers/plant compared to over-all mean. Whereas, PR-04 had highest shoot-biomass (71.63 kg/plot) at all four locations followed by PR-03 (50.84 kg/ kg/plot) and PR-11 (46.38 kg/plot). Mean essential oil content (all locations) extracted from biomass was highest for PR-11 (9.23 g/kg) and followed by PR-38 (8.59 g/kg) and PR-12 (8.50 g/kg).

Chrysanthemum breeding

A total of 378 F1 hybrids of Chrysanthemum were developed through controlled crossing programme. Out of those, twelve potential F1 hybrids (Fig. 2) multiplied through clonal propagation were morphologically evaluated under protected cultivation at Palampur (L1), Pragpur (L2), Bajaura (L3), and Nagri (L4). Maximum flower head diameter was reported in CH-18-5 (12.63 cm) followed by CH-18-7 (10.52 cm) both are standard type and suitable for cut flower purpose. Whereas, minimum flower head diameter was recorded in CH-18-9 (5.54 cm) followed by CH-18-11

Table 1. Performance of 10 selected lines of palmarosa under field conditions

	Plant height (cm)				Number of tillers/plant			
Line no.	**L1**	**L2**	**L3**	**L4**	**L1**	**L2**	**L3**	**L4**
PR-03	248.30*	232.65*	249.20*	245.38*	94.14*	88.67*	99.55*	91.00*
PR-04	258.67*	254.20*	257.98*	254.91*	106.68*	103.02*	113.42*	105.59*
PR-11	233.17*	232.78*	232.87*	230.87*	96.52*	92.78*	98.58*	89.46*
PR-12	189.13	185.31	189.02	189.50	34.60	32.11	39.55	37.29
PR-15	134.37	133.01	133.67	129.90	62.13	62.76	62.07	62.49
PR-38	223.30*	222.08*	226.65*	221.25*	45.47	44.30	45.80	46.87
PR-40	200.63*	196.42*	201.46*	196.81*	53.68	53.06	56.56	52.92
PR-41	104.50	107.31	107.59	108.21	72.44*	70.24*	77.15*	69.02*
PR-44	138.63	136.28	137.08	132.40	42.50	42.66	46.45	42.11
PR-92	164.93	161.92	166.94	160.66	64.06	66.55*	69.91	64.82
Mean	189.56	186.20	190.25	186.99	67.22	65.61	70.90	66.16
SE(d)	4.585	3.87	4.32	6.24	3.417	5.861	5.615	5.777
C.V.	2.962	2.55	2.78	4.09	6.22	10.94	9.698	10.695
	Biomass yield (kg)/plot				**Oil content g/ kg**			
PR-03	50.99*	49.82*	51.28*	48.37*	7.73	8.28	8.55*	8.09
PR-04	72.21*	70.92*	72.22*	71.18*	7.65	7.80	8.12*	8.73*
PR-11	46.86*	46.11*	45.90*	46.65*	9.31*	9.49*	8.57*	9.54*
PR-12	30.89	30.08	30.23	30.65	8.63*	8.70*	8.16*	8.52*
PR-15	42.15	39.91	42.37	41.32	8.32	8.17	7.61	8.28
PR-38	34.79	35.60	35.66	35.78	8.83*	8.56*	8.59*	8.37*
PR-40	40.27	39.56	40.70	39.91	8.38	8.46*	7.66	7.70
PR-41	40.07	39.97	39.48	39.28	7.81	8.18	7.55	7.96
PR-44	32.32	32.76	32.81	34.13	6.85	7.32	7.92	7.83
PR-92	43.20	43.29*	43.80*	43.02	7.70	7.84	8.19*	8.20
Mean	43.37	42.80	43.45	43.03	8.12	8.28	8.09	8.32
SE(d)	2.656	2.056	1.992	2.048	0.268	0.351	0.269	0.329
C.V.	7.5	5.882	5.616	5.829	4.041	5.184	4.067	4.845

(6.62 cm) and CH-18-4 (6.76 cm), which are suitable for pot/bed planting.

Highest plant height was observed in CH-18-5 (112.62 cm) followed by CH-18-2 (94.84 cm) and CH-18-1 (92.23 cm); which are suitable for cut flower. While, lowest plant height was recorded in CH-18-4 (50.44 cm) followed by CH-18-8 (51.09 cm) and CH-18-9 (54.13 cm) which are dwarf type and suitable for pot/bed planting (Table 2).

Maximum number of flowers/plant was reported in CH-18-6 (198.5), followed by CH-18-1 (96.25) and CH-18-4 (82), which are spray type and will be suitable for pot and bed planting whereas, minimum number of flowers/plant was recorded in CH-18-5 (23.5) which is standard type and suitable for cut flower purpose.

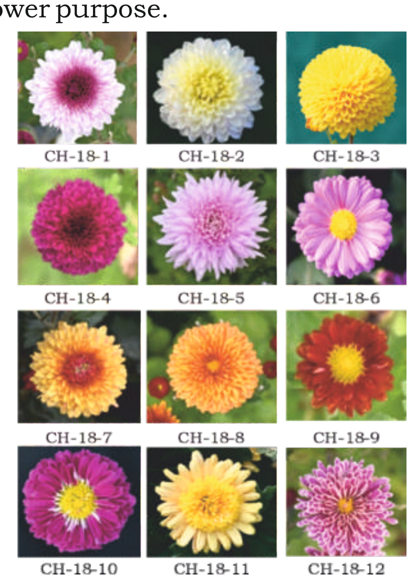

Fig. 2 Potential F1 hybrid selection of Chrysanthemum

Table 2. Performance of chrysanthemum F1 selections at different locations

Selection No.	Field code	Flower colour	Plant height (cm)			
			L1	L2	L3	L4
CH-18-1	SP-59	Pink white with magenta red centre	99.09	93.78	91.33	84.73
CH-18-2	SP-30	White flower with yellow centre	98.37	95.34	92.67	92.99
CH-18-3	PMP-15	Orange yellow	67.01	69.02	71.55	65.28
CH-18-4	MINI-29	Magenta-red	45.65	49.95	53.41	52.76
CH-18-5	ST-20	Light pink	114.36	115.76	111.13	109.21
CH-18-6	SP-51	Pink petals with yellow disc	87.84	91.15	89.25	92.55
CH-18-7	SP-40	Yellow flower with maroon red centre	68.93	70.37	64.17	75.37
CH-18-8	MINI-8	Blaze orange	53.07	53.6	46.27	51.43
CH-18-9	MINI-27	Red maroon with greenish yellow disc	50.63	56.07	56.73	53.1
CH-18-10	MINI-44	Magenta petals with white base and yellow disc	59.8	65.8	52.83	53.47
CH-18-11	SP-99	Golden yellow	92.17	90.43	88.37	89.6
CH-18-12	SP-110	Light magenta petals with white outline and yellow disc	75.44	71.96	73.17	74.22
Mean	-	-	76.03	76.94	74.24	74.56
SE(d)	-	-	3.06	2.94	3.3	3.18
C.V.	-	-	4.94	4.68	5.45	5.22

Selection No.	Flower head diameter (cm)				Number of flower/ plant			
	L1	L2	L3	L4	L1	L2	L3	L4
CH-18-1	8.6	8.5	8.58	8.53	94	96	99	96
CH-18-2	7.37	7.5	7.55	7.3	69	69	71	72
CH-18-3	7.4	7.43	7.3	7.13	53	50	49	52
CH-18-4	6.43	6.87	6.97	6.78	83	81	82	82
CH-18-5	12.47	12.83	12.43	12.77	23	22	24	25
CH-18-6	7.13	7.04	7.63	7.15	195	202	193	204
CH-18-7	10.5	10.55	10.42	10.6	23	22	21	25
CH-18-8	6.83	6.6	6.99	6.49	79	80	77	84
CH-18-9	5.3	5.85	5.77	5.23	65	67	76	76
CH-18-10	6.5	6.47	6.86	6.63	40	36	42	38
CH-18-11	8.3	8.23	8.1	8.37	65	63	65	60
CH-18-12	7.27	7.99	7.62	7.82	25	30	29	30
Mean	7.84	7.99	8.02	7.9	67.67	68.25	68.83	70.36
SE(d)	0.21	0.24	0.21	0.28	2.82	2.9	3.08	2.68
C.V.	3.2	3.73	3.25	4.34	5.1	5.2	5.48	4.66

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Entomology and Pest Management

Entomology, Botanicals, Entomopathogenic fungi, Pest Management, Biopesticides, Apiculture and Sericulture

Insect and mite pests play a major role in reducing the economic yield if pest management practices are not initiated timely. Indiscriminate and non-judicious application of synthetic pesticides for the control of pests leads to insecticide resistance, resurgence, harmful to beneficial insects (predators and parasitoids), human beings, environment etc. Use of bio-pesticides for the control of pests increased at national and global level. Therefore, our group is mainly working on screening of plant extracts, fractions, essential oils, isolated compounds/molecules for insecticidal activities against crop pests (*Plutella xylostella*, *Aphis craccivora*, *Planococcus liacinus*, *Tetranychus urticae* etc.) and stored grain pests (*Callosobruchus chinensis*, *C. maculatus*, *Tribolium castaneum* etc.) for identification of lead (s) for development of botanical formulation. Similarly, we are also working on isolation, characterization of native strain (s) of entomopathogenic fungi from insect cadavers'/soil and its evaluation against target pests. My group is also working on creation of bee keeping clusters in different parts of India for integration of apiculture in aromatic, medicinal, floricultural and fruit orchards for pollination and enhancement of livelihood of farmers. CSIR-IHBT developed an improved bee hive in collaboration with CSIR-CSIO, Chandigarh and validated it in the field conditions for quality and hygienic extraction of honey. Developing rearing protocol of mulberry silkworm (*Bombyx mori*) on mulberry leaves grown under hydroponic conditions during winter due to non availability of leaves for feeding.

Insecticidal activity of extracts, fractions and pure molecules of *Cissampelos pareira* against aphid, *Aphis craccivora*

Insecticidal activity of root/stem extracts/fractions, and pure molecules from *C. pareira* was screened for their bioefficacy against *A. craccivora* for identification of lead(s). Among root extract/fractions, *n*-hexane fraction was most effective (LC_{50} =1828.19 mg/L) against *A. craccivora* followed by parent extract (LC_{50}=2211.54 mg/L). Among stem extract/fractions, *n*-hexane fraction (LC_{50}=1246.92 mg/L) was most effective than water and *n*-butanol fraction. Based on GC and GC-MS analysis, among different compounds identified from *n*-hexane fraction of root and stem, ethyl palmitate (known to possess insecticidal activity) was present in highest concentration (24.94 to 52.95%) in both the fractions. Among pure molecules, pareirarineformate was found more effective (LC_{50}=1491.93 mg/L) against *A. craccivora* followed by cissamine (LC_{50}=1556.31 mg/L).

Insecticidal and enzyme inhibition activities of leaf/bark extracts, fractions, seed oil (SO) and isolated compounds from *Triadica sebifera* against *Aphis craccivora*

Results showed that, among the extracts, ethanolic bark extract 80% (LC_{50}=5115.98 mg/L) was more effective against *A. craccivora*. *n*-hexane fraction of leaf (LC_{50}=425.73 mg/L) was more promising than ethyl acetate fraction of bark (LC_{50} =813.45 mg/L) and seed oil (LC_{50}=850.94 mg/L). Among compounds, gallic acid was the most effective (LC_{50}=1303.68 mg/L) compared to shikimic acid and quercetin. The blends/mixtures/combination of seed oil with leaf/bark ethanol aqueous extract (LEE+BEE) showed synergistic effect against *A. craccivora*. Leaf/bark extracts and seed oil significantly inhibited the acetylcholine esterase (AChE) and glutathione-S-transferase (GST) in *A. craccivora*.

Chemical composition and insecticidal activities of essential oils against pulse beetle

The chemical composition and insecticidal activities of essential oils (EOs), their combinations and compounds were screened against pulse beetle under laboratory.-isomenthol, carvone and *β*-ocimene are the major components of tested oils using GC-MS. *Mentha spicata* showed promising fumigant toxicity against *C. chinensis*(LC_{50}=0.94 µL/ml) and was followed by *M. piperita*(LC_{50}=0.98 µL/ml), where as *M. piperita* (LC_{50}=0.92 µL/ml) against *C. maculatus*. Combination of *Tagetes minuta* + *M. piperita* showed more toxicity against *C. chinensis* after 48 h (LC_{50}=0.87 µL/ml) than *T. minuta* + *M. spicata* (LC_{50}=1.07 µL/ml). L-Carvone showed fumigant toxicity against *C. chinensis* after 48 h (LC_{50}=1.19 µL/ml). Binary mixtures of *T. minuta* + *M. piperita* and *M. spicata* showed promising toxicity and synergistic activity. EOs also exhibited repellence and ovipositional inhibition.

Chemical composition, insecticidal, persistence and detoxification enzyme inhibition activities of essential oil of *Artemisia maritima* against the pulse beetle

The primary components of the essential oil (EO) of *A. maritima* is 1,8-Cineole (41.14%) and bornyl acetate (18.1%). EO showed promising fumigant toxicity to *Callosobruchus chinensis* and *C. maculatus* (LC_{50}=1.17 and 0.56 mg/L, respectively) after 48 h. EO at 8 mg/L showed 92–96% repellence after 1 h. EO also showed ovipositional deterrence against *C. chinensis* (OD_{50}=3.30 mg/L) and *C. maculatus* (OD_{50}=4.01 mg/L). Higher concentrations of oil (8 and 6 mg/L) in *C. maculatus* showed significant inhibition of GST enzyme.

Effect of *Tagetes minuta* oil on larval morphology of *P. xylostella* through scanning electron microscopy and mechanism of action by enzyme assay

The larvae of *P. xylostella* treated with *T. minuta* oil showed reduction in the length of the setae as compared to untreated setae. The cuticular setae were clubbed, swollen and shaft of the hair was broken after 72 h of treatment and then hair socket was fragmented the bloated setae. Similarly, the larval cuticle, thoracic and abdominal legs after treatment were also presented (Fig. 1-4). Higher concentration of *T. minuta* oil significantly inhibited the GST and AChE activity in *P. xylostella*.

Synthesis and screening of kojic acid derivatives for their bio-efficacy against *P. xylostella*

Kojic acid derivatives containing urea and thiourea linkage has been synthesized and tested against second instar larvae of *P. xylostella* under laboratory conditions. Compound 3b at 1% was found more effective (83.3% mortality) after 96 h. Other compounds of 4h and 4j showed 80% mortality as compared to 3c, 4c and 4m (76.6% mortality).

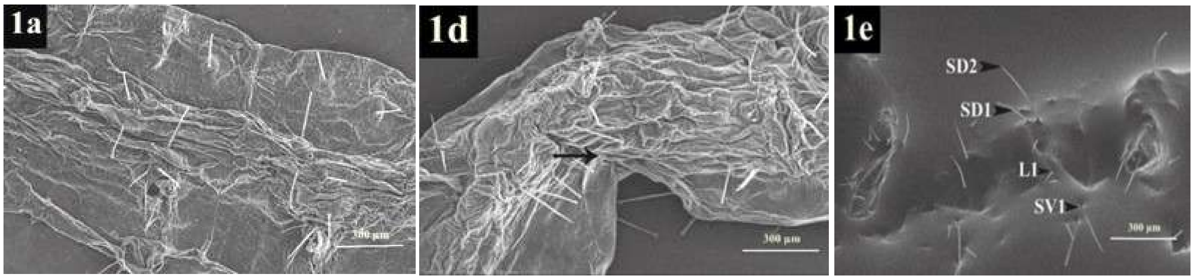

Fig. 1 Abdominal cuticle disintegration of *P. xylostella* (1a)-Untreated larva; (1d) Treated after 72 h; (1e) Treated after 96 h.

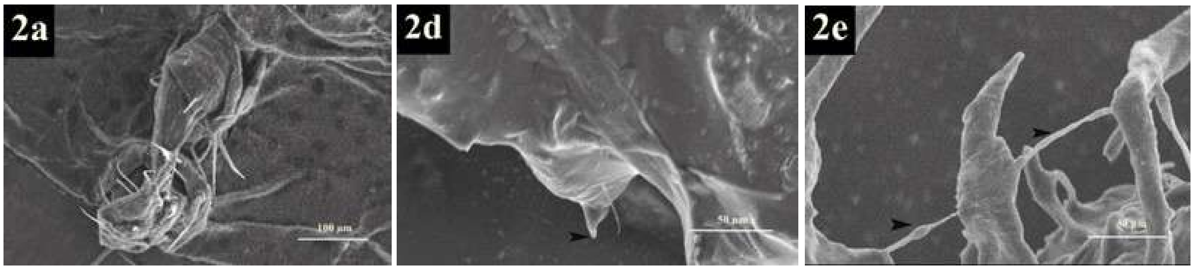

Fig. 2 Thoracic legs deformed symptoms at different intervals of time (2a) Untreated; (2d) Treated after 72 h; (2e) Treated after 96 h.

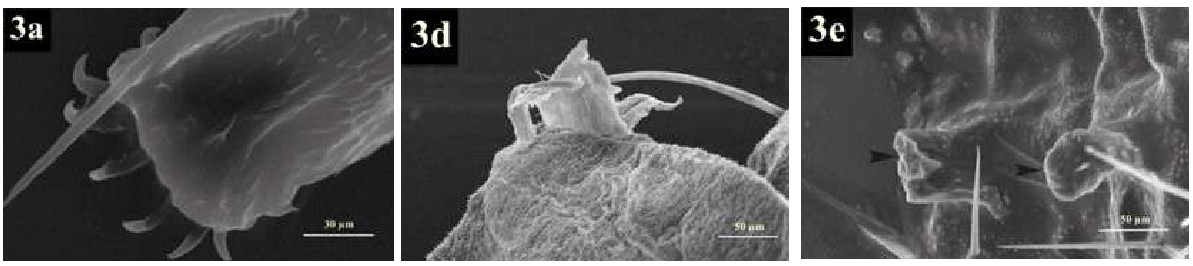

Fig. 3 Abdominal legs deformed symptoms at different intervals of time (3a) Untreated larva; (3d) larva treated after 72 h; (3e) larva treated after 96 h.

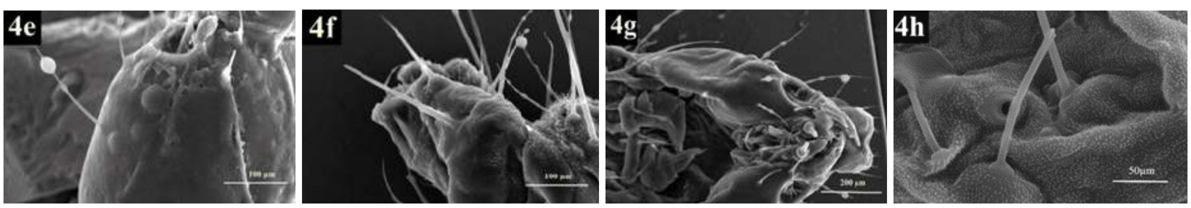

Fig. 4 Deformed setae on various segments of the larva (4e) Deformed setae near stemmata; **(4f) Deformed setae near 9-10th abdominal segment; (4g) Deformed setae near lower part of mouth parts; (4h) Normal setae (Untreated control).**

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Floriculture

In vitro propagation in *Iris* × *hollandica* Tub. cv. Professor Blaauw (Dutch Iris)

Dutch iris is an ornamentally important monocotyledonous bulbous crop whose propagation through seedlings is difficult due to the poor rate of seed set and germination. Therefore, traditionally, irises are propagated by bulbs or rhizomes vegetatively which is also very slow and inefficient. Therefore, to meet the demand of quality planting material of this commercially important cultivar, plant tissue culture is one of the promising alternative for propagation of Dutch Iris. In the present study, the significance of a novel aromatic cytokinins, meta-topolin (mT) on *in vitro* organogenesis, *in vitro* proliferation and rhizogenesis of Dutch Iris have been studied (Fig. 1). As a better substitute to BAP and Kn, the cytokinin mT at 1.0 mg L^{-1} has resulted in maximum shoot induction response (86.11±4.81 per cent) and increased emergence of micro shoots (4.95±0.05) per explant and average shoot length of 5.65±0.13 cm from twin scale explants in a shorter time. The collective consequence of cytokinin-auxin (1.0 µM mT + 0.25 µM NAA) showed considerably higher number of shoots (17.53±0.29) with mean shoot length (6.90±0.08 cm) and maximum number of bulblet (2.74±0.08). The superiority of mT over BAP was also found during *in vitro* rhizogenesis. Shoots derived from mT medium were healthy and long enough, thus showed maximum per cent rooting (63.83±0.93) with maximum 3.42±0.08 number of roots having maximum root length of 4.48±0.14 cm on ½ MS medium + 0.5 mg L^{-1} IAA after 4 weeks. The plantlets were acclimatized in a greenhouse and showed 89.16±0.58 per cent survival with 15.24±0.086 cm height after 4 weeks of transfer under *ex vitro* conditions.

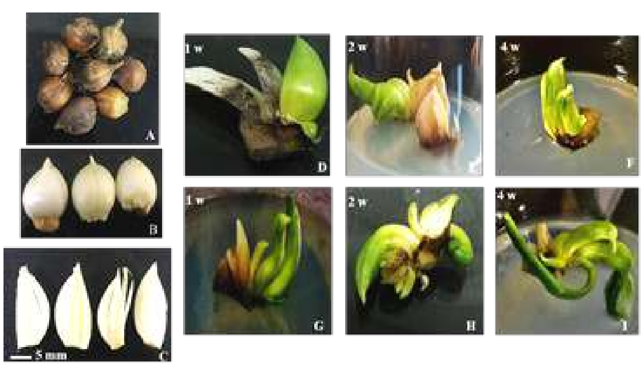

Fig. 1 *In vitro* establishment and shoot regeneration in *Iris* × *hollandica* Tub. cv. Professor Blaauw using twin bulb scale explants A) Healthy bulbs with tunics, B) Surface sterilized bulbs used for preparing explants, C) Sterilized twin-scale explants, D-F) In vitro establishment from twin scale explants on the MS medium with 0.5 mg·L-1 BAP after 1, 2 and 4 weeks respectively, G-I) In vitro establishment from twin scale explants on the MS medium with 1.0 mg·L-1 mT after 1, 2 and 4 weeks respectively.

Table 1. Effect of different concentrations of the cytokinins such as BAP, Kn, and mT on in vitro shoot induction from twin scale bulb explants *of Iris* × *hollandica* Tub. cv. Professor Blaauw after 4 weeks of culture

Cytokinins (mg L^{-1})	Shoot induction response (%)	Number of shoots (mean±SE)	Shoot length (cm) (mean±SE)
Control	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}	0.00 ± 0.00^{a}
BAP 0.5	69.44 ± 4.81^{e}	1.50 ± 0.50^{b}	2.90 ± 0.04^{f}
BAP 1.0	47.22 ± 9.62^{c}	1.08 ± 0.02^{b}	2.38 ± 0.19^{e}
BAP 1.5	66.67 ± 8.33^{de}	1.73 ± 0.12^{b}	2.89 ± 0.07^{f}
BAP 2.0	55.56 ± 4.81^{cd}	1.48 ± 0.27^{b}	2.04 ± 0.04^{d}
Kn 0.5	27.78 ± 4.11^{b}	1.20 ± 0.15^{b}	1.27 ± 0.10^{bc}
Kn 1.0	22.22 ± 4.23^{b}	1.07 ± 0.07^{b}	1.17 ± 0.03^{bc}
Kn 1.5	25.00 ± 14.43^{b}	1.23 ± 0.15^{b}	1.37 ± 0.14^{c}
Kn 2.0	16.67 ± 8.33^{b}	1.05 ± 0.05^{b}	0.94 ± 0.07^{b}
mT 0.5	77.78 ± 9.62^{ef}	4.27 ± 0.37^{d}	4.73 ± 0.23^{h}
mT 1.0	86.11 ± 4.81^{f}	4.95 ± 0.05^{e}	5.65 ± 0.13^{j}
mT 1.5	80.56 ± 4.80^{ef}	3.12 ± 0.06^{c}	5.09 ± 0.09^{i}
mT 2.0	72.22 ± 9.61^{ef}	3.15 ± 0.21^{c}	4.11 ± 0.12^{g}

Melatonin application ameliorates salt stress impact on growth and photosynthesis of *Tagetes erecta* L.

Melatonin (N-acetyl-5-methoxytryptamine) is a ubiquitous signaling molecule playing crucial role in growth and development of plants under stress. Soil salinity is one of the major abiotic stress limiting plant growth and productivity across the globe. Usage of melatonin as a bioregulator to ameliorate stress impact in plants is emerging. Here, we investigated the role of exogenous melatonin application in alleviating salt stress in an important floricultural crop *Tagetes erecta* L. (marigold). Four-week old marigold seedlings were given a pretreatment of 100 µM melatonin and exposed to soil salinity of 100 and 200 mM NaCl. Salt stress doses significantly reduced plant growth characteristics and photosynthetic efficiency, where a decline in root and shoot biomass, chlorophyll content, photosynthetic activity, and photosystem II (PSII) efficiency was observed (Fig. 2). However, exogenous melatonin pretreatment improved growth and photosynthetic parameters, suggesting the stress ameliorative effects of melatonin against salt stress. Overall, this study unraveled the crucial role of melatonin in salt stress mitigation on growth and photosynthetic traits in marigold seedlings, demonstrating its usage in salt stress management in floriculture crops.

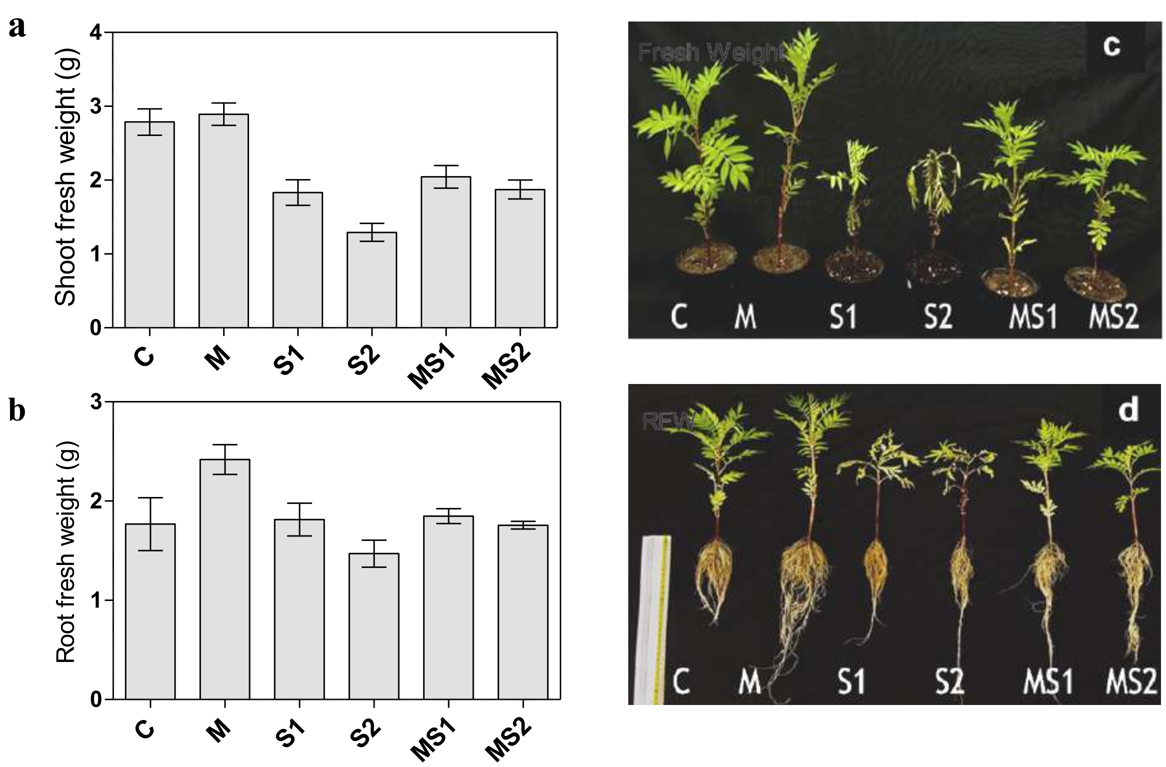

Fig. 2 Effects of melatonin on the tolerance of *Tagetes erecta* L. (marigold seedling) to salinity stress a) Shoot fresh weigh b) Root fresh weight c) Shoot phenotype d) Root phenotype. Data are the means + SE of three replicates.

Effect of essential oil of lemon grass on postharvest life of gladiolus

Gladiolus (*Gladiolus grandiflorus* Andrews), a member of the Iridaceae family, is an important bulbous cut flower originated from Cape Provinces of South Africa. However, the short vase life of gladiolus cut flower limits its marketing and commercial value. In this study, the effect of lemon grass (LG) essential oil as an antimicrobial agent was studied towards increasing the vase life of gladiolus. The current studies observed that as compared to control (distilled water), treatment with a lower concentration of 5 μL L^{-1} lemon grass essential oil prolonged the vase life of gladiolus cut spikes up to 11 days (d) by improving water relations, reducing bacterial growth at the stem ends, subsequently retaining intact vasculature (Fig. 3). Also, higher antioxidant activities were maintained due to the upregulation of antioxidant related gene expression, in comparison with the control. Thus, we suggest LG essential oil as an eco-friendly agent has potential to improve the vase life of cut flowers.

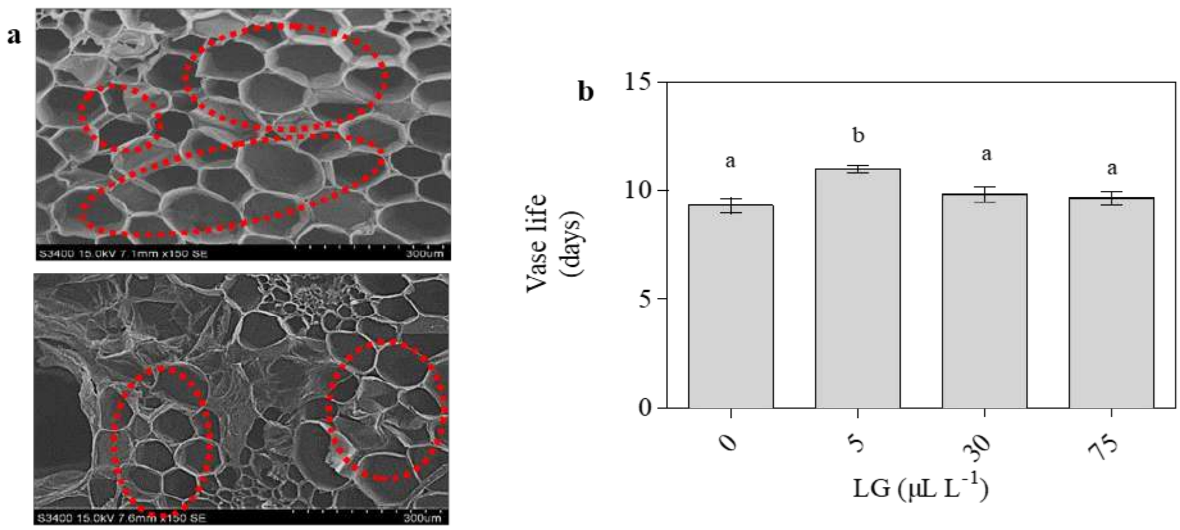

Fig. 3 (a) SEM characterization of stem ends of 5 μl L^{-1} LG essential oil Observations were carried out on 5th and 7th day. Scale bars: 300 μm. Red circle indicates intact vasculature with lesser blockage (b) Vase life of gladiolus.

Effect of nanoparticles on postharvest life of bird of paradise (BOP)

Bird of Paradise (*Strelitzia reginae* L.) of the Strelitziaceae family is an evergreen, monocotyledonous, perennial herbaceous flowering plant. Growing conditions, harvest stage, different holding conditions, and criteria used for evaluating inflorescence postharvest life could all contribute to the variability of vase life of cut flower of the BOP. In the current study, cut spikes of BOP were treated with various concentrations of nanoparticles (NPs) and were characterized by using various parameters, demonstrating that NPs could extend the vase life of BOP. Cut spikes treated with NPs effectively prevented microbial proliferation, increased the relative water uptake leads to increase the water relations of cut spikes of the BOP. The synergistic effect of GO+SNP at 1 μL L^{-1} was most effective in preventing the microbial density, increasing relative water uptake, floret opening, relative fresh weight (RFW), preserving proteins, decreasing MDA accumulation, and boosting the antioxidant enzyme activity. Therefore, the combined application of GO+SNPs can be recommended as the most appropriate vase solution to extend the postharvest life of cut flowers due to its excellent antimicrobial property which has great potential in the agriculture sector (Fig. 4). This technique can be used as a novel and potential postharvest technology for commercial application to cut flowers of BOP and can be extended to other flowers of commercial value.

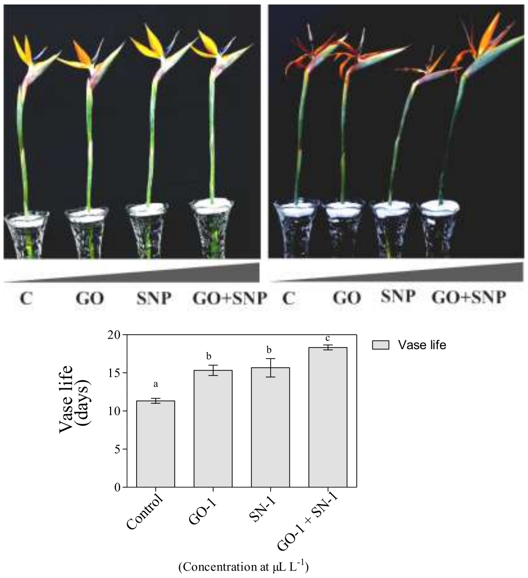

Fig. 4 Effect of different nanoparticles on vase life of cut spike of bird of paradise.

Research group: Vikas Soni, Balwant Raj, Dr Vipasha Verma, Dr Raghwendra, Dr Meenakshi Thakur, Dr Ankush Bajad, Dr Tanvi Sharma, Dr Jyoti Verma, Priti, Anjali Chandel, Anjali Rakwal, Ujala, Diksha Sharma, Gurpreet Singh, Navdeep, Ruchika Dogra, Rohini, Dikshit, Akhil Kumar, Sourabh, Jhaanvi, Mohar Singh

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Plant Biology

Research activities of my lab are highlighted below:

Endophytes of *Nepenthes khasiana* and their role in nutrient acquisition

Analysis of the transcriptome data of the highly specialized *N. khasiana* leaf comprising the leaf base lamina, tendril and the different parts/zones of the pitcher tube viz. digestive zone, waxy zone and lid revealed transcripts showing homology to genes of microbial origin. Some of these transcripts matched genes that code for acid phosphatase, acid protease and peptidase. Is it likely then that microbes associated with *N. khasiana* might play a role in protein degradation and nutrient acquisition? To address this question, we have isolated and identified about 100 bacterial and fungal endophytes from the different plant parts of the *N. khasiana* plant, including seeds (Fig. 1).

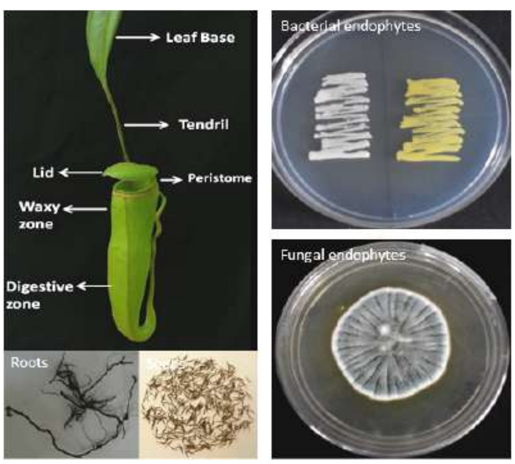

Fig. 1 Selected bacterial and fungal endophytes isolated from the *N. khasiana* leaf, including roots and seeds.

Enzymes of *Nepenthes khasiana* and their role in prey digestion and plant defence

Nepenthes khasiana employs a wide range of enzymes for prey digestion and plant defence. Aspartic proteinases nepenthesin I and nepenthesin II, class IV chitinase, C-terminal peptidase and defensin are expressed exclusively in the digestive zone while acidic endochitinase, serine carboxypeptidase and thaumatin-like proteins are expressed throughout the *N. khasiana* leaf with elevated levels in the digestive zone. We used the assembled transcript data of Dkhar et al. (2020) to amplify, clone and express some of these enzymes-encoding genes (Fig. 2).

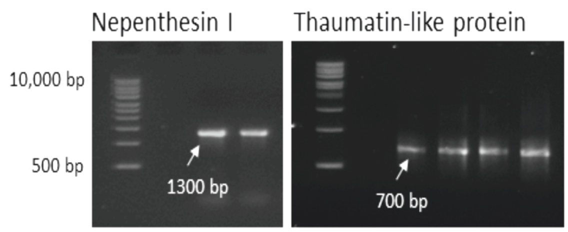

Fig. 2 PCR amplification of Nepenthesin I and thaumatin-like protein from *N. khasiana.*

***In vitro* propagation of the commercially important spice *Cinnamomum verum* (cinnamon)**

The import value of cinnamon in India is around 100M US$. The introduction and largescale cultivation of cinnamon in areas not covered earlier can increase its production, which in turn can reduce the import and make India self-reliant. Dissected leaves and shoot tips of 2-3 years old cinnamon, including seeds, were used as explants to develop a protocol for its mass multiplication (Fig. 3a-c). These explants were sterilized and inoculated in MS medium supplemented with different concentrations of growth regulators. Multiple shoots and roots were observed on the inoculated shoot tips inoculated in MS medium supplemented with 1.0 mg/L BAP and 2.5 mg/L TDZ (Fig. 3d). This protocol is being used for the mass multiplication of cinnamon (Fig. 3).

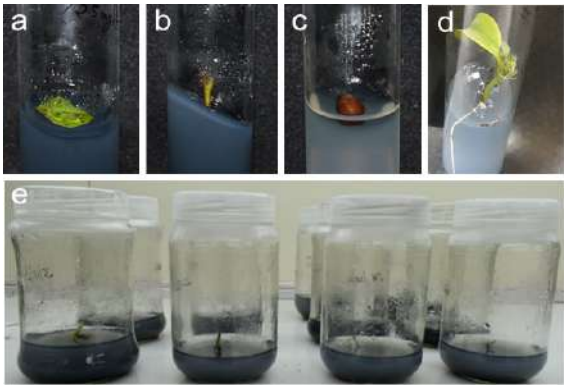

Fig. 3 Mass multiplication of *Cinnamomum verum* (cinnamon).

A note on the identity of the Spikenard

Spikenard is a common name for the Himalayan medicinal herb *Nardostachys jatamansi*. It is a small perennial rhizomatous herb that is restricted in geographic distribution to specialized habitats in high altitudes of the Alpine Himalayas encompassing India, Nepal and China, between 3000-5000 masl. It is known as 'Jatamansi' in India and Nepal, and 'Gansong' in China. Finding *Nardostachys* in India is no longer an easy task. We somehow managed to get 5 plants, which we believed belonged to the genus *Nardostachys*, from the Great Himalayan National Park, Himachal Pradesh, India. We used these plants to amplify and sequence the nuclear rDNA ITS region, the chloroplast *rbc*L gene and *trn*K intron (including the *mat*K gene) to reassess its taxonomic identity (Fig. 4).

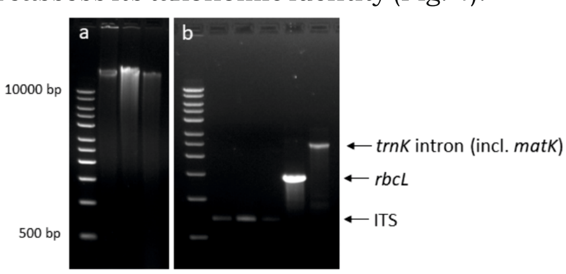

Fig. 4 DNA isolation (a) and PCR amplification of ITS, *rbcL* gene and *trnK* intron (including *matK* gene) (b) of *Nardostachys jatamansi*.

Genetic basis of carnivorous leaf development

Plant carnivory is often manifested as dramatic changes in the structure and morphology of the leaf. These changes appear to begin early in leaf development. For example, the development of the *Sarracenia purpurea* leaf primordium is associated with the formation of an adaxial ridge, whose growth along with that of the leaf margin resulted in a hollow structure that later developed into a pitcher. In *Nepenthes khasiana*, pitcher formation occurs during the initial stages of leaf development, although this has not been shown at the primordial stage. The formation of the *Utricularia gibba* trap resulted from the growth of the dome-shaped primordium in both the longitudinal and transverse directions. Recent research has begun to unfold the genetic basis of the development of the carnivorous leaf (Fig. 5).

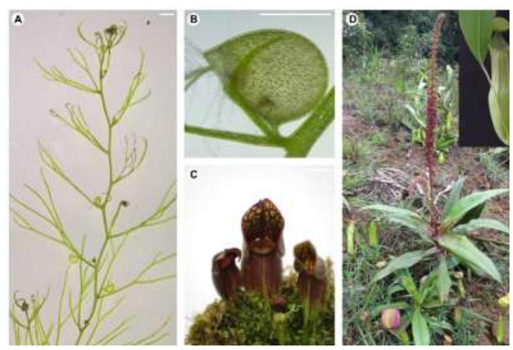

Fig. 5 Innovative leaf morphologies of *U. gibba* (A, B), *S. purpurea* (C) and *N. khasiana* (D).

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Plant Breeding

The research focus of my lab is on genetic improvement and varietal development of high value important crops like German chamomile (*Matricaria recutita* L.), Lavender (*Lavandula angustifolia*), Heeng (*Ferula assa-foetida*), Dalchini (*Cinnamomum verum*) and Quinoa (*Chenopodium quinoa*).

Evaluation of German chamomile selections at multi-locations: A total of nine superior selections (made on flower yield trait from different populations developed through hybridization) were evaluated at four different locations *ie.*, Palampur, Gumarwin, Kullu and Sinhuta

Table 1 Fresh flower yield of German chamomile at different locations pooled over 2020 and 2021.

Selections	Fresh flower yield (Kg/plot)				
	Palampur	Kullu	Ghumarwin	Sinhuta	Mean
MC19005	2.92*	2.16*	2.74*	2.40*	2.55*
MC19016	2.18	1.60	2.02	1.81	1.90
MC19023	2.49	1.56	2.26	1.77	2.02
MC19039	2.06	1.82	1.97	1.92	1.94
MC19047	2.10	1.73	2.11	1.82	1.94
MC19048	2.49	1.68	2.26	1.94	2.09*
MC19049	1.62	1.58	1.55	1.57	1.58
MC19050	1.90	1.44	1.84	1.61	1.70
MC19054	2.11	1.48	2.09	1.67	1.84
Mean	2.21	1.67	2.09	1.83	1.95
CD ($p \leq 0.05$)	0.30	0.33	0.20	0.26	0.12
SE(d)	0.14	0.15	0.09	0.12	0.06

*Signicantly ($p \leq 0.05$) higher than mean

Table 2 Essential oil content of German chamomile at different locations pooled over 2020 and 2021.

Accessions	Essential oil (g/Kg)				
	Palampur	Kullu	Ghumarwin	Sinhuta	Mean
MC19005	3.47*	3.58*	3.51*	3.49*	3.49*
MC19016	2.44	2.62	2.97	2.52	2.64
MC19023	2.86	2.30	2.58	2.04	2.45
MC19039	1.89	2.06	2.26	1.80	2.00
MC19047	3.09	2.67	3.07	2.55	2.84*
MC19048	2.76	2.60	2.96	2.51	2.71
MC19049	2.77	2.41	2.52	2.23	2.48
MC19050	1.58	1.82	1.91	1.74	1.76
MC19054	2.29	2.45	2.60	2.19	2.39
Mean	2.56	2.50	2.71	2.34	2.53
CD ($p \leq 0.05$)	0.88	0.71	0.41	0.72	0.27
SE(d)	0.41	0.33	0.19	0.34	0.13

*Signicantly ($p \leq 0.05$) higher than mean during 2020 and 2021. The experiments were laid out in the plots of 3m × 2m size with 40 cm row to row and 20 cm plant to plant spacing in a randomized block design over all the locations. The results showed significant variations among different selections for fresh flower yield (Table 1) and essential oil content (Table 2) observed over different locations. Among them, selection "MC19005" was recorded significantly higher flower yield (2.55 kg/plot) and essential oil content (3.49 g/kg) than the mean (1.95 kg/ha and 2.53 g/plot, respectively) over all the locations.

Evaluation of lavender accessions at multi-locations: A total of seven superior accessions selected based on fresh spike yield from newly generated variation through hybridization were evaluated along with check (Sher-e-Kashmir) at four different locations *ie.*, Palampur, Sinhuta, Lahaul and Tissa during 2020-21 and 2021-22. The experiments were laid out in the plots of size of paired row of 3 m length (3m × 2m) with 1 m row to row and 50 cm plant to plant spacing in a randomized block design over all the locations. The results showed significant variations among different accessions for fresh spike yield (Table 3) and essential oil content (Table 4) tested over different locations. The accession "LOH15141" has significantly higher spike yield (3.03 kg/plot) and essential oil content (12.59 g/kg) than

Table 3 Fresh spike yield of lavender at different locations pooled over 2020 and 2021.

Accessions	Fresh spike yield (Kg/plot)				
	Palampur	Sinhuta	Lahaul	Tissa	Mean
LOH15046	2.17	2.58	2.31	2.97	2.51
LOH15059	2.14	2.61	2.28	2.85	2.47
LOH15110	2.40	2.76	2.40	2.91	2.62
LOH15134	2.06	2.56	2.17	2.75	2.39
LOH15140	2.62*#	2.99*#	2.39	3.15	2.79*#
LOH15141	2.66*#	3.05*#	3.14*#	3.27*#	3.03*#
LOH15154	2.05	2.42	2.22	2.70	2.35
Check (Sher-e-Kashmir)	2.40	2.71	2.37	3.03	2.63
Mean	2.31	2.71	2.41	2.96	2.60
CD ($p\leq0.05$)	0.210	0.213	0.389	0.205	0.053
SE(d)	0.097	0.098	0.018	0.095	0.027

*Signicantly ($p\leq0.05$) higher than mean; # Signicantly ($p\leq0.05$) higher than check

Table 4 Essential oil content of lavender at different locations pooled over 2020 and 2021.

Accessions	Essential oil (g/Kg)				
	Palampur	Sinhuta	Lahaul	Tissa	Mean
LOH15046	10.40	11.25	10.91	12.35	11.23
LOH15059	10.16	11.46	10.62	11.96	11.05
LOH15110	10.75	11.72	12.06#	11.79	11.58
LOH15134	10.32	11.18	10.34	11.54	10.84
LOH15140	11.26	12.15	10.99	12.40	11.70*#
LOH15141	11.33*#	13.22*#	12.38*#	13.42*#	12.59*#
LOH15154	9.97	10.91	10.33	11.41	10.66
Check (Sher-e-Kashmir)	10.62	11.79	10.69	12.40	11.37
Mean	10.60	11.71	11.04	12.16	11.38
CD ($p\leq0.05$)	0.700	0.803	1.190	0.881	0.203
SE(d)	0.323	0.371	0.549	0.407	0.103

*Signicantly ($p\leq0.05$) higher than mean; # Signicantly ($p\leq0.05$) higher than check the check (2.63 kg/ha and 11.37 g/plot, respectively) over all the locations.

Evaluation of true cinnamon in Himachal Pradesh

A total 200 diverse seedlings of true cinnamon (*Cinnamomum verum*) are being evaluated at IHBT, Palampur in an augmented design. The first year growth parameters under its new and non-traditional environment of Himachal Pradesh were observed and given in Table 5. The growth index was calculated by averaging widest width, perpendicular width and height.

Table 5 First year growth parameters of cinnamon plantation in Himachal Pradesh.

Growth parameters	Minimum	Maximum	Mean	Standard deviation
Plant height (cm)	15.50	62.10	43.12	7.92
Stem girth (mm)	2.07	10.80	8.09	2.50
Number of branches	1.00	16.00	6.81	2.51
Leaf length (cm)	3.00	13.53	8.40	2.27
Leaf width (cm)	1.83	6.50	3.59	0.95
Growth index	9.50	38.50	24.74	3.66

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Floriculture

Our group is involved in exploring the nutraceutical potential of edible ornamental flowers. We are also focusing on breeding and agrotechnology of floricultural crops.

Evaluation of proximate and phytochemical content in some edible flowers

Edible flowers are gaining popularity as a nutraceutical and functional food with strong antioxidant molecules and mineral elements that exert positive effect on human health. In the present study we have analysed proximate and phytochemical composition of four edible flowers viz., Kachnar (*Bauhinia variegata*), Nasturtium (*Tropaeolum*), Marigold (*Tagetes erecta*) and calendula (*Calendula officinalis*). Among all the flowers studied. Marigold was found superior for total carbohydrates (Fig. 1). The total reducing sugar was highest in nasturtium. Kachnar contained high amount of soluble protein and also crude protein. Marigold reported highest total flavonoids whereas, kachnar was found to have highest total phenols among the studied edible flowers. Metabolomics of these edible flowers (Targeted and non-targeted metabolites has been analyzed using UHPLC- QTOF-MS/MS) revealed that Quercetinand p-cat acid were the major flavonoids in kachnar and marigold flowers, respectively (Fig. 2). Apart from these phytochemicals, amino acid and minerals have been estimated from these edible flowers. We also studied the effect of different drying techniques on various bioactive compounds of four varieties of marigold. It was observed that oven-dried flowers exhibit high amount of bioactive compounds in comparison with other drying methods and as well as fresh flowers.

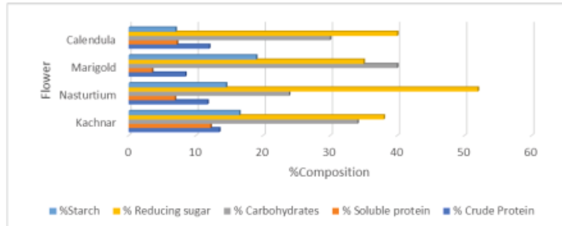

Fig. 1 Nutritional profile of edible flowers.

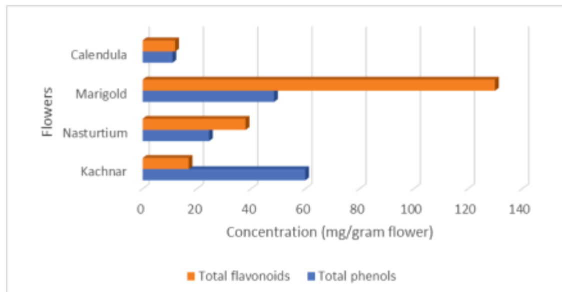

Fig. 2 Phytochemical composition of different edible flowers.

Characterization of rose genotypes

Roses are one of the most widely grown commercial flower crops in the world, valued for their beauty, scent, and nutritional properties. We have a unique collection of roses at CSIR- IHBT, Palampur, including Hybrid Teas, Floribunda, miniature, and climbers. Various plant parts of rose have been reported to contain several bioactive compounds with several health benefits. In the present investigation we have analysed phytochemical composition of leaves of different rose genotypes. Among different genotypes, total phenolic content varied from 6.30 to 14.07 mg/g. Genotype R111 exhibited the maximum value of total phenols. In case of total flavonoids genotype R170 (15.97 mg/g) leaf extract contained maximum flavonoids compared to the other genotypes. The colour parameters such as L, a, and b values for abaxial and adaxial leaf surfaces exhibited the significant differences among genotypes. Total carotenoid content ranged from 13.86 to 35.66 µg/g (Fig. 3).

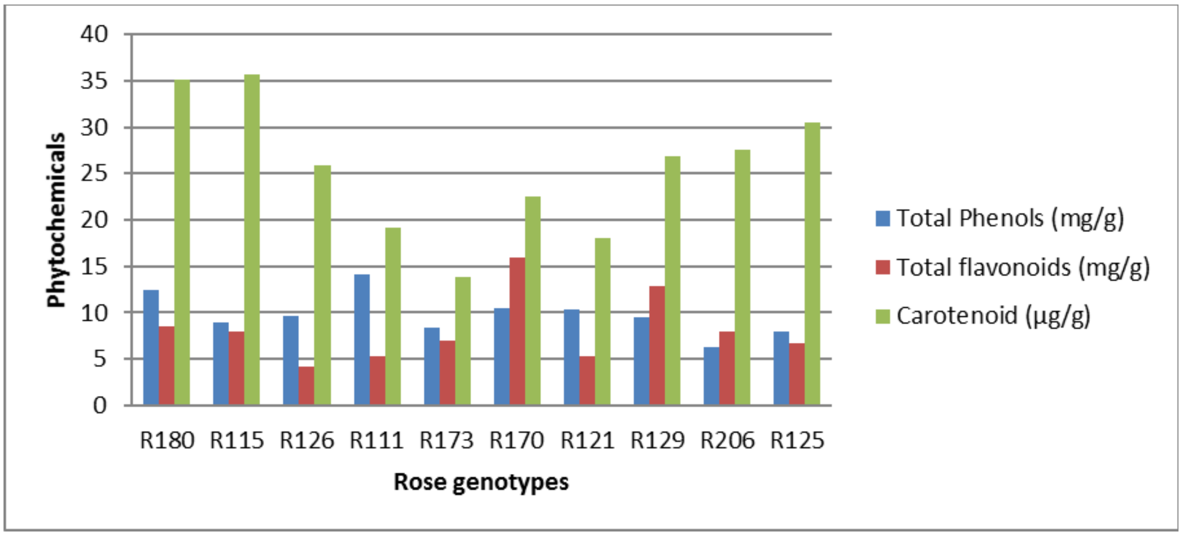

Fig. 3 Phytochemical composition of different rose genotypes.

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Agronomy

Our group is focused on the development of agrotechnology for medicinal and aromatic crops of high-altitude regions. We are also involved in the introduction and extension of Dalchini (*Cinnamomum verum*) and Heeng (*Ferula assa-foetida*) in the non-traditional areas of Himachal Pradesh.

Effect of fertilizer management on dry root yield of *Saussurea costus*

Saussurea costus (Falc.) Lipsch. commonly-known as kuth {synonym *Saussurea lappa* (Decne.) Sch. Bip.} is a critically endangered medicinal plant of Himalayan region. It is used as a carminative, antiarthritic, expectorant, aphrodisiac, antiseptic, and vermifuge in Ayurveda, Unani, Sidha, Tibetan, and Chinese traditional systems of medicine. A field experiment consisting of 19 fertilizer treatments was conducted in Lahaul to optimize the fertilizer dose for better yield. The analyzed results revealed that the fertilizer combination (N3P3K1) @ 120:60:20 kg/ha produced significantly higher dry root yield (53%) over control. However, this treatment was at par with N2P3K2, N2P3K1, N3P2K1, N3P2K2, N2P2K2, N3P3K2 and N2P2K1 (Fig. 1).

Introduction of *Dalchini* (*Cinnamomum verum*) in Himachal Pradesh

Cinnamon (*Dalchini*) is one of the topmost used spices in the world. The most useful part of cinnamon is the outer bark, which is commonly used as a spice and for many natural medicinal applications. India imports 45,318 tonnes (worth Rs. 909 crores) of cinnamon from China, Sri Lanka,

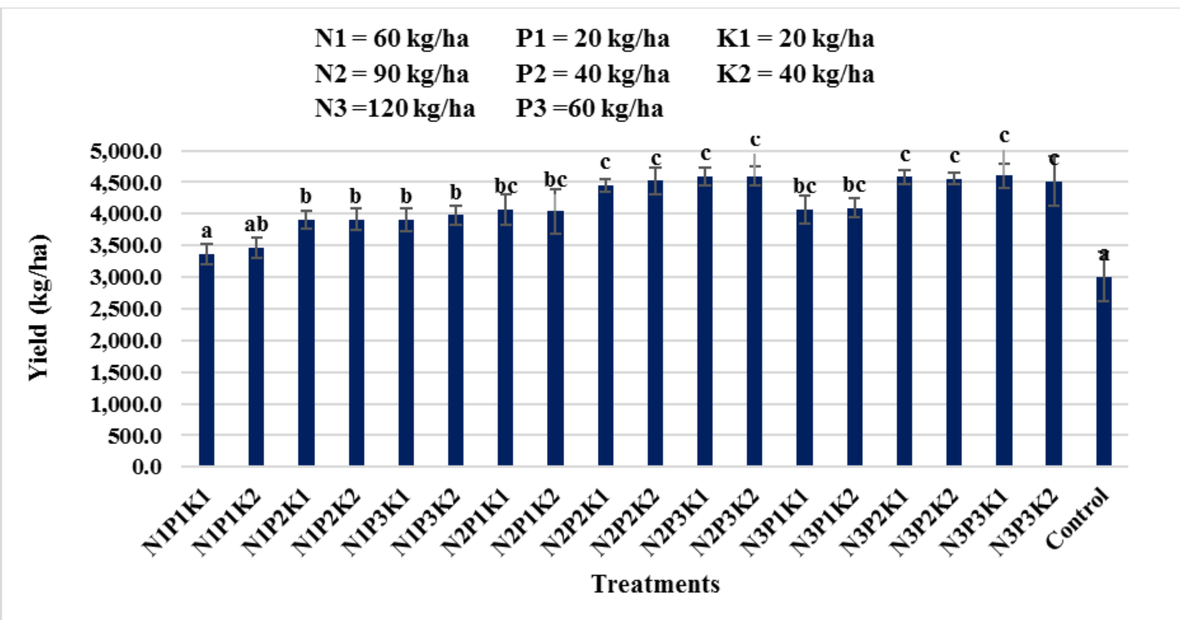

Fig. 1 Effect of fertilizer treatments on dry root yield of *S. costus*.

Vietnam, Indonesia, and Nepal every year. By studying the model on the basis of physical and environmental conditions, it was found that the low-lying areas of Himachal Pradesh especially areas nearby Pong Dam, Gobind Sagar Lake and the surrounding parts of Renuka Lake are suitable for cinnamon cultivation. Realizing its importance, a MoU between CSIR-IHBT and ICAR-Indian Institute of Spice Research, Calicut, Kerala and Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth, Dapoli, Maharashtra has been signed for a joint collaboration for the cultivation of cinnamon in Himachal Pradesh.

The first sapling of cinnamon was successfully planted at farmer's field at village Kholin, Distt. Una in H.P. by Sh. Virender Kanwar, Hon'ble Minister for Rural Development, Panchayati Raj, Agriculture, Animal Husbandary and Fisheries, Himachal Pradesh in presence of Dr. Sanjay Kumar, Director, CSIR-IHBT on 29th September, 2021 (Fig. 2&3). Further, training programs were organized on cinnamon cultivation and demonstration plots were laid out at villages Nandpur Bhatoli, Kherian in Kangra; Kosarian in Bilaspur; Sakrala in Hamirpur; Barnoh in Una; Dadahu and Bhajon in Sirmaur districts of Himachal Pradesh.

Director General, Dr. Shekhar C. Mande of CSIR, also marks the cultivation of cinnamon by planting the sapling of cinnamon at Kherian, Distt. Kangra (H.P.) on 6th March, 2022

Fig. 2 Plantation of cinnamon at village Kholin, Distt. Una on 29th September 2021.

Fig. 3 Plantation of cinnamon at village Kherian, Distt. Kangra on 6th March 2022.

Research group: Diksha Dhiman, Vikrant and Sidharth Baghla

BIOTECHNOLOGY DIVISION

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Plant Adaptation and Secondary Metabolism

Our research group has been working on understanding the mechanism(s) of adaptation in plants of the Himalayas and gene prospection for societal and industrial uses.

Elucidation of molecular mechanism underlining prickle morphogenesis in rose

Using a domesticated prickle-bearing cultivar of rose, *Rosa hybrida* L. cv. "First Red (FR) (Fig. 1A), we investigated the molecular mechanism underlining prickle morphogenesis in rose (***Plant Direct***, 5: e00325, 2021). Morphological, molecular, and associated metabolic changes during three distinct stages of the prickle morphogenesis, namely, emerging tiny initiating prickles, partially greenish soft prickles, and brownish hard prickles (Fig. 1B), revealed that prickles emerge as an outgrowth from the epidermis or cortical tissue and accumulate secondary metabolites, especially flavonoids (Fig. 1B and C). RNAseq-based global transcriptome analysis revealed a gradual upregulation of genes involved in secondary metabolism with prickle morphogenesis; and an upregulation of epidermal cell differentiation-related genes at the early phase. Based on RNAseq and subsequent qRT-PCR-based validation, an MBW transcriptional activator-inhibitor complex comprising of an R2R3- or R3-MYB, a bHLH, and a WD40 protein, was proposed to be involved in secondary metabolite accumulation and prickle morphogenesis (Fig. 1D), which was then validated using a prickle-less cultivar, *R. hybrida* cv. Himalayan wonder (HW). These results supported the proposition that prickles evolved from trichomes and provided molecular clues toward engineering prickle-less roses.

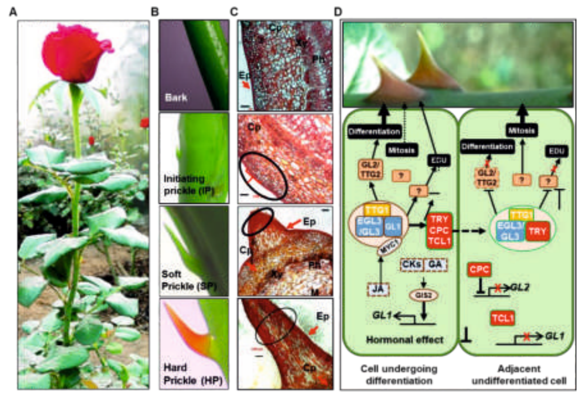

Fig. 1 Molecular mechanism of prickle morphogenesis in rose. (A) A healthy plant of *Rosa hybrida* L. cv. "First Red" in the flowering stage. (B) Bark tissue and three stages of prickle development, initiating prickle (IP), soft prickle (SP), and hard prickle (HP). (C) Transverse section of bark and bark with IP, SP, and HP. (D) A proposed model describing the involvement of the MBW transcriptional activator-inhibitor complex in prickle morphogenesis. (adopted from Swarnkar et al., 2021).

Identification of ice structuring proteins from Himalayan grains and their recombinant expression

This ice recrystallization inhibition (IRI) property of antifreeze proteins is of great importance during cryopreservation in food and medical industry. Our group screened the Himalayan grains for IRI activity. Results showed that barley (*Hordeum vulgare* var. dolma) exhibited maximum IRI activity. In addition, total protein from the grain reduced the drip loss and prevented the freeze-induced loss in vitamins B4, B6 and C in green peas (***Cryobiology***, 104: 1-7, 2022). Purification of ice structuring proteins yielded two polypeptides, *Hv*ISP1 and *Hv*ISP2, as identified by mass spectrometry. Of these two polypeptides, *Hv*ISP1 was heterologously expressed in *E. coli* and purified (Fig. 2). The purified protein also showed IRI properties and prevented vitamin content loss in peas during cryo-storage.

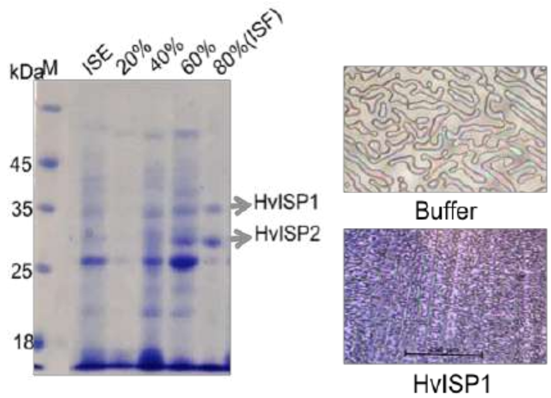

Fig. 2 Purification of HvISP1 from *Hordeum vulgare*, which showed significant ice recrystallization inhibition (IRI) property.

Beneficial cultivable endophytes of *Arnebia euchroma*

Arnebia euchroma (Ratanjot) is an endangered medicinal plant that grows naturally in extreme cold and arid environments in the Himalayas. We provided a detailed overview of the cultivable endophytic diversity associated with the root and leaf of *A. euchroma,* along with their plant growth-promoting (PGP) traits (Fig. 3). A total of 60 bacteria dominated by phylum Proteobacteria, with the abundance of class Gammaproteobacteria (76.67%) and genus *Pseudomonas,* were isolated. Among fungal endophytes, Ascomycota was most abundant phylum dominated by class Eurotiales (42.42%) and genus *Penicillium.*

Notably, two yeast endophytes, *Tausonia pullulans* and *Naganishia liquefaciens*, were recognized as the plant endophytes for the first time. Isolated endophytes exhibited essential PGP characteristics such as the ability to make ACC deaminase, indole acetic acid, and siderophore and the ability to solubilize phosphorus and potassium. Data showed that endophytic mutualism between plant and microorganisms offers several benefits to host, including growth promotion and stress tolerance (***Front. Microbiol.*** doi: 10.3389/fmicb.2021.696667). These isolated endophytes are now being tested for improving stress tolerance in plants grown under nutrient deficient and cold/arid conditions.

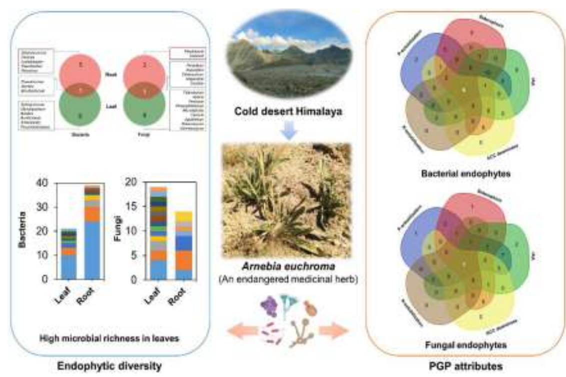

Fig. 3 Endophytic diversity and plant growth promotion attributes of microbial endophytes isolated from roots and leaves of *Arnebia euchroma.*

The first in-house developed draft genome sequence of *Picrorhiza kurrooa*

We reported the first indigenously developed draft genome of an endangered Himalayan medicinal herb, *P. kurrooa* in association with bioinformatics group led by Dr. Ravishanker (***Sci. Rep***., 11: 14944, 2021). The size of assembled genome was 1.76 Gb with 37.89% GC content and a scaffold N50 of 129.6 kb. The repeat sequences accounted for 76% of the genome (Fig. 4). From a single institution, it is one of the first and biggest draft genomes of a plant species reported from India. The assembled draft genome of *P. kurrooa* offers a valuable resource and reference information to understand the biology of this endangered Himalayan medicinal plant. The study also provides a novel computational strategy for assembling while dealing with a highly repetitive and complex genome.

Total Contigs	12,924
Maximum contig length	6,38,644 (638 Kb)
Contig Length > 1Kb	100
N50	1,29,641 (129.6 Kb)
Total bp	1,57,22,32,662 (1.57 Gb)
Total average	1,21,652.171309192 (121 Kb)
GC Percentage	37.89

Fig. 4 Statistics of draft genome assembly of *Picrorhiza kurrooa.*

Molecular basis of sustaining under water deficit conditions in *Podophyllu hexandrum*

Environmental conditions such as fluctuating temperature, UV-B, low partial pressure of gases, and inadequate availability of water and nutrients, pose stressful conditions for the survival of plants in Himalayan niches. Despite these unfavorable conditions, plants such as *Sinopodophyllum hexandrum* can sustain and complete their life cycle. Deciphering the mechanisms by which this plant deal with these cues is essential for understanding its adaptability. We recently revealed that stress-responsive *cis*-regulatory elements in the podophyllotoxin biosynthetic genes underline increased podophyllotoxin biosynthesis and sustainance of *S. hexandrum* under water deficit conditions (Fig. 5) (Kumari et al., ***FiPS***, 2022).

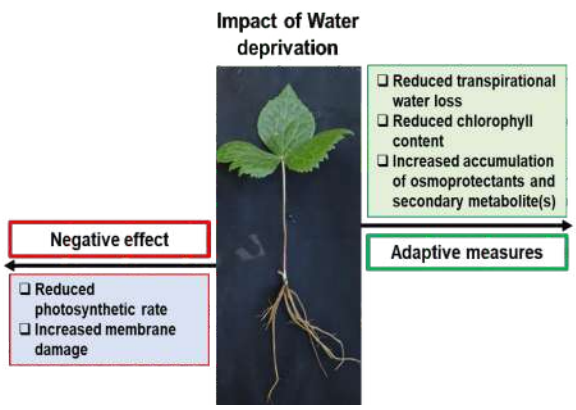

Fig. 5 Strategy adopted by *S. hexandrum* to sustain reduced water availability.

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Plant Growth Promoting Rhizobacteria

Up-scaled production of disease free corms of saffron (*Crocus sativus*)

The major focus of this project was to develop a cost effective protocol for *in vitro* production of saffron corms. In this regard, during the current year corm production media was standardized which not only reduced the cost of the media substantially but also promoted formation of bigger sized corms with profuse rooting (Fig 1 and 2). On an average 3 to 5 corms were harvested from each flask (Fig. 3). These corms when planted in trays containing soil, sand, and FYM in 1:1:1 ratio, sprouted after 35-45 days and followed the vegetative cycle of growth (Fig. 3 and 4). The survival rate of these *in vitro* raised corms were about 91%. The developed protocol is 3 times cheaper and reduces the time of entire cycle (explant to corm formation) atleast by 30 days compared to traditional protocols.

Fig. 1 Corm ready for harvesting.

Fig. 2 Profuse rooting.

Fig. 3 Harvested corms.

Fig. 4 Sprouting of *in vitro* raised corms.

The stress tolerance and plant growth promoting attributes (PGP) of *Bacillus altitudinis* (earlier isolated from saffron rhizosphere) were analyzed. It was observed that the bacteria could tolerate wide range of temperature spanning across 4°C to 50°C. Whole genome sequencing was also carried out to understand its genetic characteristics and it was observed that this bacterium harbors several genes associated with cold tolerance, heat tolerance and stress tolerance. Further, it was noticed there are multiple genes associated with phosphate solubilization, siderophore formation, IAA production and root colonization. The potential of *Bacillus altitudinis* as biofertilizer was assessed by laying field trials at farmers' field. Several farmers of the nearby are areas were encouraged to take up saffron cultivation. Planting material, agri-inputs and biofertilizer were provided by the Institute. Flowering were observed in all the fields. Corm harvesting will be done in May 2022 and thereafter data will be analyzed to assess the impact of biofertilizer on corm production.

To assess the potential of biofertilizer consisting of *Bacillus altitudinis* and IHBB 13602, a field trial of potato was laid at Guru Nanak Dev University Amritsar (GNDU) in Nov 2021 (Fig 5). Upon harvest in March 2022, significant differences were noticed in biofertilizer treated and controlled potato plants. The yield was twice in biofertilizer treated plants as compared to control counterparts. Key antioxidant associated enzyme activities like SOD, APX and GPX were found to be higher in biofertilizer treated leaves as compared to control plants. Further, biofertilizer treatment considerably increased the content of photosynthetic pigments like chlorophyll a and chlorophyll a+b upto 3.5 time and 1.42 times respectively, as compared to control plants. Based on our findings, it can be concluded that this consortium is efficient in promoting growth of potato and can be used commercially for sustainable agriculture.

Fig. 5 Field trail of Potato at GNDU Amritsar.

The quest for new PGPR continued and five promising PGPR strains were isolated from rhizosphere of *Rhododendron arboreum* growing in wild in the area of Prasher lake, Mandi district Himachal Pradesh. Sixty seven bacterial strains were screened w.r.t plant growth promoting attributes. Studies are underway to understand the rhizospheric microbial community.

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Plant Microbe Interaction of Plant Viral Pathogens

My 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 are entitled "Functional characterization of the host (plant) and vector (whitefly) proteins in systemic immunity and transmission of virus and virus-like pathogens (CSIR-NCP project)", Characterization of reverse transcriptase (RNA dependent DNA polymerase) activity from greenhouse whitefly *Trialeurodes vaporariorum* (CSIR-First) and "Studies to identify host factors that are manipulated by Cucumber mosaic virus for disease development and spread (DST SERB)" deals with plant microbe vector interaction studies involving Cucumber mosaic virus, tomato leaf curl virus and apple scar skin viroid. Functional role of their proteins/ RNA in disease development and spread is under investigation.

Serological and molecular analysis indicates the presence of distinct viral genotypes of Apple stem pitting virus in India

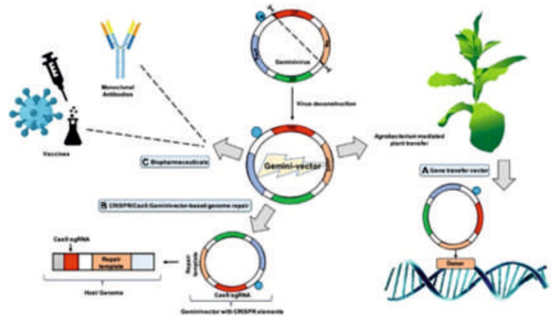
Recombination leads to the generation of new viral progeny which remain undetected by routine testing procedures and may be a threat to the infected host. The complete genome sequences of two isolates of Apple stem pitting virus from apple cv. Red Chief (Palampur) and cv. Gold Spur (N) with distinct serological reactivities, has been characterized. The viral genomes consisted of 9267 nucleotides for isolate Palampur and 9254 nucleotides for isolate N, excluding the poly (A) tail and contained 5 open reading frames (ORFs). Isolate N shared 80.8% sequence identity with ASPV apple isolate GA2 from China, while isolate Palampur shared 81.4% sequence identity with ASPV apple isolate PB66 from the United Kingdom. The serological difference of isolates N and Palampur along with their low sequence identity indicated the existence of two distinct virus genotypes which was corroborated by evolutionary and genetic diferentiation analyses. Recombination events were detected in the RdRp and CP sequences of Palampur isolate thereby suggesting the role of recombination in the evolution of distinct virus genotypes.

Chrysanthemum stunt viroid infection in cucumber leads to yellow net symptoms

Chrysanthemum stunt viroid (CSVd), is known to cause severe stunting symptoms in chrysanthemum. Here, we have identified a CSVd strain that infects chrysanthemum in India and have biologically characterised it by generating in vitro RNA transcripts from the cloned viroid genome. Transcripts inoculated on chrysanthemum caused severe stunting (characteristic of the viroid) and mottling in chrysanthemum and stunting symptoms in cucumber var. Summer green is also reported. Sequence changes in the Terminal Conserved region corroborated with change in RNA secondary structure might have implications associated with the viroid pathogenicity. Viroid infection on cucumber is not known and opens up a new range of pathogens which may infect plants of the cucubitacease family.

Geminivirus-Derived Vectors as Tools for Functional Genomics

A persistent issue in the agricultural sector worldwide is the intensive damage caused to crops by the geminivirus family of viruses. The diverse types of viruses, rapid virus evolution rate, and broad host range make this group of viruses one of the most devastating in nature, leading to millions of dollars' worth of crop damage. Geminiviruses have a small genome and can be either monopartite or bipartite, with or without satellites. Their ability to independently replicate within the plant without integration into the host genome and the relatively easy handling make them excellent candidates for plant bioengineering. This aspect is of great importance as geminiviruses can act as natural nanoparticles in plants which can be utilized for a plethora of functions ranging from vaccine development systems to geminivirus-induced gene silencing (GIGS), through deconstructed viral vectors. Thus, the investigation of these plant viruses is pertinent to understanding their crucial roles in nature and subsequently utilizing them as beneficial tools in functional genomics. This work, therefore, highlights some of the characteristics of these viruses that can be deemed significant and the subsequent successful case studies for exploitation of these potentially significant pathogens for role mining in functional biology.



Molecular insights into pathogenicity determinant proteins of geminiviruses

Plants have evolved several ways to combat geminivirus invasion that include resistance genes, autophagy, protein ubiquitination, suppression of virus gene expression, RNA silencing, and hormone-mediated defense. Geminiviruses have evolved to encode a few multifunctional proteins that interfere with most of the defense processes. These findings indicate the presence of a continuous evolutionary race among host plants and geminiviruses and in this context, more research is warranted to unravel the complexity of the plant geminivirus interactions. Collectively, the information would be helpful for the development of resistance strategies against geminivirus infection.

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Biotechnology

The current effort of my group is utilize Molecular Genetics and Genomics approaches for harnessing natural diversity for genetic improvement of Himalayan plant genetic resources and commercial important plant species. The group made following significant achievements during the period under report.

Molecular dissection of heat stress associated thermotolerance in tea (*Camellia sinensis* (L.) O. Kuntze)

Tea, *Camellia sinensis* (L.) *O Kuntze* is highly heterogeneous self-incompatible tree species of family theaceae, widely cultivated in the tropical and sub-tropical region of the world. The most daunting issue of global climate change is the deleterious impact of extreme temperatures on tea productivity and quality. The current study aimed to unravel molecular programming underpinning thermotolerance by characterizing heat tolerance and sensitivity response in 20 diverse tea cultivars (Fig. 1).

The significantly higher negative influence of heat stress was recorded in a sensitive cultivar with reduced water retention (47%), chlorophyll content (33.79%), oxidation potential (32.48%), and increase in membrane damage (76.4%).

A total of 38 million of filtered reads obtained in the comparative transcriptome sequencing of control and heat-treated samples of sensitive and tolerant tea cultivars assembled into 52,588 contigs with minimum sequence length and N50 of 300bp and 1408, respectively. Further,

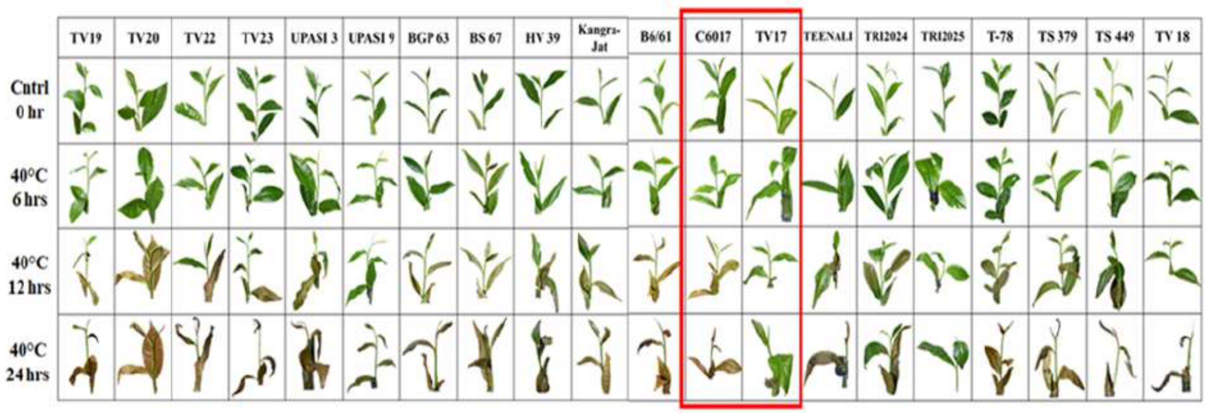


Fig. 1 Heat stress response evaluation of 20 diverse tea cultivars based on scorching effects in plant.

clustering resulted into 50441 unigenes encapsulating 33898 genes and 16543 isoforms. Functional annotation with various publicly available databases annotated 37509 (nr), 28607 (swissprot), 35178 (TAIR10), 20115 (TF) with 34894 gene ontologies and 8954 KEGG pathway databases. Interestingly, 3045 unigenes exhibited significant upregulation (FC=2, FDR < 0.05) in the tolerant than 3292 in the sensitive tea cultivars with respect to control under heat stress. Further, *in silico* prediction identified 2627 with functional domain in their coding sequence, 586 hypothetical and 81 uncharacterized unigenes exhibiting significant differential expression during heat stress. Additionally, 2831 heat stress associated unigenes were successfully mapped to 15 chromosomes of sequenced reference tea genome (Fig. 2).

Transcriptional profiling of most tolerant and sensitive cultivars identified 78 differentially expressed unigenes with chaperon domains, including low and high molecular weight heat shock protein (HSP) and heat shock transcription factors (HSFs) involved in heat shock response (HSR). Further, predicted transcriptional interactome network revealed their key role in thermotolerance via well-co-ordinated transcriptional regulation of aquaporins, starch metabolism, chlorophyll biosynthesis, calcium, and ethylene mediated plant signaling system (Fig.3).

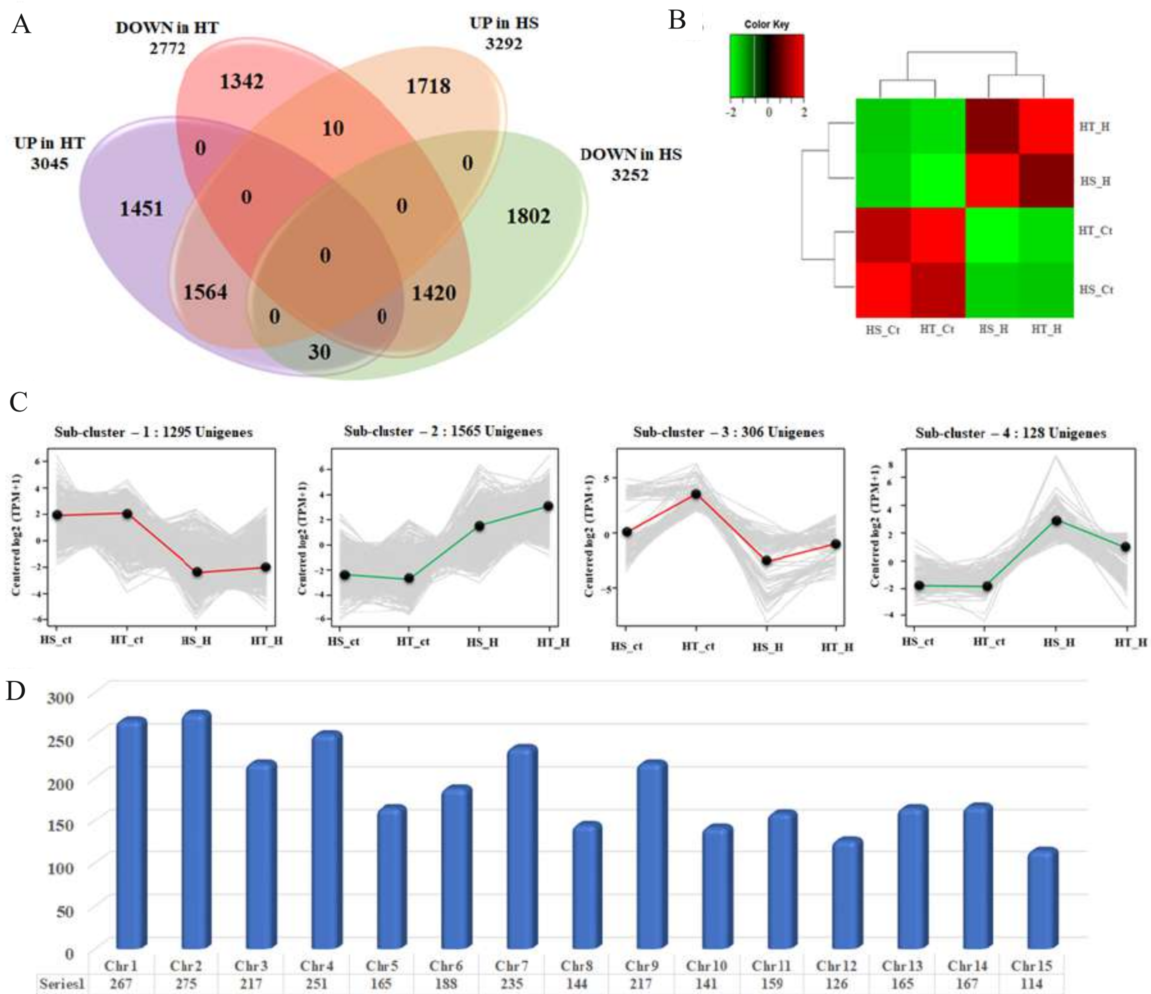


Fig. 2 Transcriptional parameters, clustering and assigning of significantly differentially expressed (SDEU) unigenes in heat stress transition in tea (A) Venn diagram representing pair-wise significantly differentially expressed in tolerant and sensitive cultivar. (B) correlation plot of SDEU based on their median TPM values (FC=2, FDR < 1e-4). (C) Clustering of significantly differentially expressed unigenes based on median TPM values considering FC=2, FDR < 1e-4. (D) Assignment of significant differentially expressed unigenes to 15 chromosomes of tea.

The study identified the key role of HSPs (CsHSP90) in regulating HSR in tea, wherein, structure-based molecular docking revealed the inhibitory role of geldanamycin (GDA) on CsHSP90 by blocking ATP binding site at N-terminal domain of predicted structure. Subsequently, GDA mediated leaf disc inhibitor assay further affirmed enhanced HSR with higher expression of CsHSP17.6, CsHSP70, HSP101, and CsHSFA2 genes in tea. Through the current study, efforts were made to extrapolate a deeper understanding of chaperons mediated regulation of HSR attributing thermotolerance in tea

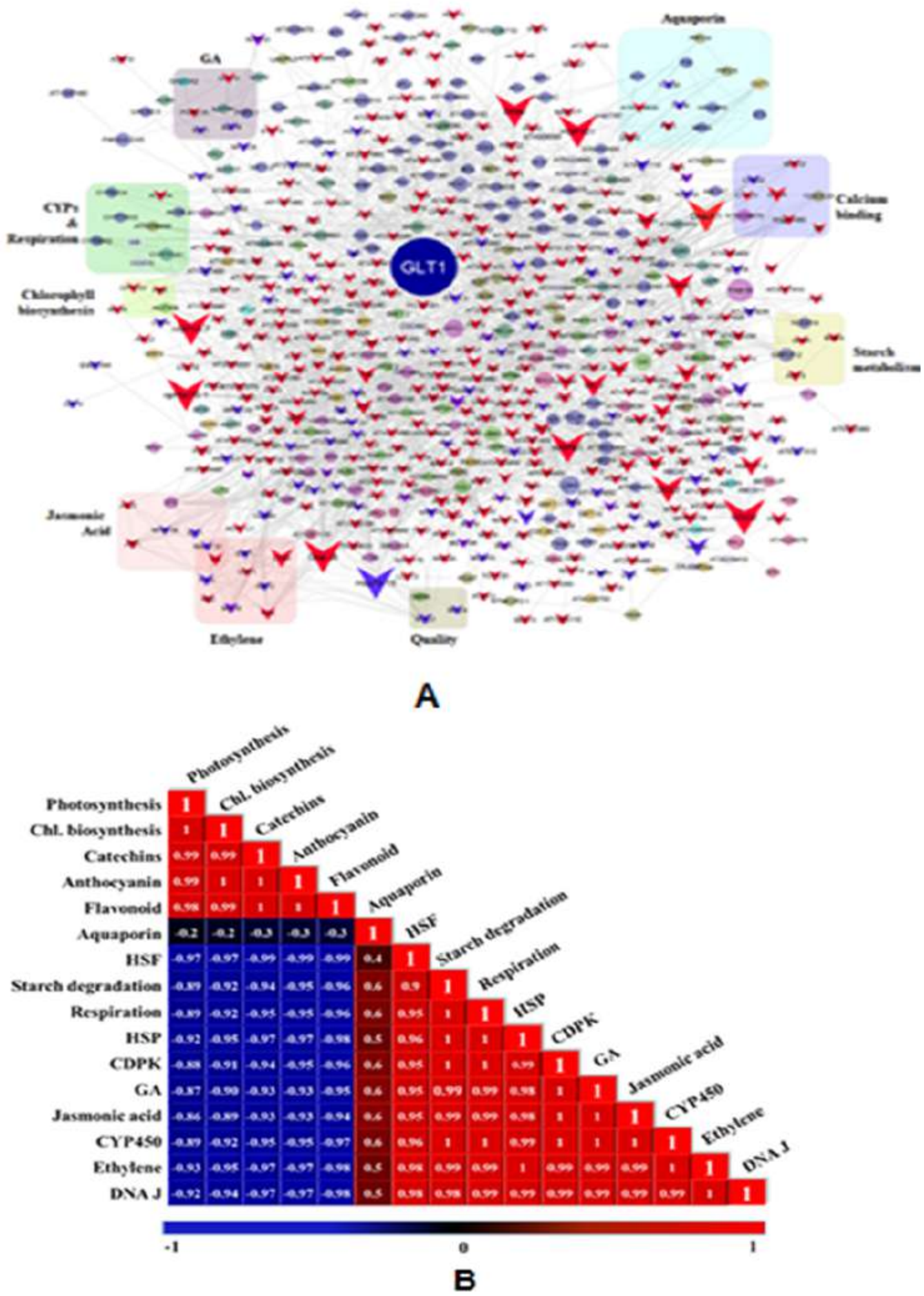


Fig. 3 (A) Predicted heat stress associated transcriptional interactome network of tea. (B) Pearson's correlation of enriched pathways in predicted network.

(Seth et al. Horticulture Research (2021) 8:99).

Genome-wide characterization of functionally relevant transcription factor derived microsatellites markers in tea

Microsatellites or Simple Sequence Repeats (SSRs), the ubiquitously abundant variable tandem DNA repeats (1-6bp) generated due to replication slippage and DNA repair mechanism are widely distributed across prokaryotes and eukaryotes. Contrary to decades old belief of junk DNA, SSRs have been reported to play crucial role in chromatin organisation affecting gene function and DNA metabolic processes. SSR markers particularly derived from functionally characterised protein coding and non-coding un-translated regions (UTRs) act as "functional markers" widely used for genome mapping, diversity characterization, evolutionary and comparative genomic studies.

Tea, one of the most popular beverage requires molecular breeding interventions for genetic improvement of quality, stress and yield traits, yet limited, due to scarcity of validated functional markers. Transcription factors (TFs) being "master regulator" of various cellular processes can be an excellent target for identification of functionally relevant SSR markers for genetic improvement of quality, yield and stress tolerance in tea. A total of 2776 transcripts encoding TFs harbouring 3687 SSR loci yielding 1843 flanking markers were identified from traits specific transcriptome resource of 20 tea cultivars. *De novo* assembly of high quality reads using Trinity-RNA seq assembler resulted into 194558 non-redundant (NR) transcripts. Search for microsatellite loci in individual assembled NR transcripts identified 16867 SSR motifs. BLAST searched with Plant-TFIIdb retrieved 2776 TF encoding transcripts harbouring 3687 SSRs (3263: perfect; 423: compound repeats). Overall, di-nucleotide SSRs repeats were most abundant (2269; 61.5%), followed by tri- (1284; 34.8%), tetra- (58; 1.57%), hexa- (41; 1.11%) and penta-nucleotide repeats (35; 0.94%). Further, localisation identified presence of SSR repeats in CDS (50%), 5'UTR (35%) and 3'UTR (15%) respectively, wherein, tri-nucleotide repeats were found more abundant in CDS (Fig. 4).

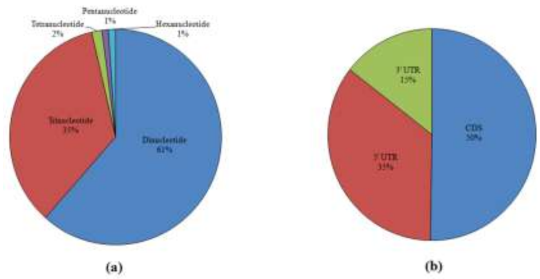
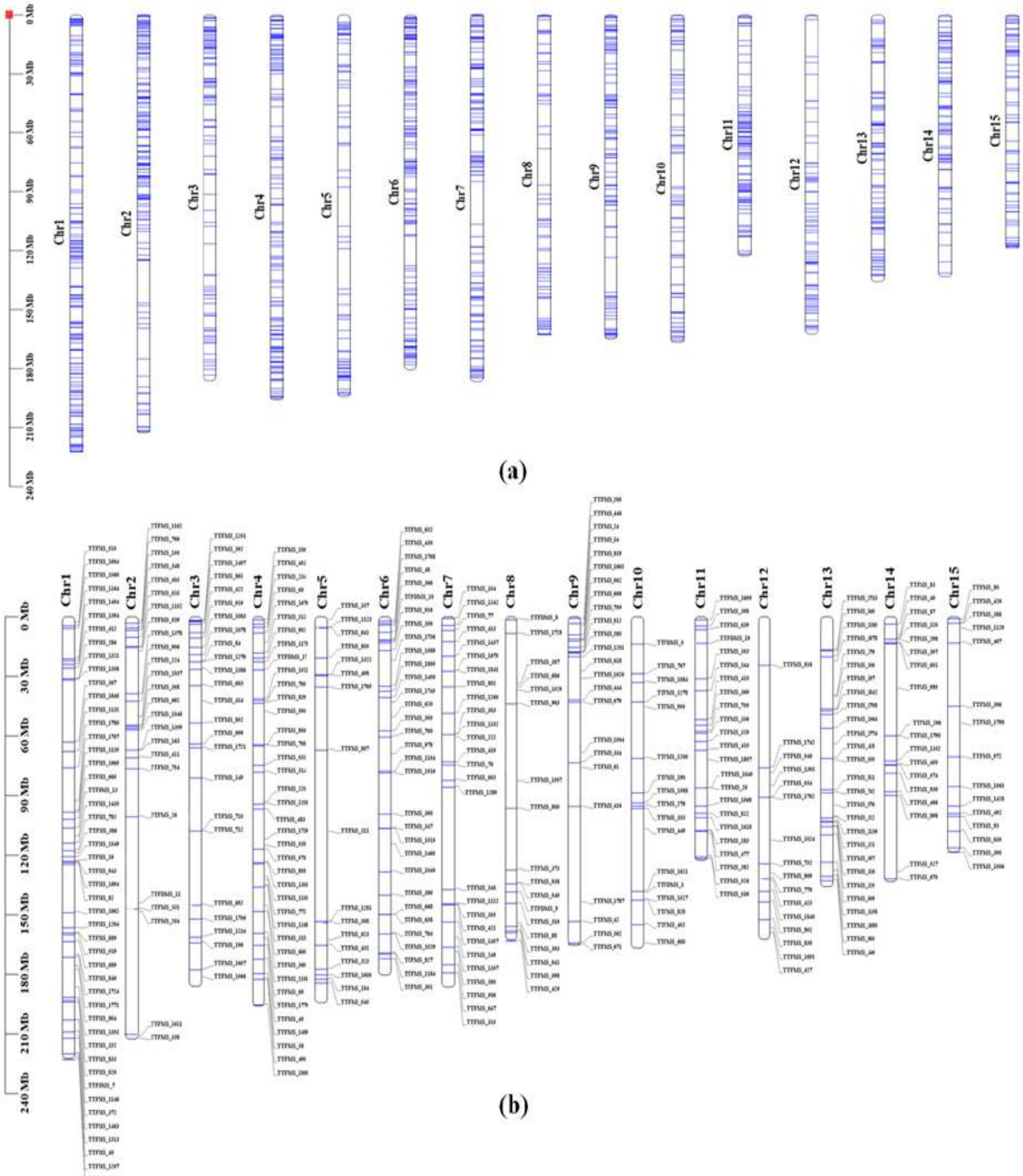


Fig. 4 Abundance and localization ofSSRs transcription factors in tea: (a) Overall abundance of various SSR repeats; (b) Localisation of SSR repeats in CDS and UTRs.

TF-SSRs revealed higher abundance in bHLH (14%) followed by Myb-related (8%), WRKY (8%), C2H2 (7%), C3H (6%), ERF (6%), NAC (5%), FAR1 (5%), G2-like (5%) and MYB (5%) TF families. Of these, 689 having role in yield/quality and stress tolerance were successfully validated and assigned to 15 chromosomes (*Chr*) of CSS genome (Fig. 5). Furthermore, single amino acid repeat reiteration due to tri-nucleotides in CDS also revealed presence of favoured and hydrophobic amino acids. Successful deployment of markers for genetic diversity characterization of 135 tea cultivars and segregating in bi-parental population suggests their wider utility in high-throughput automation for larger-scale genotyping studies in tea ***(Parmar et al Scientific Reports (2022) 12: 201).***



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Studio of Computational Biology and Bioinformatics

The Research Works: Last year we had talked about the role of RNA binding proteins in miRNA biogenesis. We had given a snapshot of the way these two post-transcriptional regulators of living system perform "Jugalbandi" to make the living system run. It was first of its kind reporting and where we were able to show how mature miRNA formation depended upon the networks of interactions of various RNA binding proteins, which ensured highly spatio-temporal formation of microRNAs.

Based on this finding we had developed a Bayesian networks analysis and machine learning fusion system, miRBiom where one just need to flux RNA-seq data and the miRNAome profile for that condition is accurately predicted. The miRBiom system is now published and made available as open access server software at SCBB as well as open source source code at GitHub.

While working on miRNA-RBP relationship, we also got attention towards the fact that there was a huge dearth for software to identify RBP interaction spots across RNAs. Ironically, RNAs can't exist in system even for a moment without associating themselves with RBPs. RBPs are essential entities for meaning, purpose and existence of any type of RNA. And our knowledge about RBP-RNA interaction is so limited, and hardly any credible software existed. We took this challenges and excavated several terrabytes of high-throughput data for 137 RNA bidning protein and their pattern of RNA interactions Using Deep Neural Nets (DNN), very accurate models for all these RBPs and their RNA interactions were built which outperformed the recnetly published advanced software for the same job and maintained an accuracy level above 90% consistently for all the RBPs studies , and across wide range and types of experimetnally validated benchamrking datasets (Fig. 1). This study also introduced a new dataset for such kind study and showcased how earlier studies missing on such important aspects of machihne learning and model building for RBPs interactions with RNAs. Named as RBPSpot, this software has been made available at SCBB website as well as open source software at Github.

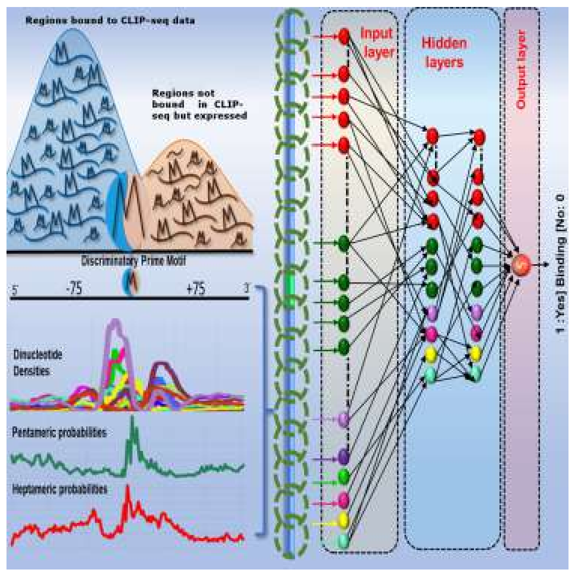


Fig. 1 The workflow of implementation of RBPSpot software to detect RBP-RNA interactions (Courtesy: Sharma et al, 2021, iScience; https://doi.org/10.1016/j.isci.2021.103381).

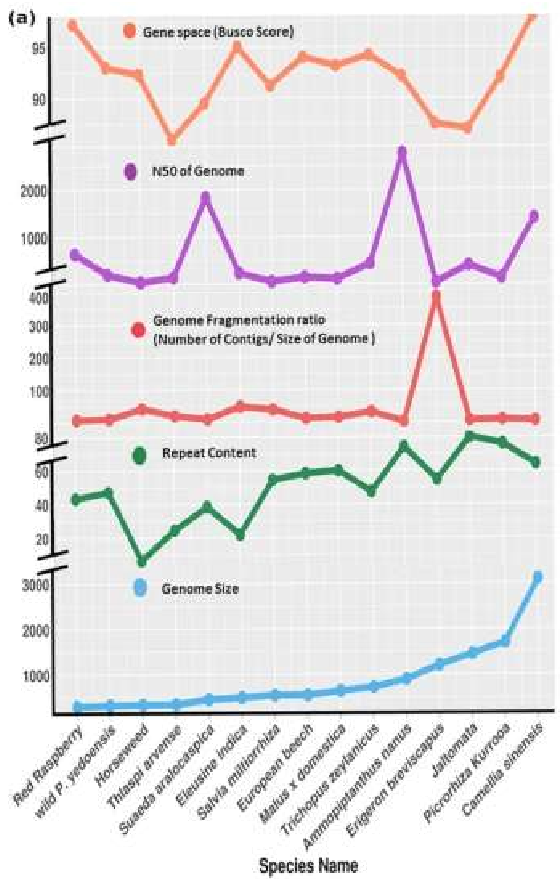
The next important research work published in the year 2021-22 has been the first draft genome of *Picrorhiza kurrooa*, an endangered medicinal herb of Himalaya.

This work becomes important for many reasons:

1) It is perhaps the biggest and most complex

plant genome reported form India (n=1.7 GB), in totally single institution manner.

2) It applied a novel genome assembling software approach to deal with high repeat contents where other assmeblers fail. And without involving any high cost scaffolding and mapping experiments like Mate Pairs or Digital Mapping etc, just using shotgun sequencing type of reads from Pacbio & Illumina Hi-seq, asseblies were achieved which outperformed the assemblies derived using digital mapping and scaffoldign experiments as well as platforms like 10X Genomics. The below given Fig. 2 underlines how Picrorhyza draft



genome assembly stood at par and better than much costlier experiments to assemble genomes of equally complex or lesser complex genomes:

3) The study has established the phylogenetic association of Picrorhyza in Veroniceae tribe after multi-angled phylogenomic/genetic analyses.

4) The genome assmeblies were validated through 4 different analysis including directed PCR experiments which confirmed very high credibility of the assembled genome.

5) Full in-depth annotaiton of the genome has been done identifying 24,798 protein coding genes, >700 miRNAs, 9,789 lncRNAs, while revealing that more than 75% of the genome is covered by complex repeats full of Gypsy and Copia LTR retroposons!

Finally, this year we released and published the proteome map of Picrorhiza kurroa using mas spectrometry, in collaboration with our experimental partner Dr. Rajiv Kumar. A total of 5186 proteins were identified in this work.

Establishment of DBT Bioinformatics Centre (BIC):

Recently DBT scrapped all existing BICs and selected afresh around 50 labs from India to establish its new BIC centers. With Dr. Ravi Shankar as its PI and Coordinators, we have been given one such BIC with name of **The Himalayan Centre for High-throughput Computational Biology & Bioinformatics (HiCHiCoB).** A grant of ~195.00 lakh was received for the same.

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Biotechnology (Bioinformatics)

Next-generation Superoxide dismutase with superior kinetic properties and thermal-stability

Identification of hyper-thermostable Cu, Zn Superoxide dismutase (SOD) with high catalytic efficiency and resistance to toxic compounds is desired to meet ever-increasing industrial demands of this enzyme. The Cu, Zn SODs exhibit dismutation function, and therefore widely used in the food, pharmaceutical, cosmetic, agricultural, and environmental industries. Protein engineering via site-directed mutagenesis is the widely used method to improve structural stability or kinetic properties of an enzyme. In our previous work, a highly thermostable Cu, Zn SOD (WT) was isolated from a high altitude plant, *Potentilla atrosanguinea*, and studies were conducted to understand the structural-functional details to identify the molecular determinants of its thermostability. Intending to develop next-generation SOD with superior kinetic properties, we applied a structure-guided consensus approach on Cu,Zn SOD to improve its enzymatic properties (Fig. 1).

A Cu, Zn SOD (WT) from a high altitude plant (*Potentilla atrosanguinea*) was engineered by substituting a conserved residueprolineglycine at position 61 (P61G). The computational analysis showed higher structural flexibility and clusters in P61G than WT. The P61G exhibited moderately highercatalytic efficiency (K_m=.029µM, V_{max}=) than WT protein (K_m=.038µM, V_{max}=1290.11). P61G showed higherthermostabilityrevealed from residual activity (72.25% for P61G than 59.31% for WT after heating at 80°C for 60 min). Interestingly, the P61G mutation also resulted in enhanced tolerance to H_2O_2inactivation than WT protein.

In another study (Fig. 2), the polar uncharged amino acid (threonine) at position 97 of wild-type (WT) SOD was selected as a target residue for substitution by aspartate (T97D) through site-directed mutagenesis.

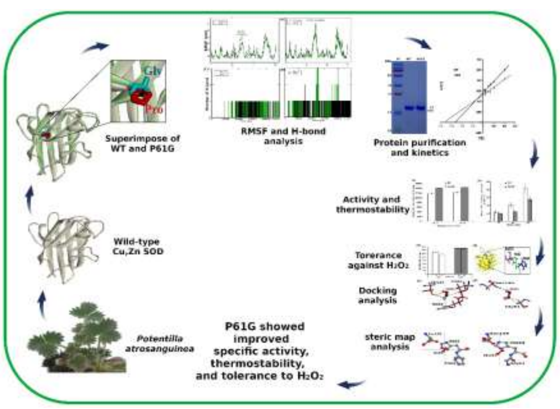

Fig. 1 A structure-guided consensus approach followed to improve the kinetic properties of Cu,Zn SOD.

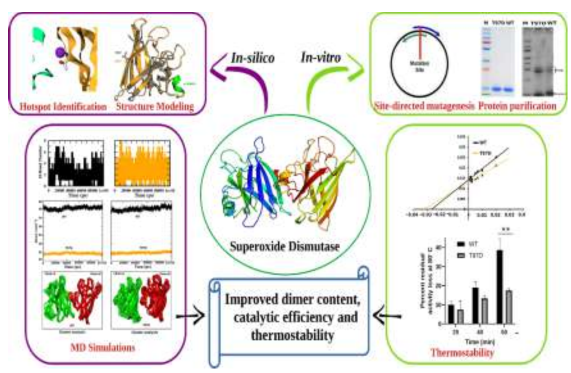

Fig. 2 Overall workflow to generate T97D SOD mutant for improving catalytic efficiency and thermostability.

The WT and T97D were examined by a combinative approach consisting of robust computational and experimental tools. The in-silico analysis indicated improved dimeric stability in T97D as compared to the WT.

The strong interactions between the monomers were related to improved dimerization and enhanced catalytic efficiency of T97D. These results were validated by in-vitro assays showing improved dimer stability and catalytic efficiency in T97D than WT. Moreover, the mutation also improved the thermostability of the enzyme. The combined structural and functional data described the basis for improved specific activity and thermostability. This study could expand the scope of interface residue to be explored as targets for designing of SODs with improved kinetics.

Combating COVID19 by Targeting Non Structural Proteins of SARS-CoV-2

The SARS-CoV-2 is the causative agent of COVID-19 pandemic that is causing a global health emergency. The lack of targeted therapeutics and limited treatment options have triggered the scientific community to develop new vaccines or small molecule therapeutics against various targets of SARS-CoV-2. Natural plant products may be a valuable source of novel drugs to fight with COVID-19 pandemic. Indeed, various phytoconstituents, including polyphenols and flavonoids, have shown the ability to prevent SARS-CoV-2 replication and infection to mitigate the clinical consequences of the infection. In this context, the tea plant (*Camellia sinensis*), rich in micro-nutrients, polyphenols, and vitamins in tea mixture was considered as a source for bioactive molecules in this study. The tea polyphenols were reported to exhibit antiviral activities against various viruses, especially positive-sense single-stranded RNA viruses. Bioactive tea compounds manifest antiviral activity against a broad spectrum of human viruses, including Dengue, Chikungunya, Zika, herpes simplex virus, HIV, hepatitis B, hepatitis C, and influenza.

The non-structural protein 12 (nsp12), also called the RNA-dependent RNA polymerase (RdRp), performs a significant function in the replication and transcription cycles of SARS-CoV-2 by catalyzing the synthesis of the viral RNA, making it one of the most critical targets for viral inhibition. RdRp is a promising target for inhibition, firstly, due to its critical involvement in the viral life cycle; secondly, it conserved the nature of its structure and sequence across several RNA viruses; and lastly, due to the missing homologs in the host. RdRp is a prime target for Remdesivir and other nucleotides analog-based antiviral drugs. We showed three bioactive molecules from tea (epicatechin-3,5-di-O-gallate, epigallocatechin-3,5-di-O-gallate, and epigallocatechin-3,4-di-O-gallate) that showed better interaction with critical residues present at the catalytic center and the NTP entry channel of RdRp than antiviral drugs Remdesivir and Favipiravir (Fig. 3). Our computational approach to identify these molecules included molecular docking studies, followed

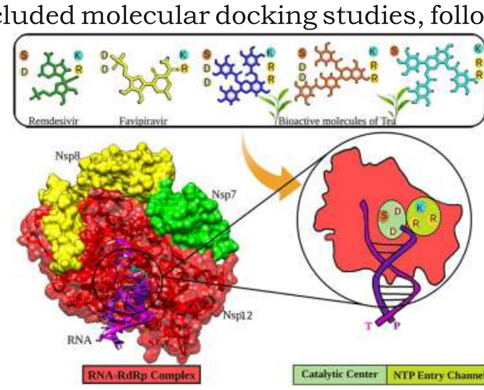

Fig. 3 Bioactive molecules of tea showed better interaction with critical residues present at the catalytic center and the NTP entry channel of RdRp.

by robust molecular dynamics simulations. All the three molecules are readily available in tea and could be made accessible along with other medications to treat COVID-19 patients. However, these results require validation by further *in vitro* and *in vivo* studies.

In another study (Fig. 4), we conducted molecular docking and structural dynamics studies with a set of 65 Tea bioactive compounds to illustrate their ability to inhibit non-structural protein 16 (NSP16) of SARS-CoV-2. Six bioactive tea molecules showed better docking scores than the standard molecule Sinefungin. These molecules were compared to standard inhibitor sinefungin. The stable trajectories and low RMSD and RMSF values revealed structural stability of selected protein-ligand complexes. Further, these results were complemented by hydrogen bond analysis, RMSD clustering, and analysis of molecular interactions at different time-intervals. Theaflavin conferred the higher binding free energy among all the selected compounds. Hence, this investigation states theaflavin as a new persuasive inhibitor of the SARS-CoV-2 NSP16 than sinefungin. However, its inhibitory potential against NSP16 of SARS-CoV-2 needs to be examined by suitable in-vivo and in-vitro analyses.

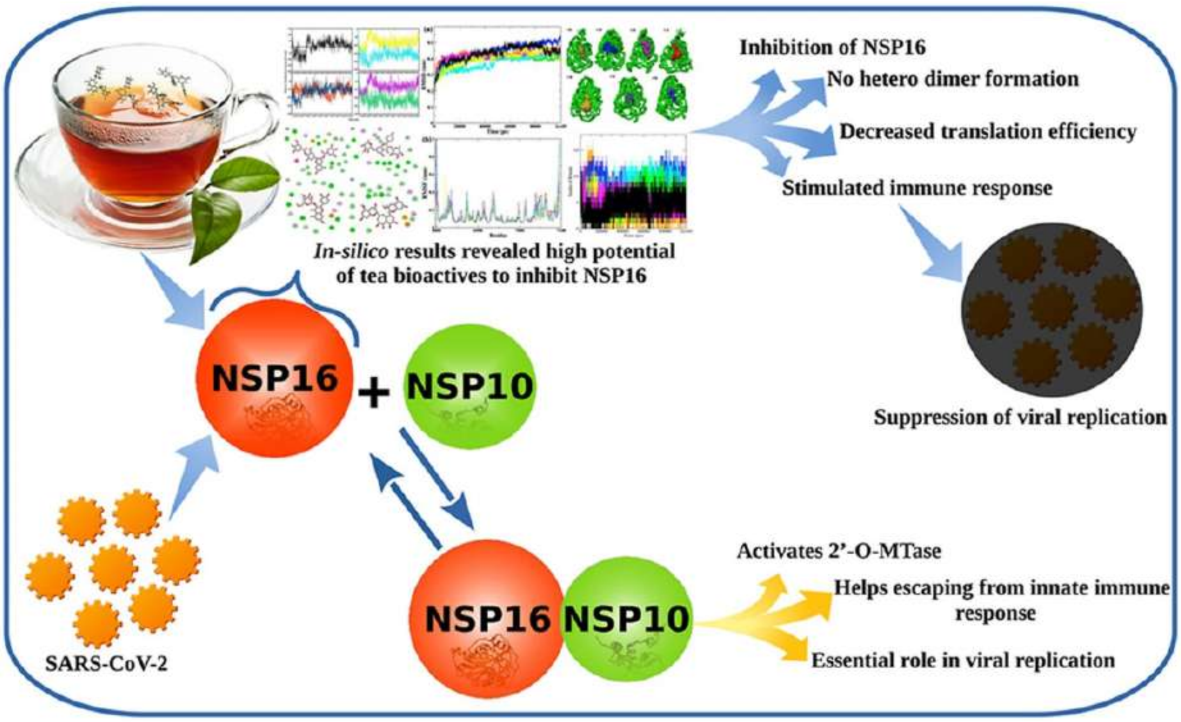

Fig. 4 Computational strategy to target non-structural protein 16 of SARS-CoV-2.

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Molecular and Microbial Genetics

Understanding Microbial Adaptation to Himalayan Niches for Industrial Applications

The focus of my lab is on bioprospecting microbes from high-altitude Himalayan niches for industrial applications. We are trying to understand the adaptation of microbes to extreme niches in the Himalayas. It is a well-established fact from our past studies that these niches are unique for finding new biomolecules and enzymes.

Microbial Adaptation to High-Altitude Stresses in the Lake environments

Glacial and kettle lakes in the high-altitude Himalayas are unique habitats with significant scope for microbial ecology. The present study provides insights into the bacterial community structure and function of the sediments of two high-altitude lakes using 16S amplicon and whole-genome shotgun (WGS) metagenomics. Microbial communities in the sediments of Parvati kund (glacial lake) and Bhoot ground (kettle lake) majorly consist of bacteria and a small fraction of archaea and eukaryota. The bacterial population has an abundance of phyla Proteobacteria, Bacteroidetes, Acidobacteria, Actinobacteria, Firmicutes, and Verrucomicrobia. Despite the common phyla, the sediments from each lake have a distinct distribution of bacterial and archaeal taxa. The analysis of the WGS metagenomes at the functional level provides a broad picture of microbial community metabolism of key elements and suggested chemotrophs as the major primary producers. In addition, the fndings also revealed that polyhydroxyalkanoates (PHA) are a crucial stress adaptation molecule. The abundance of PHA metabolism in Alpha- and Betaproteobacteria and less representation in other bacterial and archaeal classes in both metagenomes was disclosed. The metagenomic insights provided an incisive view of the microbiome from Himalayan lake's sediments. It has also opened the scope for further bioprospection from virgin Himalayan niches.

***Kluyveromyces marxianus* PCH397, a Yeast from Yak Milk asProbiotics withProperties**

Recently, probiotics have gained much attention for their roles in various clinical conditions. Obesity is a worldwide health problem that triggers various other major complications like type 2 diabetes (T2D) and cancers, including colorectal cancer (CRC). Earlier, *Kluyveromyces marxianus* PCH397 isolated from yak (*Bos grunniens*) milk has been characterised by us for its efficient β-galactosidase-producing ability, an important probiotic property. In the present study, yeast PCH397 has been evaluated for various parameters for its probiotic use. PCH397 exhibited tolerance to GI tract conditions (low pH, pancreatin, pepsin, and bile salts) with 78 to 99% survivability, possessed around 81% cell surface hydrophobicity, and 96% autoaggregation ability. They also exhibited lower intracellular lipid accumulation, triglyceride storage, and reactive oxygen species in differentiated adipocytes, indicating their anti-adipogenic ability. Also, CFE and intact cells (ICs) exhibited 73.33±1.11% and 34.88±2.80% DPPH radical scavenging activity, respectively. Furthermore, CFS showed a cytotoxic effect on SW-480 colorectal cancer (CRC) cells and induced the cell cycle phase arrest after 24of treatment. In conclusion, these results demonstrated that *K. marxianus* PCH397 could be used as a potential probiotic yeast and presents a therapeutic potential against obesity, T2D, and colon cancer.

Production ofCellulase by*Bacillus* sp. PCH94 Using Agricultural Waste

Sustainable bioenergy based on lignocellulosic biomass needs efficient cellulolytic microbes and enzymes. The present study revealed a thermophilic Bacillus sp. PCH94, is a potential cellulolytic bacterium supported by its genomic and functional studies. The genome analysis of strain PCH94 uncovered key cellulolytic enzymes such as endoglucanase, exoglucanase, and β-glucosidase. Bioinformatic tools identified CAZyme gene clusters and unveiled 106 genes for carbohydrate utilization. Molecular characterization revealed a wide temperature (4–80°C) and pH (4.0–12.0) active cellulolytic enzymes (1.95/ mg) produced on damaged rice grain powder. Further, response surface methodology enhanced specific activity by 2.32- fold (4.53/mg). At 10.0working volume in a fermenter, the upscale process yielded 1122cellulase activity in 9at 50°C. The crude enzyme was tested on a range of substrates such as CMC, filter paper, avicel, xylan, and starch, which confirms the functionality of lignocellulolytic genes encoding enzymes in the genome of Bacillus sp. PCH94. The crude cellulase enzyme showed the highest specific activity of 6.2/mg, which is 4 to 6 times higher than commercial cellulases investigated. Thus, our findings unearth a potential bioresource for efficient cellulase production using damaged rice grain waste, which has future applications in bioethanol, detergent, and textile industries

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Chemical Nanotechnology and Nanobiology and Biomaterials

Protein corona formation on nanoparticle surface modulates protein - nanoparticle interaction:
In continuation to our previous work to identify the proteins responsible for off-targeting of nanoparticles under *in vivo* conditions, we developed protein coated nanoparticles. Weak interactions play an important role in soft corona (SC) formation and thus help in evaluating the biological fate of the nanoparticles (NPs). Pre-adsorption of specific proteins on NP surface, leading to SC formation, has been found to help NP in evading immunosurveillance. However, the role of different pre-adsorbed biomolecules in determining the NP pathophysiology and cellular association, on their re-exposure to *in vivo* condition, has still remained elusive. Here, differently charged gold NPs (AuNPs) were pre-coated with two different blood components *viz.*, red blood cell (RBC) and human serum albumin (HSA) protein and these were then re-exposed to human serum (HS). Cloaking nanoparticles with protein, improved the NP colloidal stability and other physico-chemical properties along with increased cellular association (Fig. 1). Detailed proteomic analysis suggested that protein camouflaged NPs showed decrease in immune responsive proteins compared to their bare counterparts. Further, it was also observed that the secondary protein signature on NP surface was governed by primary protein coating; however, the event was more or less NP charge independent. This study will pave the path for future strategies to make NPs invincible to the immunosurveillance system of the body.

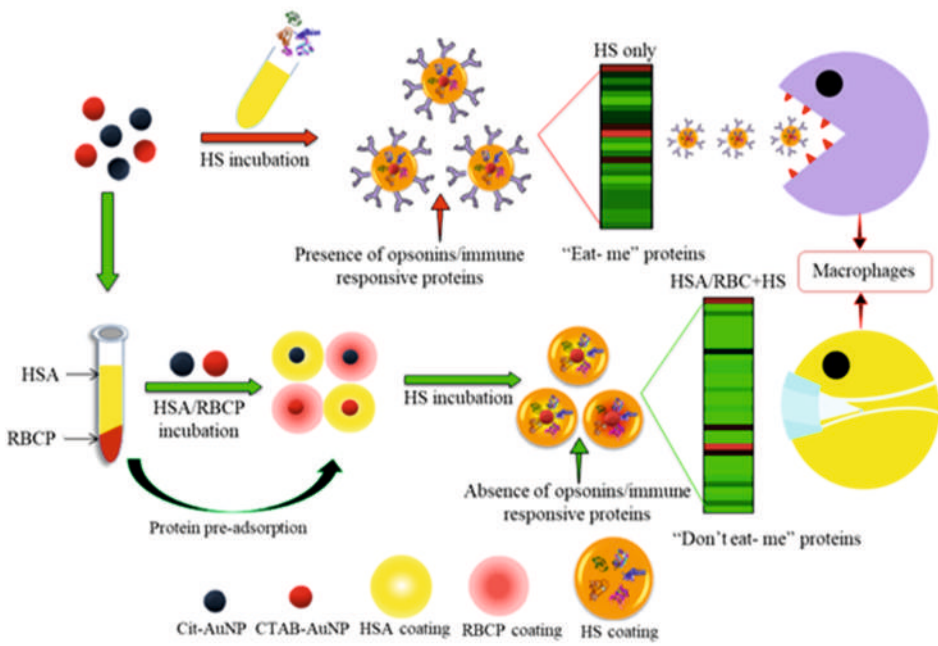

Fig. 1 Schematic diagram of Cit-AuNP and CTAB-AuNP (bare NPs) pre-coated with HSA and RBCP followed by HS coating and their comparative LC-MS studies with HS coated bare NPs. *ACS Appl. Mater. Interfaces* 2022, *14*, 337 – 349.

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Computational Genomics & Artificial Intelligence

Our research includes developing software and applying integration of network biology with machine learning to analyze and mine all kind of biological data to generate novel hypothesis that can be complemented with empirical validation. Details of research can be found at the link: fgcsl.ihbt.res.in.

Big data analysis of human cancer interactome in response to oxidative stress to reveal probable therapeutics

Amplification of oxidative stress (OS) can be utilized as a strategy to attenuate cancer progression by instigating apoptosis. However, the duration of positive response to such therapies is limited, as cancer cells eventually develop resistance. The underlying molecular mechanisms of cancer cells to escape apoptosis under oxidative stress is unknown. Employing big data, and its integration with transcriptome, proteome and network analysis in six cancer types revealed system-level interactions between DNA damage response (DDR) proteins, including; DNA damage repair, cell cycle checkpoints and anti-apoptotic proteins.

The damage to DNA leads to mutations and abnormal cell divisions. Thus, to deal with this OS-induced DNA damage, cellular machinery activates a response, referred to as DNA damage response (DDR), which includes repair of single strand breaks (SSBs) and double strand breaks (DSBs), activation of cell cycle checkpoints, and instigation of apoptosis in case DNA damage is not repaired. Due to the higher metabolic rate, elevated concentration of specific ROS intensifies DNA damage in cancer cells, therefore, cancer cells exhibit escalated DDR. Furthermore, cell division rate is much faster in cancer cells as compared to normal cells. The deregulated cell cycle checkpoints prevent cancer cells from apoptosis, allowing ungoverned cell division. Although DDR plays a critical role in preventing genomic instability in normal cells, it is exploited by cancer cells to escalate cancer pathophysiology. Therefore, targeting DDR can provide therapeutic opportunities in cancer treatment. Overall, DDR collectively includes a series of distinct but functionally interwoven pathways that are defined mainly by the processing of various DNA lesions. Among those pathways, we have focused on a systemic view of OS-induced damage repair protein network that might underline the survival and transformation of cancer cells.

Cancer system biology is used to elucidate mechanisms for cancer progression, but networks defining mechanisms causing cancer resistance is less explored. Using system biology, we identified DDR hubs between G1-S and M phases that were associated with bad prognosis. The increased expression of DDR network was involved in resistance under high oxidative stress. We have validated our findings by combining H_2O_2 induced oxidative stress and DDR inhibitors in human lung cancer cells to conclude the necessity of targeting a ‘disease-causing network’.

To further elaborate the work, we have utilized metaanalysis and network biology based approach using existing transcriptome information during the progression of 6 cancer types. Meta analysis and subsequent network analyses identified potential hubs and bottleneck that play a significant role in cancer progression, prognosis, and resistance to cancer therapies. Earlier studies were largely focused on prognostic genes to predict patient survival and tumor progression, which were beneficial in predicting biomarkers. Since prognostic genes tend to be non-hubs, they could not uphold promising strategic outcomes. Therefore, although bad prognostic genes decrease the survival rate in cancer patients, they are difficult to target because of their high numbers, cancer-specificity, and low connectivity. Since targeting bad prognostic genes individually is not feasible, hubs that harbor them could be suitable targets in cancer therapies. According to this notion, our study was designed to select modules in various cancer types that displayed high correlation with cancer progression (Fig. 1a, 1b). The DDR module of Lung cancer involved in bad prognosis consisted of nodes which primarily comprised of cell cycle checkpoints, and DNA damage repair proteins especially those involved in HR repair (Fig. 1c,d). We have identified DDR hubs: BRCA1, BRCA2, FOXM1, RAD51, RAD51AP1, RAD54, and PRC1 and bottleneck XRCC2; as key targets of DDR network connected with nearly 60 known Lung cancer-specific bad prognostic genes/proteins. Apart from these DDR targets, we have observed other nodes involved in cancer progression. The differential gene expression analysis of OS module in Lung cancer showed increased expression of anti-apoptotic genes (Fig. 1e,1f). Based on our findings from network analysis and in vitro experiments, we propose four levels of resistance between G1-M transition towards OS-mediated therapies. FOXM1 expression is increased in G1-S phase, and it is phosphorylated by CDK1 in G2-M phase. This suggests first line of resistance caused by FOXM1 towards OS by overexpressing antioxidant response. The HR overexpression in cancer cells provides second line of resistance, which is supported by the fact that HR deficient cells are susceptible to apoptosis. Our network hypothesis, gene expression and immunoblot results suggests that targeting overexpressed HR proteins-network or HR proteins complex (BRCA2-RAD51) instead of single drug targeting of HR protein RAD51 can be more efficient to inhibit HR pathway.In Lung cancer DDR module, network analysis of HR proteins displayed interactions with kinases in both gene co-expression and PPI network. This suggested that increase in HR expression can lead to entry in G2-M transition, and kinases like CDKs, PLKs, AURORAs, and cyclins are upregulated to resume cell cycle and promote entry in mitosis. During early mitosis, there is increase in expression of spindle assembly checkpoint proteins and microtubule-associated proteins for proper chromosomal segregation. During late mitosis or telophase, anaphase promoting complex associates with Cdc20 to degrade spindle-associated proteins, microtubule-associated proteins including PRC1, cyclins and kinases to initiate cytokinesis. We found increased expression of PRC1 in differential expression in RNA-Seq data of Lung cancer, network analysis and RT-qPCR results. Studies have depicted that the upregulation of PRC1 promote proliferation in A549 cells. Depletion of PRC1 increases bi- or multinucleate cells causing G2/M cell cycle arrest and finally apoptosis due to defective cytokinesis. Hence, targeting PRC1 provides the third line of resistance in progressive Lung cancer cells. Finally, systemic analysis of Lung cancer DDR hubs: BRCA1, BRCA2, FOXM1, RAD51, RAD51AP1, RAD54, and PRC1 displayed network interaction with mitotic slippage protein CEP55, which possibly propose the fourth line of resistance in lung cancer cells. CEP55 plays a functional role in protecting aneuploid cells from apoptosis and thus helps cancer cells to escape mitotic arrest. Collectively, our work will provide insights toward designing strategies for network pharmacology to combat resistance in cancer research.

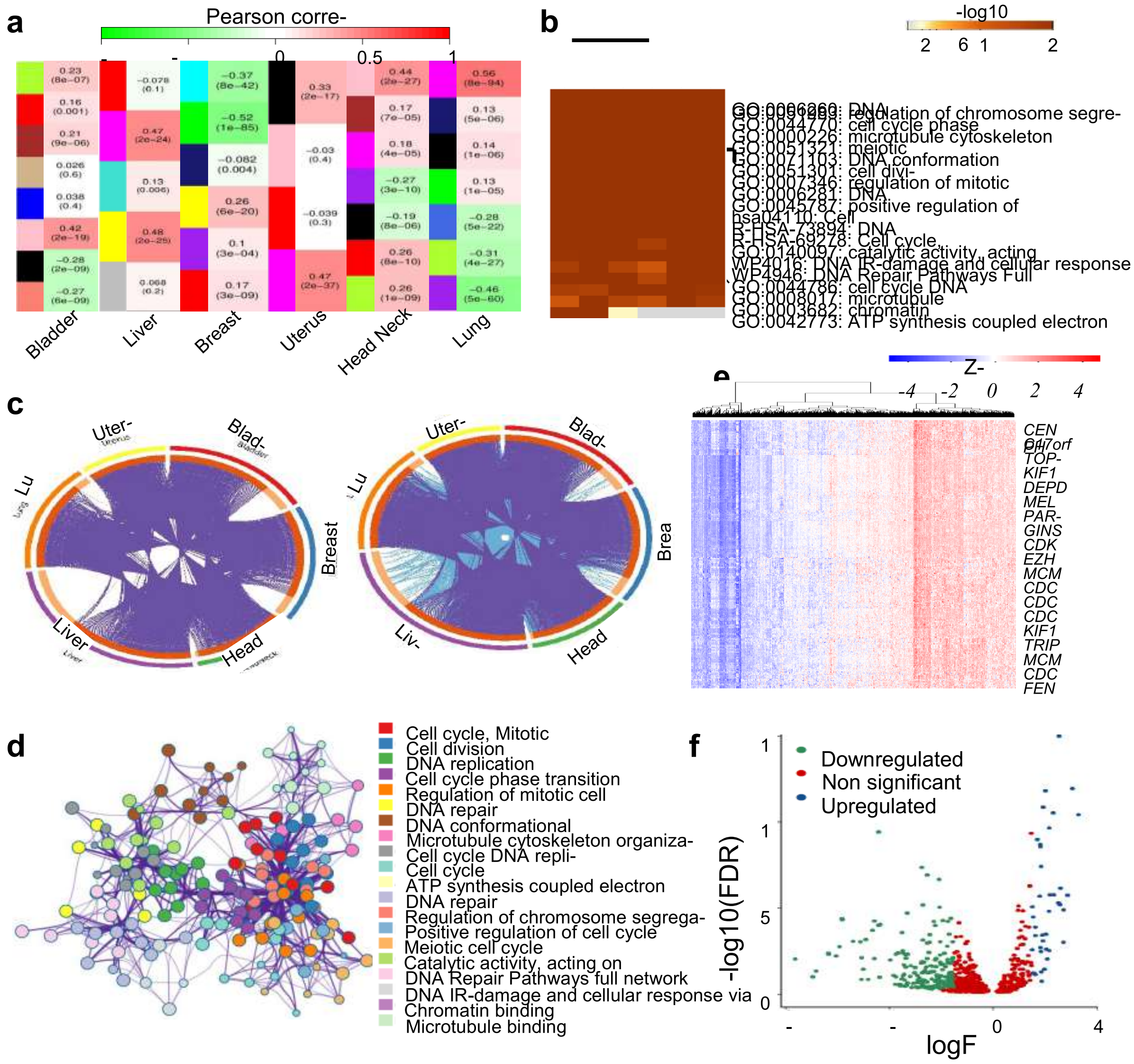

Fig. 1 (a) The correlation of different modules with cancer phenotypes (Normal, Primary Tumor, Recurrent Tumor and Metastatic) in six cancer types. The different color bands represent clustered modules of gene co-expression network. Darker red and green color on scale represents higher values of positive and negative correlation, respectively. (b) Functional and pathway enrichment analysis of positively correlated OS module in (a). (c) The Circos plot showing overlapping genes in six cancer types. The outermost arc represents different colors assigned to each cancer type. Dark orange color in inner arc represents the genes that appear in six cancer types and light orange color represents genes that are unique to particular cancer type. (d) Network layout of representative terms from the full cluster enrichment. Each term is represented by a circle node, where its size is proportional to the number of input genes in the enriched cluster, and its color represent its cluster identity (i.e., nodes of the same color belong to the same cluster (e) Heatmap layout of differentially expressed genes (DEGs) in OS module in Lung cancer (f) Volcano plot of miRNA expression targeting hubs and bottleneck from DDR module in Lung cancer.

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Plant-Microbe Interaction

Research focus: Work was focussed on identification of TIR-NBS-LRR gene(s) involved during host interaction with *Alternaria solani* in *Solanum tuberosum* (Potato) and *Solanum lycopersicum* (Tomato). Under collaborative work, role of BAR domain protein in fungal endocytosis and pathogenesis also reveled and published using *Ascochyta rabiei*-chickpea interaction.

Identification of TIR-NBS-LRR gene(s) from *Solanum tuberosum* (Potato) and *Solanum lycopersicum* (Tomato)

Resistance gene analogs (RGAs) comprising NBS-LRR gene family members are considered prominent candidates in development of disease resistant genotypes. NBS-LRR gene family comprised of very large number of genes, therefore, members of one sub-family TIR-NBS-LRR (TNL) are identified in the present study from *Solanum tuberosum* genome, followed by their bioinformatics characterization. The study identified a total of 44 genes encoding 60 TNL transcripts with two prominent clusters at chromosome 1 and chromosome 11. Expression analysis of 14 TNL genes after *Alternaria solani* infection at 1, 2, 3, 5 and 7 days post inoculation in two disease tolerant varieties, Kufri Jyoti and Kufri Pukhraj and one relatively susceptible variety, Kufri Chandramukhi showed differential expression of many genes including high expression (>15 fold) of *StTNLC6G2T1*, and *StTNLC11G9T1* (Fig. 1A). Functional characterisation of one such gene, *StTNLC7G2* reveal localisation in plasma membrane (Fig.1B) and involvement in generation of reactive oxygen species under *A. solani* attack, implicating its putative role in plant defense via hypersensitive response.

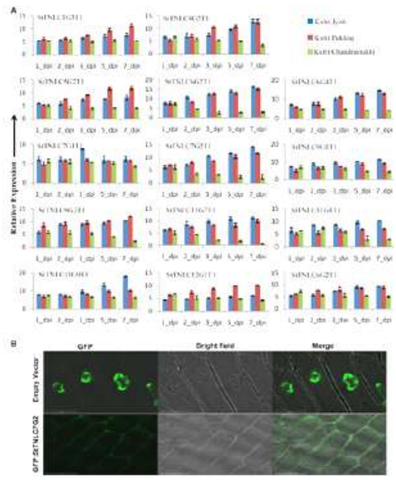

Fig. 1 TNL expression analysis (A) and localisation result (B) for *StTNLC7G2* (*StTNL41857*) protein.

27 full length TNLs were also identified from genome wide analysis in tomato (Fig. 2). There full length transcripts were thoroughly annotated and their physical location on chromosome confirmed. No significant gene cluster observed, as all the genes found distributed on different chromosomes.

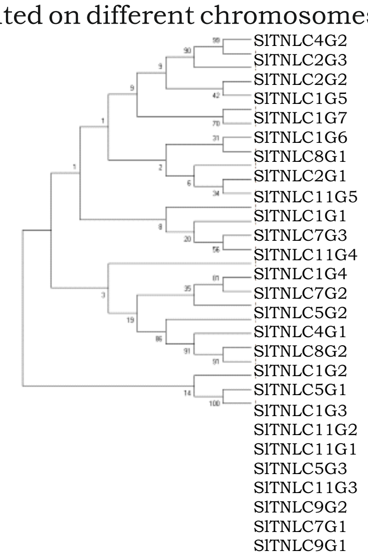

Fig. 2 Phylogenetic tree of 27 TNL from tomato showing their affinity and homology.

F-BAR dependent actin remodelling and endocytosis required for fungal virulence in *Ascochyta rabiei*

Polarized hyphal growth of filamentous pathogenic fungi is an essential event for host penetration and colonization. The long-range early endosomal trafficking during hyphal growth is crucial for nutrient uptake, sensing of host-specific cues, and regulation of effector production. Bin1/Amphiphysin/Rvs167 (BAR) domain-containing proteins mediate fundamental cellular processes, including membrane remodeling and endocytosis. An F-BAR domain protein (ArF-BAR) in the necrotrophic fungus *Ascochyta rabiei* was identified and found essential for endosome-dependent fungal virulence on the host plant *Cicer arietinum*.

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Plant Tissue Culture

Our group mainly focuses on the development of high-efficiency *in vitro* protocols for mass propagation of economically and medicinally important plants and study their response during *in vitro* callogenesis and organogenesis.

Optimization of micropropagation protocol for *Ferula assa-foetida* using leaf explant

Conventional propagation of *F. assafoetida* is restricted by long seed dormancy, thus an alternative method of propagation is the need of the hour to establish and propagate *en-masse*. Keeping the above facts in mind, *in vitro* protocol for callus induction for indirect somatic embryogenesis, shoot regeneration, or secondary metabolite production was established. Excised leaves from the healthy plants grown under controlled conditions and, *in vitro* leaves and petioles were used as explants for callus induction. Thoroughly sterilized leaves were inoculated to MS medium supplemented with different phytohormones in combinations. Induction of callus was observed after 45 days of incubation under specified regimes of temperature and light. The proliferation of callus, somatic embryogenesis and shoot regeneration was also observed in presence of various phytohormone combinations (Fig. 1).

Fig. 1 Commercial scale micropropagation of *Ferula asafoetida*.

Establishment of mass-scale micropropagation of *Siraitia grosvenorii* for commercial plantation

Siraitia grosvenorii (Swingle) C. Jeffrey is a perennial vine of the family cucurbitaceae and is endemic to Southern China. However, due to low germination and survival rate, the conventional propagation is time-consuming and more prone to viral diseases which affects the quality and yield of fruits. Consequently, it is important to establish commercial-scale micropropagation and hardening protocol to establish this crop in India. Shoot nodal segments were cultured in a medium supplemented with different concentrations of phytohormones and multiple shoot formation and root proliferation was observed under *in vitro* conditions (Fig. 2). Fully developed *in vitro* plantlets were transferred to a sterilized potting mixture for hardening. Fifteen days old plants were successfully acclimatized under field conditions. The present *in vitro* propagation method is the first report on the successful establishment of commercial-scale cultivation of *S. grosvenorii* in India.

Fig. 2 Commercial scale micropropagation of *Siraitia grosvenorii*, hardening and field transfer.

Establishment of saffron in Himachal Pradesh through mass-scale *in vitro* propagation

Saffron (*Crocus sativus* L.) is the most expensive spice (dried stigma) of the world. No doubt in India, Kashmir has the virtual monopoly of saffron and contributes immensely to its agricultural economy, however, very recently the crop has been introduced in some other parts of the country viz., HP, Assam, Uttrakhand etc. CSIR-IHBT has standardized tissue culture technologies for producing elite, disease free saffron corms (Fig. 3). With the support of State Agriculture Department H.P., we are focusing on propagating saffron corms at mass-scale under *in-vitro* conditions and trying to establish its cultivation practices in Himachal and other high altitude regions with similar climatic conditions.

Fig. 3 Commercial-scale micropropagation of *Crocus sativus*, and its establishment at the Palampur region of H.P.

Commercial-scale propagation of different bamboo species

Because of their fast-growing nature and being an inexpensive and renewable resource for biomass production, bamboo can be used as a substitute for expensive timber or wood, and hence is termed as "the green gold". However, macro-propagation (through seeds and cuttings) is restricted by the environmental factors such as temperature, humidity, water balance, soil conditions, light intensity, wind speed and pathogens. Therefore, the increasing market demand cannot be met through macro propagation. Consequently, it is important to establish an efficient micropropagation protocol for commercial scale production of different bamboo species such as *Dendrocalamus hamiltonii, Dendrocalamus asper, Bambusa nutans, Bambusa balcooa and Phyllostachys pubescens* under National Bamboo Mission (Fig. 4).

In addition, we also commercially propagated more than 13676 bamboo plants during 2021-2022 through cuttings, layering and seeds and supplied them to State Agriculture Department and other stakeholders.

Fig. 4 Commercial-scale propagation of bamboos through tissue culture (Upper panel), Cuttings, Seedlings and Seeds (Middle panel). Supply of bamboo plants to government agencies and other planters (Lower panel).

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Plant-Microbe Interaction, Plant Adaptation, and Plant Physiology

Our research group focuses on exploration of endophytes associated with Himalayan medicinal plants for improvement of plant growth, secondary metabolite biosynthesis, and tolerance to environmental stress.

Endophytes of *Valeriana jatamansi* and *Podophyllum hexandrum*

The Himalayan region harbors various medicinal plants, that are continuously exposed to extreme environmental conditions therefore, these are the promising source of potential endophytic microbes that can be used to enhance the secondary metabolite production, crop yield and stress tolerance. We are exploring the endophytes of *V. jatamansi* and *P. hexandrum* to improve plant yield and secondary metabolite production. A total of 331 endophytes have been isolated from different plant parts of *V. jatamansi* (190 endophytes) and *P. hexandrum* (141 endophytes). Isolated endophytes are being molecularly characterized and tested for their efficacy to promote plant growth and enhancing the *in planta* secondary metabolite production, and the associated mechanism is being identified (Fig. 1).

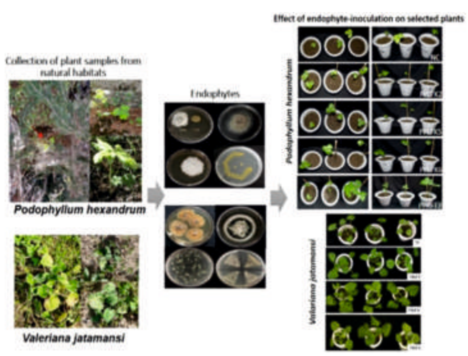

Fig. 1 Exploration of endophytes of *Podophyllum hexandrum* and *Valeriana jatamansi* for plant growth improvement.

Endophytes as probiotics for plant *in-vitro* system

In-vitro technologies for plants are widely used for the commercial applications of important plants and quality improvement of plant produce used as pharmaceuticals, colors, flavors, food additives, agrochemicals and biopesticides. *In-vitro* technologies are also used for the conservation of threatened plant species. Poor hardening efficiency and acclimatization of tissue culture generated plants in the soil and greenhouse/field conditions, and reduced contents of secondary metabolites are the major problems limiting their use and acceptability at a large scale. It also limits the conservation of various plant species localized in specific environmental conditions. We are exploring the endophytes of important Himalayan plants such as *Rhodiola imbricata, Fritillaria roylei*, *Picrorhiza kurrooa* and *Trillium govanianum* for plant *in-vitro* system to improve the performance of *in-vitro* generated plants under soil/field conditions. Endophytes are being isolated and identified from selected medicinal plants collected from their natural habitats (Fig. 2).

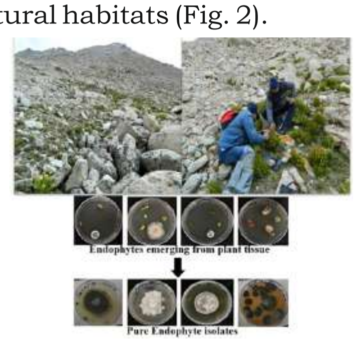

Fig. 2 Collection of *Rhodiola imbricata* from Chang La (~17500 ft) and Khardung La (~18000 ft) regions in Leh. Representative picture showing the emergence of endophytes from plant tissues and pure endophytic isolates.

Evaluation of role of endophytes in mogroside production

Mogroside, an alternative natural sweetener, is extracted from the fruits of *Siraitia grosvenorii* (monk fruit), which is predominantly produced in Guangdong, Guangxi, and Hunan provinces of China only. Its cultivation is limited and specific to environmental conditions that limit its uses on a large scale and makes its use expensive. Endophytes are important for plant health and secondary metabolite production. Therefore, we are unraveling the role of endophytic microbes associated with *S. grosvenorii* plants. We isolated different endophytes from male and female plants of *S. grosvenorii,* and the efficacy of isolated endophytes to promote plant growth and modulate mogroside biosynthesis is being tested on *in-vitro* generated endophyte-free plants (Fig. 3).

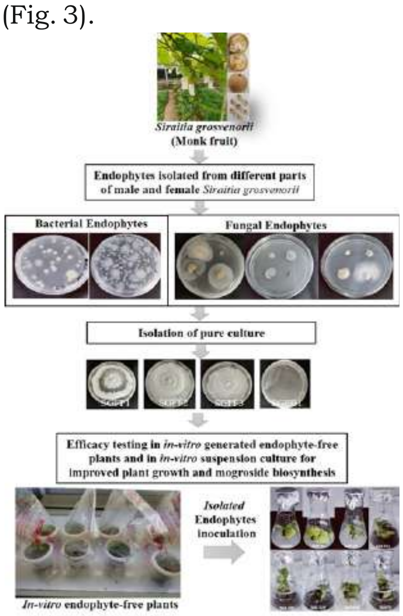

Fig. 3 Testing the efficacy of endophytes to improve plant growth of *in-vitro* generated *Siraitia grosvenorii.*

Genome-editing of *Camellia sinensis*

Tea [*Camellia sinensis* (L.) O. Kuntze] is one of the most widely consumed drinks worldwide, second only to water. Increasing consumers' awareness of its medicinal properties raised its demands. Therefore, its trait improvement has enormous commercial importance. Previous efforts for tea improvement are based on the conventional breeding approach, which has several limitations such as high inbreeding depression, self-incompatibility, differences in the time of flowering and fruit-bearing capability, long period of juvenility (6-10 years), a low success rate of hand pollination, time and labor-intensive processes, and scarcity of land and labor. Therefore, the application of advanced biotechnological approaches such as genome editing using CRISPR/Cas9 to improve *C. sinensis* is most promising. We are developing a genome editing platform using CRISPR/Cas9 system to silence polyphenol oxidase and caffeine synthase in tea to reduce the tea browning during leaves processing and caffeine content, respectively. To achieve this, we amplified the target genes (*TCS* encoding Caffeine synthase and *PPO* encoding Polyphenol oxidase) from the selected cultivars of *Camellia sinensis* and cloned in cloning vector, and sequenced. gRNAs for the silencing of the target genes have been identified and synthesized. These are cloned in the CRISPR-Cas9 plant transformation vector (pKSE401). Developed CRISPR constructs have been transformed in the *Agrobacterium* strain GV3101. These are being used for the transformation of selected cultivars of *C. sinensis*. Transformation of selected tea cultivars (Him Sphurti, UPASI-9, TV23, Kangra Asha) has been initiated in collobration with Dr. Rohti Joshi. Transformation in the successfully proliferated calli is being carried out using the *Agrobacterium*-mediated plant transformation method.

Furthermore, we are applying the combination of different phytohormones for efficient cultivation of *Bunium persicum* by breaking their seed dormancy and attaining the synchronous flowering in Chamomile.

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Plant Tissue Culture and Cell Culture,
Hydroponic and Aeroponic Cultivation, and Molecular Biology

Plant tissue culture and cell culture, Hydroponic and aeroponic cultivation. Our research work aims to develop alternative approaches for metabolite production from high-altitude Himalayan medicinal plants using tissue culture, cell culture and modern farming techniques.

Effect of tyrosol feeding for phenylethanoids production in cell suspension culture of *Rhodiola imbricata* (Edgew.)

Precursor feeding is a potential strategy for increasing specialized metabolite production in plant cell culture systems. In the present study, cell suspension cultures were developed and subsequently evaluated for precursor feeding investigations. Cell suspension cultures were established in Murashige and Skoog (MS) medium containing 0.5 mg/L thidiazuron (TDZ) + 1 mg/L α-naphthalene acetic acid (NAA). The maximum cell dry weight (DW) was observed in leaf cell suspension (1.22 g/100 mL) and root cell suspension culture (1.12 g/100 mL) on day 21. The results revealed that leaf cell suspension treated with 3 mM tyrosol concentration detected maximum salidroside content (26.05 mg/g DW) on day 15, incubated under photoperiod (16L/8D h) condition. Similarly, under photoperiod (16L/8D h), root cell suspension treated with 3 mM tyrosol produced maximum salidroside content (26.62 mg/g DW) on day 12. The investigation suggests that the immediate pathway precursor, tyrosol has a strong effect on enhanced production of salidroside, irrespective of explant type and light regimes (Fig. 1).

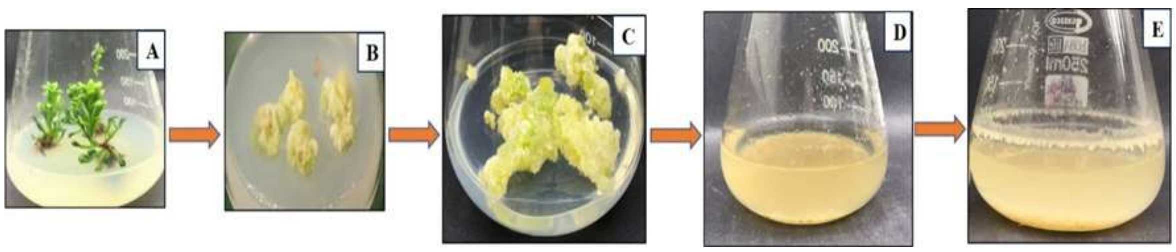

Fig. 1 Schematic representation of establishment of cell suspension culture; A- *in vitro* raised *R. imbricata* plant, B- initiation of callus culture, C- friable callus, D & E - established cell suspension cultures (day 12 and day 21).

Rhizome callus culture of *Picrorhiza kurrooa* for picrosides production

Picrorhiza kurrooa is an industrially important Himalayan medicinal herb and is well known for its therapeutic potent picrosides compounds. The limited availability and medicinal usage of its rhizome commercially have initiated the search for an alternative platform. Therefore, the present study developed a robust callus culture protocol from rhizome explant of *P. kurrooa* to produce picrosides and its precursors metabolites. MS medium (pH- 5.78; agar- 0.8 %) with thidiazuron (TDZ) (0.5 mg/L) + picloram (5.0 mg/L) were used for callus induction (CI). Whereas, TDZ (0.5 mg/L) + indole-3-butyric acid (IBA) (0.3 mg/L) were used for callus proliferation (CP).

In rhizome callus, picrosides (PI, PII and PIII; 1.887 mg/g DW), precursors (2.118 mg/g DW), p-hydroxy acetophenone (0.316 mg/g DW), and 4-hydroxy acetophenone (0.032 mg/g DW) content were quantified. Study revealed that callus culture of *P. kurrooa* may offer a cost effective and environmentally friendly platform for sustainable production of picrosides (Fig. 2).

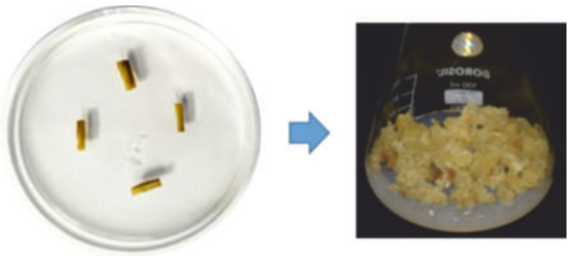

Fig. 2 Development of rhizome callus culture of *Picrorhiza kurrooa*.

Fruit derived callus culture for mogrosides production in *Siraitia grosvenorii* (Swingle)

The fruit of *Siraitia grosvenorii* (Luo Han Guo) is commercially consumed for its zero-calorie natural sweetener compounds known as mogrosides. The present work aimed to establish a cell culture platform from the fruit mesocarp and provide an alternative source for mogrosides production in*S.*. The maximum frequency of callus induction was observed in mesocarp (95.78 %) and stem (97 %) explants cultured on Murashige and Skoog (MS) medium supplemented with thidiazuron (0.5 mg/L) and picloram (2.5 mg/L). The maximum proliferation response of suspended cells in suspension culture was observed in MS medium fortified with thidiazuron (0.3 mg/L) and indole-3-butyric acid (0.3 mg/L). The mogroside V (2.96 mg/g DW), 11-oxo-mogroside V (0.66 mg/g DW), siamenoside I (0.26 mg/g DW), and mogroside IIIE (0.08 mg/g DW) were quantified in mesocarp callus using UPLC-PDA-ESI-Q-TOF-MS technique (Fig. 3). The developed-*in vitro* cultures offer the possibility for year-round production of specialized metabolites, i.e., 11-oxo-mogroside V, mogroside V, siamenoside I, and mogroside IIIE.

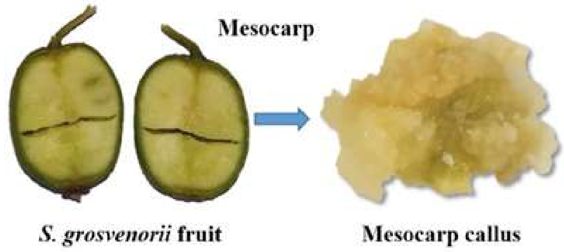

Fig. 3 Callus culture of *S. grosvenorii*.

Hydroponic farming of *Picrorhiza kurrooa* for quality biomass production

In vitro raised plants were developed using nodal explant of *P. kurrooa* plant. Different media combinations and plant hormone concentrations were standardized for micropropation (Fig. 4). These tissue culture raised plants were further transferred for primary hardening in sand under controlled conditions. After acclimatization, plants were transferred to hydroponic system for further growth and secondary metabolites accumulation. Plant growth analysis was done by assessing different morphological parameters i.e. plant height, shoot length. number of leaves, leaf length, leaf width, number of roots, length of rootlets after every two weeks in one month. The experiment was conducted continuously for six months. The maximum growth was observed in six month grown hydroponic plants (plant height 25 cm, number of leaves 25, leaf length 11 cm, leaf width 2.5, number of rootlets 30 and length of roots 16 cm) which is 2-5 folds maximum as compared to *in vitro* and 3 month grown plants (plant height 5 to 15 cm, number of leaves 10 to 15, leaf length 2 to 8 cm, leaf width 0.5 to 1.5 cm, no. of rootlets 5 to 20 and length of roots 2 to 10 cm). Metabolites quantification of these tissues revealed that P-I found maximum (i.e. 1%) in leaf tissue after 3 month which was 33-folds and 3-folds higher as compared to *in vitro* and 6 month grown leaf tissue i.e. 0.03 and 0.3% respectively. Whereas P-II found maximum (i.e. 2%) in 6 month grown root tissue in hydroponic system which was 5-folds and 4-folds higher as compared to *in vitro* and 3 month grown leaf tissue containing 0.4 and 0.5 % content respectively.

Fig. 4 Hydroponic cultivation of *P. kurroa*; a) Wild plant as a source for nodal explant b) *In vitro* raised plants c) Primary hardened plants d) Hydroponically cultivated plants after 6 months.

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Plant Proteomics

Research focus: Research in our lab focuses on the comprehensive mapping of transcriptome, proteome, metabolome, and epigenome of medicinal plants that will help to understand the multilayered control of the adaptation process.

Cold acclimation and freezing tolerance: Role of metabolic signatures

Plant adaptation is an evolutionary process that increases survival and reproduction in newly encountered climatic conditions. Plants are sessile organism constantly challenged by environmental stresses such as temperature extremes, UV radiation, salinity, drought, flooding, mineral toxicity, and pathogen attack. Among different environmental stresses, cold severely affects plant growth and development, alters membrane fluidity, water and ionic balance, generate reactive oxygen species that impair DNA, RNA, and protein stability, hamper photosynthetic efficiency and slow down biochemical reactions, which in turn reduces crop productivity and limits the geographical distribution of plants. Therefore, understanding the plant responses and adaptation processes towards cold/freezing stress is important for the development of cold resilient plants, which is critical for global food security.

Plants encounter two types of low-temperature regimes in their natural habitat. The temperature range between 0-15°C causes cold/chilling stress, while temperatures below 0°C cause freezing stress, and distinct adaptive mechanisms help plants to deal with these two cold stress types. Plants employ avoidance and tolerance strategies to mitigate cold stress. Avoiding mechanism involves preventing the formation of ice crystals inside the cell and is primarily associated with structural aspects. However, cold tolerance involves acquiring tolerance to low non-freezing temperature through a process known as cold acclimation, which includes prior exposure to nonlethal low temperature. Cold acclimation is mainly characterized by the regulation of gene expression and metabolic changes that lead to various morphological, biochemical, and physiological alterations in plants.

Cold acclimation involves plasma membrane rigidification that affects ion concentration and metabolite transport from apoplast, endomembranes, and organelles, which initiates downstream cold signaling. These signaling cascades ultimately regulate the expression of cold-responsive (COR) genes. COR genes are induced by C-repeat Binding Factors (CBFs), which are under the control of the Inducer of CBF Expression (ICE). Further, the ICE-CBF-COR regulatory module is a central pathway affecting cold response in plants. Cold inducible genes regulate the synthesis of compatible solutes (Soluble sugars and proline), pigments (Xanthophylls and carotenoids), and cold-responsive proteins like antifreeze proteins, LEA proteins, heat shock proteins, cold shock proteins, and dehydrins, which eventually impart cold tolerance.

High altitude Himalayas region is characterized by extremes temperatures. Medicinal plant species of this region have successfully acclimatized to extreme temperature conditions and thus can serve as a model for explication of cold/freezing stress tolerance mechanisms. *Picrorhiza kurrooa* Royle ex Benth. (Family Plantaginaceae), a perennial herb of Himalaya (3000-5000 masl), has been used in traditional and modern medical systems. The molecular response of *P. kurrooa* to cold/freezing at high altitudes is largely unknown.

To determine metabolic signatures of *P. kurrooa*, four conditions (Control; 18°C, T1; 4°C 24h, T2; 4°C 7D, and T3; -4°C 24h)

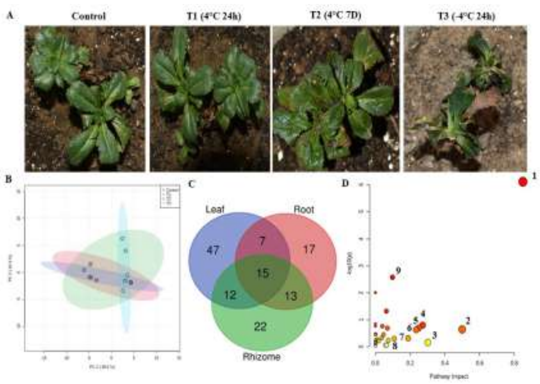

Figure 1: *P. Kurroa* plants were subjected to cold/freezing stress treatment (A), PCA of four different (Control, T1,T2 and T3) samples (B), Venn diagram showing organ specific comparison of metabolites (C), and pathway analysis (D).

plants from three different biological replicates to reduce variation. Metabolites were extracted from leaf, root, and rhizome tissue of four different stress conditions. A total of 143 primary and secondary metabolites were identified ($p<0.05$) from four stress conditions using 6560 Ion mobility Q-TOF LC/MS, representing an inventory of metabolites and their role in *P. Kurrooa* cold/freezing stress. Principal component analysis suggests all the four treatment conditions are metabolically different (Fig. 1B). Among 143 metabolites, 15 are familiar to all organ, whereas 44, 17, and 22 are unique to leaf, root, and rhizome, respectively (Fig. 1C), suggesting each organ have distinct metabolite composition. Further, we explored metabolic pathways associated with these metabolites and found nine prominent pathways with different organs in response to cold/freezing stress (Fig. 1D; Table 1). This report represents an extensive metabolic signature of *P. kurrooa* towards cold/freezing stress.

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Table 1 Prominent pathway associated with Cold/freezing tolerance in *P. Kurrooa*

Sr No.	Pathways	p Value	-log(p)	FDR	Impact
1	Flavone and flavonol biosynthesis	0.00	6.1116	0.00	0.85
2	Isoquinoline alkaloid biosynthesis	0.22638	0.64515	1	0.5
3	Galactose metabolism	0.68762	0.16265	1	0.30161
4	Butanoate metabolism	0.15661	0.80519	1	0.27273
5	Fatty acid degradation	0.19883	0.70152	1	0.24998
6	Pyruvate metabolism	0.23371	0.63132	1	0.23462
7	Pyrimidine metabolism	0.47784	0.32072	1	0.18862
8	Tyrosine metabolism	0.49684	0.30378	1	0.10811
9	Flavonoid biosynthesis	0.002661	2.575	0.12	0.0983

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Enzyme and Metabolic engineering, Host-pathogen interactions

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 and, (2) to understand the mechanisms of genetic resistance in crops against pathogens (bacterial and fungal) and abiotic stresses at the molecular and biochemical levels and exploit this information for crop improvement. In line with these goals, we are currently focusing on the following projects.

Bioprospecting kinetically stable lytic polysaccharide monooxygenases (LPMOs) 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 a classes of copper metalloenzymes that have received considerable attention due to 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 of considerable interest in biotechnological utilization of abundant lignocellulosic plant waste. With this background, we aim to bioprospect Himalayan-bioresources from the identified niche areas to clone kinetically stable LPMOs as promising biocatalysts for enhancing the degradation of lignocellulosic biomass. We have identified potential sources of LPMOs and cloned their genes for expression and characterization in a heterologous system. One of the genes refrerred to as TrLPMO have been cloned in pET-28a vector and its expression conditions optimized for production (Fig. 1) and detailed biochemical characterization.

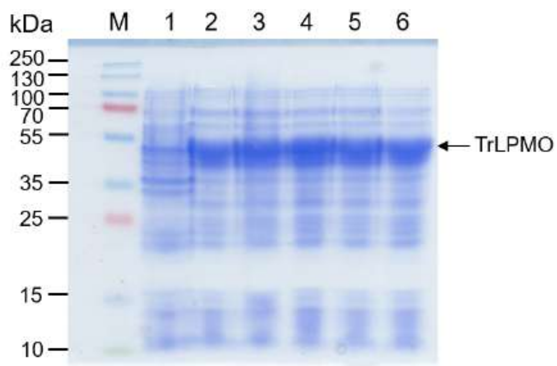

Fig. 1 Optimization of expression of TrLPMO in *E. coli* Rosetta™(DE3) cells.

The protein was induced at 28 °C using different concentrations of IPTG and run on 12% SDS-PAGE followed by staining with coomassie brilliant blue. M: Pre-stained protein ladder (Thermo Scientific, USA). Lanes 1 to 6 represent expression under 0, 0.5, 1, 2, 4 and 6 mM conc. of IPTG.

Dissecting genetic determinants of resistance/susceptibility in rice against *Rhizoctonia solani* AG1-IA

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. Therefore, a detailed understanding of Rice-*R. solani* interactions at the molecular and biochemical level can give us some insights into virulence mechanism 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. Two rice genotypes namely PR114 (hereinreferred to as PR; susceptible) and ShB (moderately tolerant) varying in the level of tolerance to *R. solani* were selected for detailed studies. Different stages of infection were established using visual, biochemical and scanning electron microscopy studies and expression dynamics was studied (Fig. 2) to dissect the resistance/susceptibility mechanisms in rice against *R. solani* at genetic and epigenetic level. Functional validation of few of other

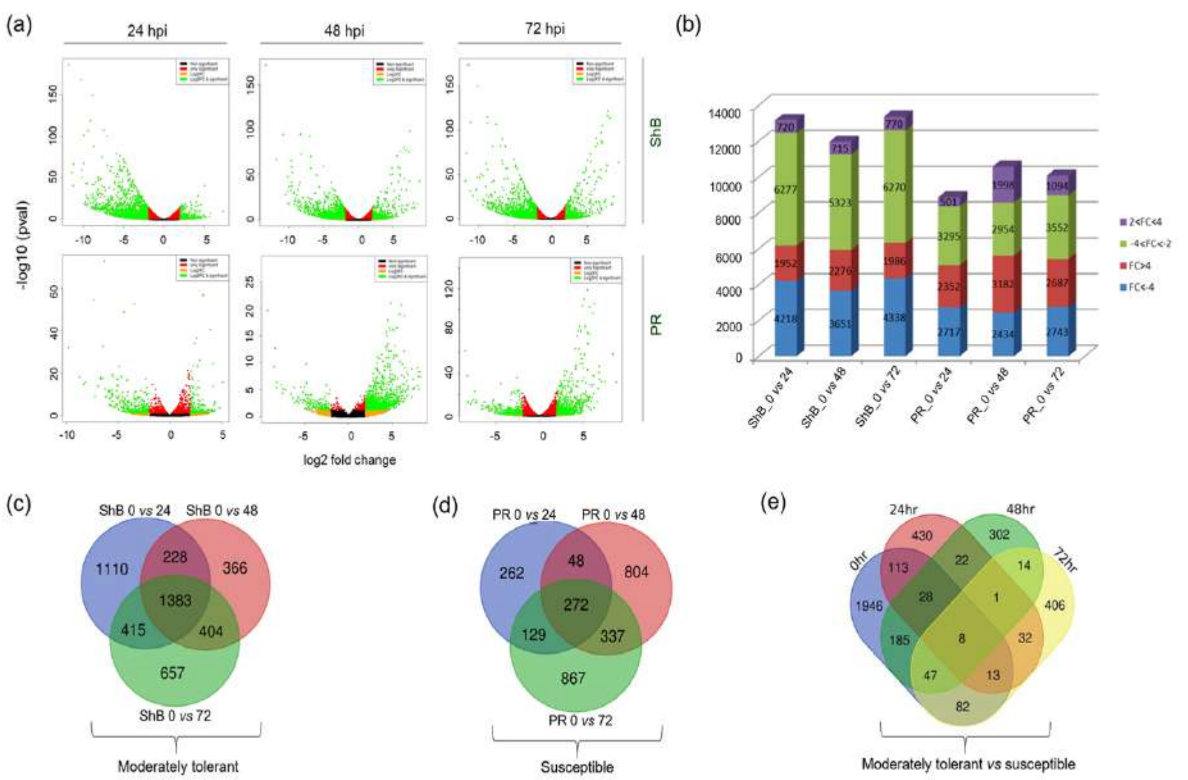

Fig. 2 Statistical significance and expression dynamics of RNA-seq data. (a) Visualization of RNASeq data as Volcano plots prepared by plotting statistical significance (*p*-value) versus fold change (log2FC) of differentially expressed genes of rice genotypes under study. Dots in green color represent the genes that were found in high FC and were also statistically significant. Up-regulated genes are on right side whereas down-regulated genes are on the left side. (b-e) Expression dynamics of dysregulated genes in rice genotypes ShB and PR upon infection with *R. solani* AG1-IA isolate. (a) bar diagram showing distribution of number of transcripts under different fold change (FC) categories calculated as log_2FC w.r.t. to their respective 0 h un-inoculated control samples. Venn diagrams of common and uniquely expressed genes at 24, 48, and 72 hpi in moderately tolerant and (b) susceptible genotypes compared to their respective 0 h controls. Cross-comparison of common and unique significant genes when comparing moderately tolerant and susceptible genotypes for each time point (d). Only significantly expressed genes with P < 0.05 and log2 FC > 2 were considered for comparisons.

identified genes is in progress.

We also characterized the role of an evolutionarily distinct rice *BAHD-Acyltransferase* gene family in rice susceptibility to *Rhizoctonia solani* AG1-IA (Kumar et al., 2021). A total of 85 rice *OsBAHD-AT* genes were identified in the rice genome which were classified into five canonical clades based on their phylogenetic relationship with characterized BAHD-ATs from other plant species. The time-course RNA sequencing (RNA-seq) analysis of *OsBAHD-AT* genes (Fig. 3a) and qualitative real-time polymerase chain reaction (qRT-PCR) validation showed higher expression in sheath blight susceptible rice genotype. Furthermore, the DNA methylation analysis revealed higher hypomethylation of *OsBAHD-AT* genes that corresponds to their higher expression in susceptible rice genotype (Fig. 3b), indicating epigenetic regulation of *OsBAHD-AT* genes in response to *R. solani* AG1-IA inoculation. The results shown here indicate that BAHD-ATs may have a negative role in rice tolerance against *R. solani*

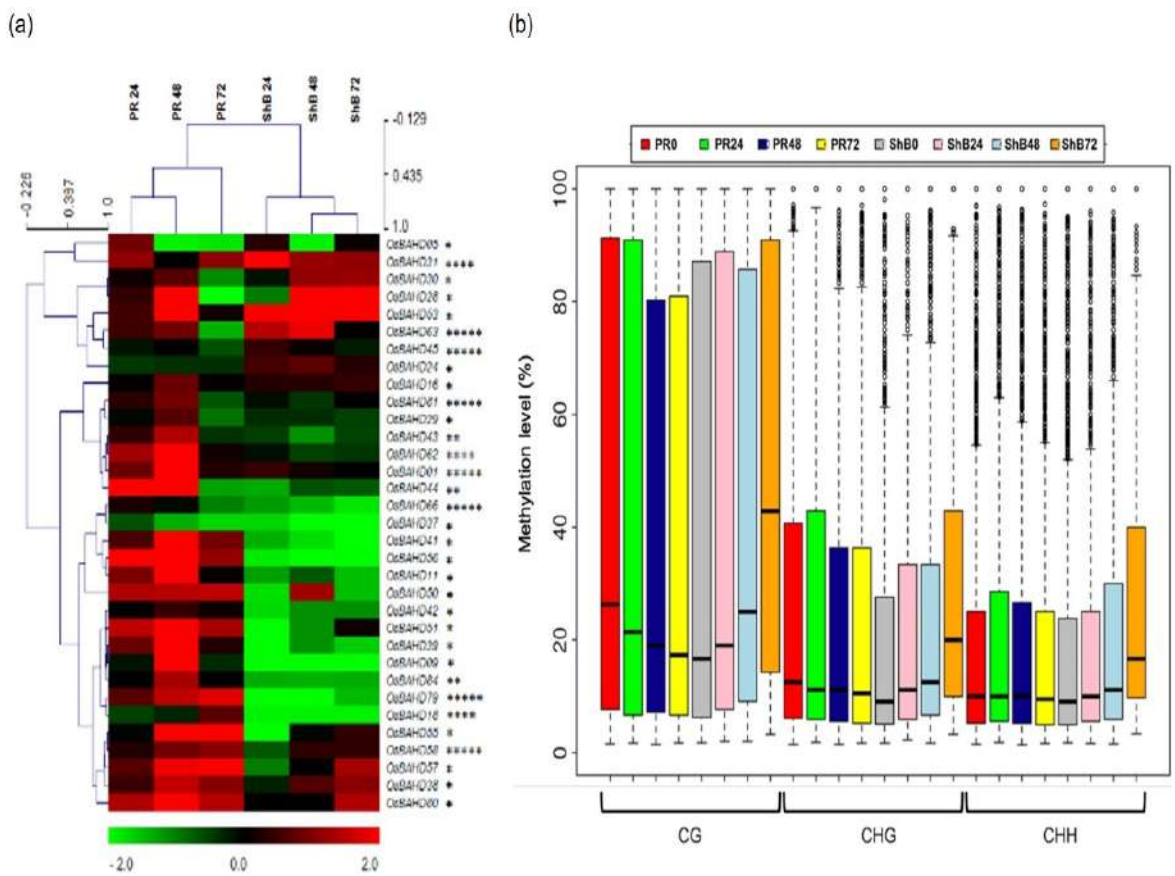

Fig. 3 Expression and methylation dynamics of *OsBAHD*s. (a) The heat map representation for the transcript abundance level of *OsBAHD-AT* genes in *R. solani* AG1-IA challenged rice genotypes viz. PR and ShB at different time intervals. The number of an asterisk (*) next to the gene name indicates the clade to which a particular gene belongs. (b) Change in the methylation level at individual methylated cytosine site of *OsBAHD-ATs* in different sequence contexts, in the control and *R. solani* AG1-IA inoculated rice genotypes, is shown via box plot. Each box shows the interquartile range for the number of methylated cytosines.

AG1-IA possibly mediated through the brassinosteroid (BR) signaling pathway.

In addition to undertanding host genetic factors involved in resistance/susceptibility to *R. solani*, we have also identified potential pathogenicity factors/genes (Fig. 4) that might contribute to its virulence. Few are these genes are being silenced using host-induced silencing approach to study their effect on the virulence potential of *R. solani* AG1-IA.

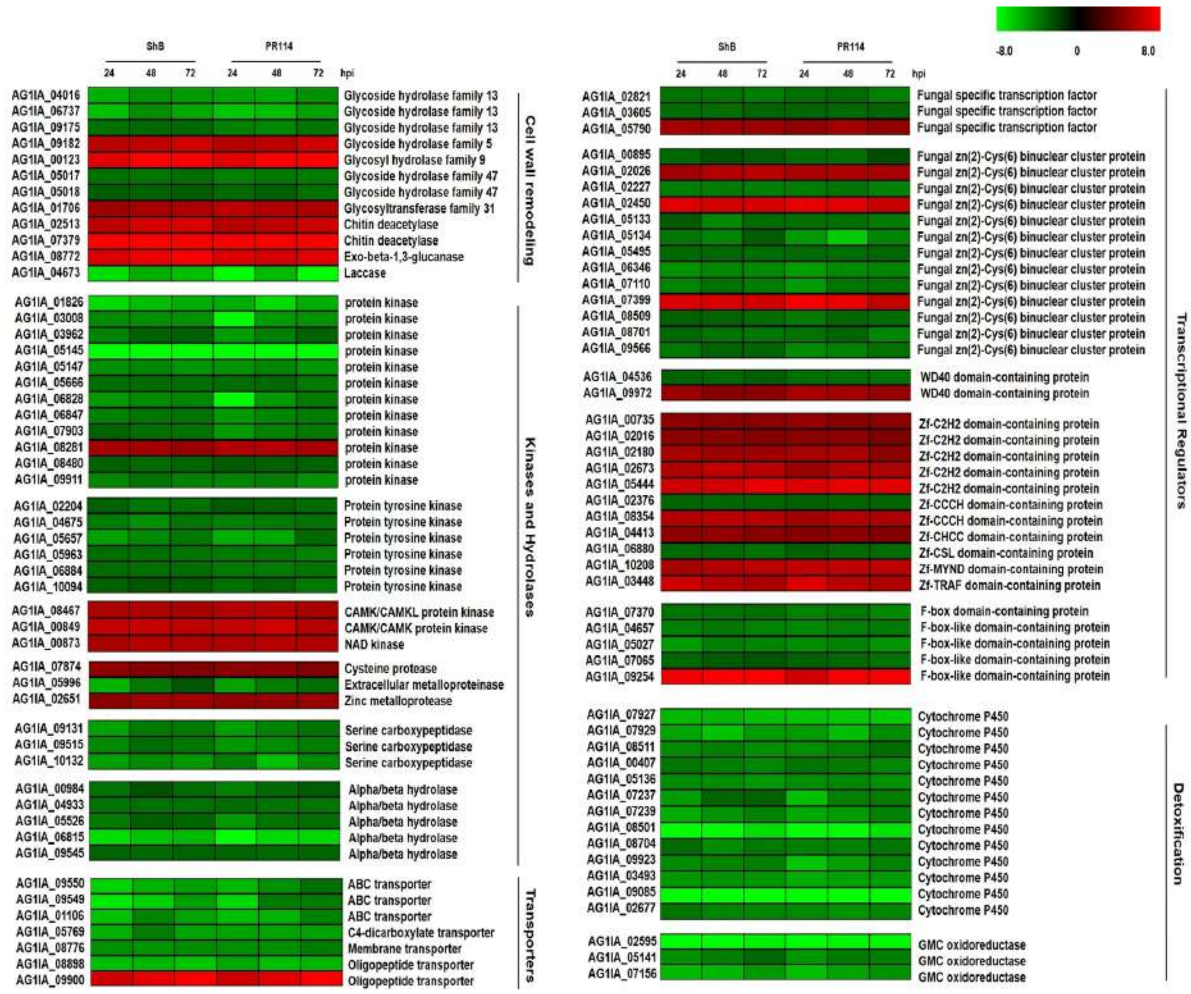

Fig. 4 Differetial expression profile of *R. solani* genes involeved during pathogenicity at 24, 48 and 72 hpi. Heatmap of cell wall remodeling enzymes, kinases, hydrolases, transporters, transcriptional regulators, GMC oxidoreductases and cytochrome P450 during infection in ShB and PR114 rice genotypes. Red and green colour indicate a significantly up (|log2FC| = 2) and down (|log2FC| = 2) regulated gene expressoion, respectively. Colour sacle indicate log_2fold change values ranges from -8 to 8.

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

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 M^{pro} protein. Using wet-lab and *in-silico* studies, we identified a tea molecule as a potential inhibitor of SARS-CoV-2 and deciphered it's mechanism of action. Several other natural molecules varying in their potential for inhibition of SARS-CoV-2 were also identified. One of the molecules showed 99% inhibition of virus at 200 µM concentration. Interestingly, we also identified a a plant based peptide (ricin) to be a potential inhibitor of M^{pro}. It was revealed that a ricin-based peptide from barley with no allergenicity and hemolytic activity was able to inhibit the M^{pro} with IC_{50} of 0.52 nM (Fig. 5A). To understand the binding of BRIP and M^{pro}, 3D structure of BRIP was predicted and used for finding the potential binding pockets on the surface of M^{pro} of SARS-CoV-2 (Fig. 5B). The BRIP peptide was completely covering the catalytic pocket of M^{pro} at the metastable conformation. This work was done in collaboration with Dr. Rituraj Purohit.

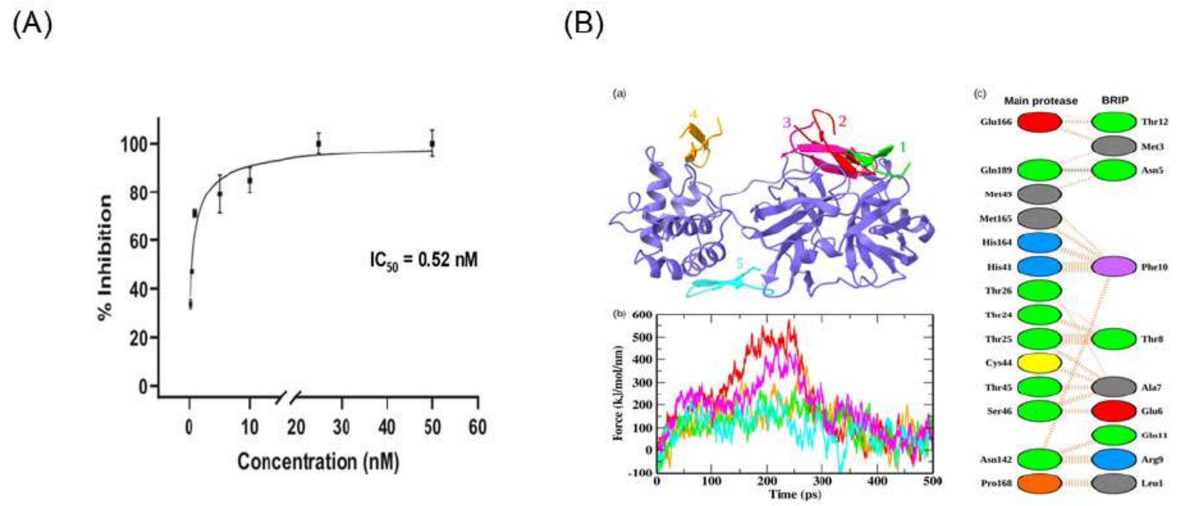

Fig. 5 (A) Effect of BRIP at different test concentrations on inhibition of M^{pro} activity. (B) Detection of the protein-peptide binding site. (B) Detection of the protein-peptide binding site. (a) BRIP docked on the top five predicted binding sites on M^{pro}. (b) The pull force profiles of BRIP attached to the binding pockets of M^{pro}. The pull force trajectories are colored according to the binding poses shown in panel a. (c) The M^{pro}-BRIP interactions at the most favorable binding site. The solid blue color lines represent hydrogen bonds, while the striped line denote non bonded interactions. The residue color coding scheme: positive (blue), negative (red), neutral (green), aliphatic (gray), aromatic (purple), proline and glycine (orange).

A limited number of protein-peptide structures have been experimentally solved in comparison to the protein-ligand complexes with respect to the anti-COVID drug finding. This study opens the gateway of possibilities to find anti-COVID solutions in nature-inspired therapeutic peptides.

Evaluation of thermostable variants of copper, zinc superoxide dismutase in combating oxidative stress in *Arabidopsis thaliana*

In our previous work, a highly thermostable Cu,Zn SOD (WT) was isolated from a high altitude plant, *Potentilla atrosanguinea,* and studies were conducted to understand the structural-functional details to identify the molecular determinants of its thermostability (Kumar et al, 2012; Kumar et al., 2016; Kumar et al., 2021). *Using site-directed mutagenesis, a variant of WT referred to as C95A was developed by replacing Cys95 with Ala. Compared to WT,* *the engineered variant C95A exhibited higher specific activity and thermal stability as revealed by a lesser loss in activity after* autoclaving (heating for 121 °C at 15 psi for 20 min) and almost double time for thermal inactivation at 80 °C (Kumar et al., 2012). Intending to develop next-generation SOD with superior kinetic properties, thermal stability, and resistance to inhibitors, we next looked for other amino acid substitutions on the polypeptide backbone of WT. Mutation of Glu151 to Ala (mutant referred to as Q151A) enhanced the K_m and thermal stability of the enzyme (manuscript under preparation).

These superior variants of SOD can help plants cope up with adverse climatic conditions such as heat, cold, freezing, drought, salinity, flooding, or oxidizing agents that result in enhanced ROS production. Since SODs acts as the first line of defense against ROS-mediated oxidative stress, the improved efficiency of dismutation of $O_2^{\cdot -}$ with increased structural/thermal stability may confer an additional advantage to plants. However, the superior performance of these SODs tested *in vitro*, could be translated *in vivo* remains to be ascertained. With this background, we are complementing the loss of function mutants of *Arabidopsis thaliana Cu,Zn SOD* with the WT and its engineered variants to characterize them in detail.

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Stress and Adaptation Biology, Cell Signaling, Synthetic Biology

Research interests and long-term goals of our lab are (i) understanding the adaptive mechanisms in high-altitude plants for sustaining adverse conditions to extrapolate the findings for engineering stress reliance in other plants; (ii) investigating the environmental regulation of active metabolite accumulation in plants; (iii) deciphering the epidermal cell differentiation mechanisms promoting the formation of outgrowth and secondary metabolite accumulation, which could be used to manipulate outgrowths and secondary metabolites accumulation. In line with these goals, we are currently working on the following projects:

Understanding adaptive mechanisms in high-altitude plants for sustaining adverse conditions

At high altitudes, environmental conditions such as fluctuating temperature (warmer days and cooler nights), high-intensity radiations such as UV-B, low partial pressure of gases, and inadequate availability of water and nutrients, pose stressful conditions for survival of plants. Despite such unfavorable conditions, high-altitude plants such as *Sinopodophyllum hexandrum* and *Picrorhiza kurrooa*, can sustain and complete their life cycle. Deciphering mechanisms by which these plants deal with these cues is essential for understanding the adaptability of these extremophiles. Accordingly, we recently revealed that stress-responsive *cis*-regulatory elements underline podophyllotoxin biosynthesis and better performance of *S. hexandrum* under water deficit conditions (Fig. 1). Water deprivation reduces soil moisture content and water availability to plants, which induces membrane damage and cell death. To counter this, *S. hexandrum* prevents excess transpirational water loss; however, this negatively impacts the photosynthetic rate. In response, the species accumulates lesser chlorophyll to avoid unnecessary light-harvesting and reactive oxygen species generation. Besides, the osmoprotectants, including proline and free sugars, accumulate along with the secondary metabolite, podophyllotoxin, which helps plants to sustain the non-permissive conditions.

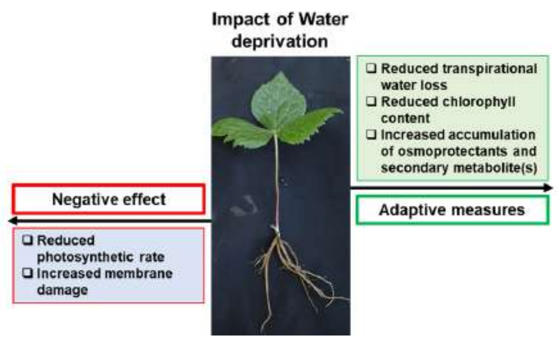

Fig. 1 Strategy adopted by *S. hexandrum* to sustain reduced water availability.

Plants growing in high-altitude environmental extremes experience very high light intensity together with low temperatures and UV, which presents photoinhibiotry stress; however, these plants can sustain these adverse conditions via their evolved excess energy dissipation and ROS scavenging systems. To understand the photoprotective mechanisms in Himalayan plants, we are focusing on *P. kurroa* to decipher their excess energy dissipation and ROS scavenging mechanisms activated by retrograde signaling in these plants.

Deciphering stress-induced changes in chloroplast homeostasis to find clues to engineer damage-resilient photosynthetic machinery

Chloroplasts have been projected as environmental sensors, where any perturbation in the local or global environment affects chloroplast homeostasis. In response, chloroplast activates retrograde signaling pathways to reprogramme nuclear genes expression and trigger cognate response to deal with adversity. Using model plant *Arabidopsis thaliana*, we are investigating stress-induced changes in chloroplast homeostasis. Various stress factors such as high light, UV radiation, temperature fluctuations, drought, and nutrient stress, directly affect the photosynthetic electron transport chain generating ROS. The ROS, thus generated, primarily target photosynthetic machinery leading to reduced efficiency. We are investigating the high light- and high temperature-induced changes in chloroplast protein homeostasis (proteostasis) to identify and map the oxidative damage in proteins. We have mapped stress-induced chloroplast oxi-proteome. Based on preliminary results, we are now validating our data using gene editing and site-directed mutagenesis and identifying natural variants of these proteins in the Himalayan plants. For this work, we have selected proteins involved in light-dependent and light-independent reactions of photosynthesis. Until now, various site-directed mutagenesis-based synthetic constructs are prepared and transformed in wild-type and cognate mutants in *Arabidopsis thaliana*.

Decoding stress-induced and chloroplast-triggered cell cycle arrest and programmed cell death

It has been observed that sub-lethal stress levels induce growth inhibition in plants by arresting chloroplast division and cell cycle and activating controlled and programmed cell death. However, the precise mechanism is not clear. To decipher this retrograde signaling, we have carried out a chemical-based mutagenesis screening of an Arabidopsis mutant with dysfunctional chloroplasts, cell cycle defects, and light-dependent cell death. We have identified specific second site mutants showing attenuation of cell death, chloroplast and growth defects (Fig. 2). These suppressor mutants are now being characterized to delineate chloroplast-triggered stress responses.

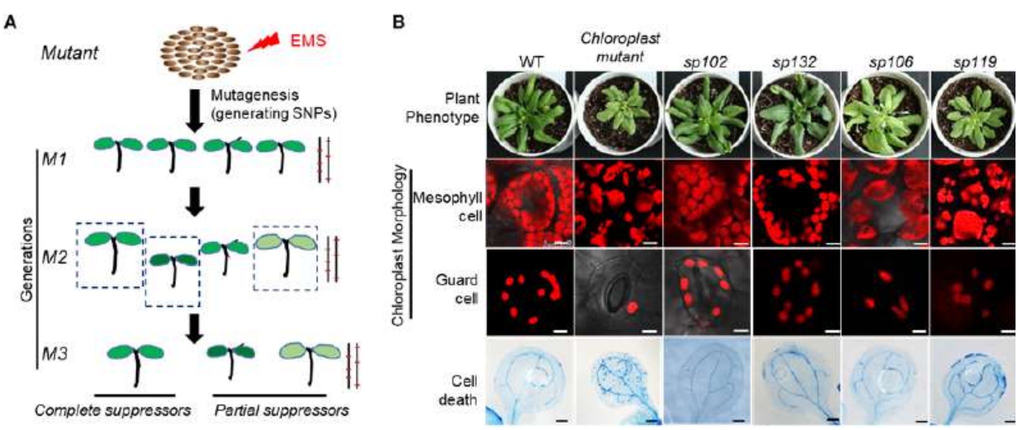

Fig. 2 Forward genetic screening of a dysfunctional chloroplast mutant to unveil stress-induced and chloroplast-triggered cell cycle arrest and programmed cell death. (A) Schematic representation of ethyl methanesulfonate (EMS)-induced mutant screening to identify partial and compete suppressors (*sp*). (B) Screened second site mutants having attenuated cell death and improved chloroplast morphology and growth defects.

Deciphering epidermal cell differentiation mechanisms promoting the formation of outgrowth and secondary metabolite accumulation

On developmental signaling, we have initiated a project on understanding epidermal cell differentiation promoting the formation of outgrowth, including trichomes, prickles, and bladders, and their coupling with secondary metabolite accumulation. In collaboration with Dr. Sanjay Kumar, we have recently deduced a transcriptional module that seems to have a role in prickle morphogenesis and secondary metabolite accumulation in Rose (Fig. 3).

Differentiation of epidermal cells is determined by MYB proteins, where R2R3 MYBs promote while R3 MYBs inhibit the differentiation process. R2R3 MYB proteins Glabra 1 (GL1) or MYB23 together with bHLH TF Glabra 3 (GL3) or Enhancer of Glabra 3 (EGL3) and WD40 protein Transparent Testa 1 (TTG1) constitutes an MBW activator complex. MBW activator complex induces the expression of homeobox Leucine zipper protein, Glabra 2 (GL2) and WRKY44 protein, Transparent Testa 2 (TTG2), which triggers the differentiation of epidermal cells forming outgrowth. MBW activator complex probably also induces the expression of certain, yet unknown, factors that regulate mitosis and endoduplication (EDU). These factors probably allow outgrowing epidermal cell to undergo a few rounds of division and then EDU to form prickle. Besides, the MBW activator complex also induces R3 MYBs, including genes encoding Tryptichon (TRY), Caprice (CPC), and TCL1 (Trichomeless 1), which move to adjacent cells and prevent the formation of MBW activator complex. TRY competes with GL1, whereas CPC and TCL1 repress the expression of GL2 and GL1, respectively. This cell remains undifferentiated and keeps on dividing. Hormones GA, cytokinins, and JA induce the expression of MBW complex genes, and therefore, like in trichomes, appear as the master regulators of prickle morphogenesis (Fig.3).

Using this transcriptional module, we are now trying to engineer prickle-less roses using overexpression, VIGS, and CRISPR-based methods. In addition, we have initiated a project on increasing the accumulation of secondary metabolites in mentha using gene-editing tools and germplasm screenings.

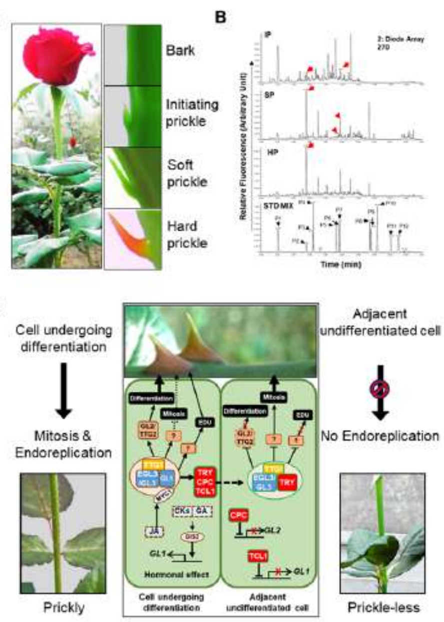

Fig. 3 Canonical MBW transcriptional module governs the secondary metabolite accumulation and prickle morphogenesis in *Rosa hybrida*. (A) Developmental stages of prickle: Bark tissue with no outgrowth, initiating prickle (IP), soft green prickle (SP), and Hard brown prickle (HP). (B) Targeted metabolite analysis in IP, SP, and HP. (C) Model depicting the molecular mechanism underlying epidermal cell differentiation coupling secondary metabolite accumulation and prickle morphogenesis in *R. hybrida*.

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Gaurav Zinta
Senior Scientist

Adaptation, Climate change, Genomics/Epigenomics

Our lab is broadly interested in exploring the intricacies of plant-environment interactions at various scales, from genes to plants to ecosystems (PlantAdaptOme). The specific research interests lie in advancing the mechanistic understanding of plant responses to global climate change factors such as rising atmospheric CO_2, temperature and drought. We work on crops of the Himalayan region (e.g., Amaranth and potato) and also try to answer fundamental research questions by using the model plant *Arabidopsis thaliana*.

Pseudocereals - as future climate crops?

Global climate change threatens agricultural productivity and nutritional quality. The frequency and intensity of extreme heat events are predominant among the predicted features of global climate change. Heat stress affects plant growth and development and negatively affects fitness and yield. There is an urgent need for crop diversification to feed the world's growing population. Underutilized crops such as C4 grain amaranths are nutritionally rich and possess high adaptability towards climate change factors.

Grain amaranths (*Amaranthus hypochondriacus*, *A. cruentus* and *A. caudatus*) are C4 dicotyledonous pseudocereals belonging to the family Amaranthaceae. It contains more protein and minerals than cereal crops such as wheat, maize, and rice. Grain amaranths have high lysine content, an essential amino acid limiting in most cereals and C4 crops. The gluten-free grains contain high amounts of amino acids such as lysine, arginine, and histidine. Importantly, grain amaranths have higher adaptability to environmental perturbations such as drought and salinity, making them a suitable crop for future climate and crop diversification.

However, the responses of grain amaranths to heat stress are less explored. Thus, assessing heat stress sensitivity of grain amaranths is highly crucial. We exposed *A. hypochondriacus* to heat stress at vegetative and reproductive stages, followed by physiological and biochemical analyses (Fig. 1). Heat Shock Factors (HSFs) are known to form the central module of thermotolerance mechanisms in plants. Hence, the characterization of HSF genes was perused wherein gene structure and promoter analysis were performed, followed by HSF expression profiling in different tissues and developmental stages under heat stress (Fig. 1).

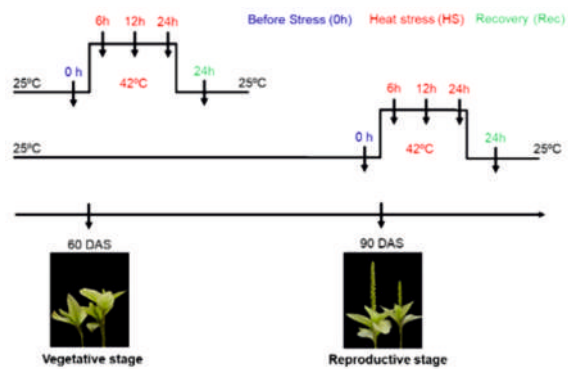

Fig. 1 Schematic representation of *A. hypochondriacus* exposed to heat stress at vegetative (60 DAS) and reproductive (90 DAS) stages. Arrow represents different sampling time points i.e., before, during heat and recovery.

Physiological and biochemical stress markers showed faster stress recovery at the vegetative stage than at the reproductive stage (Fig 2).

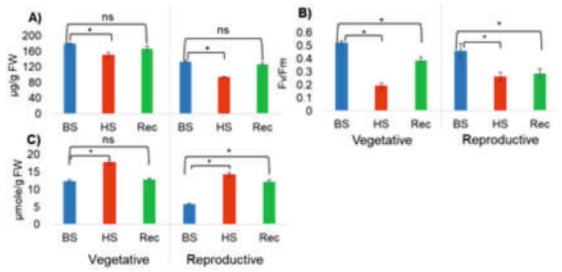

Fig. 2 Physiological and biochemical analysis performed at different sampling time points, i.e., before, during heat and recovery in *A. hypochondriacus* exposed to heat stress at vegetative (60 DAS) and reproductive (90 DAS) stages. A) Total chlorophyll content, B) Chlorophyll fluorescence (Fv/Fm), C) Lipid peroxidation (MDA).

We identified 13 HSFs that showed enrichment in stress-related cis-regulatory elements. Diversity in HSF gene structure (Fig. 3a) and gene expression patterns (Fig. 3b) was observed in different tissues and stress exposure time points.

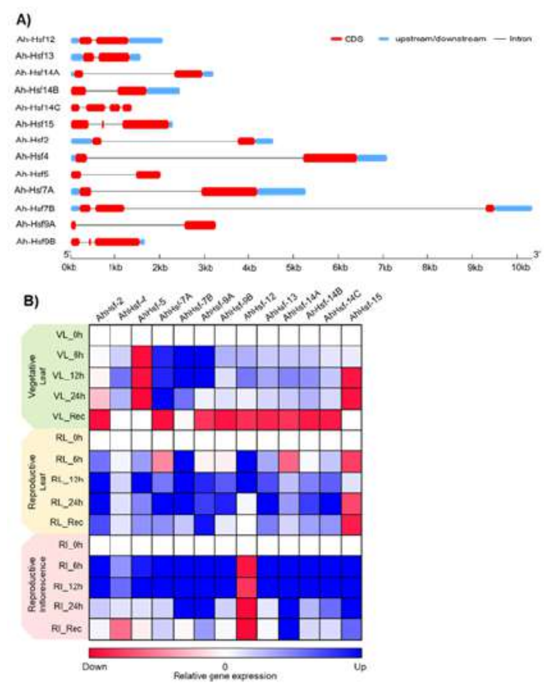

Fig. 3 a) Gene structure of 13 AhHsf proteins identified in *A. hypochondriacus*. b) Temporal gene expression of *AhHsfs* quantified at vegetative and reproductive stages.

The information generated here is crucial for advancing our knowledge on C4 crop adaptation to climate change. Also, we have cloned several genes (e.g. Rubisco Activase) that are ready for the transformation. The physiological and molecular information generated in this underutilized crop would be essential to breed climate-proof and nutritionally rich grain amaranth varieties in the face of ongoing climate change.

Dissecting thermotolerance mechanisms in potato (*Solanum tuberosum*)

High temperature influences plant growth and developmental processes. An increase in the intensity and frequency of heat stress events is a key facet of global climate change. Potato is a temperate crop consumed globally as a staple food. High temperature negatively impacts the tuberization process, eventually affecting crop yield. Thus, there is an urgent need to tap the genetic variation controlling tuberization under environmental perturbations such as high temperatures. Also, epigenetic components regulate various developmental and physiological processes in plants. DNA methylation is a conserved epigenetic mark determined by the dynamic concurrent action of cytosine-5 DNA methyltransferases (C5-MTases) and demethylases (DeMets). However, DNA methylases and demethylases remain uncharacterized in potato. Also, the interplay between genetic and epigenetic factors is less explored in potato.

A comparative analysis of heat sensitive and tolerant genotypes at physiological, biochemical, and transcriptional levels would help elucidate thermotolerance mechanisms. Here, we compared growth and photosynthetic responses of heat sensitive (Kufri Chandramukhi, CP2141/A-2708) and heat tolerant (Kufri Kiran, CP4803/A-2708) genotypes under high-temperature stress (Fig. 4).

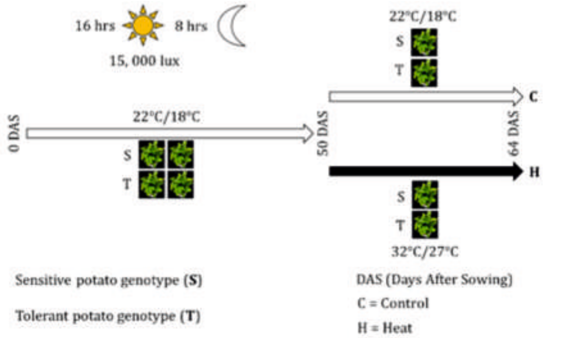

Fig. 4 Schematic representation of exposure of heat sensitive (Kufri Chandramukhi, CP2141/A-2708) and tolerant (Kufri Kiran, CP4803/A-2708 potato genotypes to high temperature stress.

Heat resulted in the increase in plant height in both the genotypes, but a biomass decline was observed. However, the decline in plant biomass was lesser in the tolerant genotype (Fig. 5)

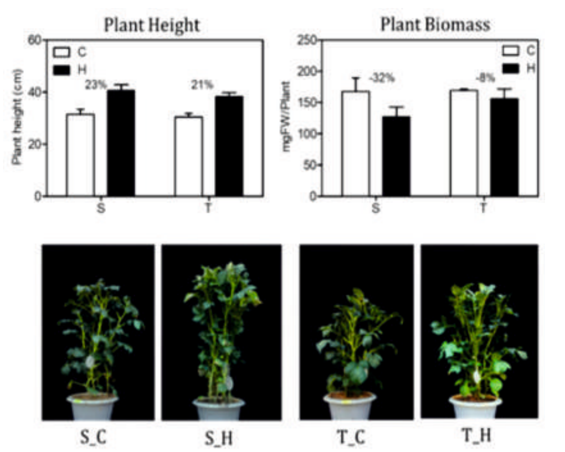

Fig. 5 Growth responses (plant height and biomass) of heat sensitive and tolerant genotypes to high temperature stress.

Little is known about the expression patterns of C5-MTase and DeMets under high temperatures in potato. So we performed genome-wide analysis and identified ten C5-MTases and eight DeMets in potato. Analysis of their conserved motifs, gene structures, and phylogenetic analysis grouped C5-MTases into four subfamilies (StMET, StCMT3, StDRM, StDNMT2), and DeMets into three subfamilies (StROS, StDML, StDME) (Fig. 6).

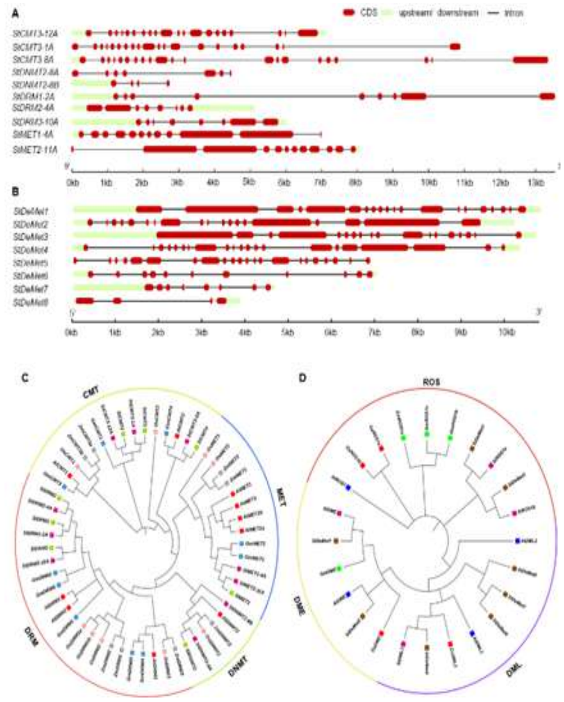

Fig. 6 Schematic structures of conserved domains present in StC5-MTase (A) and StDeMet (B) proteins. The conserved motifs present in C5-MTase (C) and DNA demethylase (D) genes in *Solanum tuberosum.*

The qPCR expression data revealed that high temperature resulted in pronounced upregulation of *CMT, DRM* and *DeMets* genes in the HT genotype. Also, high temperature induced the expression of positive regulators of tuberization in the leaf and stolon samples of HT genotype, possibly through active DNA demethylation and RNA-directed DNA methylation (RdDM) pathway components (Fig. 7).

Overall, elucidation of genetic and epigenetic regulators under high temperature stress can provide mechanistic insights into thermotolerance mechanisms in potato. Also, we cloned several genes with a possible role in heat stress tolerance and potato tuberization have been cloned. This would help breed heat-tolerant varieties and improve tuber yield to ensure global food security.

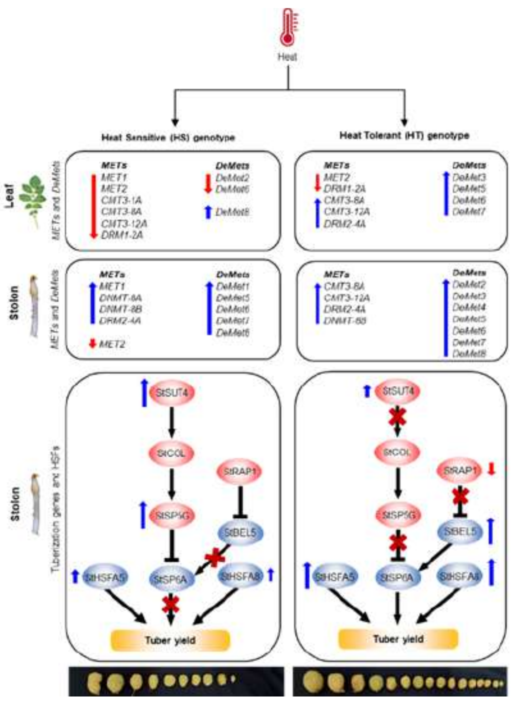

Fig. 7 The schematic model depicting the expression of *METs* and *DeMets* in different organs (leaf and stolon) along with the positive (*StSP6A* and *StBEL5*) and negative regulators (*StSUT4*, *StSP5G*, *StRAP1*) of potato tuberization in the heat sensitive (HS) and tolerant (HT) genotypes.

Demystifying molecular features underlying high temperature stress adaptation

The rise in Earth's temperature is a key feature of global climate change, which is affecting global agricultural productivity. Especially the cold biomes of Earth, including the Himalayan region, are predicted to be highly sensitive to temperature rise. How do global warming and extreme heat events affect plant growth and development? What are the signaling networks underlying warming and heating? Also, what adaptive mechanisms underly long-term stress exposure (transgenerational adaptation)?

Arabidopsis thaliana is an excellent model system to answer these fundamental questions because of its short generation time, availability of high-quality genome data, and genetic resources.

Warming and heating not only differ from each other in terms of their degrees on a thermometer but also trigger very different kinds of plant responses. For instance, high ambient temperature induces various phenological and developmental changes in plants, including early flowering and elongation of vegetative organs. Oppositely, extreme heat stress inhibits growth and photosynthesis and causes floral abortion. In our lab, we are dissecting the molecular signatures underpinning these high temperature regimes (warming and heating) in the model plant *Arabidopsis thaliana*.

Also, short-term high temprature stress responses i.e., those applying within one generation, are relatively well characterized at the molecular and physiological levels. In sharp contrast, very little is known about the extent and mechanisms by which stress experiences of parents affect the offspring. Thus, we are also exploring the mechanisms underlying transgenerational heat stress adaptation in Arabidopsis by growing them under optimal and high temperature conditions for multiple generations.

The multi-generational experiments have been undertaken with various Arabidopsis ecotypes originating from different geographic regions of the world. Also, various epigenetic mutants related to DNA methylation and histone modifications are being used. This comprehensive analysis will allow us to capture evolution in action under hot climates.

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Biotechnology

Our lab is involved in understanding saffron plant developmental biology, mainly flowering regulation and corm development. Flowering determines saffron crop yield, whereas vegetative growth determines corm quality, the only source of its propagation. Thus, understanding the corm development, its multiplication, and the flowering transition will help to develop new agro technological practices to produce standard quality and quantity of corms. Simultaneously, new biotechnological approaches such as genome editing, cisgenic, etc., can also be applied to develop new varieties with the desired trait.

Photoperiodic regulation of corm development

Saffron (*Crocus sativus*. L) is an autumn-flowering perennial geophyte producing an expensive spice used in medicines and culinary. Saffron has a modified, underground stem called a corm, which acts as a storage and perennating organ. Saffron being triploid, does not produce seeds, and thus corms are the only source of propagation. Corm quality is an important factor affecting the yield of saffron; the bigger the size of the corm, the chance it flowers. There is a decrease in saffron production in India due to a lack of quality corms as seed material. Thus corm development in saffron is of utmost importance yet not explored. Two main environmental factors determining plant growth and development are photoperiod and temperature. Ecological factors regulating corm development in saffron are not studied, and molecular factors regulating corm development are unknown. Thus in our lab, we are trying to understand the environmental and molecular control of corm development in saffron.

In natural growth conditions, corm development coincided with an increase in photoperiod. Thus to study the effect of photoperiod on the corm development of saffron, we monitored the corm development in different photoperiod (Long and Short) and natural field conditions. Saffron corms were grown in (a) Natural conditions in the field at CSIR-IHBT, (b) Long photoperiod (16/8 Light/Dark), (c) Short photoperiod (8/16 Light/Dark).

Corm development and plant growth varied among all three conditions. In the Long photoperiod, corm development began early in December compared to natural conditions and short photoperiod, where corm development commenced in January and February (Fig. 1). Plants in long photoperiod and natural conditions senescence early compared to short photoperiods. In short, photoperiod plants continued to grow and showed no sign of senescence till the end of the experiment. Overall the results suggest that corm development in saffron is mediated by photoperiod. Further experimentations are on the way to identifying molecular factors involved in photoperiod-mediated corm development regulation.

Molecular cloning, characterization and expression profiling of PEBP family genes in saffron identifies flowering and vegetative growth regulators

Saffron flowering determines the crop yield, and thus its regulation is of utmost importance. It is known that PEBP member genes have a conserved role in flowering

Fig. 1 Effect of photoperiod on plant growth and corm development. The figure shows corm development stages in (A) Natural Condition in Field, (B) Long Photoperiod (16/8 Light/Dark), and (C) Short photoperiod (8/16 Light/Dark). Corm development coincides with an increase in photoperiod. Corm development was observed to be early in long photoperiod and natural conditions than short photoperiod.

regulation in several plant species but not studied in saffron. Therefore, the study was carried out to isolate and characterize the PEBP family genes in saffron and identify their distinct role in flowering regulation. To date, only limited studies predict the involvement of a few genes which can be involved in flowering and sprouting regulation in saffron, but the major limitation is defining their specific role. Saffron is a geophyte, which can be hysteranthous or synanthous, producing flowers and leaves periodically or simultaneously. Most previous studies (Renau-Morata et al. 2021; Hu et al. 2020) have used sprouting apical buds as a whole (which contains both flowers and leaves) to study the initiation and formation of flowering, which might delude on the specific role of genes in flowering or vegetative growth. In the present study, we used comparative tissue-specific (flowering vs non-flowering tissue) expression profiling to differentiate between flowering and vegetative growth regulators. In saffron, the apical buds produce both flowers and leaves, whereas axillary buds mainly produce leaves; else, they sprout similarly. Additionally, only big size (>8g) corms are supposed to flower while small-sized corms don't. We utilized this ability to identify and differentiate flowering and vegetative growth regulators precisely. To establish the role of PEBP genes in saffron corm sprouting and identify their distinct role in promoting flowering, we have isolated PEBP gene family members from saffron, cloned them and characterized them during the process. PEBP gene members were determined using a combinational approach of previously submitted transcriptome databases and gene/protein sequences submitted at NCBI. In summary, this is the first comprehensive report in which we have isolated and cloned 6

FTs, 2 TFL1s and 2 MFTs homologues full-length genes and, after characterization them during the flowering transition and sprouting, have identified their specific roles. A total of 10 genes belonging to the PEBP family were identified. The PEBP gene family in saffron consists of 6FTs, 2TFL1s and 2MFTs homologues genes at least. Out of 6 FTs, two FTs behave differently that is FT4 and FT6. FT4 has proline instead of Glutamine at 144 position which is a conserved characteristic of FT like genes, while CsatFT6 has Histidine (His88) instead of Tyrosine, which is a characteristic of TFL like genes. The phylogenetic analysis clustered the aligned sequences into two main clades. The first clade comprised FT-like sequences and the second clade contained both TFL1-like and MFT-like genes.

Sprouting in saffron occurs after summer dormancy, while flower initiation occurs during summers in the field and in storage. To identify developmental changes leading to the initiation and formation of flowers, we followed the flower developmental stages and sprouting occurring in saffron corms under controlled conditions. In April, freshly harvested/lifted corms of saffron were sorted. Corms of >10g in weight that is considered competent for flowering were used for the study. Samples were harvested at an interval of 5 weeks (35 days approx.) every month from May to September and were pictured to monitor developmental changes (Fig. 2). The corms were dormant when harvested (stage 0) and showed no external growth for about a month. Some budging (increase in size) of apical bud was observed after one month of storage (stage 1) in the first week of June (7th). Microscopic analysis suggests that the flower initiated between stages 0 to 1 and was visible at stage 1. The apical buds showed more outgrowth at stage 2 (12th July), and microscopic analysis suggests that flower and leaf initiation has already advanced during this phase (Figure 3). Flowers, stamen and leaves were visible with naked eyes in the further stage (stage 3, 16th August). At stage 4, the corm contained a full developed flower with tepals, stigmas, and stamens, and had expanded leaves in September (22nd).

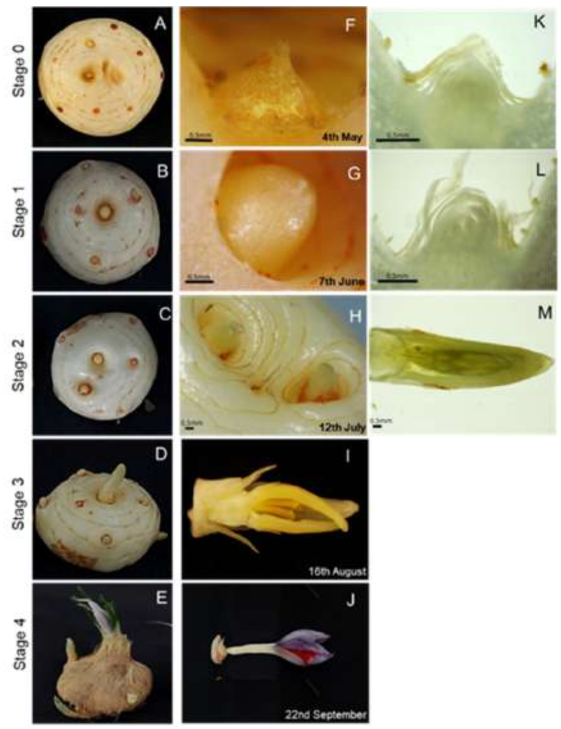

Fig. 2 Morphological and developmental changes during apical bud outgrowth lead to flowering and vegetative growth. Representative images of different developmental/morphological changes occurring during flower formation in saffron. The saffron corms were stored in controlled conditions, as mentioned in the methods section. Images were captured by a camera (A-E), followed by microscopic analysis of intact apical bud (F-J). For stages 0,1, and 2, apexes were dissected for the microscopic image to follow the flower initiation process (K, L and M). Flower initiation can be seen from stage 1, while different flower parts are visible from stage 2. Further in stage 3, immature flowers and leaves and stage 4 complete flowers are seen. Scale Bar = 0.5mm.

Our study identified the PEBP gene family members in saffron. CsatFT1, 2 and 3 were upregulated during apical bud outgrowth (flower initiation and leaf development). The tissue-specific expression suggests that CsatFT3 presumably acts locally in apical buds to promote flowering induction, whereas CsatFT1 and CsatFT2 might promote vegetative growth (apical and axillary). CsatFT4 and 6 expressed to higher levels in dormant corms, suggesting they might have functions opposite to FT like genes and similar to TFL1 like, in regulating growth. CsatTFL1-1 and CsatTFL1-2 express opposite to CsatFT1-3 genes during flowering and vegetative growth. Their expression pattern in different tissues suggests CsatTFL1-1 might regulate vegetative growth while CsatTFL1-2 is involved in flowering regulation (Fig. 3). CsatMFT1-2 genes roles were not very clear in the studied process but their Spatio-temporal expression pattern suggested their involvement in controlling axillary bud outgrowth. The results have been summarized. Additionally, size-dependent flowering ability correlated with higher CsatFT3 expression. Overall, the study better understands PEBP family genes function in flowering regulation and sprouting and identifies CsatFT3 as plausible flowering regulators in saffron. However, further studies are required to functionally characterize these family genes by genetic approaches to understand their roles in flowering and plant developmental roles in saffron.

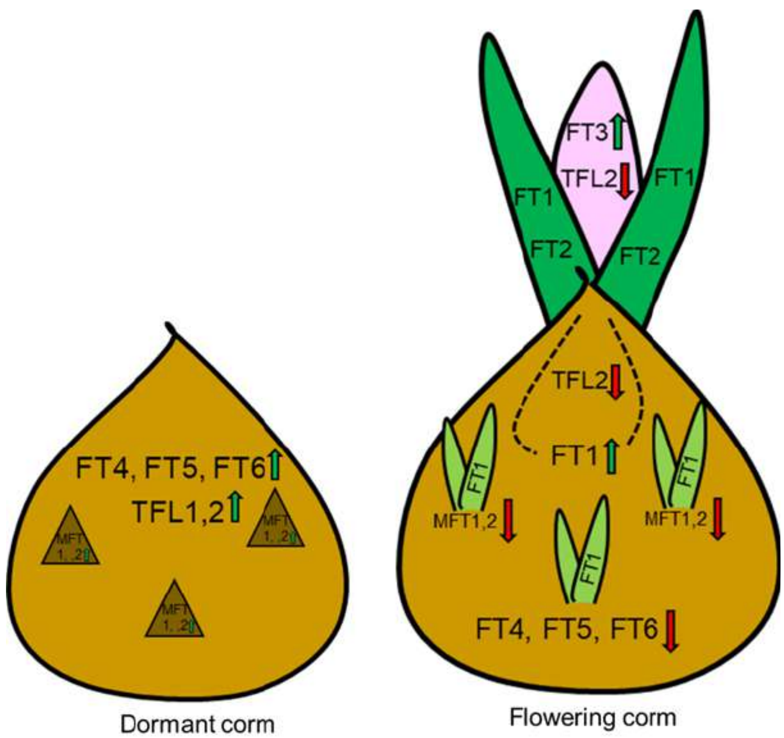

Fig. 3 Hypothetical model summarising the findings of the study. Dormant corm represents stage 0, while flowering corm represents stage 2, corresponding to stages mentioned in the study. Arrows pointing upwards (in green) shows higher expression, while pointing downwards (in red) show reduced gene expression.

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Environmental Biology

Our research group focuses on catering the society and industry through microbial interventions. In the current year, we brought positive changes in the life of dry toilet users of Lahaul valley and expanded it to Leh, Ladakh through the product "Compost Booster-Single solution for stabilization of night soil/kitchen waste". Four societies in Lahaul valley have signed material transfer and consultancy agreements and Ladakh UT authorities have extended their support in the dissemination of the technology in the region. Additionally, Military Station Headquarters, Palampur have also signed an agreement with us to tackle the kitchen waste of the cantonment using our interventions. The technology of Vitamin D_2 enriched *Shiitake* mushroom dissemination took a major boost by two more technology transfers and by functionalization of two SFURTI clusters under the Ministry of Micro, Small & Medium Enterprises (MoMSME). Further, overall research and technology dissemination of the laboratory can be categorized as follows:

Organic waste management in the Indian Himalayan region

Among the composition of the solid waste, a major portion comprises biodegradable organic waste, but extreme climate conditions (harsh and prolonged winter) make processes like composting and vermicomposting considerably inefficient in the cold hilly region. The low temperatures limit the initial microbial load and hence pose technical challenges by extending the mesophilic phase and shortening the thermophilic stage. The limited microbial population on the onset of degradation, low temperature, and moisture level, and inefficient proteo-lingo-cellulolytic microbes hinder the composting process. At our laboratory, we have developed substrate-specific efficient indigenous psychrotrophic bacterial consortia with hydrolytic and plant growth-promoting potential for obtaining enriched compost. So far, at IHBT, we have isolated psychrotrophic bacterial strains from compost samples of different Himalayan regions: Lahaul and Spiti district, Kinnaur, Palampur, and Sikkim from variable maturity stages. Bacterial consortia in the form of Effective Microbial (EM) solution have been tested for their degradation efficiency at the lab scale. Furthermore, a suitable combination of carrier materials "Compost Booster", has been prepared in order to sustain the bacterial viability for a longer time period, accelerate the degradation rate, and suppress the foul odor during the process. Both bacterial consortia and Compost Booster have successfully passed the field trials. Experimental trials at the Military Station Headquarters, Holta, Palampur (Fig. 1) gave encouraging results based on which a material transfer and consultancy agreement have been signed between the Military Station Headquarters, Palampur, and CSIR-IHBT.

Fig. 1 Composting at pilot scale in the Military Station Headquarters, Holta, Palampur.

The SFURTI cluster based on the scientifically proven technology for compost production is functional at West Sikkim and Nahan, HP providing livelihood to 400 beneficiaries. The Moonew Tareybhir vermicomposting cluster at Sikkim has been included in the community success story by Department of Science & Technology (DST) under the"Tech नींव@75" initiative as their last financial year turnover was Rs 42 lakhs.

Another major achievement in the field of organic waste management is the interventions in the Himalayan dry toilet system prevalent in the northwestern Himalaya. The traditional practice of converting human feces into organic manure was lately declining due to the social apprehensions, labour unavailability, lack of awareness, increased tourist influx, and modernization. The major limitations associated with night-soil composting was the delayed degradation process due to low ambient temperature and limited microbial load causing foul odor and unhygienic conditions. The night-soil composting process required improvisation to reduce the degradation process, foul odour, heavy metal content, and pathogenicity associated with night-soil composting. Promotion of the safe and hygienic winter dry toilets aided with the scientific intervention was necessary to sustain the agro-ecosystem and conservation of water in such highland areas. In our laboratory, we have carried out the quality assessment, safety evaluation, and microbiome analysis of the night-soil compost from Lahaul valley. Furthermore, indigenous psychrotrophic bacteria with efficient hydrolytic and plant growth-promoting attributes have been recovered from night-soil compost. The product called 'Compost Booster' using indigenous bacteria has been developed which can efficiently degrade the night soil and produce a humanure rich in nutrients for plants. The formulation also consists of plant growth promoting bacteria which can benefit the farmer by enhancing the crop productivity. The product has been distributed in Lahaul valley (Fig. 2), covering five gram-panchayats (Gushal, Muling, Tandi, Jahlma & Yurnath) and more than 15 villages; In Spiti valley, conducted single trial at Kaza; In Ladakh, the products were given to municipal ward members of Leh and Kargil; Army personnel based in HP and Ladakh have also used the products and the product has received tremendous demand and popularity. Our work on Himalayan dry toilets has also been covered by electronic media like- CNN-IBN News18, TEDxTalk, DD News Himachal Pradesh, and print media like- Mongabay, The print, HimKatha.

Fig. 2 Awareness camps and distrubtion of "Compost Booster" in Lahaul.

Technology Development and Transfer (TDT) Division, Department of Science and Technology, GoI funded our laboratory for remunerative organic waste management in cold regions. Under this, through DST sponsored scheme of Waste Management Technology, we have installed two anaerobic biogas plants with the capacity of treating 250 kg of organic waste per day at selected

Urban Local Bodies (ULB) in Himachal Pradesh and Sikkim. Nagar Panchayat Baijnath Paprola, Baijnath (Fig. 3a) and Gyalshing Municipal Council, Gyalshing, West Sikkim (Fig. 3b) has signed the MoU with IHBT and the Biogas plants have been installed at designated sites. The advanced high rate semi-automatic digester design gives higher methane-rich biogas yield and generates nutrient-rich fertilizer. We have specifically used cold-tolerant efficient hydrolytic anaerobic consortia from our laboratory in addition to the improved design with an extra component of heating and insulation to sustain prolonged winter. The temperature of the digester was maintained at 20-25 ˚C and pH of the feedstock was set between 7-8.

Fig.3 Biogas plants installed at (a) Nagar Panchayat Baijnath-Paprola, Baijnath, Himachal Pradesh and (b) Gyalshing Municipal Council, Gyalshing, West Sikkim.

Bacterial exploration from the alpine region

Mucilaginibacter sp. is known as an exopolysaccharide (EPS) producer. In the study, a potentially novel species of genus *Mucilaginibacter* was used to extract EPS (Fig. 4). Statistical optimisation by response surface methodology produced 26.4 mg/mL EPS at 20 , pH 7.4 using 47 mg carbon source/mL. The molecular weight of the extracted EPS was 3045.09 Da as determined by MALDI-TOF/TOF-MS. Structural characterisation by monosaccharide composition, methylation, Fourier-transform infrared spectroscopy, and Nuclear magnetic resonance analysis revealed that the EPS was a linear polysaccharide with the sugar backbone of α-D-Glc^{iv}(1→4) α-D-Glc^{iii}(1→3)β-D-Glc^{ii}(1→6)α-D-Glc^{i}. The extracted EPS provided 97.91% viability to mesophilic *Escherichia coli* under freezing conditions (-80) for up to 7 days. Additionally, extracted EPS showed metal ion biosorption ability for Cu^{2+} (8.36 mg/g), Fe^{2+} (4.47 mg/g), Mn^{2+} (0.12 mg/g), and Zn^{2+} (0.103 mg/g). Owing to these properties, the extracted EPS can be explored for its application as a cryoprotective agent and as a medium to remove toxic metal ions. To the best of our knowledge, this is the first report on the extraction and characterisation of EPS from the genus *Mucilaginibacter*

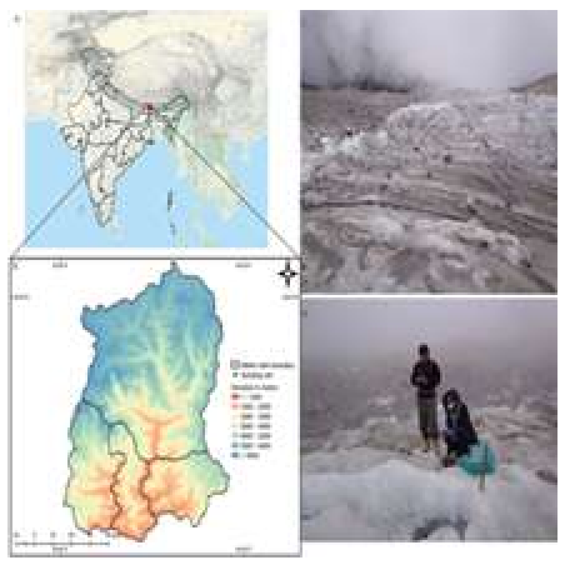

Fig. 4 Exopolysaccharide (EPS) extracted from *Mucilaginibacter* sp. and its potential role as cryoprotective and metal biosorption agent.

Microorganisms inhabiting the supraglacial ice are biotechnologically significant as they are equipped with unique adaptive features in response to extreme environmental conditions of high ultraviolet radiations and frequent freeze-thaw. While culturing bacteria from the East Rathong glacier in Sikkim Himalaya (Fig. 5a), we obtained eleven strains of *Pseudomonas* the supraglacial site that showedambiguity in terms of species affiliation. Being one of the most complex and diverse genera, deciphering the correct taxonomy of *Pseudomonas*has always been. So, multilocus sequence analysis (MLSA) was conducted usinggenes that concluded the taxonomic assignment of these strains to *Pseudomonas antarctica* (Fig. 5b). The result was further supported by the lesser mean genetic distances with *P.antarctica* (0.73%) compared to *P.fluorescens* (3.65%), and highest ANI value of ~99 and dDDH value of 91.2 of the representative strains with *P. antarctica* PAMC 27494.

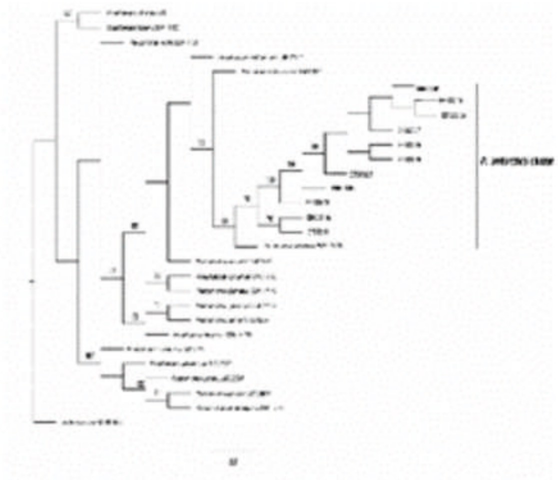

Fig. 5a) Map illustrating geographical location of the sample collection site in Sikkim Himalaya, India.)b) Phylogenetic tree of 11 *Pseudomonas* study strains based on the concatenated sequences of protein-coding genes *gyrB*-*ileS*-*nuoD*-*recA*-*rpoD* using RAxML .

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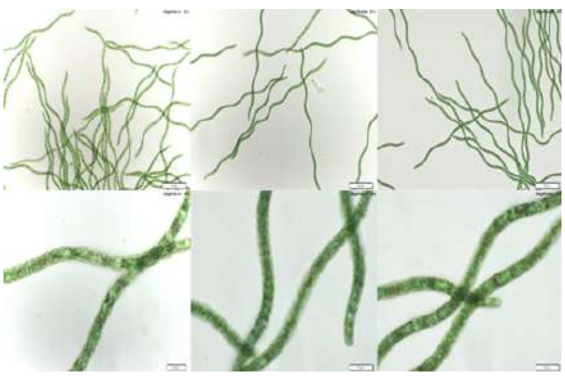
Algal Biotechnology and Nutraceuticals

Utilization of industrial wastes for cultivation of microalgae

We propose utilization of beverage processing industry waste such as sludge, reverse osmosis reject salts for cultivation of commercially important microalgae such as *Spirulina platensis* and *Chlorella pyrenoidosa*. Addition of beverage waste salt to the algal growth medium enhanced the growth of *Spirulina platensis*. The cells tolerated up to 6 g/L of waste salt in the growth medium (Fig. 1). There were no negative effects on the morphology,



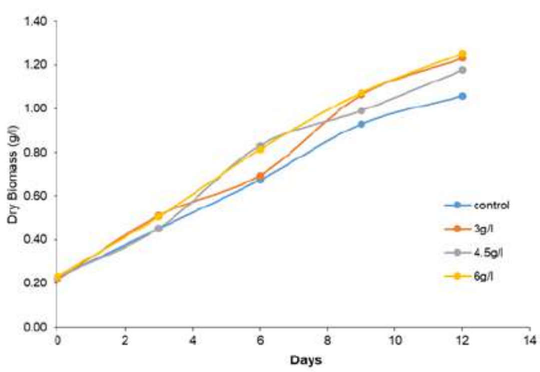


Fig. 1a Photomicrographs of *Spirulina platensis* cultivated with beverage process waste [reverse osmosis reject] salt; Fig 1b, Growth profile of *Spirulina platensis* under different concentration of waste salt.

cell size, growth of cells and accumulation of nutraceuticals such as phycobiliproteins, carotenoids and whole cell proteins.

Various low cost growth medium was developed utilizing beverage waste and agriculture fertilizers such as urea, ammonium bicarbonate, NPK fertilizers for cultivation of microalgae, *Spirulina platensis*. Maximum growth of microalgae was observed with beverage industry waste salt followed by urea enriched medium. The chemical composition of microalgae cultivated with beverage process waste salt met the quality standards recommended by Bureau of Indian standards for food/feed grade spirulina IS12895 and IS 13398. The study was sponsored by M/s. Algareal Nutraceuticals and Hindustan Coca Cola beverages.

Table 1. The Chemical composition of microalgae cultivated with beverage process waste salt

Nutrient parameters	Amount per 100 g	Standard market requirements per 100 g
Total protein, (%)	62.295 ± 0.35 (62.3%)	NLT 55%
Total soluble protein, (%)	19.61 ± 0.56 (19.61%)	NLT – 15%
Total polyphenols, (mg)	13.225 ± 0.32 (1.3%)	Not available
Total carbohydrates, (%)	17.14±0.49	NLT – 15%
Total chlorophylls, (mg)	1.88 ± 0.04	NLT – 1 mg
Total carotenoids, (mg)	172.89 ± 2.23	NLT – 120 mg
Total C-Phycocyanin, (mg)	153.955 ± 0.69	NLT 12.00 mg
Ash (%)	11.2 ± 0.09	NMT - 12%

Edible protein concentrates from agri-byproducts and microalgae

A process for isolation of edible grade proteins from the by-product of guar gum processing was developed and the protein isolates was evaluated for its safety and growth, physiology, behavioural and serum biochemistry in experimental rats. Guar or cluster beans (*Cyamopsis tetragonoloba* (L.) Taub) is a semi-arid crop predominantly cultivated in North Western India. Guar gum obtained from the endosperm is used as thickening and gelling agent in food and chemical industries. The residue obtained after gum extraction is called guar korma which are rich source of proteins and other nutrients (Fig. 2). Guar korma is used as animal feed additive. The present study was taken up to evaluate the safety of protein concentrate derived from guar korma for its potential use as novel source of vegetarian protein towards development of value added food products. The guar protein is not approved under food safety standards of India (FSSAI, 2016) for its regular use as edible protein source. Hence the study provides complete details on the safety and nutritional quality of guar protein isolates. The studies were conducted according to OECD guidelines, 2008 as per the protocols described in guidelines TG 423 for single dose acute toxicity study and TG 407 for repeated dose sub-acute toxicity study. The studies were conducted in Sprague Dawley albino rats at CSIR-Institute of Himalayan Bioresource Technology, Palampur. The study revealed that supplementation of guar protein concentrate did not induce any negative effects on the growth, behaviour, haematology and serum biochemistry in rats. Minor changes induced in the growth and feed consumption at 20% guar protein supplementation in repeated dose study was observed. The protein efficiency ratio [PER] was 2.52 and feed conversion ratio [FCR] was 2.29 similar to reference protein casein and commonly used plant protein soybean. The protein digested corrected amino acid score of guar proteins was 0.95 and the 1st limiting amino acid was lysine. Based on the results, there was no observed adverse effect level (NOAEL) at the highest dose (i.e. 20%) tested in the study. The study was sponsored by M/s. Shree Ram India Gums Pvt. Ltd., Jodhpur, Rajasthan, India.

Fig. 2 Edible protein isolation from guar korma after extraction of polysaccharides [gums].

Microalgae based protein sources

The global demand for protein ingredients is continuously increasing owing to the growing population, rising incomes, increased urbanization, and aging population. Conventionally, animal-derived products (dairy, egg, and meat) satisfy the major dietary protein requirements of humans. With the global population set to reach 9.6 billion by 2050, there would be a huge deficit in meeting dietary protein requirements. Therefore, it is necessary to identify sustainable alternative protein sources that could complement high-quality animal proteins. In recent years, microalgae have been advocated as a potential industrial source of edible proteins owing to their wide and excellent ecological adaptation. Microalgae can grow in marginal areas utilizing non-potable wastewaters with high photosynthetic efficiency. Previously microalgae species such as *Arthospira*, *Chlorella* have been used as single-cell proteins (SCP) with limited application in pharmaceutical industries. In recent years, the demand for innovative and sustainable functional ingredients for food applications has renewed the interest worldwide towards microalgae proteins. We propose utilization of defatted microalgae biomass as source of edible proteins (Fig. 3). It can be summarized that microalgae proteins are comparable to reference proteins such as soy and casein both in terms of amino acid (AA) quality and techno-functional properties. However recalcitrant cell wall poses a challenge in digestibility and effective utilization of the microalgae proteins. The essential amino acid score of microalgae proteins are better compared to cereals like wheat, maize and comparable to soybean. Microalgae proteins are limited in lysine, histidine and sulphur amino acids in comparison to FAO/UN/WHO recommendations for essential amino acids for the age group 2 to 10 years. Novel applications of microalgae proteins include meat analogues, emulsifying agents, and bioactive peptides. Development of low-cost cultivation strategies, wet biomass-based downstream processing along with the bio-refinery approach of complete biomass volarization would enhance the sustainability quotient for human food applications (https://doi.org/10.1016/j.foodres.2022.111338; Food Research International, 157, 111338, 2022).

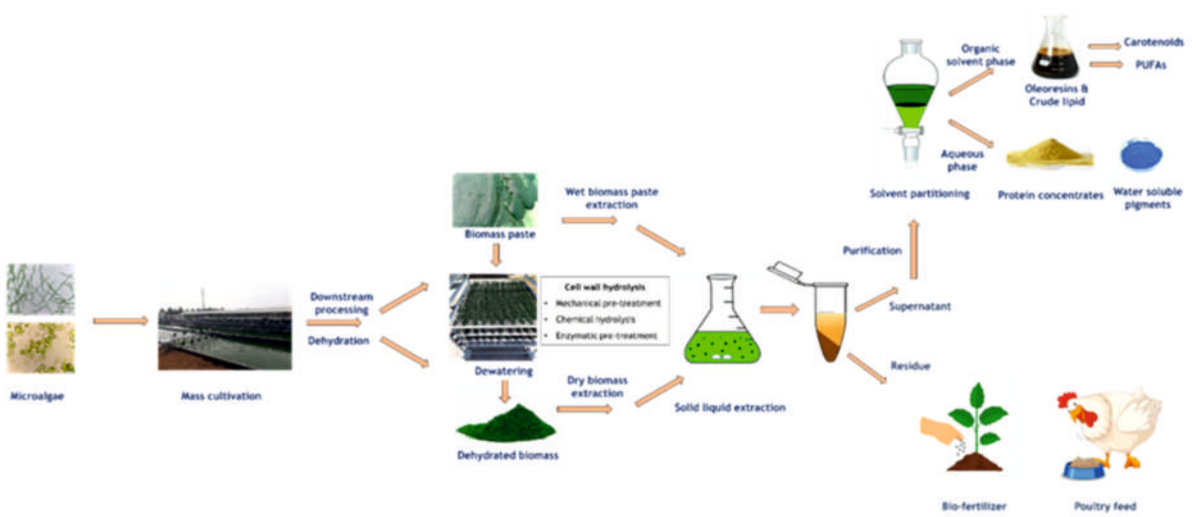


Fig. 3 Integrated biorefinery approach for production of microalgae based edible proteins.

POSHAN MAITREE - A pilot scale supplementation of micronutrient fortified food products developed at CSIR-IHBT

POSHAN Maitree, a pilot scale nutrition supplementation program funded by Directorate of Women and Child Development, Govt. of Himachal Pradesh was organized by CSIR-IHBT (Fig. 4). The program involved supplementation of iron, zinc and protein rich food products to moderately malnourished children (MAM) and severe acute malnourished (SAM) children, very weak pregnant and lactating women (P&L) of Panchrukhi block, Palapmur tehsil. The nutrition supplements were provided along with the monthly take home rations.

Following products were distributed among the beneficiaries

- Iron and Calcium enriched fruit bars
- Iron and Zinc enriched Spirulina based energy bars
- Protein and fiber enriched multigrain energy bars
- Multigrain high protein beverage mixes

The nutritional supplements (fortified food products) were evaluated for their safety and quality in experimental animal models at CSIR-IHBT and evaluated for its acceptance and bio-efficacy in anaemic patients at Rajiv Gandhi Government Post Graduate Ayurvedic College, Paprola, Himachal Pradesh. The products were distributed every month at the respective anganwadi centres of Panchrukhi block covering the following circles (Banuri, Rajpur, Sungal, Rajot, Bhuana, Chadiyar and Panchrukhi). Overall the products were well accepted by the beneficiaries (children and pregnant & lactating women) and regular consumption of products improved the body weight gain among the beneficiaries. Further, a survey on the nutritional habits of children and pregnant women were conducted during the course of supplementation. In addition to these, training and awareness programs were conducted on the importance of balanced diet, personal hygiene and role of micronutrients in maintaining the good health to the young mothers and pregnant and lactating women. Lastly, anganwadi workers, supervisors and ASHA workers of the respective anganwadi centres of Panchrukhi block were trained on the importance of micronutrients and balanced diet for further effective dissemination to the beneficiaries.

Fig. 4. POSHAN Maitree activities organized by CSIR-IHBT in association with Directorate of Women and Child Development, Govt. of Himachal Pradesh

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Plant Molecular Genetics and Genomics Lab

Our key research focuses on the development of molecular markers, genetic dissection and molecular breeding for important traits of high altitude plants.

Assessment of Genetic Diversity and Molecular Characterization of Rose Germplasm

Rose (*Rosa.*) is one of the most important ornamental crop worldwide with high economic, cultural and symbolic value. Due to its varying ploidy level (diploid; 2n= 2x= 14 to decaploid; 2n=8x=56), which makes this crop with potentially diverse, resistant to biotic and abiotic factors and enables it to survive in different habitats in the field. In the present study, we evaluated the genetic variation among forty-eight rose accession collected from the CSIR-IHBT using fifty-six polymorphic SSR markers. The phenotypic data was also taken to analyze the variation in prickles (Fig. 1) and data was also compared with the genotypic data (Fig. 2).

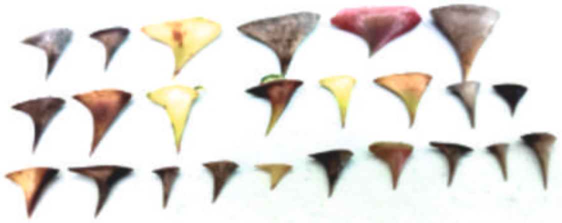

Fig. 1 Representative image showing the variation in prickles in rose germplasm.

The results showed that an effective number of alleles varied from 1.1406 to 1.9998, Nei's gene diversity varied from 0.1233 to 0.4999 with an average Shannon's index value of 0.5846. The PIC value of polymorphic markers was ranged from 0.1948 to 0.375 with an average value of 0.3471. Based on UPGMA (unweighted pair group method with arithmetic mean), a dendrogram was constructed and categorized all accession into two clusters. The principal coordinate analysis (PCoA) was also conducted to identify the less dissimilar accession which might be easy to know about the genetic relatedness of the accessions. The present study explained high genetic variation among rose germplasms meanwhile the accessions which are farther from each other show a high level of diversity, thus would be suitable as parents in breeding programs.

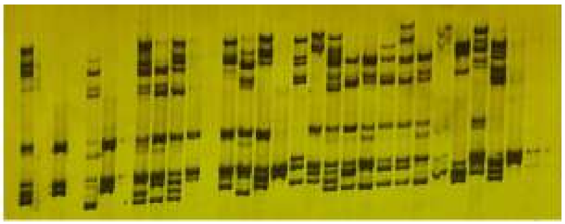

Fig. 2 PAGE gel image of SSR markers in rose genotype.

Identification and Comparative Analysis of MIPSs in Rosaceae and their Expression Under Abiotic Stress in Rose (*Rosa chinensis*)

The MIPS gene family is involved in myo-inositol synthesis and plays an important role in signal transduction, membrane biogenesis, oligosaccharide synthesis, auxin storage and transport, programmed cell death, and abiotic stress tolerance in plants. The MIPS genes in Rosaceae plant species were identified comprehensively in this work, with 51 MIPS genes found from 26 Rosaceae species. The MIPSs were classified into two clades based on phylogenetic study (clade I; subfamily Amygdaloideae specific and clade II; subfamily Rosoideae specific, Fig. 3).

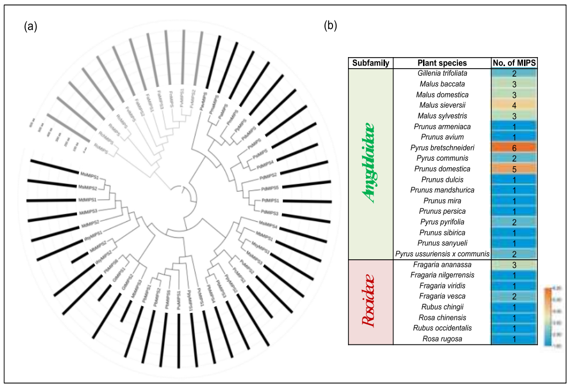

Fig. 3 Phylogenetic relationship among MIPSs belonging to the 26 Rosaceae plant species.

MIPS genes from all 26 Rosaceae species have identical gene structure, motif, and domain composition, indicating that they are conserved. The analysis of cis-regulatory elements (CREs) indicated that the majority of Rosaceae MIPS genes are involved in growth, development, and stress responses (Fig. 4). Furthermore, the qRT-PCR studies showed that drought stress upregulated RcMIPS gene expression. The current study's findings add to a better knowledge of the biological function of Rosaceae MIPS genes, which might be utilised in future functional validations.

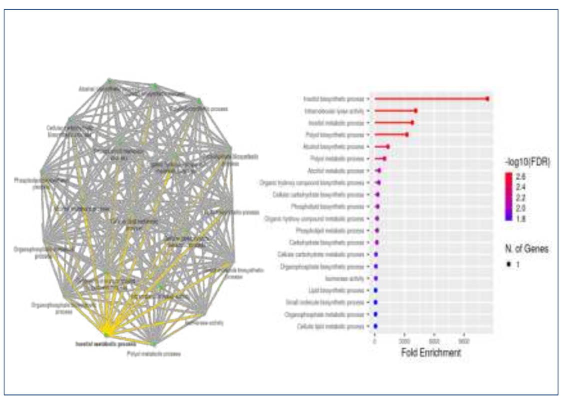

Fig. 4 GO analysis using ShinyGo identified enriched biological processes of *RcMIPS* gene.

Molecular Authentication of True Cinnamomum (*Cinnamomum verum*) through ISSR Markers

Cinnamomum, one of the most important flavouring agents in the food and beverage industry, has been recognized for its flavouring and medicinal properties. There are four main economically important species of cinnamon in the genus *Cinnamomum*. The first one is *Cinnamomum verum*, translation "true cinnamon". It is also called Sri Lankan or Ceylon cinnamon. The other three main species of cinnamon are *Cinnamomum cassia*, *Cinnamomum burmannii*, and *Cinnamomum loureiroi*. These three are classified as Cassia Cinnamon, due to similarities in color, shape, and coumarin content. *Cinnamomum cassia* has high levels (about 0.4-0.8%) of coumarin, it carries a risk of causing liver damage or failure in sensitive individuals, and among those who consume the Cassia cinnamon daily, or in large amounts that's why some European countries have banned the Cassia variety. *Cinnamomum verum* bark is frequently adulterated with a rougher, thicker, cheaper, and less aromatic bark of the morphologically similar *C. cassia*. Therefore it is necessary to discriminate between these two main types and to detect food adulteration. Our aim is to discriminate between two cinnamon varieties *Cinnamomum verum* and *Cinnamomum cassia* using ISSR (Inter-Simple Sequence Repeat) marker. We have analyzed total 72 different ISSR markers. Out of these, 8 ISSR markers have found to be discriminate between cassia and verum (Fig. 5).

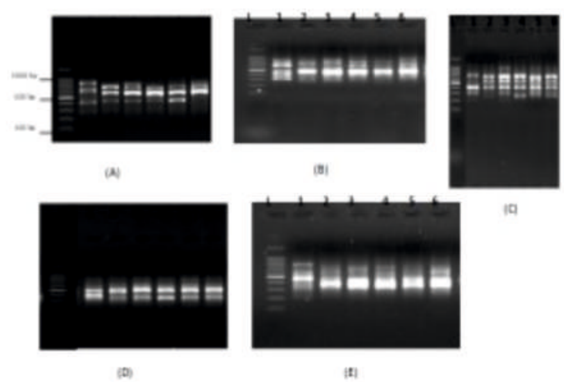

Fig. 5 Representative gel image showing profiling of ISSR marker in *Cinnamomum* spp.

Treatment of Saffron Corms with Different Methylating Agents

Saffron corms were treated with hypomethylating agents like Sulfamethazine, Zebularine, Decitabine, Ethionine, and 5-Azacytidine with discrete concentrations by both in vivo and in vitro approach (Fig. 6). Different doses of each chemical in triplicates were given to the uniform size saffron corms and, corms were dipped in the solution for 18h. A total of 1050 saffron corms were raised during crop season 2021-22. The treated corms along with untreated corms (control) were phenotypically evaluated in the open field (research farm, CSIR-IHBT, Palampur) and controlled conditions. We observed significant differences in days to germination, number of sprouts, leaf length, and flowering in chemically treated plants than control plants.

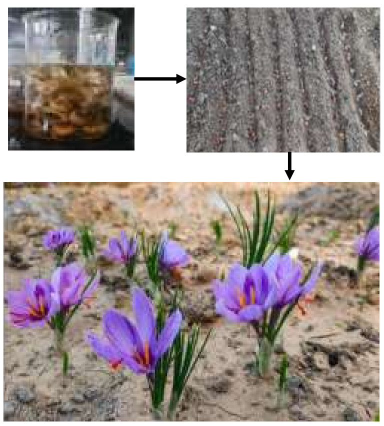

Fig. 6 Chemical treatment of saffron corms and raised population.

Determination of Ploidy Level and DNA Content in Saffron (*Crocus sativus*) assessed by flow cytometry

Saffron (*Crocus sativus* L.) is the most expensive spice in the world, known as “redgold”. It is a triploid (2n=3x=24, x=8) male sterile plant and thus propagated vegetatively. Polyploidization is one of the possibilities for the improvement of saffron crop. For this purpose, we treated corms with two anti-mitotic agents, colchicine and trifluralin. Colchicine and trifluralin both bind to tubulins and prevent the formation of microtubules or spindle fibers. This prevents chromosome segregation during mitosis and stop cell cycle at metaphase. Polyploid plants have vigorous growth, thicker and darker leaves, large leaf and flower size. Therefore, we notedleaf emergence, bud emergence, flower emergence, leaf length, leaf width, number of sprouts, number of leaves, number of stomata and senescence data. A representative image showing stomatal density is given in Fig. 7.

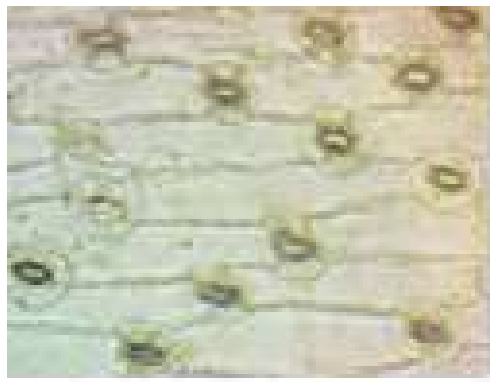

Fig. 7 Leaf epidermis of *Crocus sativus* showing stomatal density.

Flow cytometry was used to analyze DNA content. Compared to conventional chromosome counting flow cytometry is simple, accurate and less time-consuming. To estimate nuclear DNA content, the suspension of nuclei is stained with a DNA-specific fluorochrome. Flow cytometry results are obtained in the form of a histogram of relative fluorescence intensity (Fig. 8).

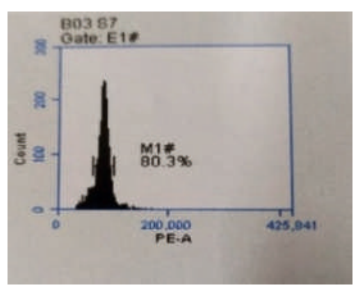

Fig. 8 Histogram of relative fluorescence intensity after analysis of nuclei isolated from *Crocus sativus*.

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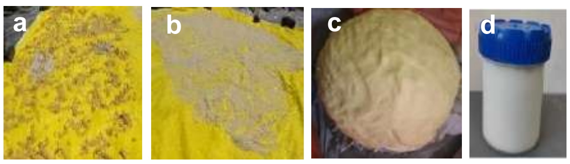
Fermentation Technology and Microbiology

My research group is working on the evaluation of diverse probiotic cultures obtained from different dairy and non-dairy based traditional fermented foods of cold desert of Western Himalaya for their therapeutic properties. Further, we are also working on extremophilic microbial enzymes acquired from cold desert regions of Western Indian Himalayan as the microbial enzymes have gained interest for their widespread uses in industries and medicine owing to their stability, catalytic activity, and ease of production and optimization than plant and animal enzymes.

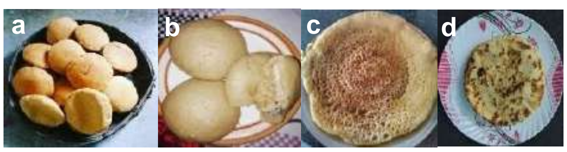
Production of dairy based functional food using dairy and non-dairy based traditional food products of cold desert of Western Himalaya

Due to their increased shelf-life, safety, sensory, functionality, and nutritional properties, the fermented foods and beverages are very popular globally. The fermented foods include the presence of bioactive molecules, vitamins, and other constituents with increased availability because of the fermentation process. Further, the ethnic fermented foods marketed in the Himalayan region are produced by an age-old indigenous process of natural fermentation. Most of the ethnic fermented foods of Indian Himalaya are yet to be scientifically investigated for controlled commercial production. The available knowledge is mostly about the microbial diversity in the marketed finished products of Eastern Himalaya, and limited information is available about the Western Himalayan fermented foods. Some ethnic fermented foods of Asia such as shoyu, miso, sake, natto of Japanese, tempe of Indonesia, kimchi of Korea had already been commercialised globally more than 40 years but India as such has not recognized its indigenous ethnic fermented food products yet. The global fermented food market size will grow by USD 58.15 billion during the period from 2018-2022 with a CAGR of 7 %. In many fermented foods, there are also live microorganisms that can enhance gastrointestinal health and provide other health benefits, including reducing the risk of type two diabetes and cardiovascular diseases. These live organisms are called probiotics, which have a beneficial impact on the host's health through enhancing the composition of intestinal microflora when consumed in appropriate quantities. Probiotics can play a beneficial role in several medical conditions, in addition to improving gut health, including lactose intolerance, cancer, allergies, hepatic disease, *Helicobacter pylori* infections, urinary tract infections, hyperlipidaemia, and cholesterol assimilation. The global probiotics market value is approximately USD 15 billion per year, and the probiotics industry is growing at a rate of 7% annually. Further, the milk and milk based products also contain probiotics. Therefore, keeping all these views, in continuation with previous work done, we have collected different dairy and non-dairy based traditional fermented foods (58 samples) from cold desert regions of Western Himalaya. The isolation and screening of the probiotic isolates from these foods was done using standard protocols. Till now, we have 300 microbial isolates and now, we are investigating the probiotic attributes of these isolates as described in the guidelines given by World Health Organisation (WHO, 2002). We are also investigating these food samples for their nutritional and micronutrient profiling i.e. carbohydrates, moisture, minerals, vitamins, proteins, fat contents, phenols and antioxidant assay etc.

Indigenous cow (zomo), yak (dimo) and goat (rama) respectively from cold deserts of Western Himalaya.



Sample of dairy products a) dried chhurpe, b) soft chhurpe, c) maar and d) labo, respectively from cold deserts of Western Himalaya.



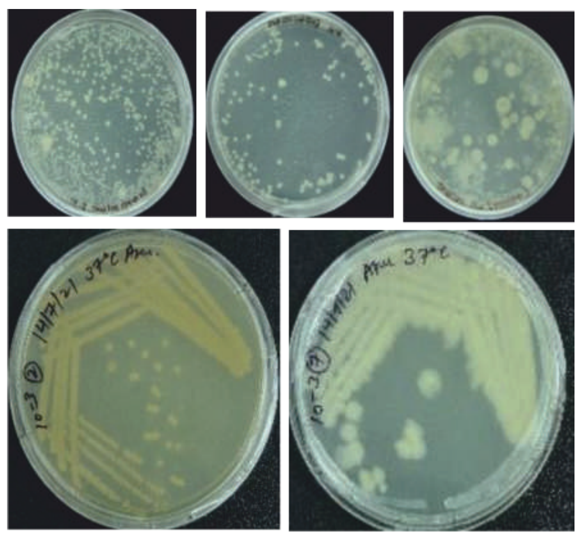
Non-dairy based traditional Fermented foods a) marchu, b) siddu c) Chilra and d) bhatooru from cold desert of Western Himalaya.

Plates showing the microbial growth after enrichment of the collected dairy and non-dairy based traditional fermented food samples on the MRS media.

Medium engineering for the production of thermostable cellulase free xylanase and pectinase from Himalayan microbial sources

The commercially important industrial groups of enzymes, members of which demonstrate various xylanolytic and pectinolytic enzymatic activities, are xylanase and pectinase. These enzyme groups have tremendous commercial potential because their biotechnological applications cover a wide range of industries, such as biofuels, pulp-paper, food, animal feed, textiles, fabrics, etc. Of these, biofuel industries need these xylanolytic and pectinolytic enzymes to play their complementary role to the core cellulase enzymes in improving plant biomass saccharification. In the animal feed industry, however, the combination of cellulase, xylanase and/or pectinase is needed to improve the nutritional quality of grain and feed. Conversely, the cellulase-free xylanase and pectinase enzymes are needed by the pulp and paper and textile industries for their respective applications, i.e. to prepare hemicellulose-free cellulose papers, to remove pectin coating from cotton and denim fibres, xylanase and pectinase enzymes are also required by the food and beverage industries to clarify the pectin polymer fraction from fruit juices and to enhance the tea flavour. These applications add value to the organisms that can produce the enzymes xylanase and pectinase, and the cellulase-free nature of these enzymes is an added benefit. In addition, the global market value of these enzymes is growing rapidly in different sectors, and most of these enzymes are imported from other countries, hence, production of these enzymes will play a very significant role in the country's economy. Further, for their various potential industrial applications, there is therefore a need to provide a method for the production of thermostable cellulase free xylanase and pectinase. Keeping in view these factors and to attempt to solve the problem, we have collected 59 different water and soil samples from different areas of cold desert regions of Western Himalayan of India. The isolation of the microbes was done by serial dilution method and enrichment was done using nutrient broth and nutrient agar media at 37°C and 50°C as we are focussing on thermophilic or extremophilc enzymes. Till now, we have isolated 355 different microbial isolates. Then these isolates were qualitatively screened for xylanase and pectinase enzymes on the nutrient agar plates containing pectin/xylan (2% w/v) at 37°C and 50°C. After colonization, the plates were flooded with iodine-potassium iodide solution (1 g iodine, 5 g KI for 330 mL distilled water) and incubated at room temperature for 15 min. The qualitative estimation of xylanase production was performed by Congo red staining. Following incubation, the plates were investigated for the determination of pectin and xylan hydrolysis zones. Out of 355 isolates, we found that 181 isolates showed hydrolysing zones for pectin and 61 isolates showed hydrolysing zones for xylan. Further, 20 isolates showed hydrolysing zones for both the substrates. All the isolates were maintained on nutrient agar slants at 4 °C and were preserved in glycerol stocks (20%) at -20°C for future use. Sub culturing is also done periodically.

Exploration of water and soil sample from different hot springs and nearby sites of cold deserts from Indian Western Himalaya.



Screening of microbial isolates for xylanase and pectinase enzymes on nutrient agar plates

Microbial isolates with xylanase hydrolysis zone formation

Microbial isolates with pectinase hydrolysis zone formation

Research group: Kumari Shanu, Kumari Anu, Ms. Shalini Kumari, Mr. Sahdev Choudhary

CHEMICAL TECHNOLOGY DIVISION

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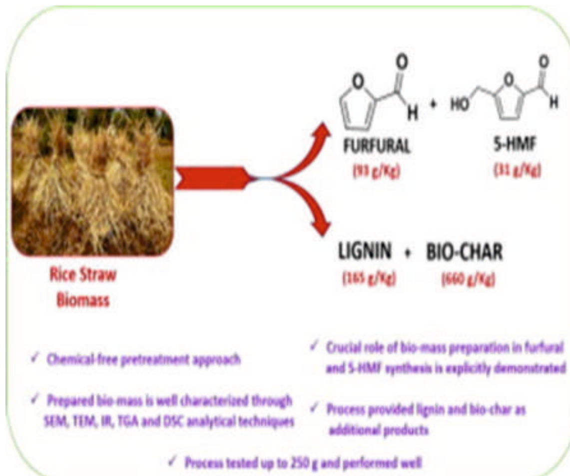
Synthetic Organic Chemistry and Process Development

Our research group has been constantly engaged in the development of various modern and challenging organic transformations through catalysis and reagent chemistry. Among these, development and chracterization of metal nano-particles as heterogeneous catalyst and their applications in carbon monoxide fixation, semi-hydrogenation reaction, aryl benzamides and benzimidazoles synthesis have been achieved in this year.

Lignocellulosic bio-waste utilization: Lab scale process for commercially important 5-hydroxymethylfurfural (5-HMF) and furfuraldehyde has been developed from rice-straw, sugarcane bagasse, corn-cob and other carbohydrates. The developed process was patented, published, and further scaled-up progress is still underway for future technology development.

Rice straw (*Oryza sativa L.*) biomass conversion to furfural, 5-hydroxymethylfurfural, lignin and bio-char: A comprehensive solution

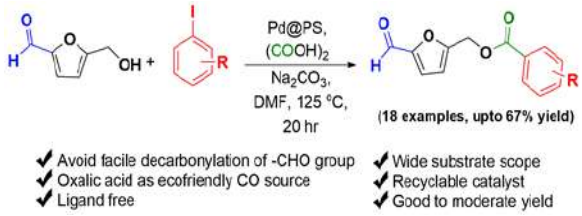
A sustainable, easy to operate, scalable, and chemically pre-treatments free method has been explored for rice straw (RS) biomass conversion to furfural, (5-HMF) lignin and bio-char production. Initially, the RS was dipped into liquid nitrogen in a thermos flask and grinded easily to fine powder, which reduces the volume of biomass and enhances the surface area of RS biomass. The prepared RS biomass was further analysed by SEM, TEM, IR, TGA and DSC, and then validated by its fruitful conversion to furfural, 5-HMF, lignin and bio-char synthesis in satisfied yields. The developed acidic process was performed at 130 °C for 6 hrs under a closed reaction system in reflux conditions to afford furfural and 5-HMF in >90% UPLC purity. Moreover, the method was also examined in 250-gram scale and found to perform well.



Rice straw biomass conversion to furfural, 5-HMF, lignin and bio-char.

Pd-catalysed decarbonylation free approach to carbonylative esterification of 5-HMF to its aryl esters synthesis using aryl halides and oxalic acid as C1source

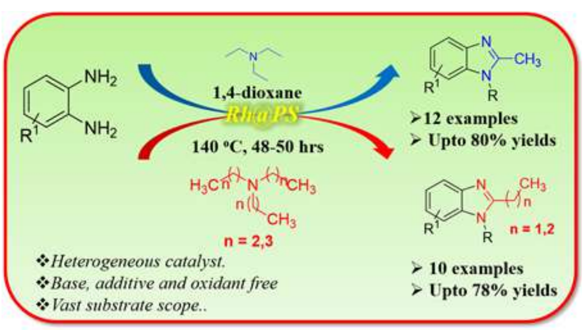
A decarbonylation free, polystyrene-supported, Pd@PS catalysed carbonylative esterification of the hydroxy group of (5-HMF) to its corresponding aryl esters has been developed. The use of Pd@PS, oxalic acid as CO source, and aryl halides was first time explored for the aryl ester of 5-HMF synthesis. Here, we investigated the vital role of a polystyrene support to avoid the commonly known decarbonylation of 5-HMF. The reaction exhibits vast substrate scope with comparably good yield and catalyst recyclability.



Pd-catalyzed decarbonylation free approach for carbonylative esterification of 5-HMF to its aryl esters.

Rhodium catalyzed 2-alkyl-benzimidazoles synthesis from benzene-1,2-diamines and tertiary alkylamines as alkylating agents

First time polystyrene supported rhodium (Rh@PS) catalyst was explored for substituted 2-alkyl-benzimidazoles synthesis from benzene-1,2-diamine and tertiary amines as alkylating agent. The reaction mechanism involved the oxidation of alkylamines and transamination followed by oxidative cyclization with benzene-1,2-diamines for targeted products synthesis in good yields. The additional advantages of present methodology included vast substrate scope, several functional groups tolerance, and recyclability of Rh@PS catalyst up to four cycles without significant loss in catalytic activity.



Rh@PS catalyzed synthesis of substituted benzimidazole.

Supported-Pd catalyzed tandem approach for N-arylbenzamides synthesis

A single step tandem approach for the N-aryl benzamides synthesis has been developed through bifunctional transformation of aryl iodides with *in situ* from $(CO_2H)_2NaN_3$ two different pathways of carbonylation and azidation. The polystyrene supported palladium (Pd@PS) catalyst was found to be well compatible to perform the domino-reaction in a double layer vial (DLV) system under base, ligand and additive-free conditions. Moreover, the same approach was further extended with aryl azides for unsymmetric N-aryl benzamides synthesis. Furthermore, the DFT studies were also performed to support the proposed mechanism.

Pd catalyzed tandem approach for N-arylbenzamides synthesis.

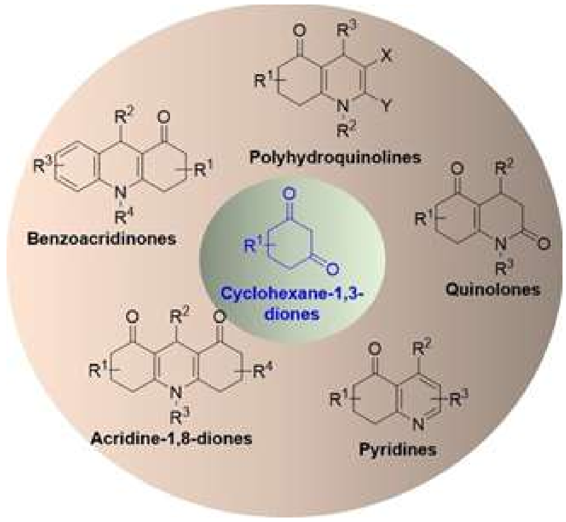
Polystyrene stabilized iridium nanoparticles catalyzed chemo- and regio-selective semi-hydrogenation of nitroarenes to N-arylhydroxylamines

Polystyrene stabilized Iridium nanoparticles (NPs) as a heterogeneous catalyst have been developed and characterized by IR, UV–Vis, SEM, TEM, EDX and XRD studies. The prepared catalyst showed excellent reactivity for chemo- and regio-selective controlled-hydrogenation of functionalized nitroarenes to corresponding N-arylhydroxylamine using hydrazine hydrate as reducing source and environmentally benign polyethylene glycol (PEG-400) as green solvent. The reaction performed at 85 °C or ambient temperature and completed within 5–80 minutes. The developed methodology performed well with variety of substrates. The catalyst can easily be filtered out from reaction mixture and reused.

Ir@PS catalyzed semi hydrogenation of nitroarenes to N-arylhydroxylamines.

Application of cyclohexane-1,3-diones for six-membered nitrogen-containing heterocycles synthesis

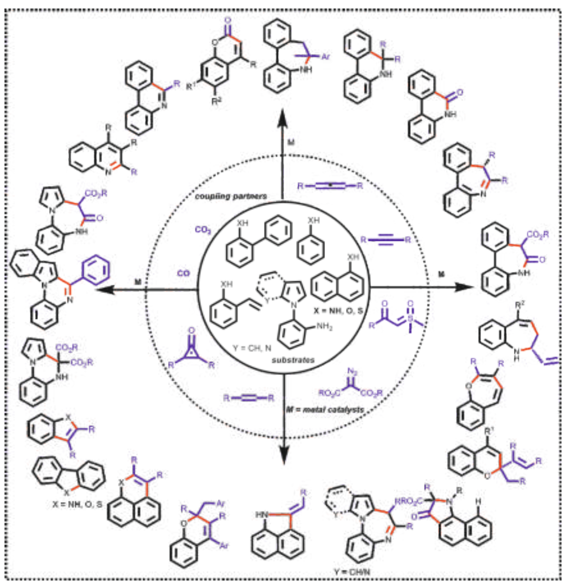
Cyclohexane-1,3-dione and its derivatives are imperative precursors in synthetic organic chemistry as they are useful intermediates for biologically active natural products, heterocycles and pharmaceuticals. Recently, cyclohexane-1,3-diones have been utilized for six-membered nitrogen-containing heterocycles synthesis in the presence of various aldehydes, acetoacetic esters, malononitrile, chalcones, coumarins, acetophenones, amino acids, amines etc. under catalytic and non-catalytic conditions. This article mainly covered the synthetic pathways for six-membered *N*-heterocycles *i.e.* 1,4-dihydropyridine, acridine-1,8-diones, benzoacridinones, quinolones and pyridine derivatives from cyclohexane-1,3-diones.



Cyclohexane-1,3-diones as precursor for six-membered N-containing heterocycles.

Free amine, hydroxyl and sulfhydryl directed C-H functionalization and annulation: Application to heterocycle synthesis

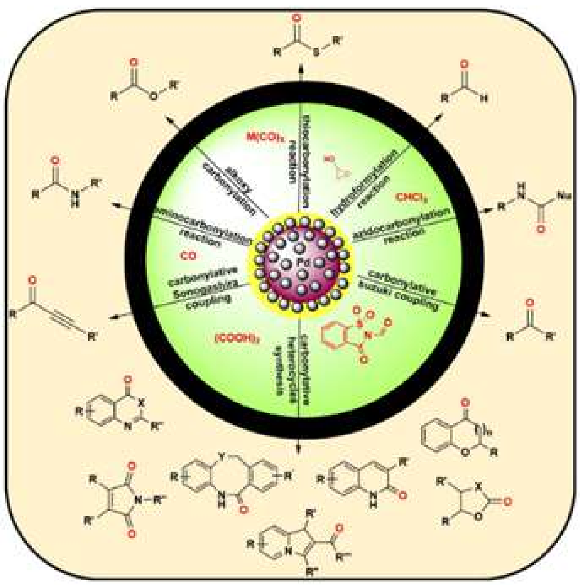
Transition metal-catalyzed direct C-H bond functionalization is recognized as an efficient strategy to assemble heterocyclic frameworks. For this purpose, directing groups (DGs) installation on an organic molecule has remained a widely exploited strategy for the years. The installation of directing groups, especially for the amine, alcohol and thiol containing reactants, and their removal after the reaction need additional steps. In this regard, the use of free amine, hydroxyl and sulfhydryl as directing groups in native form is advantageous and in recent times, these transformations have stirred undisputable advancements for applications to heterocycle synthesis. In this review, the aromatic sp^2-C attached free amine, hydroxyl and sulfhydryl as native functionalities are shown to be useful for the construction of five to seven-membered *N*-,*O*- and *S*-heterocycles.



Heterocycles synthesis.

Supported palladium catalyzed carbonylative coupling reactions using carbon monoxide as C1 source

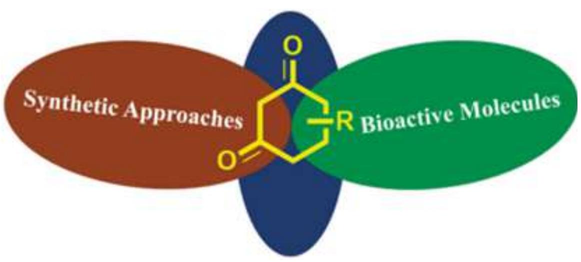
The supported palladium catalyzed carbonylative coupling reactions are very popular reactions for the synthesis of bioactive molecules, pharmaceuticals, intermediates and fine chemicals. Due to cost effectiveness and easy handling of recyclable supported palladium catalyst, it became more popular among researchers either working in academic institute or industry. In recent years, several advancements have been done through surface selection, designing and condition improvement to achieve high yield in the area of carbonylative coupling reactions. We have summarized the last 20 years reports in the field of CO insertion reactions using diverse range of supported palladium catalysts under carbon monoxide or its sources as C1 source.



Supported palladium catalyzed carbonylative coupling reactions using CO as C1 surrogate.

Synthetic approaches for cyclohexane-1,3-diones as precursor for bioactive molecules

Cyclohexane-1,3-dione derivatives are considered as a key structural precursor for the synthesis of plethora of synthetically significant compounds such as 4*H*-chromenones, 2*H*-xanthenones, coumarins, enaminones, acridinedione, 1,4-dihydropyridine, different other heterocycles, and natural products. These compounds show diverse range of biological activities that include herbicidal, pesticidal, anti-bacterial, anti-inflammatory, anti-tumor, analgesic, anti-convulsant, anti-viral, anti-plasmodial, anti-malarial, anti-allergic, anti-cancer etc. Keeping the importance of cyclohexane-1,3-dione derivatives in our view, we inspired to do a compilation of their synthetic methods from different precursors, which are mainly published in last two decades.



Synthetic routes for cyclohexane-1,3-diones synthesis as bioactive molecules.

Research group: Pushkar Mehara, Sheetal, Poonam Sharma, Yamini, Shaifali, Arvind Singh Chauhan, Ajay Kumar, Ajay Kumar Sharma, Rohit Bains, Ashish Kumar

Vijay Kant Agnihotri, Principal Scientist
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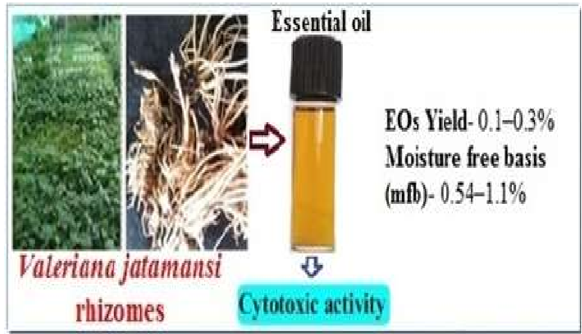
Natural Products Chemistry and Bio-prospection

Research Interests: Present focus of my lab is on isolation and characterization of components/ novel molecules from aromatic and medicinal crops. Development of value added products using natural products. Moreover, laboratory is also working on techno-economic assessment for improvement of recovery and value addition on isolated molecules. In addition our group is also working on metabolic profiling of primary and secondary metabolites using modern analytical techniques.

Comparative studies of essential oils composition and cytotoxic activity of *Valeriana jatamansi* Jones

The aim of this study was to investigate comparative essential oils (EOs) composition and cytotoxic activity of *Valeriana jatamansi* Jones, from wild growing samples at higher altitude and cultivated sample at lower altitude. Hydrodistilled EOs from the rhizomes of this herb were analyzed using Gas Chromatography with Flame Ionization Detector (GC-FID), Gas Chromatography/ Mass Spectrometry (GC/MS), and Nuclear Magnetic Resonance (^{13}C NMR). Thirty-six diverse metabolites were characterized in EOs samples accounting 68.5-88.2% of the total oils. The extracted EOs were found to be enriched in patchouli alcohol (7.6-70.5%), β-bisabolol (17.2-21.4%), maaliol (0.3-28.1%) and α-bulnesene (1.4-8.5%). The obtained EOs were further evaluated for cytotoxic activity against human lung carcinoma (A549) and human skin carcinoma (A431) cancer cells. Isolated component (patchouli alcohol) and extracted oils were represented good to moderate cytotoxic activity.



Essential oil composition and cytotoxic activity of *Valeriana jatamansi*.

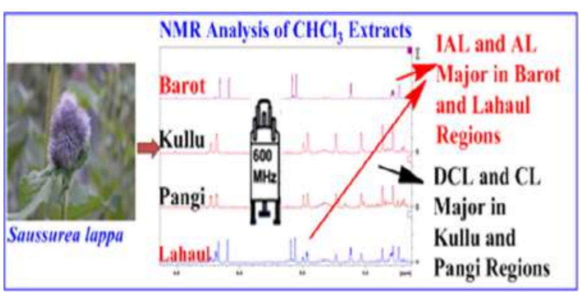
Comparative chemical profiling of *Zanthoxylum armatum* DC. from western Himalayan region

The objective of this work was to evaluate chemical composition of (EOs) extracted by hydrodistillation from different parts of the *Zanthoxylum armatum* (DC.) i.e. leaves, aerial part (a bunch containing unriped fruits along with leaves), unripe and ripe fruits. The EOs metabolites were analyzed using GC/GC-MS (Gas Chromatography/ Gas Chromatography Mass Spectrometry) and NMR (Nuclear Magnetic Resonance). Highest yield was observed in ripe and unripe fruits (1.5% and 1.3%, respectively). Twenty seven different metabolites were characterized in all samples, representing (82.3-96.6%) of the total oils. Extracted EOs were dominated by monoterpenes (26.6-83.0%) and oxygenated (12.5-55.1%) monoterpene hydrocarbons with β-phellandrene (5.3-40.6%), sabinene (0.4-18.5%), β-myrcene (3.8-8.6%), limonene (5.5-12.5%), linalool (0.1-32.4%), terpinen-4-ol (3.0-12.9%), 1,8-cineole (0-11.6%), undecan-2-one (9.8-15.2%) and *cis*-sabinene hydrate (1.8-6.9%).

Essential oils from plant organs *of Zanthoxylum armatum* DC.

NMR based profiling of sesquiterpene lactones in *Saussurea lappa* roots collected from different location of Western Himalaya

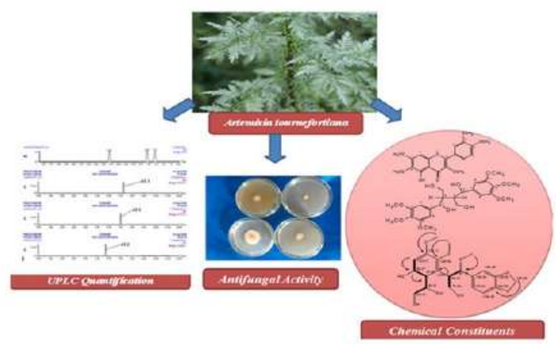
Saussurea lappa (Decne.) Sch.Bip is a well known herbal medicine has been extensively used for many therapeutic purposes. We have accomplished targeted profiling of *S. lappa* roots samples collected from different locations (Pangi, Lahaul, Barot and Kullu) of the western Himalayan region using NMR. This study allowed us to assigned four major sesquiterpenes of this plant, including costunolide (CL), dehydrocostus lactone (DCL), alantolactone (AL), isoalantolactone (IAL). Quantification of sesquiterpene lactones have also been accomplished using ^{1}HNMR, and a wide diversity in the concentration of these active metabolites was observed. It has been observed that AL and IAL were major in the samples collected from Lahaul and Barot regions, and CL and DCL were major in the samples collected from Kullu and Pangi regions.



NMR based profiling of sesquiterpene lactones in *Saussurea lappa* roots.

Isolation, characterisation, antifungal activity and validated UPLC/MS/MS method for novel compound from *Artemisia tournefortiana*

Investigation into the chemical diversity of *Artemisia tournefortiana* resulted in isolation of one novel compound named tournefort in A and two known artemet in and tournefort in B bioactive compounds. Tournefort in B is first time obtained from natural source. The structure of all the isolated compounds were elucidated by detailed 1D and 2D NMR including HSQC, HMBC, ^{1}H-^{1}H COSY and NOESY spectroscopic techniques. Minimum inhibitory concentration (MIC) of all the compounds tested against fungal strains found between 0.4 and 6.4 mg/mL and lowest MIC of 0.4 mg/mL of compound tournefortin A was found against *Alternaria alternate*. All the isolated compounds were quantified through UPLC/MS/MS and the developed method will serve as a first fingerprint method for the rapid determination of these phytomolecules in various plant extracts. Tournefortin B was found to be present in higher concentration.

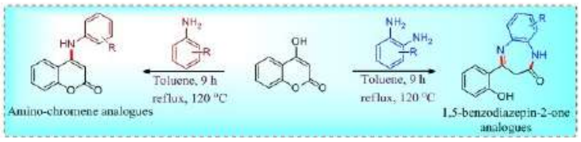


Isolation and characterization molecules from *Artemisia tournefortiana.*

Selective and Efficient Synthesis of 1,5-benzodiazepin-2-one and Amino Chromenes as Biologically Versatile Scaffolds

A convenient methodology has been disclosed for the synthesis of 1,5-benzodiazepin-2-one and amino chromene-

2-one analogues. The synthesized compounds act as biologically potent compared to 4-hydroxycoumarins. The reaction was carried out using 4-hydroxy coumarin and aniline derivatives containing both electron donating and electron withdrawing groups in toluene under reflux at 120°C. A library of compounds has been synthesized using different derivatives of aniline. The product formation has been achieved at stipulated time of 6 hours. The required compounds were obtained using column chromatographic technique and were characterized by ^{1}H-NMR, ^{13}C-NMR and mass spectrometry. The products were obtained in high yield with good anticancer activity and significant antibacterial effects. Out of the synthesised derivatives, compound- **2a, 2b, 4b, 4e, 4g, 4k** displayed selective and potent cytotoxic effects against different cell lines as compared to that of parent compound. Among all the compounds, **4g** and **4f** were found to be highly active in inhibiting bacterial growth to the significant extent.



Synthesis of 1,5-benzodiazepin-2-one and amino chromenes.

Research group: Ram Chander, Antim Kumar Maurya

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Synthetic Organic & Medicinal Chemistry, Chemical Biology

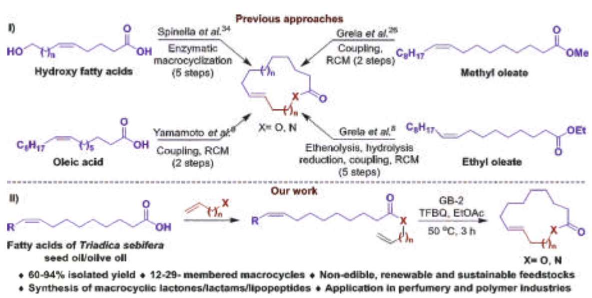
Our group is involved in the synthesis of bioactive natural products, their analogues and small molecule compound library. We are also working on the development of novel catalytic methods for chemical transformation.

Recyclable heterogeneous catalyst for the sustainable synthesis of (di)carboxylic acids from olefins

The development of green and sustainable processes for the synthesis of active pharmaceutical ingredients (APIs) and key starting materials (KSMs) is a priority for the pharmaceutical industry. We have developed a heterogeneous vanadium catalyzed green and sustainable methodology for the oxidative cleavage of olefins utilizing 70% aq. TBHP as an oxidant under the solvent-free condition for the synthesis of (di) carboxylic acids including an industrially important azelaic acid from various renewable vegetable oils. Various (substituted)styrenes were well tolerated and furnished the desired carboxylic acid. Notably, the catalyst could be recycled up to 5 cycles without significant loss in yield.

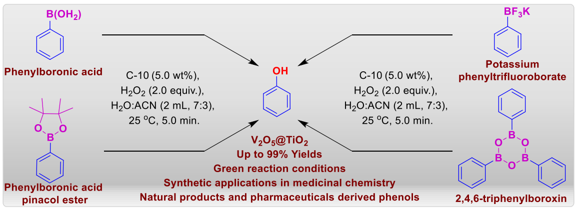
Azelaic acid, an aliphatic dicarboxylic acid, is an important building block for polymers, biodegradable lubricants, perfumery, cosmetics, and an active pharmaceutical ingredient used to treat acne. Several methods have been reported to synthesize azelaic acid utilizing various precursors. The current industrial method for synthesizing azelaic acid mainly utilizes oleic acid as a key starting material *via* Ozonolysis. However, very few reports utilize vegetable oils containing a predominant mixture of unsaturated fatty acids to synthesize azelaic acid. We recently reported a heterogeneous VO@TiO$_2$ catalyzed additive-free green protocol for the oxidative cleavage of *Triadica sebifera* seed oil and other oils for the sustainable synthesis of azelaic acid (*Chem. Commun.* **2021**, *57*, 5430. DOI: 10.1039/D1CC01742J). The work is **"Featured in Org. Chem. Highlights: Oxidation"** alongside reputed international journals (https://www.organic-chemistry.org/Highlights/2022/21March.shtm) and highlighted in synfacts 2021, 17 (09) 1030.

A Sustainable Approach for the Synthesis of Macrocyclic Lactones, Lactams and Cyclolipopeptides from Biomass



A sustainable, straightforward, and eco-friendly approach to synthesize high-valued macrocyclic lactones and lactams utilizing non-edible vegetable oil extracted from renewable *Triadica sebifera* seeds under greener reaction conditions. The strategy allows the conversion of biomass into valuable 12-29 membered macrolactones, macrolactams, and therapeutically important macrocyclolipopeptides.

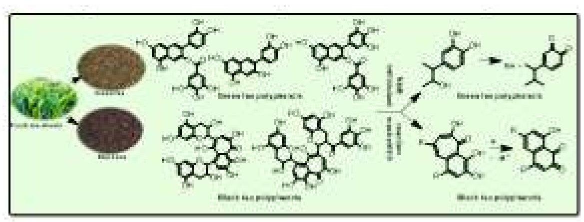
Highly efficient heterogeneous $V_2O_5@TiO_2$ catalyzed the rapid transformation of boronic acids to phenols



A $V_2O_5@TiO_2$ catalyzed green and efficient protocol for the hydroxylation of boronic acid into phenol has been developed utilizing environmentally benign oxidant hydrogen peroxide. A wide range of electron-donating and electron-withdrawing groups containing hetero(aryl) boronic acid were transformed into their corresponding phenols. The methodology was also applied to successfully transform various natural and bioactive molecules like tocopherol, amino acids, cinchonidine, vasicinone, menthol, and pharmaceuticals such as ciprofloxacin, ibuprofen, and paracetamol. Gram scale synthetic applicability, recyclability, and short reaction time are other important features of this developed protocol. This work was highlighted in a *Synfacts* **2021**, 17(12), 1376, 17.11.2021.

Mechanistic studies on polyphenol rich fractions of Kangra tea by HPTLC and NMR for their antioxidant activities

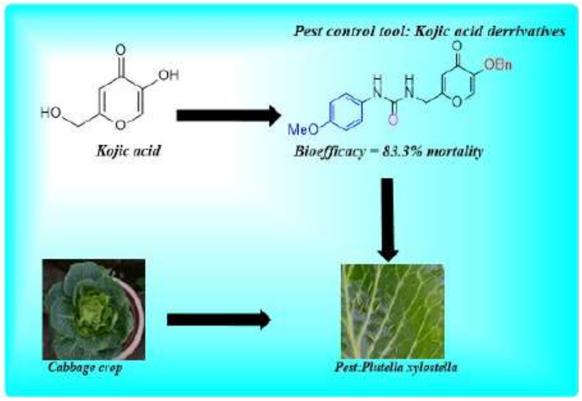
Tea (*Camellia sinensis* (*L.*) O. Kuntze) is a non-alcoholic beverage worldwide consumed widely throughout the globe. Tea contains many molecules such as polyphenols, alkaloids, volatile components, polysaccharides, amino acids, lipids and vitamins. Polyphenols are the major bioactive compounds in tea and are considered better antioxidants than vitamins E and C. The polyphenols present in tea shoots show antioxidant, anti-viral and anti-carcinogenic activities. Polyphenols are well known for free radical scavenging activity. Tea shoots contain different types of teas such as green tea (GT), black tea (BT), oolong tea and white tea; among them, green tea and black tea are the most widely consumed teas. Green tea contains catechin (C), epicatechin (EC), epigallocatechin (EGC), epicatechin gallate (ECG), epigallocatechin gallate (EGCG), while black tea contains theaflavin (TF), theaflavin-3-gallate (TFG3), theaflavin-3'-gallate (TFG3') and theaflavin-3,3'-digallate (TFDG). These teas and their chemical constituents are well-known antioxidants estimated by radical scavenging models such as DPPH, ABTS and FRAP assay. The antioxidant activity in tea is mainly due to polyphenolic compounds. However, the antioxidant reaction mechanism and the compounds involved are not well characterized. We have reported the antioxidant reaction mechanism of green tea and black tea and their polyphenolic fractions with free radical using different analytical techniques and their qualitative and quantitative analysis.



This study found that green tea polyphenols (GTP) showed the highest polyphenol content, whereas BT contains the least. The highest flavonoid content was observed in GT followed by BT whereas the lowest content was observed in black tea polyphenols (BTP). A total of eight catechins *viz,* C, EC, EGC, ECG, EGCG, GC, CG and GCG were identified in tea which contributes to the antioxidant potential and organoleptic properties with broad applications in the food industry. These catechins significantly impacted the taste of tea infusion compared to EGC, EC and C. Catechins enriched fraction was separated into five different catechins *viz* C, EGCG, ECG, EGC and EC. Antioxidant activity–mainly depends on a number of the hydroxyl group in the catechins and theaflavins. The number of hydroxyl groups is directly proportional to the antioxidant activity. The ^{13}C NMR analysis indicates the transformation of the hydroxyl group to the carbonyl group in all the catechins. The study suggests that the B-ring is involved in antioxidant activities. The signal formation for carbonyl group (C=O) was observed after the reaction with DPPH. The other signals of the molecules remain unchanged and seem to be intact. Black tea mainly contains theaflavins such as TF, TFG3, TFG3' and TFDG. The appearance of new signals corresponding to the carbonyl group after the reaction showed that the benzotropolone moiety of theaflavins plays a vital role in antioxidant activity.

The study revealed the radical scavenging mechanism associated with the antioxidant profile of different teas, *i.e.* GTP and BTP. In GT and GTP, we observed that B-ring is the principal site for oxidation with free radical, rather than the 3 galloyl moiety, which plays a crucial role in the antioxidant reactivity, which involves the transformation of a hydroxyl group to the carbonyl group. In BT and BTP, the seven-membered benzotropolone ring is converted to a six-membered ring. Although reaction with free radicals certainly is among the most probable antioxidant reactions of polyphenolic compounds in biological systems, reactions with other oxidants may also occur. Overall, our study provides the antioxidant reaction mechanism in teas and proposes a similar mechanism in the living system.

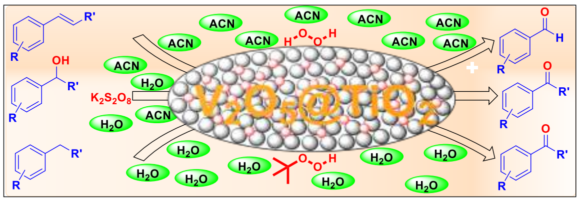
Synthesis and screening of Kojic acid derivatives for their bio-efficacy against diamondback moth (Plutella xylostella L.)



In the quest for novel insecticidal molecules, a library of 32 derivatives of kojic acid has been synthesized. The synthesized molecules contain urea and thiourea linkage was tested against second instar larvae of diamondback moth (*Plutella xylostella*) under laboratory conditions. Most of the compounds showed = 50 % mortality against second instar larvae of *P. xylostella*. The one compound was found more effective against *P. xylostella* (83.3% mortality at 10000 ppm) after 96 h of treatment. Two compounds showed significant 80% mortality at 10000 ppm and whereas three compounds showed 76.6% mortality at 10000 ppm. The compound bearing *p*-methoxy group on the aromatic ring-containing urea linkage is the most promising among the library. The results demonstrated that the synthesized compounds could be candidates for further development to obtain a lead molecule.

V_2O_5@TiO_2 catalyzed green and selective oxidation of alcohols, alkylbenzenes and styrenes to carbonyls

The versatile application of different functional groups such as alcohols (1° and 2°), alkyl arenes, and (aryl)olefins to construct carbon-oxygen bond via oxidation is an area of intense research. Have, we developed a reusable heterogeneous



V_2O_5@TiO_2 catalyzed selective oxidation of various functionalities utilizing different mild and eco-compatible oxidants under greener reaction conditions. The method was also successfully applied for the alcohol oxidation, oxidative scission of styrenes, and benzylic C-H oxidation to their corresponding aldehyde and ketones. The utilization of mild and eco-friendly oxidizing reagents such as $K_2S_2O_8$, H_2O_2 (30% aq.), TBHP (70% aq.), broad substrate scope, gram-scale synthesis, and catalyst recyclability are notable features of the developed protocol.

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Chemical Technology

Design, fabrication and setting up of distillation units and catalyzing setting up of farmer's cooperatives for marketing of the produce (Mission Aroma phase-II)
Essential oils are the main economic ingredient of the aromatic crops which are extracted by means of distillation. To enable farmers to distill the oil from their crop five multipurpose essential oil distillation units were designed, fabricated, installed commissioned to various registered societies (Fig. 1).

Fig. 1 Installation and commissioning of different capacities distillation units at farmers' sites under Aroma Mission.

Processing of Damask rose flowers on pilot plant: Fresh Damask rose flowers were processed on pilot plant and produced 800 liters of rose water during the season for sale and as well as complimentary samples.

An efficient process for extraction of volatile compounds from *Valeriana jatamansi*: A patent is filed with Indian patent office in which the invention discloses a process for extraction of oil from the *Valeriana jatamansi* Jones by supercritical fluid extraction (SFE) process with non-polar solvent and polar solvent as co-solvent. 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. Later the same material has been extracted with polar solvent (alcoholic series of C1 & C2) as the co-solvent. The qualitative comparison of essential oil has been done between the essential oil obtained from 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
Catechins have 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.

Process Optimization for purification of catechins at industrial scale i.e. 500 kg batch fresh tea leaves: Design, Technical consultancy for procurement, installation of process equipments such as Adsorption column, Reverse Osmosis Water system, purification column, Sparkler type filter press, Spray dryer was given to M/s Baijnath

Pharmaceutical Pvt. Ltd., Paprola as shown in Fig. 2a & 2b.

Fig. 2 Design and Installation of a) Stainless steel adsorption column & b) Spray dryer at Company site.

Design and installation of process equipment at chemical technology lab pilot plant of the CSIR-IHBT Palampur

Design, procurement, installation & commissioning of sanctioned process equipment namely Separation Column along with accessories and Solvent recovery system along with accessories was done.

Fig. 3 Installation and commissioning of DBT-BIRAC funded Solvent recovery system.

Fig. 4 Installation & commissioning of DBT-BIRAC funded Separation columns.

Processing of green tea leaves on DBT BIRAC funded equipment's: A 50 kg batches of fresh tea leaves were processed on the installed facility at CSIR-IHBT Palampur. The batch was processed using the DBT BIRC funded equipment's namely Separation columns and Solvent recovery unit. The finished product yield obtained was 2.6% (w/w on fresh basis). The total purity of total catechins was 61%.

Fig. 5 Processing of green tea leaves @ 50 kg scale for catechin using DBT- BIRAC funded equipment's at CSIR-IHBT Pilot plant.

Process upscaling for color extraction from red cabbage and herbal gulal formulation on pilot scale: The lab scale process for extraction of anthocyanin coloring compound was up scaled at pilot scale. Various process parameters were optimized at pilot scale. Further, eco-friendly herbal gulal based formulation around 6.650 kg pink colour and 12.700 kg yellow colour was developed on pilot scale (Fig. 6 & 7).

Fig. 6 Herbal Gulal formulation produced on pilot plant.

Fig. 7 Upscaling of process for extraction coloring compound at pilot scale.

Formulation of stevia liquid drops and powder

A green process is developed for direct processing of dry stevia leaves into formulated liquid drops. MoUs were signed with following parties for production of Stevia liquid & powder at Chemical Technology Division Pilot Plant.

- M/s USAS, Palampur
- M/s Agri Natural India, Ludhiana
- M/s Relsus India Pvt. Ltd., Gurugram

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Catalysis for C-H Activation, Natural Product Chemistry, Medicinal Chemistry

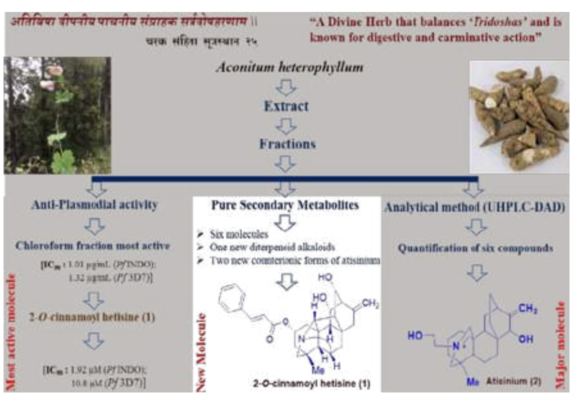
Our group is involved in the development of catalytic method for the synthesis of bioactive quinolines. This year, five novel catalytic methods have been developed for the synthesis of >160 new quinolines derivatives *via* innovative C-H activation/functionalization strategy.

In natural product chemistry, our group is involved in phytochemical investigation of medicinal plants. This year phytochemical investigation of *Aconitum heterophyllum, Cissampelos pareira* and *Trillium govanianum* led to the isolation of five molecules including a new alkaloid. Further ultra-performance liquid chromatography-diode array detection methods were developed and applied for the quantification of active constituents and quality assessment of these plants. Biological assessment of extract, fractions and pure molecules isolated from these three plants has also been carried out.

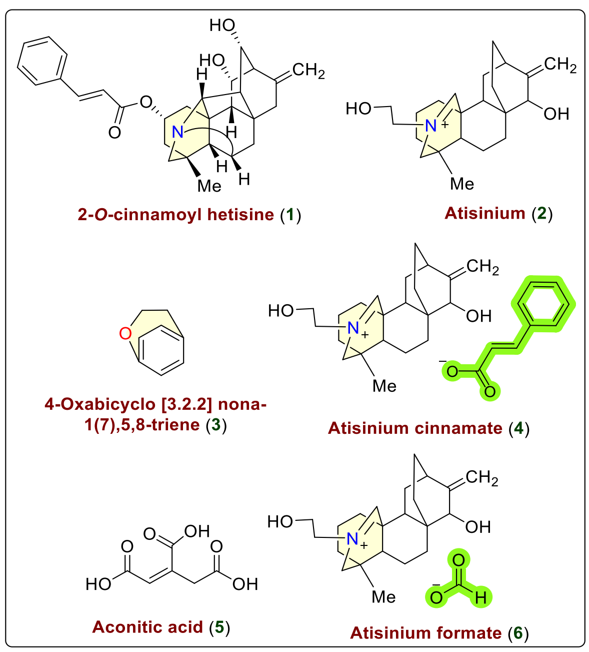
Phytochemical Investigation

Aconitum heterophyllum

Aconitum heterophyllum Wall. ex Royle is a traditionally important medicinal plant having numerous therapeutic actions as documented in Ayurveda. This plant is traditionally used alone and in combination



with other plants to prepare various anti-malarial formulations. However, there is no report on the assessment of its anti-plasmodial activity, and the metabolite(s) responsible for this activity. The main aim of this study was to conduct phytochemical investigation of *A. heterophyllum* roots for the preparation of extract, fractions, and isolation of pure molecules to identify active fractions/molecules responsible for the anti-plasmodial activity, and development of UHPLC-DAD based analytical method which can be used for the quantification of marker compounds in the extracts and fractions. Phytochemical investigation of *A. heterophyllum* root led to the isolation of six specialized metabolites *viz.* 2-*O*-cinnamoyl hetisine (**1**), atisinium (**2**), 4-oxabicyclo [3.2.2] nona-1(7),5,8-triene (**3**), atisinium cinnamate (**4**), aconitic acid (**5**), and atisinium formate (**6**). Compound **1** is a new hetisine type diterpenoid alkaloid, compounds **4** and **6** are new counter ionic



forms observed with atisinium ion, and compound **3** is being reported for the first time from this genus.

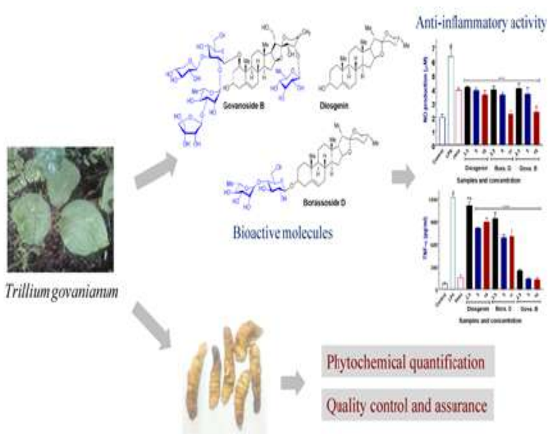
Structure of isolated molecules

Chloroform fraction was found to be the most active with IC_{50} (µg/mL) 1.01 (*Pf* INDO) and 1.32 (*Pf*3D7). The molecule 2-*O*-cinnamoyl hetisine (**1**), a new diterpenoid alkaloid isolated from chloroform fraction, showed promising antiplasmodial activities with IC_{50} (µM) 1.92 (*Pf* INDO) and 10.8 (*Pf* 3D7). The activity of chloroform fraction was further validated by the developed UHPLC-DAD based method as the quantity of 2-*O*-cinnamoyl hetisine (**1**) was higher in the chloroform fraction (≅200 mg/g) than in all other fractions (< 7 mg/g). Atisinium (**2**) and 2-*O*-cinnamoyl hetisine (**1**) were found to be the main marker compounds of this plant based on quantity and antiplasmodial activity, respectively. This study provides the scientific rationale for the traditional use of this plant in treating malaria. Further, this study revealed that the anti-malarial potential of this plant might be due to the presence of diterpenoid alkaloids.

Trillium govanianum

Steroidal saponins of *Trillium govanianum*: quality control, pharmacokinetic analysis, and anti-inflammatory activity

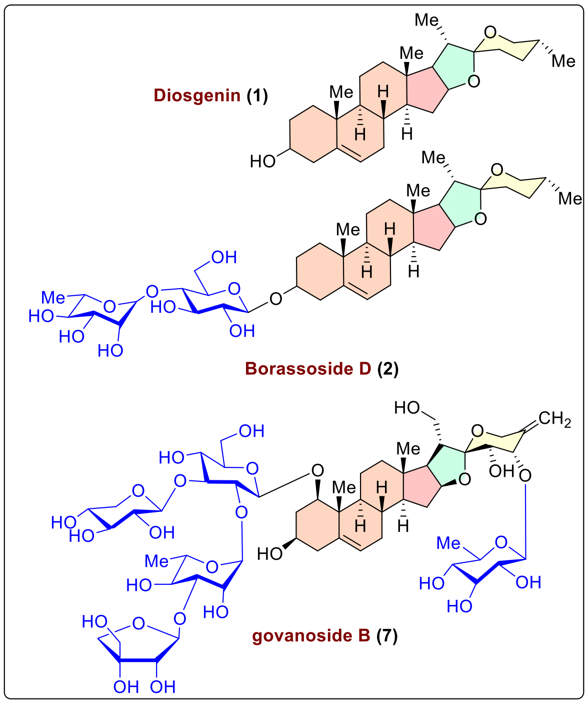
The rhizomes of *Trillium govanianum* have



traditionally been used in the Ayurvedic system of medicine to treat inflammation, pain, burn, and reproductive malfunctions. However, the ethanopharmacology and chemical constituents of *T. govanianum* have not been effusively explored to date. The present study attempted to uncover the phytochemical constituents and quality parameters of *T. govanianum* rhizomes, along with an evaluation of the anti-inflammatory potential of the extract, fractions, and isolated steroidal saponins. The quality control parameters such as moisture content, ash value, pH, heavy metals, alpha toxins, residual pesticides, and microbial load were observed within the permitted limits as per AOAC guidelines, suggesting good quality and safe nature of *T. govanianum* rhizomes. Phytochemical analysis revealed the presence of steroidal saponins (78.3 ± 0.61 mg/g), phenolics (12.3 ± 2.76 mg/g), flavonoids (3.54 ± 0.24 mg/g), and carbohydrates (473 ± 2.27 mg/g) in the rhizomes. Macrophages cytocompatibility demonstrated that cell viability was not affected at any tested concentration of extract, fractions and pure compounds [diosgenin (**1**), borassoside D (**2**), and govanoside B (**7**)]. The LPS-stimulated macrophages secreted nitric oxide (NO) and pro-inflammatory cytokines (TNFα, IL-1β, and IL-6), which were inhibited by the extract, fractions, and compounds **1**, **2**, and **7** in a concentration-independent manner.

Structure of the molecules (1, 2 and 7)

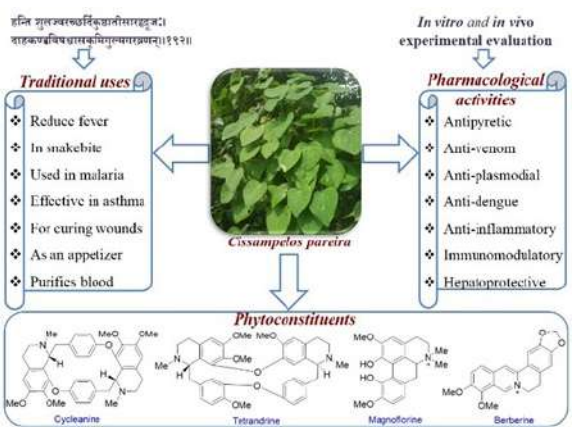
Additionally, *in silico* pharmacokinetics revealed that compound **1** has good membrane-permeability followed by compound **2**, while compound **7** showed the non-membrane permeability. This study validates the traditional uses of rhizomes of *T. govanianum* in the treatment of inflammation, and this activity might be due to the presence of steroidal saponins.



Cissampelos pareira

Cissampelos pareira L.: A review of its traditional uses, phytochemistry, and pharmacology

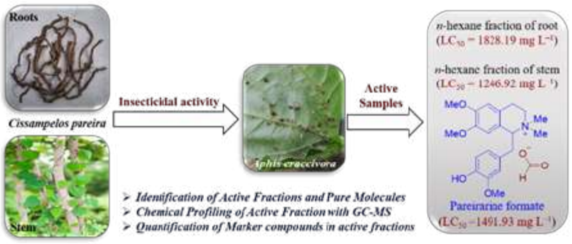
Cissampelos pareira, a well-known medicinal climber-plant of the Menispermaceae family, has been extensively used in the traditional medicinal system since the ancient time for



the treatment of numerous diseases such as ulcer, wound, rheumatism, fever, asthma, cholera, diarrhea, inflammation, snakebite, malaria, rabies, and also recommended for blood purification. It is to provide updated information on ethnopharmacology, phytochemistry, chromatographic and spectroscopic analysis, pharmacology, and toxicology of *C. pareira* along with the possible future research. To date, approximately 54 phytomolecules have been isolated and characterized from *C. pareira* including mainly isoquinoline alkaloids along with few flavonoids, flavonoid glycosides, and fatty acids. The crude extracts of *C. pareira* have shown various pharmacological activities such as antipyretic, anti-inflammatory, antiarthritic, antiulcer, antidiabetic, anticancer, antifertility, antimicrobial, antioxidant, antivenom, antimalarial, and immunomodulatory, etc. The chemical fingerprinting of *C. pareira* was analyzed using HPTLC, HPLC, UPLC, LC-MS, and GC-MS, which revealed the presence of alkaloids (isoquinoline alkaloids), fatty acids, and flavonoid glycosides. Moreover, the toxicological assessment of *C. pareira* has been moderately investigated, which requires further comprehensive studies. Although some of the traditional uses have been well clarified and documented by modern pharmacological analysis, the correlation between its pharmacological activities and particular phytoconstituents still needs to be validated. Furthermore, there is partial data available on most of the pharmacological studies, along with incomplete toxicological screening. Future research needs to pay more attention to pharmacological studies of *C. pareira via* pre-clinical and clinical trials. Additionally, scientific validation of traditional knowledge of *C. pareira* is vital for ensuring safety, efficacy, and mechanism of action before clinical uses.

Insecticidal activity of extracts, fractions and pure molecules of _Cissampelos pareira_ Linnaeus against aphid, _Aphis craccivora_ Koch

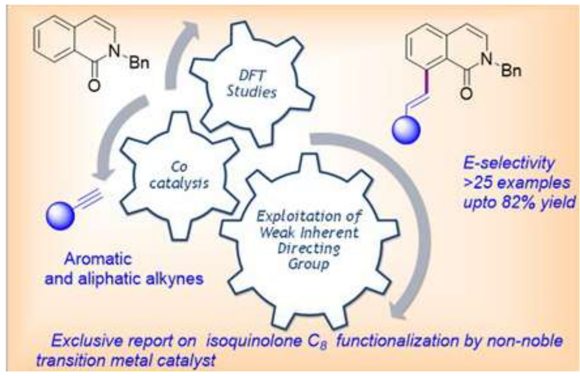
Aphis craccivora Koch is the major pest of legumes that also transmit viruses and reducing the economic yield. Indiscriminate and frequent usage of the same insecticide (s) without rotating different modes of action led to the development of resistance.



Due to the negative effects of insecticides against natural enemies of insects, environment and consumers, there is a need for an alternate biopesticide for effective management of aphids. Therefore, here we have evaluated the insecticidal activity of root/stem extracts/fractions, and pure molecules from *Cissampelos pareira* Linn against *A. craccivora* for identification of lead(s). Among root extract/fractions, *n*-hexane fraction was most effective (LC_{50} =1828.19 mg/L) against *A. craccivora* followed by parent extract (LC_{50} =2211.54 mg/L). Among stem extract/fractions, *n*-hexane fraction (LC_{50}=1246.92 mg/L) was most effective than water and *n*-butanol fraction. Based on GC and GC-MS analysis, among different compounds identified from *n*-hexane fraction of root and stem, ethyl palmitate (known to possess insecticidal activity) was present in highest concentration (24.94 to 52.95%) in both the fractions. Among pure molecules, pareirarineformate was found more effective (LC_{50}=1491.93 mg/L) against *A. craccivora* followed by cissamine (LC_{50} =1556.31 mg/L). Parent extract and fractions of *C. pareira* possess promising activity against aphid. Further, field bio-efficacy studies are necessary to validate the current findings for the development of botanical formulation.

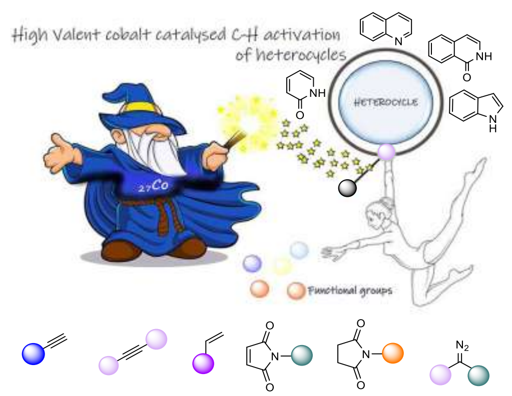
Organic Synthesis and Catalysis

Co(III)-catalysed regioselective linear C(8)-H olefination of isoquinolone with terminal aromatic and aliphatic alkynes:



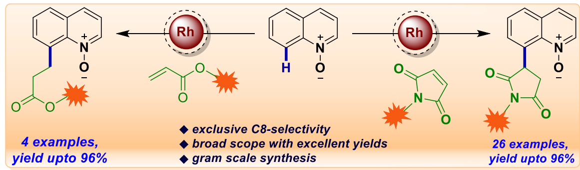
A regioselective C8 linear olefination of isoquinoline-1*H*-2-one with terminal (aromatic and aliphatic) alkynes is reported under Co(III) catalysis. This is an exclusive report for the C8 functionalization of isoquinolone using non-noble transition metal complexes. Experimental and computational mechanistic studies have also been performed to depict the reaction pathway.

Recent Advances in the High-Valent Cobalt-Catalyzed C-H Functionalization of N-Heterocycles: Direct functionalization of heterocycles using C-H activation widely relies on the precious metal complexes. In past decade, the use of earth abundant and inexpensive transition metal to functionalize heterocycles has become an attractive alternate strategy. This concept is also interesting due to the unique reactivity pattern of these inexpensive metals.



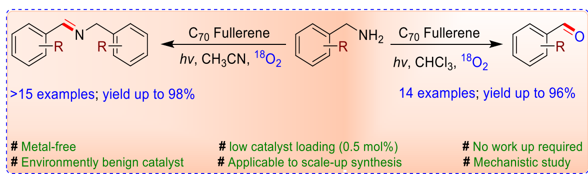
In this context we and other research groups have utilized the high-valent cobalt complexes as an inexpensive and readily available catalyst for the functionalization of heterocycles. We have reviewed recent progress made in the area of high-valent cobalt complexes Catalyzed C-H functionalization of *N*-containing heterocycles.

Rh(III)-Catalyzed regioselective C8-alkylation of quinoline *N*-Oxides with maleimides and acrylates: Herein, we disclosed the Rh(III)-catalyzed selective C8-alkylation of quinoline *N*-oxides with maleimides and acrylates. The main features of the reaction include complete C8-selectivity and broad substrate scope with good to excellent yields. The reaction also proceeded well with unprotected maleimide. The applicability of the developed methodology is demonstrated with gram scale synthesis and post-modification of the alkylated product. Preliminary mechanistic study revealed that the reaction proceeds through a five-membered rhodacycle and involve proto-demetalation step.

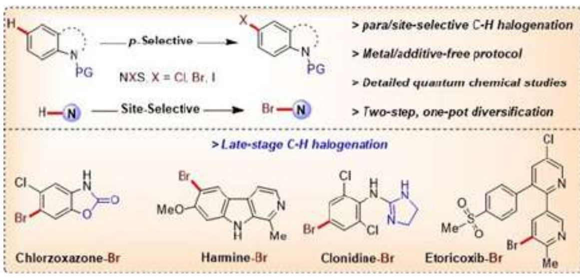


Cp*Rh(III)-Catalyzed regioselective C(sp^3)-H electrophilic trifluoromethylthiolation of 8-methylquinolines: Rh(III)-catalyzed regioselective trifluoromethylthiolation of unactivated C(sp3)-H bond of 8-methylquinolines with bench stable electrophilic trifluoromethylthiolating reagents via C(sp3)-H activation is explored. Various substituted 8-methylquinolines provided the products in good yields with high regioselectivity. Current reaction conditions are also applicable for the late-stage functionalization of natural molecule santonin and caffeine substituted 8-methylquinoline.

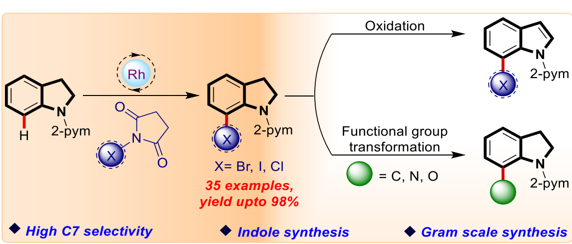
C_{70} Fullerene Catalyzed Photo-induced Aerobic Oxidation of Benzylamines to Imines and Aldehydes: C_{70} fullerene catalyzed photo-induced oxidation of benzylic amines at ambient conditions have been explored here. The developed strategy's main feature includes the additive/oxidant free conversion of benzylic amine to corresponding imine and aldehydes. The reaction manifests broad substrate scope with excellent function group leniency and is applicable up to gram scale. Further, symmetrical secondary amines can also be synthesized from benzylic amine in one pot two-step process. Various experiments and DFT studies revealed that the current reaction involves the generation of reactive oxygen species, single electron transfer reaction, and benzyl radical formation as key steps under photocatalytic conditions.



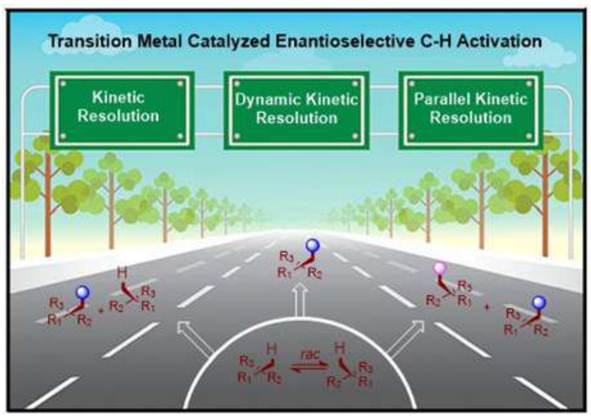
Predictable site-selective functionalization: promoter group assisted *para*-Halogenation of *N*-substituted (Hetero) aromatics under metal-free condition: Herein, regioselective*para*-C-H halogenation of *N*-pyrimidyl (hetero)aromatics through S_EAr (Electrophilic aromatic substitution) type reaction is disclosed. S_EAr type reaction has been utilized for the C5-bromination of indolines (*para*-selective) with*N*-bromosuccinimide under metal and additive-free conditions in good to excellent yields. The developed methodology is also applicable for iodination and challenging chlorination. The pyrimidyl group is identified as a reactivity tuner that also controls the regioselectivity. The present method is also applicable for selective halogenation of aniline, pyridine, indole, oxindole, pyrazole, tetrahydroquinoline, isoquinoline, and carbazole. DFT studies such as Fukui nucleophilicity and natural charge map also support the observed *p*-selectivity. Post-functionalization of the title compound into corresponding arylated, olefinated, and dihalogenated products is achieved in a one-pot, two-step fashion. Late-stage C-H bromination was also executed on drug/natural molecules (harmine, etoricoxib, clonidine, chlorzoxazone) to demonstrate the applicability of the developed protocol.



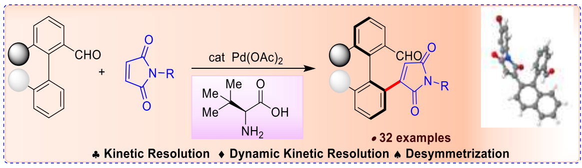
Rh(III)-Catalyzed selective C7 halogenation of indolines: An efficient Rh-catalyzed catalytic method has been developed for selective C7 halogenation of *N*-pyrimidyl indolines with *N*-halosuccinimides (Cl, Br, I) to produce corresponding halides in good to excellent yields. The advantages of this strategy include broad substrate scope and excellent regioselectivity for C7 functionalization of indolines, and feasibility at gram scale level. Various control experiments have been performed to understand the reaction pathway. Applicability of current methodology has been demonstrated by indole synthesis, and post-transformation of the C7 halogenated indolines into different valuable molecules.



Merging kinetic resolution with C-H activation: An efficient approach for enantioselective synthesis: In last two decades tremendous progress has been made in transition-metal (TM)-catalyzed C-H bond functionalization, paving the way to design complex molecules. Despite significant advances, enantioselective C-H activation is still in the age of infancy. For the enantioselective synthesis, several TM catalysts based approaches are well known, including kinetic resolution (KR) and its advanced versions [dynamic kinetic resolution (DKR) and parallel kinetic resolution (PKR)]. These strategies have recently been successfully applied synergetically with the TM catalyzed C-H activation to achieve enantioselective synthesis in a more economical and sustainable way. Here we summarize the recent advances made towards merging KR with TM catalyzed C-H activation for enantioselective synthesis.



Pd-Catalyzed atropselective C-H olefination promoted by a transient directing group: A Pd(II)-catalyzed atropselective olefination of biaryls with maleimides is reported using chiral transient directing group (CTDG) strategy. L-*tert*-leucine is used as a chiral auxiliary to obtain atropselective biaryl aldehydes with enantiomeric excess ranging from 70 to 99%. The method is also applicable for other olefins such as acrylonitrile, phenyl vinyl sulfone, and *N*-*tert*-butyl acrylamide, providing corresponding atropselective biaryl aldehydes with 97-99% *ee*. Non-linear effect studies suggest that chiral auxiliary is responsible for the atropselectivity of products. Other studies suggested the critical role of reaction time on yield and s-factor of desired products.



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Chemical Technology

Exploration of natural colors/dyes from Himalayan plants and bioactive molecules from Himalayan medicinal plants

Color is an essential sensory element of foods that often shows an important part in the market achievement of a product. More often, consumer consider color as an indicator of a variability of qualities of the food product, such as nutritional value, flavour and safety. The possible health side-effects of synthetic colorants to hyperactivity in children, and allergenicity of synthetic colorants, converted the consumer demand towards "naturally" derived colorants. The increasing demand by the consumers has been a driving force for the replacement of artificial colorants with those derived from natural sources. The increased interest on natural pigments has been enthused by their potential health benefits and concern about the safety of artificial colors/dyes. Nature produces a variety of vivid water as well as oil soluble colours such as anthocyanins, betalains, carotenoids, chlorophylls and curcumin from plant/vegetable/ flower sources. Since Himalaya is known for the enormous group of natural resources with history of traditional information and thus provide huge opportunities to explore Himalayan biodiversity in the area of natural colours. Hence, here *Rhododendron arboreum*, has been explored for natural colors.

Identification and quantification of chemical constituents in flowers of *Rhododendron arboreum*

The fresh flower petals of *R. arboreum* were collected from Palampur (Himachal Pradesh; 1450 m; latitude: 32.1461°N; longitude: 76.5611°E), India in March 2021 and were dried using lyophilization technique and powdered. The obtained freeze-dried powdered sample (40.0 g) was extracted with acidified methanol (2 400 mL) containing 0.1M HCl using ultrasonic water bath at 35°C for 30 min. The combined extract was concentrated at 40±2°C and the obtained extract (23.3 g) was subjected to Diaion HP-20. The adsorbed extract was eluted with distilled water followed by methanol and was dried under reduced pressure at 40±2°C to obtain anthocyanin enriched fraction (17.3 g).

UPLC method validation for quantitative analysis

A UPLC-PDA method was developed and validated for the quantification analysis of anthocyanin and phenolics. As shown in table 1, all the compounds accomplished good linear regression in the range, R^2 =0.9967-0.9999. The limit of detection (LOD) and limit of quantification (LOQ) were in the range of 0.12-0.46 µg/mL and 0.39-1.53 µg/mL, respectively. The RSD value of intra-day (n = 6) and inter-day (n = 3) precisions were 1.1-2.8% and 2.7-5.5%, respectively. The results indicated that the developed method is precise and sensitive for the quantitative evaluation of anthocyanins, flavonoids and phenolic acids in *R. arboreum* flowers.

Qualitative analysis using UPLC-PDA-QTOD-MS/MS

For the identification and quantification of compounds, anthocyanins, flavonoids and phenolic acids in the flowers of *R. arboretum,* UPLC-QTOF-MS/MS and UPLC-PDA technique were used. A total of twenty-five compounds were identified by comparison of their retention times, UV spectrum, and MS/MS spectra with the standard compounds and the information available in literature. The compounds were divided into three categories i.e., anthocyanins, phenolic acids and flavonoid glycosides according to their structural characteristics. The identified compounds included nine anthocyanins, six phenolic acids and nine flavonoid glycosides in positive and negative ion mode (Fig. 1).

Table 1 The regression equations, linear ranges, LOD and LOQ, intra and inter day data of quantified compounds in flowers of *R. arboreum*

Analytes	Regression equation[a]	R^2	Linear range (µg/mL)	LOD[b] (µg/mL)	LOQ[c] (µg/mL)	Intra-day[d] RSD (%) n = 6	Inter-day RSD (%) n = 3
Cyanidin-3-*O*-galactoside (**1**)	y = 5204.8x + 39433	0.9967	15.0-480	0.23	0.76	2.02	5.05
Cyanidin-3-*O*-arabinoside (**4**)	y = 3556.1x + 13892	0.9982	12.5-400	0.46	1.53	2.02	5.5
Chlorogenic acid (**10**)	y = 16288x - 49332	0.9998	6.12-200	0.23	0.78	2.8	2.7
Quercetin-3-*O*-rhamnoside (**20**)	y = 26431x + 35778	0.9999	6.12-200	0.12	0.39	1.1	2.7

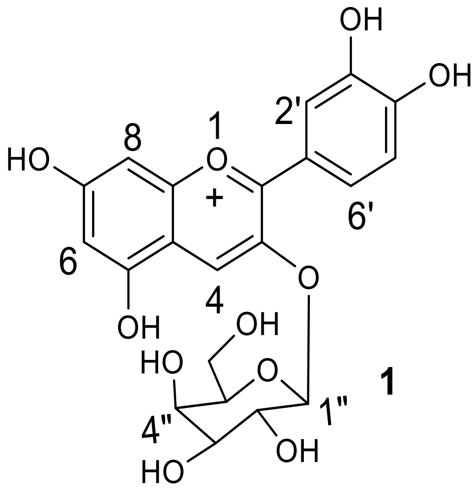
Quantitative analysis

The chromatograms for standards and samples are shown in Fig. 1. The total quantified anthocyanin content and phenolic content was 8.93±0.09 mg/g and 6.54±0.005 mg/g, respectively. A total of three anthocyanins (**1**, **4** and **8**), one phenolic acid (**10)** and five flavonoid glycosides (**16-18**, **20** and **22**) have been quantified by using UPLC-DAD methods in flower of *R. arboreum.* Among anthocyanins, cyanidin-3-*O*-*β*-galactoside (**1**), cyanidin-3-*O*-*α*-arabinoside (**4**) and cyanidin-3-*O*-rhamnoside (**8**) were determined as major component with a concentration 2.31±0.05 mg/g, 5.13±0.15 mg/g and 1.49±0.075 mg/g, respectively. The quercetin-3-*O*-rhamnoside (**20**; 3.63±0.006 mg/g) was present in highest amount followed by chlorogenic acid (**10**; 0.98±0.002 mg/g), quercetin-3-*O*-galactoside (**16**; 0.48±0.003 mg/g), quercetin-3-*O*-rhamnoside isomer (**22;** 0.37±0.018 mg/g), quercetin-3-*O*-glucoside (**17**; 0.10±0.004 mg/g) and quercetin-3-*O*-pentoside isomer (**18;** 0.098±0.001mg/g) in flowers of *R. arboreum.*

Further, the enriched fraction (1.0 g) was dissolved in water (10 mL) and subjected to prep. HPLC (Gilson) afforded two major anthocyanins, cyanidin-3-*O*-*β*-galactoside (**1**) and cyanidin-3-*O*-*α*-arabinoside (**4**). The characterization of isolated anthocyanins was performed by the analysis of NMR (1D and 2D) spectral data and mass spectrometry.

Cyanidin-3-*O*-galactoside (**1**): Red amorphous solid; ESI-MS m/z 449.1066; ^{1}H NMR (600 MHz, CD_3OD): δ 9.03 (1H, s, H-4), 8.27 (1H, d, J = 8.5 Hz, H-6'), 8.08 (1H, s, H-2'), 7.02 (1H, d, J = 8.5 Hz, H-5'), 6.90 (1H, s, H-8), 6.66 (1H, s, H-6), 5.26 (1H, d, J = 7.4 Hz, H-1"), 3.96-4.02 (2H, d, J = 3.3 Hz, H-2",4"), 3.78-3.81 (2H, m, H-5",6"), 3.68-3.70 (1H, m, H-3"). ^{13}C NMR (150 MHz, CD_3OD): δ 170.4 (C-7), 164.4 (C-2), 159.2 (C-5), 157.7 (C-9), 155.7 (C-4'), 147.3 (C-3'), 145.7 (C-3), 137.0 (C-4), 128.2 (C-6'), 121.2 (C-1'), 118.4 (C-2'), 117.3 (C-5'), 104.4 (C-1"), 103.3 (C-6), 95.0 (C-8), 77.7 (C-5"), 74.9 (C-3"), 72.0 (C-2"), 70.0 (C-4"), 62.3 (C-6").

Cyanidin-3-*O*-arabinoside (**4**): Red amorphous solid; ESI-MS m/z 419.0958; ^{1}H NMR (600 MHz, CD_3OD): δ 8.91 (1H, s, H-4), 8.32 (1H, d, J = 8.2 Hz, H-6'), 8.04 (1H, s, H-



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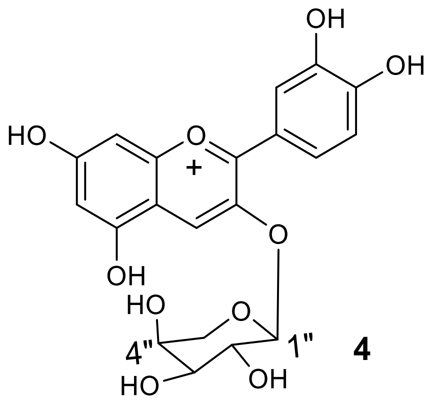

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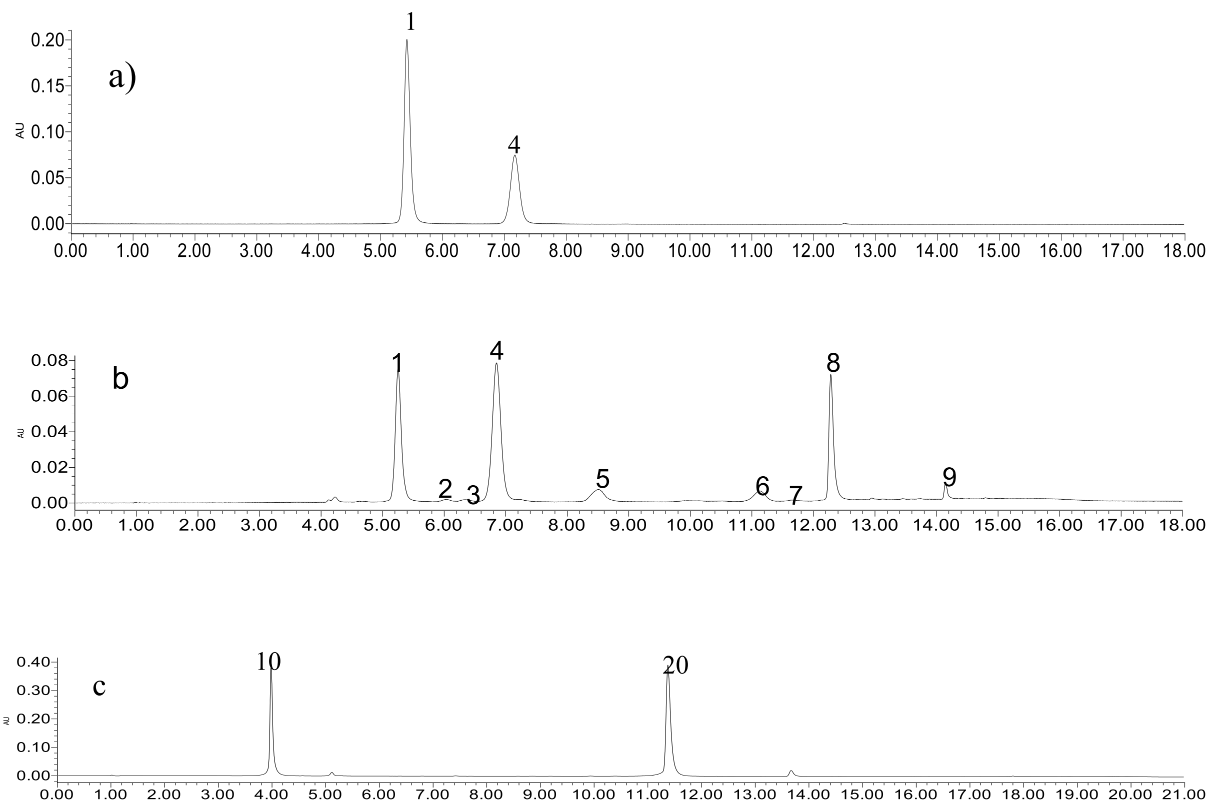
2'), 6.99 (1H, d, J = 8.2 Hz, H-5'), 6.88 (1H, s, H-8), 6.65 (1H, s, H-6), 5.29 (1H, d, J = 4.8 Hz, H-1"), 3.99-4.04 (3H, m, H-2",4",5"). ^{13}C NMR (150 MHz, CD_3OD): δ 170.4 (C-7), 164.5 (C-2), 159.1 (C-5), 157.7 (C-9), 156.0 (C-4'), 147.5 (C-3'), 145.6 (C-3), 136.3 (C-4), 131.2 (C-6'), 121.3 (C-1'), 118.4 (C-2'), 117.5 (C-5'), 113.3 (C-10), 104.1 (C-1''), 103.4 (C-6), 95.2 (C-8), 73.7 (C-3''), 72.1 (C-2''), 68.7 (C-4''), 66.8 (C-5'').

Stabilization of *R. arboreum* anthocyanins: *R. arboreum* flowers are one of the most perishable source of anthocyanins thus, limits their use as natural colorants. The unstable nature of anthocyanins has a direct impact on both bioactive and color property, hence combining spray drying technique with natural biopolymer may be a proficient way to protect the sensitive compounds by performing microencapsulation In order to protect the degradation of anthocyanin and provide stability to them, we have used microencapsulation technique using spray-



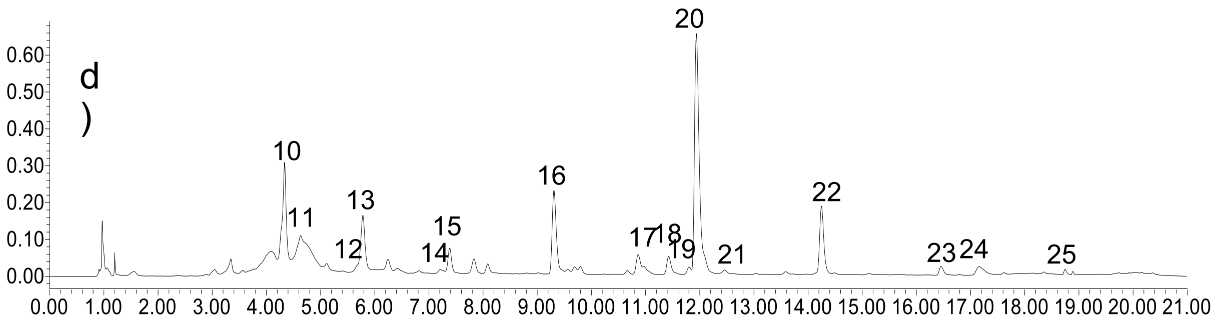


Fig. 1 UPLC-DAD chromatogram of *R. arboreum* flower: a) standard mixture of cyanidin-3-*O*-*β*-galactoside (1) and cyanidin-3-*O*-*α*-arabinoside (2); b) anthocyanin extract; c) standard mixture of chlorogenic acid (10) and quercetin-3-*O*-rhamnoside (20); d) phenolic extract.

drying method. In this era, we have explored the use of red cabbage pomace waste derived pectin (PC), as a wall material and its comparison with other commercialized biopolymers (MD, GA, xanthan gum (XG). The study insight into the physicochemical properties and impact of wall materials on the stability of anthocyanins over temperature, storage and color intensity.

For the optimization of microencapsulation process, combinations of MD/PC, MD/XG, MD/GA in a ratio 1:1, 2:1, 3:1, 4:1 and individual MD, PC, XG, GA were evaluated as wall materials to rhododendron anthocyanins (ANS). An effective microencapsulation technique relies on attaining maximum retention of the core material. The ratios of wall materials (1:1, 2:1, 3:1, 4:1) used in microencapsulation had different encapsulation efficiency, such as MD/PC as combination of wall materials with 88.92-94.30% EE, MD/GA with 89.62-92.73% and MD/XG with 69.50-89.56% EE. The best ratio of the combinations of wall material (MD/PC, MD/GA & MD/XG) were obtained in the ratio 2:1 and were further investigated for physicochemical parameters.

Spray dried powder characterization

The particle size ranged from 1.76 to 0.24 µm. The microcapsule produced with MD/XG exhibited larger diameter (1.761 µm) while microcapsules produced with GA exhibited the lowest size (0.241 µm) which is nearly similar to the microcapsules produced with PC (0.363 µm). The microcapsules produced with MD (0.642 µm) exhibited a

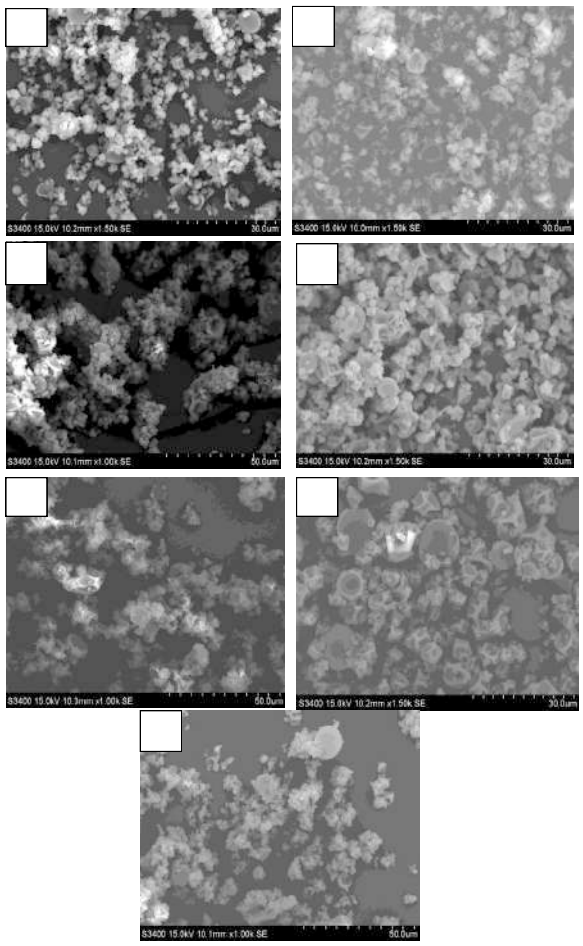


Fig. 2 Microstructural representation showing the outer morphology by scanning electron microscopy of encapsulated anthocyanin by a) MD/GA (2/1); b) MD/PC (2/1); c) MD/XG (2/1); d) MD; e) GA; f) PC; g) XG.

higher particle size than exhibited by GA & PC although combinations prepared with MD/GA was observed to be larger (1.043 µm). It has been reported that the increment in particle size is correlated to the molecular size of each wall material used and powder bulk density. Higher bulk density values of the combinations MD/XG & MD/GA showed the greater particle sizes compared to other spray-dried microcapsules. Fig. 2 presents morphological observations of spray-dried microcapsules for the combinations and individual wall material used encapsulated anthocyanin.

The combination of MD/GA(2/1)-ANS microcapsules were observed to be unwrinkled and non-uniform representing that agglomeration is very less. Whereas, MD/PC(2/1)-ANS was wrinkled in structure but less agglomeration was observed. Further, microcapsules of MD/XG(2/1)-ANS combinations was irregular, round and wrinkled structure and agglomerated.

Retention of anthocyanins after storage at 4°C, 25±2°C & -20°C in *Rhododendron arboretum*: After optimization of individual/blends of wall materials, the encapsulated anthocyanins were assessed for anthocyanin contents under different storage conditions (4°C, 25±2°C & -20°C) for 90 days. The results revealed that microcapsules stored at -20°C showed the minimum losses of anthocyanins followed by 4°C and 25°C. After 90 days evaluation, the microcapsules produced by MD/PC (2/1)

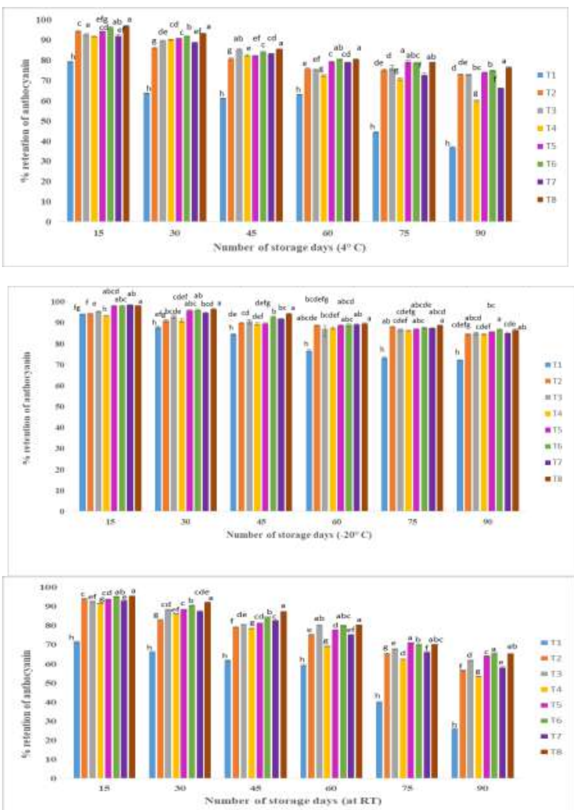


Fig. 4 Retention in anthocyanin content during 3 months storage (A) -20°C (B) 4°C and (C) room temperature. Different letters in the same column indicate a significant difference ($P < 0.05$). Bars represent the mean standard error. Where T1, T2, T3, T4, T5, T6, T7, T8 were ANS, MD-ANS, GA-ANS, XG-ANS, PC-ANS, MD/GA (2/1)-ANS, MD/XG (2/1)-ANS, MD/PC (2/1)-ANS, respectively.

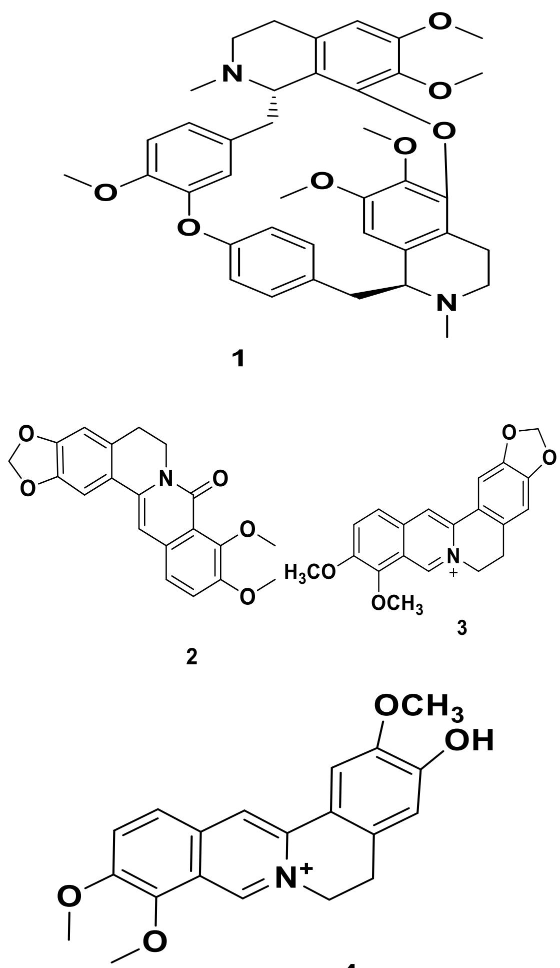


Fig. 3 Structures of isolated compounds.

and by MD/GA (2/1) contain highest anthocyanin content i.e. 86.82% & 86.42% respectively at -20°C whereas the microcapsules stored at 4°C contain 76.91% and 75.31% of anthocyanins, respectively (Fig. 4.).

Phytochemical Investigation of medicinal plants: The phytochemical investigation of *Thalictrum foliolosum* resulted into the isolation of four major compounds i.e. thalidasine (**1**, 500mg), oxyberberine (**2**, 30mg), berberine (**3**, 300mg) and jatrorrhizine (**4**, 45mg) (Fig. 3).

Production of dry colors (holi colors)

A process has been developed for the production of dry colors (holi colors) from flowers and vegetables. The prepared colors are safe and skin friendly and the technology has been transferred to M/S Nano Tech Chemical Brothers.

Holi Colors

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NMR, Metabolomics and Natural Product Chemistry

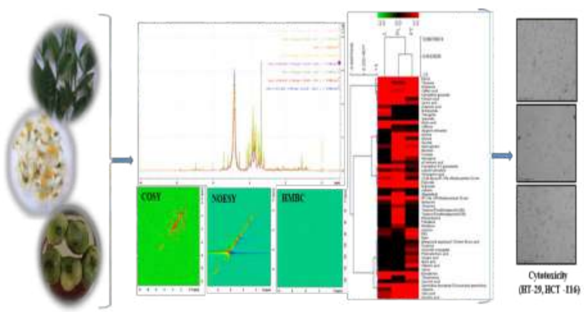
From the ancient times, plants have been utilized for the life, health and are still found significant. The products developed from them are used as such or intermediate for the discovery of valuable products. The active metabolites harnassed from plants have also been used for therapeutic values. Thus, to understand the metabolomics and their alterations in plant under different condition, along with quality assessment and control, is the need of hours. Our group is focusing on isolation and characterization of natural molecules, quality control and metabolomics for aromatic and medicinally important plants using advanced analytical techniques (NMR, GC, GC-MS/MS, LC-MS/MS and HPTLC) Moreover, our group is also working to find out mechanistic role of medicinal plants and their derived products. Process, Formulation and value addition is one of our key focused area.

NMR metabolomics and cytotoxicity (HT-29 and HTC-119 cell lines) studies insight the potential of neglected parts of *Camellia sinensis*

Camellia sinensis is an important plant having bioactive compounds that are translocated in different parts and associated with pharmacological activities such as anti-tumor. Thus, NMR based metabolomics combined with statistical analysis were used to findout the similarities and dissimilarities among the different tissues (leaf, flower and fruits). 57 metabolites (Coarse leaves: 35, flowers; 42, immature fruits; 45) of different classes such as terpenes/saponins, amino acids, sugars, polyphenols, organic acids and methhylxanthes were identified using 1D and 2D NMR spectroscopy. Further, neglected parts showed cytotoxicity against colorectal cancer cell lines overall findings revealed that tea coarse leaves, flowers and fruit were potential source of functional molecules for the pharmaceutical, nutraceutical and cosmetic sector.

Highlights

- Chemical profiling based discriminations and similarities of tea tissues
- Metabolomic profiling provided chemical markers in respective parts
- Terpenes/saponin, amino acids, sugars, polyphenols, organic acids and methhyxanthes classes of compounds were present.
- Cytotoxicity studies highlighted potential against colorectal cancer.



Picrosides, Phenolics and Cucurbitacins determination using UPLC-PDA in *Picrorhiza kurrooa* Ex Benth

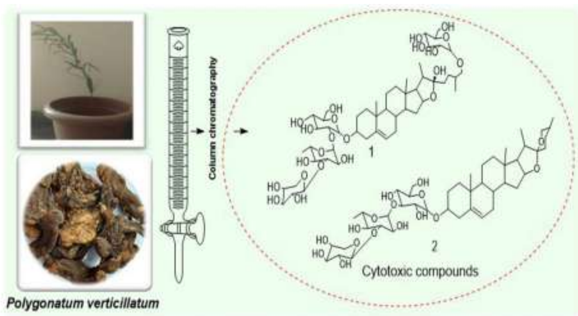
Picrorhiza kurrooa the Indian system of medicine is used majorly to treat jaundice, and fatty liver. Quality control methods have been reported earlier for picrosides-I and II, but extended coverage of markers is required for reliable authenticity. Therefore, the present study is aimed to develop and validate a UHPLC-DAD method for concurrent estimation of picrosides (I-III),-hydroxyacetophenone glucoside, cucurbitacin B hydrate, gallic, caffeic, syringic and cinnamic acids. The method was developed and validated as per the ICH guidelines for linearity, limits of detection and quantification, precision (inter- and intra-day), reproducibility, stability and recovery. This method was applied to estimate picrosides, phenolics and cucurbitacins in leaves and rhizomes. The separation of molecules was achieved at 260 nm in 20 min on a C-18 BEH column (2.1 × 100 mm, particle size of 1.7 μm) with gradient elution using 0.1% formic acid in water and 0.1% formic acid in acetonitrile. Linearity (r2) of standards was found to be 0.999, limits of detection and quantification were between 0.06–1.4 and 0.19–4 μg/mL, respectively. The recoveries of molecules were in the range of 86.6–102.7%. The method was found to be reproducible, uniform and specific. The contents of identified analytes in rhizomes were the highest in ethanol, followed by methanol and water extracts, whereas water extract of leaves contained the highest content of analytes followed by ethanol and methanol. The UHPLC-DAD method was validated for the first time to estimate simultaneously nine analytes. This method will help in quality control of material and agriculture interventions.

Cytotoxic steroidal saponins from *Polygonatum verticillatum.*

Two new steroidal saponins, named 26-O-β-d-glucopyranosyl-22ξ-hydroxy-(25*R*)-furost-5-en-3β, 26-diol, 3-O-β[xylopyranosyl (1→3)α-l-rhamnopyranosyl (1→2)β-d-glucopyranoside] (**1**) and 3-O-β-d-xylopyranosyl (1→3)α-l-rhamnopyranosyl (1→3)β-d-glucopyranoside diosgenin (**2**), along with protobioside, diosgenin,β-sitosterol andβ-Sitosterol-3-O-β-d-glucopyranoside were isolated from the rhizomes of *Polygonatum verticillatum*. The structures were elucidated based on physicochemical parameters and spectroscopic analysis. NMR (1D & 2D techniques) was employed to estimate compounds in the parent extract (E1) and its fractions (E2E4). Cytotoxicity studies of parent extract (E1) and isolates were evaluated against A549 and MCF-7 cell lines. Compounds **12** potent cytotoxic activity in both the cell lines and induces apoptosis. These findings will provide two new potent anticancer molecules for the chemical repository.

Highlights

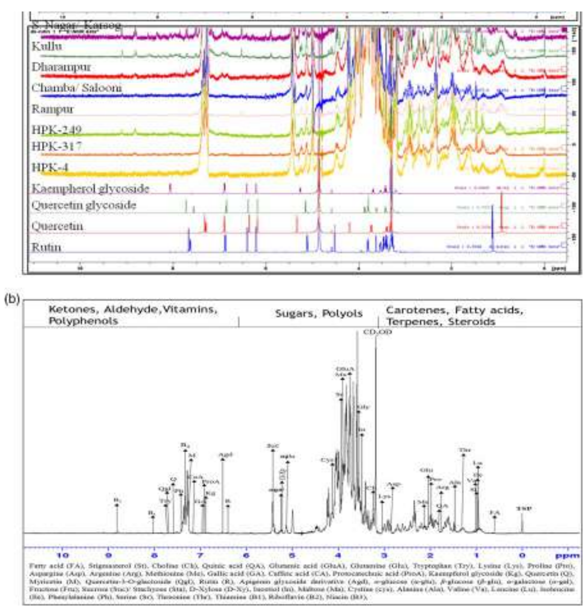
- Two new compounds (**1**&**2**) were isolated from rhizomes of *Polygonatum*.
- **1** and **2** shows significant cytotoxic activities against A549 and MCF-7 cell lines.



Nuclear magnetic resonance-based chemical signature and nutritional discrimination of *Macrotyloma uniflorum* from the alpine Himalayas

Macrotyloma uniflorum (horsegram) is cultivated in the alpine Himalayas for its nutritional benefits. The chemical diversity of *M. uniflorum* has been explored by several research groups, but none has reported the chemical signature to monitor the identity and quality. To overcome quality control problems and provide more accurate chemotype information, proton nuclear magnetic resonance (^{1}H-NMR)-based chemical signature and tentative metabotype discrimination was studied. RESULTS:

Metabolites were identified by characteristic chemical shifts and their correlations in one-dimensional (1D) and two-dimensional (2D) nuclear magnetic resonance (NMR) experiments. The identifications were confirmed by reference standards, with in-house databases, and with public databases. From the analysis of seed samples from eight locations, NMR detected 46 diversified metabolites, including 18 amino acids, nine carbohydrates, three vitamins, seven flavonoids, and nine miscellaneous molecules (fatty acids/ choline/ phenolics/ organic acids/sterols). These metabolites generated a single snapshot chemical signature for *M. uniflorum.* Greater content of identified metabolites was found at high elevations of 1829 m (55.78 g kg-1) followed by 1000–1150 m (19.30–17.23 g kg-1) and 1150–1450 m (7.33–13.41 g kg-1). Principal component analysis of samples revealed that chemotypes grouped into three distinct clusters. 'Cluster-3' was positively correlated with metabolites and found the best nutritionally enriched chemotype. CONCLUSIONS: A proton nuclear magnetic resonance-based *M. uniflorum* chemical signature was generated for the first time.

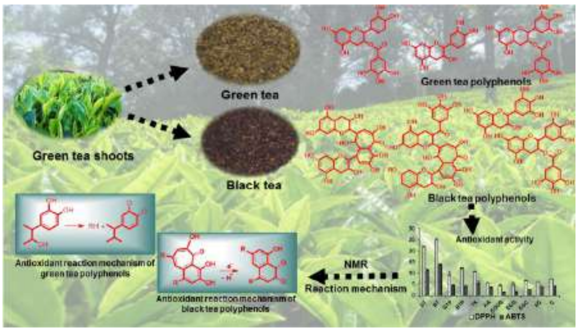


Chemical signature of the *Macrotyloma uniflorum*

The environmental conditions of 1829 m were most suitable for obtaining nutritionally enriched *M. uniflorum* crops. Overall, this information could help in the conservation, quality control, product development, and agriculture inventions of *M. uniflorum.*

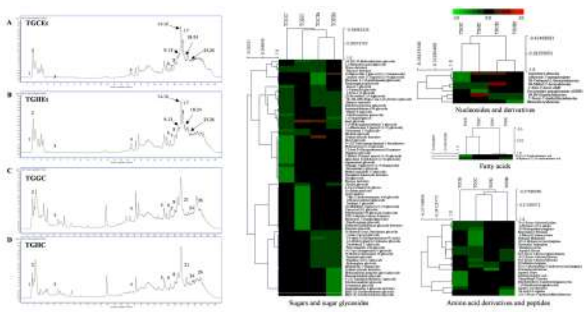
Mechanistic studies on polyphenol rich fractions of Kangra tea by HPTLC and NMR for their antioxidant activities

The antioxidant activity in tea is largely driven by its polyphenolic content, however, the antioxidant reaction mechanism and the compounds involved are not well characterized. Therefore, in this study, we performed in-depth profiling of antioxidant reaction mechanism of Green Tea (GT), Black Tea (BT), and their polyphenolic fractions with free radical using state-of-the-art analytical techniques. The polyphenol enriched fractions from GT and BT were isolated using column chromatography. Catechins were isolated and characterized by diverse spectroscopic techniques. Samples were screened for their antioxidant activity by HPTLC and further evaluated using a spectrophotometer. The free radical reactions with GT, BT, enriched fractions viz, GT Polyphenols (GTP), BT Polyphenols (BTP), and isolated catechins were studied using the ^{13}C NMR technique. The highest polyphenol content was found in GTP (795.4 ± 0.012/g) whereas GT (321.0 ± 0.028/g) showed maximum flavonoids content. Individual catechins isolated from GTP were EGCG, ECG, EGC, EC and C. Antioxidant activity followed the order EGCG > ECG > EGC > EC > GTP > C > BTP > GT > BT. In GT, the antioxidant reaction mechanism showed single electron and H-transfer in all catechins, which involved the transformation of the hydroxyl group to the carbonyl group. Whereas in BT theaflavins, conversion of the benzotropolone ring to the six-membered ring was observed.



Comprehensive Search of the Primary and Secondary Metabolites and Radical Scavenging Potential of *Trillium govanianum* Wall. ex D. Don

*Trillium govanianum*are traditionally consumed as a raw powder and decoction for the treatment of health complications. Hence, the present study aimed to investigate whether aqueous and alcoholic extracts of *T. govanianum*under hot and cold extraction conditions have similar or dissimilar chemical, nutrient, and antioxidant profiles. The total phenolics, flavonoids, carbohydrates, proteins, fats, and energy values were estimated in all the conditionally prepared samples. The total phenolics (21.23±1.4 mg GAE/g extract), flavonoids (70.57±3.24 mg RE/g extract) were found higher in hot ethanolic extract (TGHEt), while cold water extract (TGGC) showed higher nutrients including amino acids (10.545±0.219 mg/g) and nucleosides (1.803±0.018 mg/g). The nutrient energy value (2.60 and 2.49 Kcal/g extract) was higher in cold and hot ethanolic extracts. Further, TGHEt scavenged the DPPH.(IC_{50}; 870±22 μg/mL) and ABTS.+(IC_{50}; 80±1.49 μg/mL) effectively and proved its highest antioxidant activity compared to other samples. In LC/MS/MS-based metabolite profiling, twenty-six metabolites (fatty acids, steroidal saponins, triterpene saponins, ecdysteroid hormones) were confirmed with mass fragmentation and literature, while one hundred nine metabolites were identified using the METLIN database. The principal component analysis showed clustering of hot condition extracts while cold extracts were differentially located in quadrants. The heatmaps exhibited the associations and differences between metabolite composition, solvents, and extraction conditions. The identified metabolites speculatively predicted the biosynthesis pathway of *T. govanianum.* Findings also illustrated that *T. govanianum*a source of bioactive nutritional components and saponins. The current metabolite profiling of *T. govanianum* help in its agricultural and biotechnological interventions for higher quality produce.

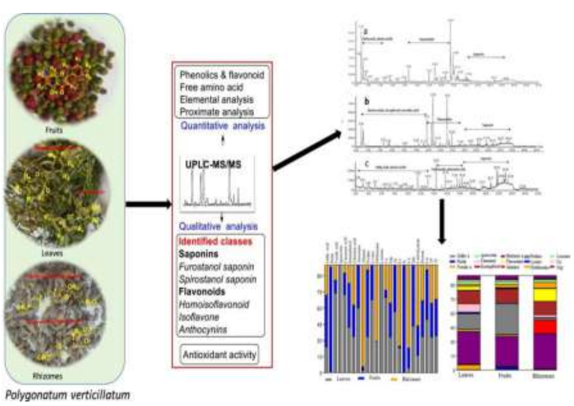


Metabolomics insights and bioprospection of *Polygonatum verticillatum:* An important dietary medicinal herb of alpine Himalaya

Polygonatum verticillatum is one of the least explored plant of genus *Polygonatum,* immense utility in food and medicine. The current study was designed to investigate and compare the metabolite diversity, including the nutritional potential of rhizomatous and aerial parts (leaves and fruits) of *Polygonatum verticillatum.* Comprehensive metabolites through UPLC-PDA-ESI/MS were tentatively identified 38, 31, and 16 compounds while 342, 414, and 314 were identified through METLIN database in leaves, fruits, and rhizomes, respectively. Total phenolic, flavonoid, protein, carbohydrate, and fat content were compared and found in the range of 24.50–27.64 and 101.40–109.50, 99–100, 58–200, 5–56µg/mg, respectively, while antioxidant activity was highest in fruits (IC_{50}DPPH.30µg/ml). Polyphenols, essential amino acids, and macro & micronutrientsestimated in all the parts of *P. verticillatum*. Leaves contained the highest number of targeted polyphenols and amino acids, followed by fruits and rhizomes. Statistical analysis (Venn-diagram, Heatmap, stacked charts, PCA, PCoA) has visualized that all parts have similar nutritional potential and chemical diversity. The current finding unleashed the possibilities of utilizing aerial parts instead of rhizomes that would save this plant from overexploitation.

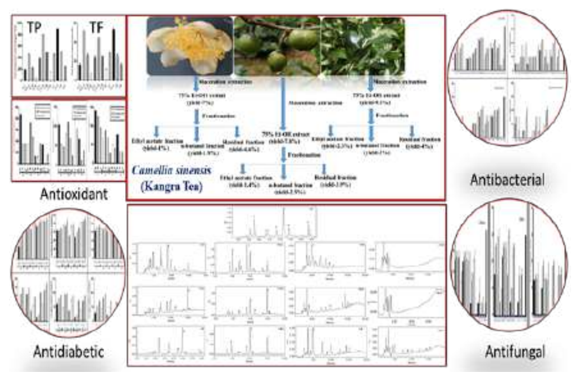
Highlights:

- UHPLC-MS/MS was used to identify non-targeted metabolites in *P. verticillatum.*
- 380, 445, 330 compounds were annotatedleaves, fruits and rhizomes respectively.
- UPLC-PDA method was employed to quantify phenolics, flavonoids and amino acids.
- Flavonoids and saponins were dominant in all the parts.
- Multivariate analysis visualized the diversification in different tissues.



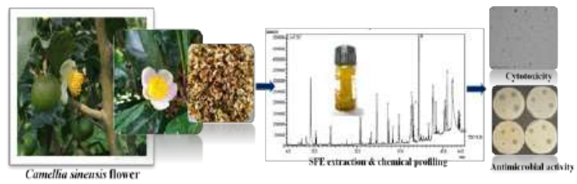
Polyphenolics and therapeutic insights in different tissues extract and fractions of *Camellia sinensis*

Polyphenolic and therapeutic insights of tea tissues (coarse leaves, flowers, and unripe fruits) extract (75 % ethanol) and fractions (Ethyl acetate, n-butanol, residual water) were studied. The total polyphenol, flavonoid content was estimated (46.25± 1.2 -907± 1.7 and 8± 0.1-54± 1.3 mg/g, respectively) with predominance in leaves followed by fruits and flowers. The HPLC based quantification of flavan-3-ols showed similar trends to polyphenols with dominance in LEA, FTEA, and FLEA (731. 32, 531.2 & 214.1, mg/g respectively). The antioxidant potential using DPPH, ABTS, and RP assays revealed the maximum activity in leaves while FIC showed antagonistic results. Further, inhibition of bacteria, fungus, α-glucosidase, and α-amylase indicated wide scope for underutilized tea parts. The leaves and fruits showed maximum α-*glucosidase inhibition* (87 %) while α-amylase inhibition was in range of 45.2 - 98.2 %. The variability in polyphenols and therapeutic competence provided different perspective for their utilization in nutraceutical and pharmaceutical sector.



GC-MS based profiling, antimicrobial activity and cytotoxicity studies (HCT-116 and HT-29) of *Camellia sinensis* (L.O Kuntz) flowers

Camellia sinensis flowers are rich source of bioactive phytochemicals but treated as waste biomass of the bush. However, flowers were used to cure health ailments from the beginning. Thus solvent free supercritical fluid extract of flowers was targeted to explore the phytochemical and bioactivity potential. Solvent free extract of *C. sinensis* flowers was prepared using supercritical fluid extraction method. SFE extract was chemically characterized using GC-MS analysis. The characterized extract was further assessed for antimicrobial and cytotoxic potential against *B. subtilis*, *S. aureus*, *E. coli* and *K. pneumonia*, C. *albicans, A. niger,* and *A. flavous* strains and colorectal cancer cell lines (HCT-116 and HT-29), respectively. Parameters of the SFE extraction was optimized (300 bar pressure, temprature 45$^{°C}$, static time 15-20 minutes and dynamic time 90 minutes) that yield, 1.005 % solvent free extract. The chemical characterization of SFE extract using GC-MS analysis resulted eighteen non-polar identified compounds that constitutes 64.18 % of the extract. Sillylation of extract identified five unsaturated fatty acids and a terpene alcohol. Further, antimicrobial studies revealed strong antifungal (20-27 mm) and appreciable antibacterial (7-12 mm) potential at the concentration of 1mg/ml. The cytotoxicity studies against colorectal cancer cell lines (HCT-116 and HT-29) showed cell death up to 80 ± 0.80 %. Overall, results and findings highlighted the importance of economically underutilized tea flowers. This also revealed the wide scope of tea flowers for pharmaceutical, nutraceutical and cosmetic sectors.



Exploration of plants for the chemical fingerprints and its important metabolies. *Camellia sinensis*, *Berberis lycium, Rhodiola imbricate*, *Swertia purpurascens*, *Polygonatum verticillatum, Macrotyloma uniflorum*, *Cymbidium aloifolium*, *Cymbopogon martini*, *Trillium govanianum*, *Malus domestica*, *Picrorhiza kurroa*, etc were explored for the metabolite profiling and quality control.

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Chemical Engineering, Chemical Technology

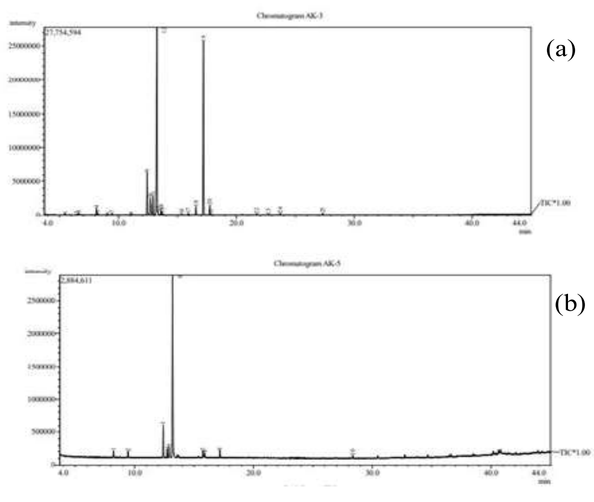
Our group has been working on the unit operations required for process intensification and downstream process technology for bio resource based products.

Value addition and downstream process technology for Peppermint oil and its derivatives under Himalayan Bio Resource Mission

The essential oil of peppermint is commercially used for producing menthol, which offers cooling and soothing effect and find wide use in pharmaceutical and cosmetic industry. Menthol, particularly I-menthol, is an important substance widely used in the field of, for example, food additives, drug components, cosmetics, fragrances and medicines. I-Menthol is commercially available in solid forms such as powders, crystals, solidified distillate, flakes and pressed articles. Peppermint Oil is described as a colourless or pale yellow liquid having a strong, penetrating odour of peppermint and a pungent taste, followed by the sensation of coldness when air is drawn into the mouth. It mainly comprises menthol (35% to 60%), and menthone (15% to 30%). Peppermint water (hydrosol) can be used as a flavouring agent or fragrance component.

Peppermint Oil is a generally recognized as safe (GRAS) ingredient for use in dietary supplement. India is at present the leading producer, consumer and exporter of menthol-mint oil in the world market with more than 80% of global share due to suitable agro-climatic conditions and availability of several improved varieties. The high price of menthol mint oil in the national and international markets, following the drop in supply of its synthetic substitute, has propelled new hope among the menthol mint cultivating farmers.

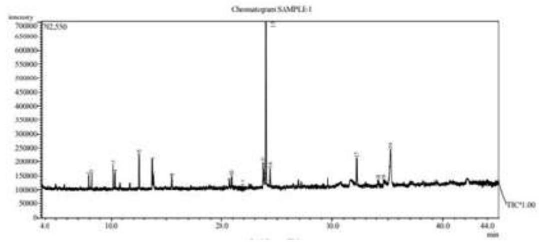
Both Mentha crystals as well as De-Mentholised Oil, hold industrial importance and farmers, entrepreneurs and small scale industries can be directly benefited out of developed process technology. Sustainable process technology to be optimized for Mentha oil and its derivatives. Recent extraction techniques and their parameters to be evaluated for the better quality and high yield of Peppermint oil. There is global demand for high quality mentha crystals. Initial study was undertaken and preliminary results are shown below. >50% I-menthol concentration and > 20% menthone concentration was observed in the oil as well as in hydrosol.



GC-MS Chromatogram of Mint oil (a) and Hydrosol (b) distilled from Mentha piperita.

Extraction/distillation and value addition of some selected natural essential oils under Floriculture Mission

The extraction of essential oil from tuberose, rose and jasmine etc is to be undertaken using conventional and advanced unit operation techniques. Further value addition products are to be made using the essential oil, hydrosol and the waxy residue for complete utilization of the raw material. Initial study was undertaken and preliminary results are shown below. >35 % concentration of methyleugenol was observed in Tuberose absolute.



GC-MS Chromatogram of absolute obtained from Tuberose

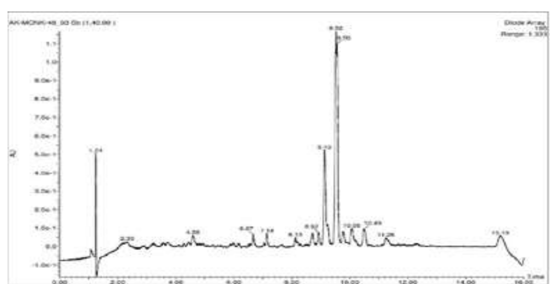
Green Process for Mogroside enriched extract from Monk Fruit on Lab Scale

The Monk Fruit (*Siraitia grosvenorii*), belongs to Cucurbitaceae family, which has been in use for centuries in Traditional Chinese Medicine for the treatment of cough, sore throat, and minor stomach and intestinal troubles. However, now this plant is known throughout the world for its intense sweet taste. The ripened fruit of this plant has the presence of cucurbitane-type triterpene glycosides known as 'Mogrosides'. The extracted mixture of mogrosides is about 300 times sweeter than sucrose. Among them, Mogroside-V is extremely sweet and has no after-taste effects.

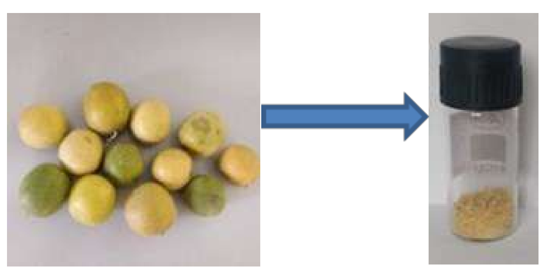
Monk fruit is generally recognized as a safe (GRAS) and has got US-Food and Drug Administration (FDA) approval. The demand for monk fruit is gradually increasing in the international market and is expected to show a steady Compound Annual Growth Rate (CAGR) of 4.37% by the year 2026 (Source: https://www.openpr.com/news/1923221/global-monk-fruit-sugar-market (2020)). Keeping in mind the importance and essentiality of non-nutritive natural sweetener, and diverse agro-climatic conditions in India, CSIR-IHBT, Palampur had introduced the seeds of monk fruit plant which were procured from China in March 2018 (bearing import permit No. 168/2017 dated 26 April 2017). After intense research, CSIR-IHBT scientists have been able to successfully establish the monk fruit plantation at their experimental farm. The fruits have also been harvested at our Experimental Farms, and the quality parameters have also been evaluated. The harvest is found to have good quality traits which are comparable to the fruits harvested in China. For Developing end-to-end technology towards commercial production of a range of products from Monk Fruit, Green, sustainable process has developed. Preliminary observations and results are compiled below.

(a). UHPLC method has been developed & validated for determination of total mogrosides (on the basis of Mogroside V, 11-Oxo-Mogroside V, Siamenoside I, Mogroside IIIE)

(b). The developed green process enhanced the Total Mogroside concentration in the final product to 46.77%.

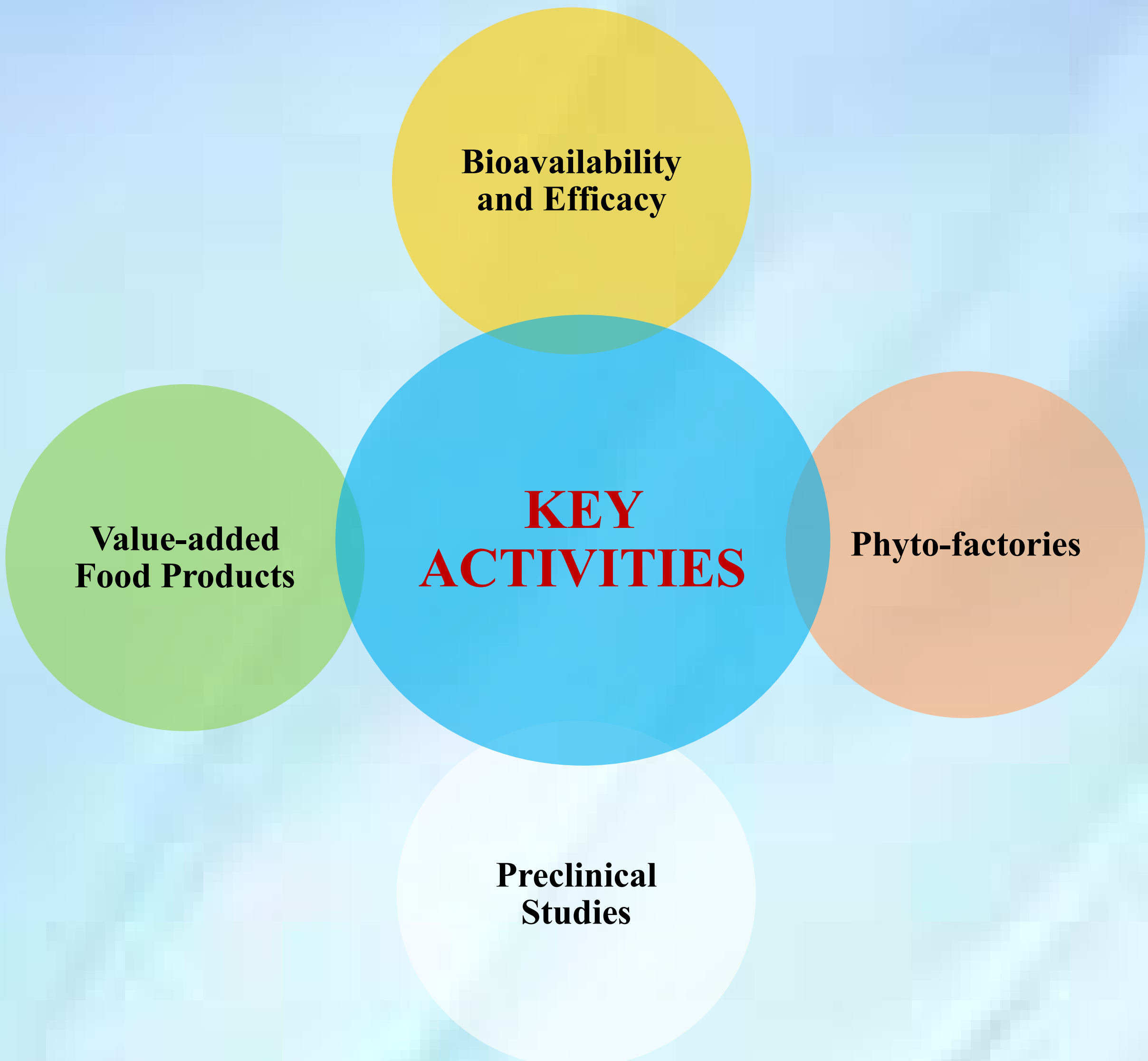


UHLC Chromatograms of enriched Final product.



Ripened Fruits grown at CSIR-IHBT. **Final Product.**

DIETETICS AND NUTRITION TECHNOLOGY DIVISION



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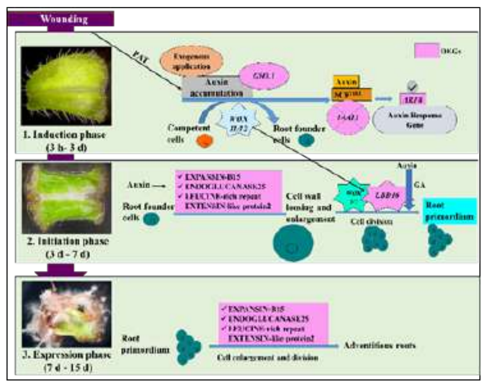
Plant Cell and Tissue Culture

Establishing sustainable production and consumption pattern for natural resources is the motto of our research work at the CSIR-IHBT. In this regard, efforts are being made to develop sustainable alternatives for the production of phytoconstituent that not only conserve the plant diversity *in situ*, but will also provide a feasible source of quality raw plant material for food, cosmetics and herbal industries at large.

Understanding the formation of adventitious root from leaf explants of *Arnebia euchroma* under *in vitro* condition

Adventitious roots seem to be a feasible and sustainable source for the production of phytoconstituents. In continuation to develop alternate routes of phytoconstituents production, the study aimed at revealing *in vitro* developmental process of adventitious root formation from leaf explant.

Adventitious root formation is a post-embryonic developmental process consisting of different phases (induction, initiation and expression). Each phase has its own morphology, hormonal requirement and necessities. In this study, Leaves from *in vitro* established *A. euchroma* shoot cultures were used as explant to induce adventitious roots in Schenk & Hildebrandt (SH) medium supplemented with 2.5 mg/L indole-butyric acid (IBA). Explant showed morphological changes after 3 days and swelling was the first sign of tissue response. Cytological studies revealed the formation of a dome-shaped bulge within 7 days which probably be the adventitious root primordia. After 10–15 days of inoculation, the expression of adventitious roots was evident. Depending on these morphological observations, eight-time points (3 h, 12 h, 24 h, 3 d, 7 d, 10 d and 15 d, with intact leaves as a control) were selected for the transcriptome analysis to uncover the genes involved in the respective phases of adventitious root formation. After analyzing the morphological, cytological and molecular data, adventitious root formation in *A. euchroma* has been divided into three phases i.e. Induction (3 h to 3 d), Initiation (3–7 d) and Expression (7–15 d).

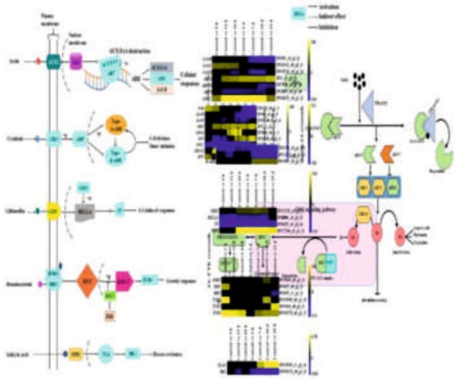


Proposed underlying mechanism for leaf induced adventitious root development from *A. euchroma* under in vitro conditions.

The significant findings of the present study are:

- It will help in understanding the key regulators of *in vitro* adventitious root development in *Arnebia* species .
- Alternative phytochemical production system which may be deployed in the future for the generation of quality raw material at a commercial scale.

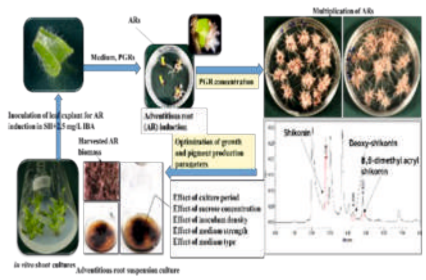
Nowadays, adventitious roots grown through plant tissue culture methods are gaining importance for production of phytochemicals such as flavonoids, anthocyanins and anthraquinones at large scale.



Relative expression (fold change 1.0) of unigenes involved in key pathways of adventitious root formation (control vs 3 h, 12 h, 24 h, 3 d, 7 d, 10 d and 15 d); +u: ubiquitination, +p: phosphorylation.

Production of naphthoquinone red pigments from adventitious roots of *Arnebia euchroma* (Patent Application No. 202111045278, filed dated 4-10-2021)

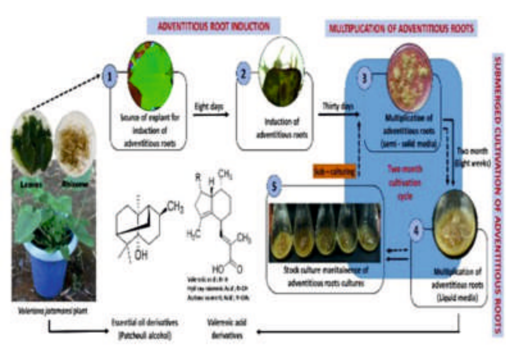
- Adventitious roots induced from *in vitro* leaf explants of *Arnebia euchroma* on Schenk & Hildebrandt medium supplemented with indole-3-butyric acid is found to be an alternate source of naphthoquinone red pigments production. The bioprocess comprises of following steps. Collection of plant material from wild
- Establishment of aseptic shoot cultures using rhizome buds as explant
- *In vitro* leaf tissues were cultured for induction and initiation of adventitious roots
- Expression and proliferation of the induced adventitious roots.
- Cultivation of adventitious roots in suspension culture for large scale production
- Extraction and quantification of naphthoquinone red pigments.
- The salient features of the study are:
- Shorter cultivation cycle (4-5 years vs 28 days)
- Devoid of genetic engineering, transformation or mutation like hairy roots which were induced by the infection of Agrobacterium rhizogenes
- Sustainable method and independent of environmental as well as geographical hurdles
- Free from adulteration
- Sustainable production of pigments throughout the year



***In vitro* production of naphthoquinone red pigments from adventitious roots of *A. euchroma*.**

Submerged cultivation of *Valeriana jatamansi* adventitious root cultures for production of valerenic acids derivatives

An efficient *in vitro* protocol has been developed for the induction of adventitious roots from leaf explant of *Valeriana jatamansi* on SH medium. Induced root were successfully cultivated under submerged condition using standardized half strength SH media supplemented with 4.92 µM IBA and 2.0% sucrose. The major finding of the work are:

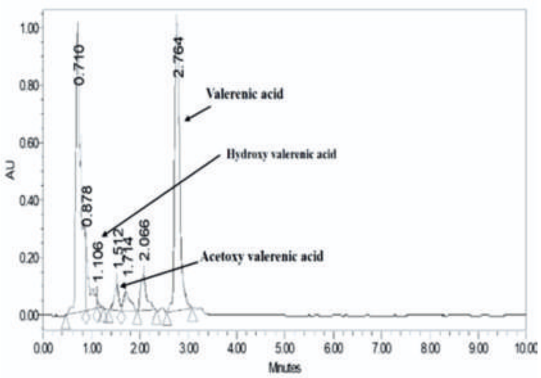


Overall process for production of phytoconstituents using leaf-induced in vitro adventitious root cultures.

- The developed bioprocess has a

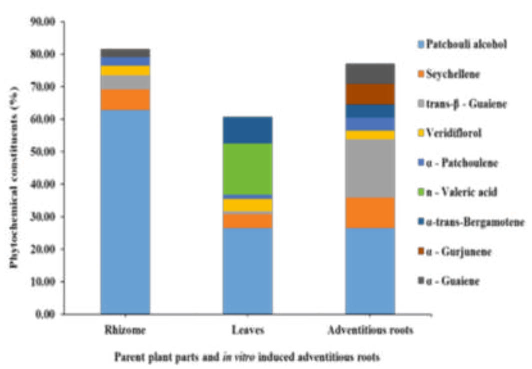
significantly shorter submerged cultivation cycle (2 months) than field grown plants (2 years).

- Induced adventitious roots had a high total valerenic acid (VA) derivatives yield with the notable presence of Hydroxy valerenic acid (HVA) .



UPLC chromatogram of marker compounds i.e. valerenic acid (VA), acetoxy valerenic acid Hydroxy valerenic acid in *Valeriana jatamansi* adventitious root cultures.

- Adventitious roots also showed an accumulation of phenolic constituents, including pharmaceutically important rutin and kaempferol.
- A substantial increase in phytochemicals was evident at subsequent culture stages with shortened in vitro cultivation cycle (2 months) than field-grown plants (24 months).
- Adventitious roots also accumulated 0.059% essential oil with patchouli alcohol (24%) as a key constituent.



Major compounds present in essential oil extracted from different *V. jatamansi* samples.

The developed bioprocess has a significantly shorter submerged cultivation cycle (2 months) than field-grown plants (2 years) which could be a crucial factor to gauze the feasibility of the developed process at an industrial scale. Conclusively, the results of the present study are demonstrating the potential of in vitro induced adventitious roots as an alternate source for the production of phytoconstituents including essential oil on a sustainable basis.

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Food Science and Technology

Nutrition Technology

My current research area is in the development of nutritionally rich food and nutraceutical development particularly nutritionally rich food products from traditional and underutilized food bioresources of Himalayan region.

A multidimensional UHPLC-DAD-QTOF-IMS gradient approach for qualitative and quantitative investigation of *Citrus* and *Malus* fruit phenolic

This study was done for a single shot UHPLC-DAD-QTOF-IMS gradient method for assessing thekey phenolics in *Citrus* spp. and *Malus* spp. fruits. It was observed that each fruit has a unique set of metabolites, which necessitating a different gradient methodseparate the phenolics. A single method for multiple species of *Citrus* and *Malus* fruits can solve this problem while also being more cost effective and time efficient. In the developed gradient technique, sixteen phenolics from *Citrus* and *Malus* sources were employed for gradient optimization, followed by optimization of injection volume, limit of detection, limit of quantification, percent recovery, and repeatability. Further, quantification studies were executed to understand the applicability of the developed method. Quantification was made of phenolic extracts of *Citrus maxima* and *Malus domestica* peel extract, freeze dried fruits and market consumables such as mixed juices and jams. All samples shown a significant amount of phenolics whereas, major marker phenolics were also detected in higher amounts.

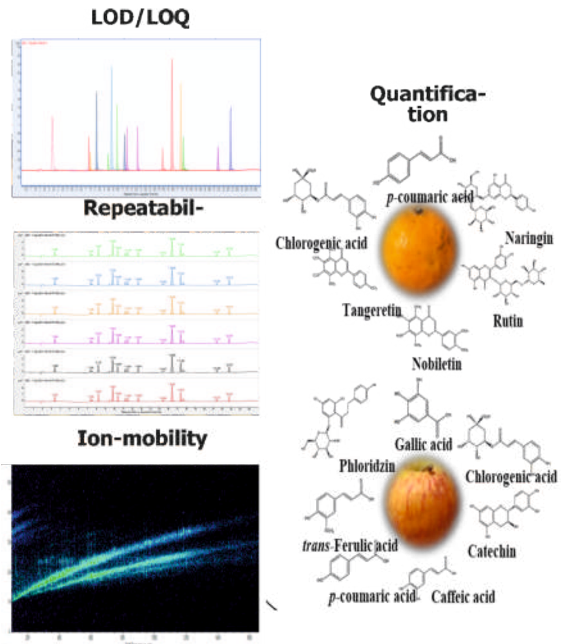
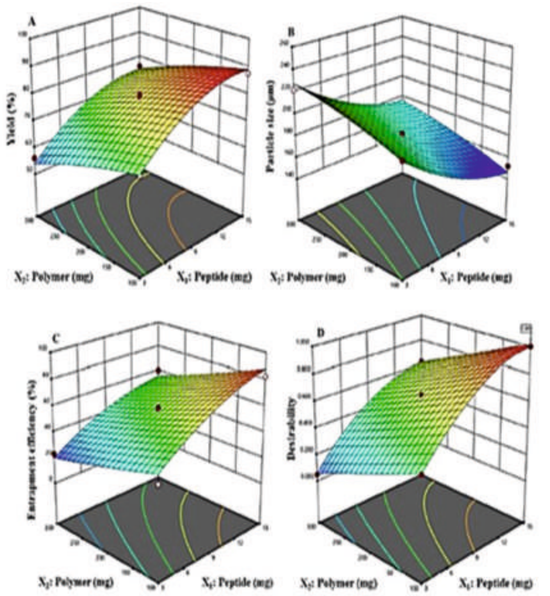


Illustration of developing UHPLC-DAD-QTOF-IMS gradient approach for *Citrus* and *Malus* fruit phenolic quantification studies.

Optimization of pearl millet-derived bioactive peptide microspheres with double emulsion solvent evaporation technique and its release characterization

From last many years a significant scientific progress in the area of food-derived bioactive peptides was observed. Although, selection of optimum carrier system, to improve release, absorption efficiency and bioavailability of these peptides is essential. Thus, in the current study peptide-loaded-eudragit S100 microspheres were developed using double emulsion solvent evaporation technique. A central composite experimental designed, using two independent variables (peptide and polymer) and was used to study the dependent variables (yield, particle size and entrapment efficiency).

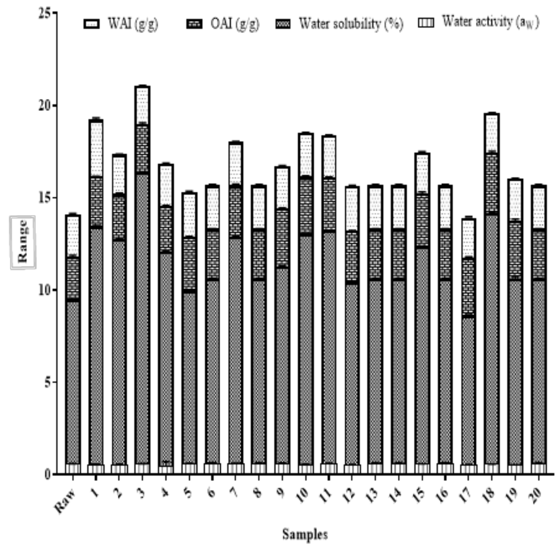


Response surface graphs showing the effect of different conditions on bioactive peptides microsphere formation.

Based on response surface methodology, thirteen formulations were developed. For the optimization of perfect microsphere central composite experimental design was used. An entrapment efficiency of 88.23% was acquired in present study. Whereas, for *in vitro* gastrointestinal release kinetic studies final formulation was analysed and found maximum peptide release after intestinal phase at pH >6.

Enhancement of nutritional and phytochemical constituents of pearl millet flour after different fermentation condition using response surface methodology

Fermentation is a traditional process for developing various food products with health benefits. In this study, fermentation conditions for pearlmillet flouroptimized using baker's yeast. A central composite experimental design with three independent variables, temperature (30°C-45°C), yeast concentration (2%–4%) and time (18–24h) was used to evaluate the dependent variables (nutritional and phytrochemical constituents). Based onresponse surface methodology, twenty run were processed.



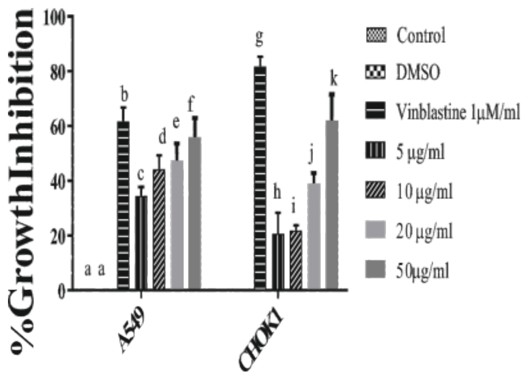
Overview of functional properties of the raw and fermented millet flour.

Regression model interpretation showed the significant relationship among dependent and independent variables. Also all linear terms, two quadratic terms (fermentation temperature and time) and all interactive terms had significant (p<0.05) effect on the response variables. The optimum fermentation condition for pearl millet flour was attained with 2% baker's yeast at 30°C for 18h. Hence process of fermentation with these conditions significantly enhanced the phytochemical constituents of pearl millet flour. Present study successfully demonstrated the optimized fermentation conditions for pearlmillet flourthe enhancement of nutritional and phytochemical constituents and can be used to develop healthy functional food products by food industries.

Formulation of fermented beverage of *Murraya Koenigii* plant extract for its nutritional and anticancer activity

Murraya koenigii L (Curry) leaves, identified for its polyphenolic content with effective antioxidant properties such as sustain oxidative stress and promote health related benefits. The Highest amount of phenolics (77.00 µg GAE/mg) and flavonoids (21.02 µg

RU/mg) along with antioxidant activity was identified in *M. koenigii* leaves extract using quantification method *via* ultra-performance liquid chromatography (UPLC).



Overview of fermented beverage formulation and its activity.

The extract unveiled proficient anti-cancer activity against A549 and CHOK1 carcinoma cell lines. Therefore, leaves of *M. koenigii* were employed to formulate fermented beverage (FB) followed by validation of its nutritional and phytochemical content at different intervals of time. This study exhibited an increase in phenolics, flavonoids, and anti-oxidant activity in FB, further quantified *via* UPLC. The quantitative analysis also exhibited a rapid upsurge in free amino acid and protein content from 0 to 96th hr with insignificant reduction at 720th hr. Therefore, *Murraya koenigii*-fermented beverage can be an appropriate alternative exhibiting effective antioxidant activity.

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Biochemistry and Molecular Pharmacology

Pharmacology and toxicology lab works in the area of safety/toxicity and efficacy evaluation of phyto-formulations and active principles by addressing their underlying molecular mechanism with special emphasis on inflammation, aging, diabetes and cancer. Rheumatoid arthritis (RA), a chronic auto-immune disease, is often result of persistent and misdirectional inflammation and cannot be effectually resolved by single-target selective drugs. Present study attempted to uncover anti-arthritic efficacy and governing molecular mechanism of Berberis lyceum Fruit Extract (BLFE) and its phytoconstituents berberine and rutin, with focus on dysregulated oxi-infammation and structural integrity during articular damage using Collagen II–CFA-induced RA mice model. NMR based phytometabolomic analysis revealed the presence of phenolics and alkaloids such as berberine and rutin (Fig. 1a). BLFE, rutin and berberine remarkably mitigated Collagen II–CFA-induced disease severity index, articular damage, immune cells infux and pannus formation (Fig. 2a and 2b). An effective decrease in levels of TNF-α, IL-6, IL-1β, IFN-γ, IL-13, IL-17, MMPs, RORγt, Ob-cadherin, Cox-2, iNOS and enhancement in IL-10, IL-4 and IL-5, BMP-6/7 was observed in BLFE, rutin and berberine treatments. Molecular and mechanistic analysis demonstrated reduction in expression of p-STAT-1/3, p-PI3K, p-Akt, p-JNK, p-p38, p-IκB, p-NF-κB and β-catenin by BLFE, rutin and berberine treatments. Furthermore, reduced activation of p-ERK and p-GSK3β and enhanced splenic Tregs was only noticed in BLFE and berberine treatments. Thus, significant presence of these phytoconstituents could contribute to the above-mentioned findings. These findings imply that BLFE could be beneficial for assuaging deleterious effects of RA mediated via perturbed inflammation.

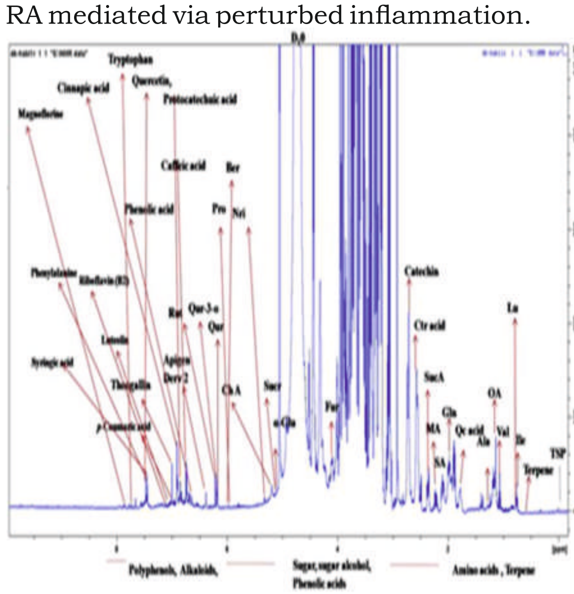

Fig. 1 H NMR-based NMR metabolomics of BLFE. c–g BLFE and its phytoconstituents rutin and berberine ameliorate progression of CIA and paw joint architecture damage. c DAI score.

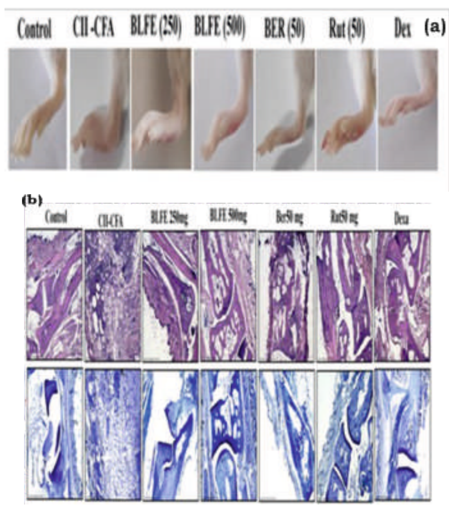

Fig. 2 (a) Representative images of paw tissue e Haematoxylin and eosin stained of paw joint sections (b) Haematoxylin and eosin stained of paw joint sections.

A large body of emerging evidence has revealed the role of p38/MK2 and PI3K/Akt/GSK3β cascades in the orchestrating process of colitis. Rutin, a bioflavonoid present in many fruits and vegetables, has been recognized to offer therapeutic attributes in acute colitis. However, its role in chronic colitic condition has not yet been delineated in reference to p38/MK2 and PI3K/Akt/GSK3β signalling. The present investigation assessed the efficacy and underlying molecular mechanism of rutin in alleviating DSS-induced chronic colitis. The analysis of signalling pathways demonstrated the robust activation of PI3K/Akt/GSK3β/MAPKs/ NF-κB and p38/MK2 in DSS-induced colitis in animals, which was efficiently alleviated following the rutin treatment. In silico studies indicated its target specificity with these pathways. Rutin administration markedly improved the disease activity score, colon length, goblet cell loss and compromised colon epithelial integrity in colitic mice (Fig. 2a) Decreased expression of oxi-inflammatory markers such as IgM, IgE, iNOS, ICAM-1, HO-1 and Th1/IL-10 cytokines ratios after treatment suggests its efficacy in regulating effector, regulatory and B cell homeostasis. Additionally, rutin demonstrated its role in restoring epithelial integrity by modulating the transcript levels of tight junction proteins, mucus-secreting proteins, epithelial cell proliferation and apoptosis. Treg expansion revealed that rutin supplementation also exhibits an immune regulatory potential and suppresses inflammatory aggravation mediated by adaptive immune responses. Overall, results indicate that the modulation of p38/MK2 and PI3K/Akt/GSK3β/NF-κB pathways (Fig. 2b) by rutin represents a novel therapeutic approach in chronic colitis that help to curb dysregulated intestinal integrity, cytokine ratio and splenic Tregs.

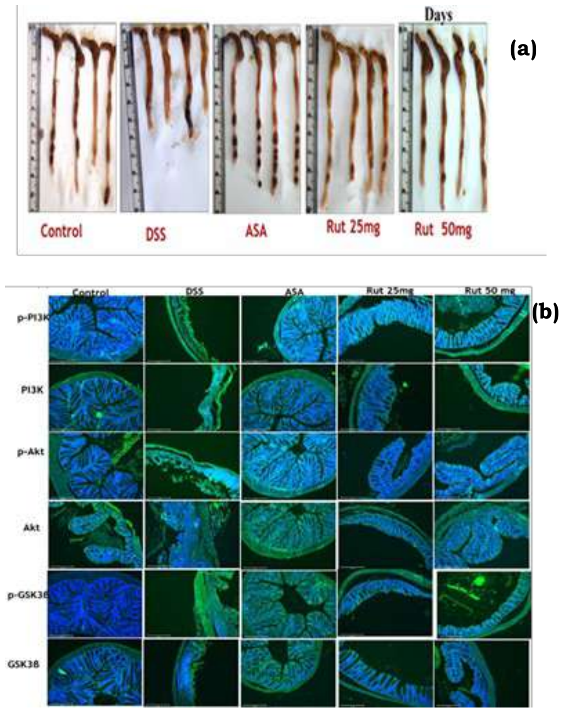

Fig. 3 (a) Representative images of colon tissues showing colon shorting (b) Immunofluorescent image of p-p38, p38, p-MK2, MK2, p-NF-κB and NF-κB in colon tissue.

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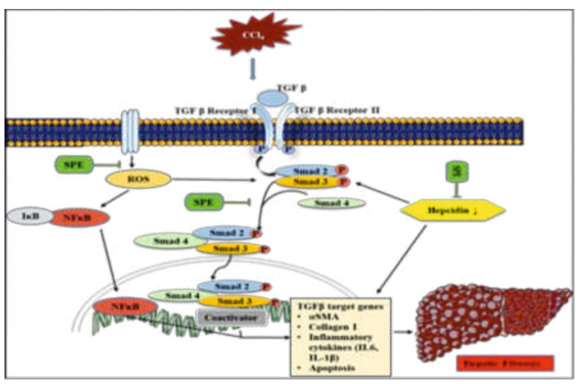
Animal Pathology and Toxicology, Dietetics & Nutrition Technology

We work on the safety and efficacy assessment of natural products, nutraceuticals and synthetic molecules for their therapeutic effects in animal models.

***Swertia purpurascens* Wall prevented the progression of hepatic fibrosis in rats:** Hepatic fibrosis is a progressive accumulation of extracellular matrix in the liver in response to chronic injury, further progressing to cirrhosis. The limited therapeutic options for the disease entail exploring new safe, and effective solutions. The plants of the *Swertia* genus are well-known for treating hepatic disorders in traditional systems of medicine worldwide. *Swertia purpurascens* Wall is well-known to treat various ailments, including diabetes, anaemia and hepatic diseases in folklore. It is used as an alternative due to the endangered status and unavailability of *Swertia chirayita*. However, minimal scientific reports on the therapeutic potential of *Swertia purpurascens* Wall against hepatic fibrosis. Therefore, we evaluated the hepatoprotective effect of the *Swertia purpurascens* Wall and elucidated the underlying mechanism of action. The metabolite profiling of the *Swertia purpurascens* Wall extract (SPE) was done using UHPLC-QTOF-MS/MS. The acute oral toxicity of SPE (2g/kg BW) was done in rats. CCl_4 intoxication model was used to develop liver fibrosis in rats, followed by SPE treatment at three doses (100, 200 and 400 mg/kg BW). The biochemical parameters, histopathology, molecular and *in silico* studies were conducted to evaluate the therapeutic effect. A total of 23 compounds were detected in the SPE. Acute oral toxicity revealed no toxicity of SPE at a 2g/kg BW dose. CCl_4-treatment in rats led to significantly altered body weight gain, relative liver weight, biochemical markers and antioxidant enzymes. However, these changes were effectively improved by SPE treatment at various doses. Histopathological analysis showed that SPE treatment reduced the deposition of fibrotic tissue in hepatic parenchyma. In addition, SPE treatment suppressed the fibrotic (TGFβ, αSMA, SMADs and Col1A), pro-inflammatory markers (NFκB, TNFα and IL1β) and apoptosis in the liver tissue. Interestingly, SPE treatment also improved the hepcidin levels in the liver, crucial in hepatic fibrosis. *In silico* analysis revealed the potential binding of various metabolites with target proteins. Overall, the therapeutic effect of SPE against CCl_4-induced hepatic fibrosis was concluded to be due to restoring the hepatic hepcidin levels and inhibiting TGFβ/SMAD/NFκB signalling in rats.



Proposed mechanism of action of *Swertia purpurascens* Wall extract (SPE) against liver fibrosis.

Collaborative work

In a collaborative work, we investigated the potential of phloretin to prevent progression of non-alcoholic fatty liver disease (NAFLD) in mice. The study revealed that phloretin attenuates NAFLD progression via inhibiting oxidative damage, hepatic inflammation and fibrosis. It has also upregulated the autophagy-mediated lipid breakdown in the hepatic cells. Thus, phloretin can be used as a potential solution to prevent development of NAFLD.

Regulatory studies

In regulatory studies, we evaluated the oral toxicity of immunity booster and microalgae based formulations developed at the institute. The studies were conducted as per OECD guideline.

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Neuro Pharmacology

Hesperidin as a potential nutraceutical for epilepsy management: A preclinical support

Hesperidin (3,5,7-trihydroxyflavanone 7-rhamnoglucoside) is a β-7-rutinoside of hesperetin (4'-methoxy-3',5,7-trihydroxyflavanone) and is found in citrus fruits. It is known to interact with various cellular pathways to show multiple pharmacological effects. We studied the anticonvulsant efficacy of hesperidin in a zebrafish model of pentylenetetrazole (PTZ)-induced convulsions. Before PTZ exposure, healthy zebrafish larvae were preincubated with hesperidin at three different doses (1, 5, and 10 µM) for 1 h. Increased seizure latency and reduction in PTZ-induced hyperactive responses were observed following hesperidin treatment. Hesperidin incubation also showed a significant reduction in *c-fos* expression, which further supported the suppression of neuronal excitation. *BDNF* expression was restored, and the level of *IL-10* was reduced following hesperidin treatment in larvae exposed to PTZ. The affinity of hesperidin for the N-methyl-d-aspartate receptor, the gamma-aminobutyric acid receptor, Interleukin 10, and the TrkB receptor of the brain-derived neurotrophic factor was observed by*in-silico*studies that supported*in vivo*. The results concluded that hesperidin suppresses PTZ-mediated seizure in zebrafish larvae via interaction with the central CREB-BDNF pathway.

Target validation to combat epilepsy-associated cardiac damage

In continuation to our previous investigation (Epilepsia, 2021, 62: 504-516), in which we identified molecular pathways involved in epilepsy-associated cardiac irregularities, in our recent study, we validated a potential pathway in zebrafish kindling model. Adult zebrafish were maintained and incubated with increasing different concentrations of rapamycin doses (1, 2, and 4 µM), followed by exposure to pentylenetetrazole (PTZ) to record seizure latency and severity. At the end of the experiment, the zebrafish heart was excised for carbonylation assay, gene expression, and protein quantification studies. Kindled fish showed reduced severity of the seizure on treatment with rapamycin. There were decreased cardiac expressions of *gpx, nppb, kcnh2, scn5a, mapk8, stat3, rps6*, and *ddit,* and increased levels of *trxr2* and *beclin 1* in the kindled fish heart. Rapamycin treatment decreased p-mTOR expression and protein carbonyls level. It was concluded that rapamycin treatment effectively inhibits mTOR activation to prevent recurrent seizures-mediated cardiac damage.

Lithium as a potential therapy against postmenupasual neurological conditions.

Menopause-induced deficiency of estrogen affects the neuronal circuit of the brain, resulting in neurobehavioral disorder development. Hormone replacement therapy is used to overcome neurobehavioral conditions following menopause, but it is associated with several side effects. Lithium treatment has been shown to maintain synaptic plasticity, reduce neuroinflammation, and initiate adult neurogenesis. Clinically it is used to treat a variety of neuropsychiatry disorders. Our study aimed to examine the effect of lithium treatment against neurobehavioral disorders in an ovariectomized rat model with a clinical resemblance to postmenopausal conditions. It was observed that Lithium treatment in ovariectomized rats effectively maintained reconsolidation of spatial and recognition memory and improved depression-like behavior. In the lithium group, pyramidal neurons of the CA1 region of the hippocampus, layer V of the somatosensory cortex, and layer II/III of the prefrontal cortex increased dendritic length and spine density. The treated group hippocampus, somatosensory cortex, and prefrontal cortex showed a significant decrease in the pro-inflammatory markers*Il2*,*Il6*, and*Il1b*. The disease group showed reactive astrogliosis that was prevented after lithium treatment. The Gsk-3β activity was also suppressed, whereas normal levels of β-catenin, CREB, and BDNF were preserved following lithium treatment. The findings demonstrated that lithium plays a protective role against ovariectomy-induced neurobehavioral conditions (Fig. 1)

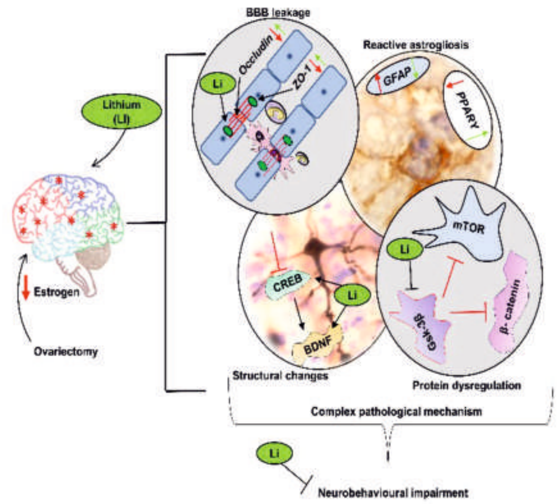

Fig. 1 Putative mechanism of action of lithium therapy in the suppression of postmenopausal neurobehavioral conditions.

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Animal Breeding and Toxicology

Our group is presently working on understanding the role of different determinants in pathogenesis of pulmonary disorders like allergic asthma and skeletal inflammatory conditions like osteoarthritis and RA. We use different non-infectious, inflammatory laboratory animal models for evaluating molecular mechanism involved in progression of diseases.

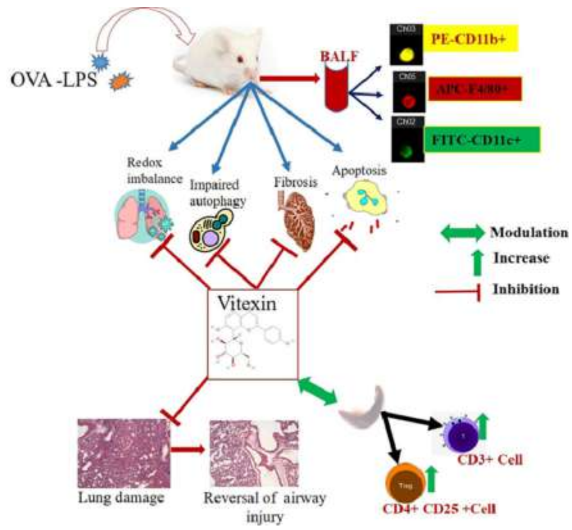
Validation of traditional knowledge for mitigating respiratory pathologies:

Respiratory diseases account for more than 10% of all disability-adjusted life-years (DALYs). Respiratory diseases are second only to cardiovascular diseases (including stroke). Respiratory diseases make up five of the 30 most common causes of death: COPD is third; lower respiratory tract infection is fourth; tracheal, bronchial and lung cancer is sixth; TB is twelfth; and asthma is twenty-eighth. Each year, 4 million people die prematurely from chronic respiratory disease. Regardless of development of several drugs, respiratory diseases still remain as substantial burden on health-care, particularly in developing countries. Due to high mortality rate, there is still huge demand of alternative strategies that could be used to prevent respiratory disorders. Mean annual cost for patients with a respiratory disease estimated to be US $4191 per patient. The global herbal medicine market size was estimated to be US$ 83 billion in 2019 and is expected to reach US$ 550 billion by 2030 at a CAGR. The role of nutraceuticals from different sources such as plants, marine and microbial have gained attention for the prevention of respiratory disorders.

Efficacy of active constituents of *Vitex negundo* Linn. (vitexin and agnuside) maintains lung homeostasis by targeting vicious loop between inflammatory aggravation and autophagy mediated via multiple redox cascade and myeloid cells alteration

We tried to decipher efficacy and governing molecular mechanism of vitexin in mitigating allergic asthma particularly mediated by vicious loop of oxi-inflammatory stress, autophagy and apoptosis. To ascertain this, OVA-LPS induced mice model was used and protective attributes of vitexin for different mediators, pathological facets and sensing pathways of allergic asthma were evaluated. We observed that Vitexin treatment remarkably inhibited OVA-LPS induced inflammatory cell infiltration, mast cell activation, alveolar collapse, congestion, fibrosis in lung architecture. These results were accompanied by suppression of immune cells hyperactivation, mucus secretion, goblet cell proliferation, persistent inflammation which were affirmed by alleviation in levels of IgE, Th1/Th2/Th17, IL-4/IFN-γ, chemokines, endopeptidases (MMP-1, MMP-13), oxidative effectors with concomitant increase in IL-15, IL-10, MMP-9 and MMP-3. Additionally, noticeable decline in p-connexin 43, p-c-Fos, TGF-β, Smad2/3/4, Caspase9/3, LC3A/B expression and upregulation in beclin-1, p62 co-localization and Bcl2/Bax indicate reversal of lung vascular permeability, mast cell degranulation, fibrosis, apoptosis, autophagosome impairment. Subsequent allergic inflammatory cascades analysis revealed p-NF-κB, p-PI3K, p-Akt, p-p38, p-Stat3, GATA3 upregulation and p-PTEN downregulation in sensitized mice, which were decisively counteracted by vitexin. In silico studies signified target specificity of vitexin with these proteins. Suppression in myeloid cells activation and enhancements of Tregs demonstrated immunomodulatory potential of vitexin in allergic airways.

Similarly, attributes of agnuside, a nontoxic, iridoid glycoside have been advocated for inflammatory disorders. However, information on its efficacy in alleviating allergic asthma largely remain ambiguous and yet to be deciphered. Present study aimed to assess efficacy of agnuside in targeting vicious circle of oxi-inflammation, autophagy and fibrosis, together with investigating its underlying molecular mechanism during OVA-LPS induced allergic asthma. Results revealed that agnuside showed prophylactic effect in assuaging asthmatic lung architecture impairment ($p = 0.01$) as indicated by suppression of inflammatory cell infiltration, congestion, fibrosis, airway remodeling and alveolar collapse in OVA-LPS sensitized group. Decreased expression level ($p = 0.05$) of allergic inflammatory mediators such as IgE, Th1/Th2, IL-4/IFN-γ, IL-4/IL-10, chemokines, endopeptidases and TGF-β, Smad2/4, Caspase9/3, connexin 43/50 observed in agnuside treatments. Analysis of redox molecular signaling cascade and autophagic proteins revealed concurrent upregulation in p-NF-κB, p-PI3K, p-Akt, p-p38, p-Stat3 activation, GATA3, LC3B expression and reduction in Bcl2/Bax, Beclin1 and p62 expression in sensitized mice ($p = 0.05$) which were intensely counteracted by administration of agnuside. Suppression in myeloid cells activation and augmentation ($p = 0.001$) of Tregs established modulatory attribute of agnuside



for innate and adaptive immune response during allergic asthma. Collectively, these outcomes confer prophylactic attribute of agnuside and signify it as promising strategy to thwart allergic asthma.

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Food and Nutraceuticals

(i) Development of value added products from aromatics and herbals

India is gifted with 8000 medicinal and 1200-2500 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 in 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 development of herbal topical formulations such as multipurpose cream, sun screen, ointments utilizing himalayan bioresources such as superoxide dismutase (SOD) and catechins.

(ii) 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 major therapeutic limitations because of their low aqueous solubility, low permeability, short half-life and low bioavailability to humans.

These limitations can be overcome by advanced pharmaceutical technologies. 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 therapeutic efficacy of nutraceuticals.

In this context, we are working on various bioactive constituents such as phloretin, epicatechin, formononetin, alpha-lipoic acid. These phytochemicals exhibit a wide variety of pharmacological activities such as antidiabetic, antioxidant, anti-inflammatory, and anticancer. However, their efficacy is hampered due to their poor aqueous solubility and bioavailability being rapidly and extensively metabolized. Therefore, to overcome these issues we are utilizing formulations based approaches to improve the bioavailability of these bioactive constituents in the view to enhance their therapeutic efficacy.

Further, recently (*Danio rerio*) zebrafish have emerged as a promising model for assessing nanomedicines because of their fecundity, physiological and anatomically similarity to mammals, optical transparency and genetic malleability. It can act as an efficient alternative vertebrate screening model to decrease the number of experiments in higher vertebrates (Fig. 1). Our group is also working to understand the fate of nanomedicines using zebrafish as a model organism.

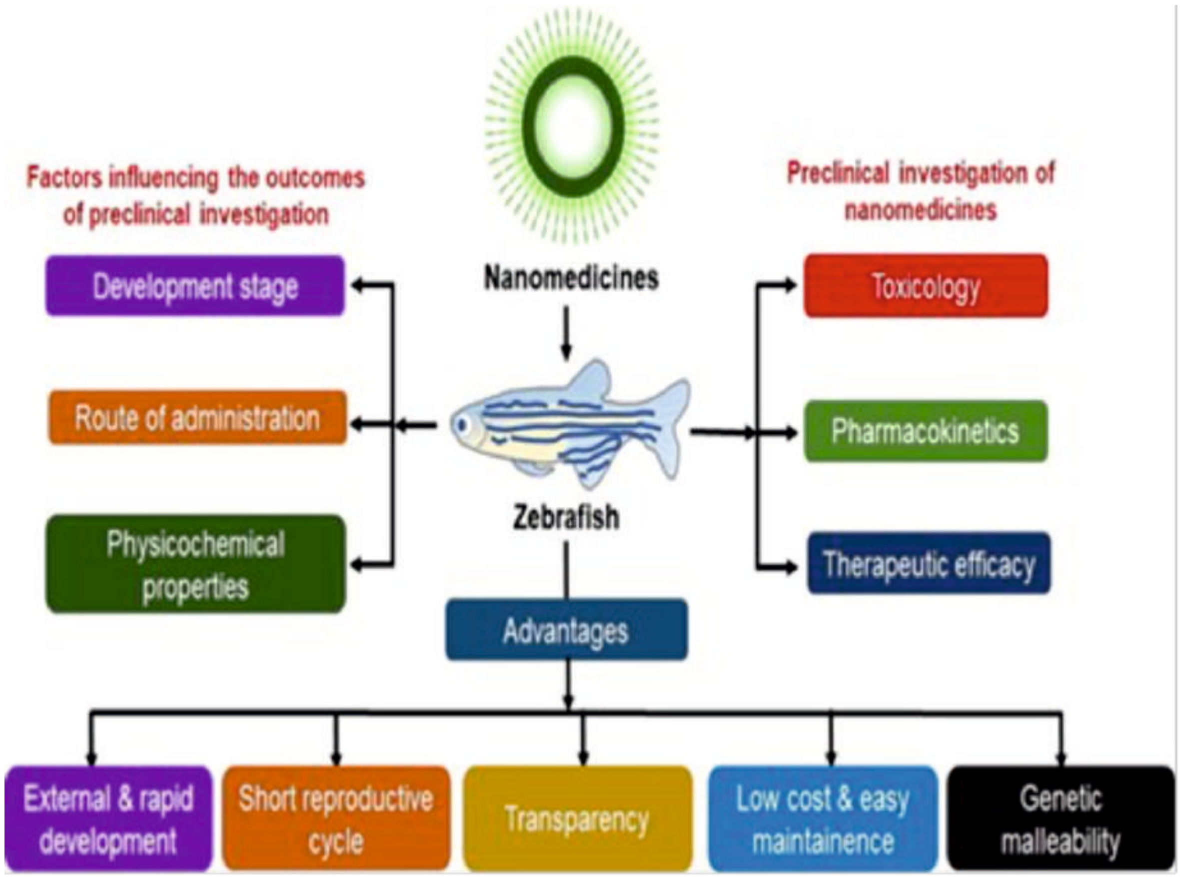

Fig. 1 Zebrafish have emerged as an alternative model for preclinical investigation of nanomedicines because of their fecundity, optical transparency, genetic malleability, low cost and easy maintenance. This model organism has been used for assessing toxicity, systemic circulation, biodistribution and therapeutic efficacy of nanomedicines, which in turn can be helpful in design and optimization of nanomedicines prior to rodent studies. Various factors such as zebrafish development stage, route of administration and physicochemical properties (such as size, surface charge, shape, corona composition or surface modification) of nanomedicine should be taken into consideration because they can influence results of nanomedicines. [Source: Ruchika, Sharma A., Saneja A.* (2022) Zebrafish as A Powerful Alternative Model Organism for Preclinical Investigation of Nanomedicines, Drug Discovery Today 1-10, inpress].

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ENVIRONMENTAL TECHNOLOGY DIVISION

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Biodiversity Conservation, Ecology, and Traditional Knowledge

Our group is primarily involved in field studies and sampling. We survey the hinterlands of Himalaya, conduct ecological sampling, record folk knowledge of the inhabitants, collect soil & plant samples. All the field collected information is analyzed, maintained and digitized for prospection, conservation, and management.

Field explorations: Eight field explorations were carried to the Kinnaur, Lahual & Spiti, Chamba, Kangra and Mandi regions of Himachal Pradesh (Fig. 1). Traditional spices (*Bunium persicum* and *Carun carvi*) were collected from these sites while *Hedychium flavescens*, a member of the family Zingiberaceae, was recorded as a new addition to the Flora of Himachal Pradesh. Status of *Corylus jacquemontii* (Fig. 2) and *Ulmus wallichina* were assessed. These tree species are of multiple utility and require priortized conservation effort.

Fig. 1 Survey & plant collection in alpine regions of HP.

Fig. 2 Fruits of *Corylus jacquemontii.*

Forest sampling: Ecological status of a community managed *'Bohal spring-shed'* forest in the foothills of Dhauladhar mountain was assessed using stratified random sampling. A total of 61 vascular plant species belonging to 33 families were noted in the sampling plots. These comprise of 36 herbs, 15 shrubs and 10 tree species. Overall, the density of herbs varied from 0.02-53.27 individuals/m^2, that of shrubs between 0.05-8.05 individuals/5m^2, and those of trees between 0.05-11.50 individuals/10m^2. A marked difference in the distribution of life forms (herb and shrub) was reported between the disturbed and undisturbed sites in the spring-shed forest (Fig. 3). Diversity indices revealed that for herbs α-richness, α-diversity, and evenness was significantly higher (p=0.05) in undisturbed site whereas for shrubs they were higher in disturbed site.

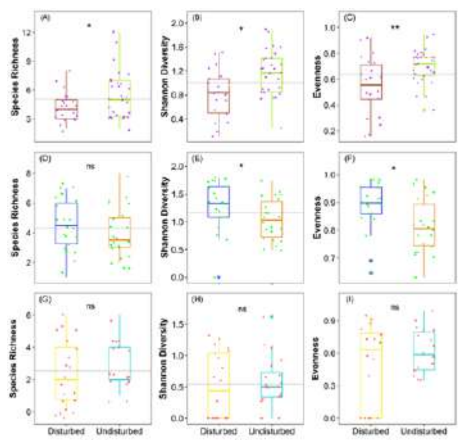

Fig. 3 Species diversity patterns in the disturbed and undisturbed sites in the *Bohal* *spring-shed forest* (Source: 10.1016/j.tfp.2022.100254).

Automated ecological recordings: The group continued its work on phenological monitoring of a *Betula utilis* forest and snow cover patterns through the installed time lapse camera setup. During the reporting period, more than1000 images were auto-clicked. The analyses of these images revealed spatio-temporal patterns of snow cover and growth phases of *Betula*. The recorded images will be of great importance for long-term monitoring vis-à-vis climate change in the Himalaya.

Traditional knowledge and resource use: Fuelwood represents an important resource for the communities of Himalaya. Therefore, knowledge and use of fuelwood species was documented amongst the *Bhangalis* through structured recordings across respondents of different age and gender. *Bhangalis* had knowledge of 29 fuelwood species, however only 22 of these were used as fuel (Fig. 4). A significant difference in the mean number of species known to the *Bhangalis* (10.02 ± 0.2) and those used by them (4.99 ± 0.1) was revealed ($Z = -13.252$; $p < 0.001$). This indicates a declining traditional knowledge. The highest Informant Consensus Factor was recorded for *Picea smithiana* Boiss. (0.88) followed by *Cedrus deodara* G. Don (0.85).

Fig. 4 Fuelwood stored for energy purposes (Source: 10.1007/s10668-022-02188-8).

Transhumance: Migration of communities along with their livestock is a common practice in the Himalaya. It ensures spatio-temporal availability of resources especially fodder for livestock. The *Gaddi* community of the Himalaya has been following it for centuries but now the practice is fast declining (Fig. 5). We, therefore, documented the emerging factors that are leading to a decline in transhumance through personal recordings with the *Gaddis* (n=39). It was revealed that while *Gaddis* still follow transhumance, their interest is declining.

Fig. 5 A *Gaddi* on migration

Table 1 Factors affecting transhumance

Categories	Factors	Number of respondents
Human-wildlife conflict	Theft	33
	Wild animal conflict	20
Environmental	Fodder scarcity	28
	Changing environment	4
	Lesser water availability	2
	Diseases	2
Social	Education	19
	Younger disinterest	9
	Lack of man-power	5
	Hardships	3
Habitat changes	Less forest	11
	Invasive species	9

Setting up of a CSIR-TKDL Point of Presence: With an increased focus on the documentation, validation, and preservation of traditional knowledge and Indian Systems of Medicine; a center targeting Tibetan System of Medicine (Sowa Rigpa) has been established at the Institute. It is engaged in digitizing information that is primarily available in Bhoti language.

Database creation: Characteristics of 200 wild edible plants were digitized for uploading on the Indian Bioresource Information Network portal.

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Remote Sensing and GIS

Our focus is to conserve and manage Himalayan bioresouces using ground and drone based remote senising and geographic information system technologies.

Drone based multispectral remote sensing for non-destructive biomass and nitrogen (N) level estimation in *Stevia rebaudiana*

Drone based modern techniques for crop management were used for biomass and N level estimations for *S. rebaudiana*. These estimations are conventionally done by harvesting of crops, which is tedious, time-consuming, and require expertise and suitable infrastructure.

Fig. 1 Drone image acquisition of *Stevia rebaudiana* from its experimental field design.

The Excess Green Index (ExG) derived from Mica sense Altum multispectral sensor on board (Fig. 1) was identified as best vegetation index for biomass estimation (R^2 = 0.7; RMSE = 23.77 g/m^2; nRMSE = 29.14%). The Enhanced Normalized Difference Vegetation Index (ENDVI) was found as best predictor for N level estimation (R^2 = 0.9; RMSE = 1.75 g/m^2; nRMSE = 14.59%).

This work will provide information on available biomass of *S. rebaudiana* at the time of its harvesting enabling farmers for post-harvest planning. Requisite dose of 'N' at the required crop sections can be done with the precise prediction of nitrogen level in the canopy avoiding its overdose and wastage.

Identification of medicinal plants using hyperspectral remote sensing techniques

Identification of medicinal plants in the field requires taxonomic skills, which is one of the major bottlenecks in the conservation and management of these plants. In this background, a hyperspectral library of three medicinal plants (*Saussurea costus*, *Valeriana jatamansi* and *Picrorhiza kurrooa*) were prepared by collecting its spectral data from Himachal Pradesh and Uttarakhand states of Indian Himalaya (Fig. 2). The Random Forest classifier has identified Green (555-598 nm), red (605 nm), and NIR (725-840 nm) wavelength regions suitable for discrimination of above medicinal plants. The findings of this study have provided an approach for rapid and onsite identification of the medicinal plants in the field.

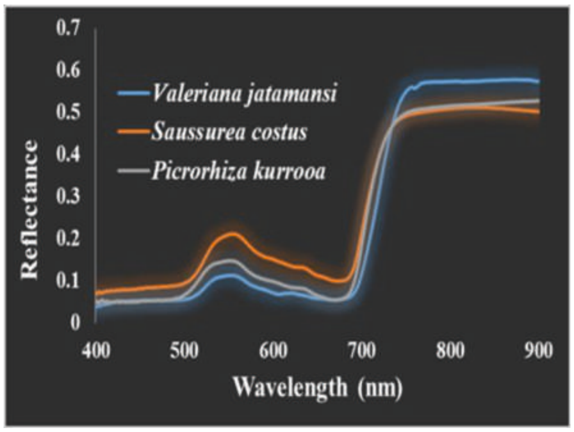

Fig. 2 Spectral signatures of medicinal plants.

Delineation of alpine treeline ecotone of Himalaya using satellite remote sensing for climate change studies

Remote sensing data such as Resourcesat-1, Resourcesat-2, Landsat-1, Landsat-2 and Landsat-3 images, Cartosat Digital Elevation Model (DEM) were used for digital image processing and niche modelling to delineate treelines of Himalaya during the period 1970 to 2014. Shift of *Betula utilis* to higher elevation regions in the Indian Himalaya was observed due to increasing diurnal temperature range. The treeline shift was highest in Arunachal Pradesh Himalaya and lowest in Jammu and Kashmir Himalaya.

Development of protocol for prioritisation of watershed requiring conservation measures

Himalayan terrains consist of several watersheds which have varying levels of degradation. These watersheds can be prioritised for conservation depending upon their degree of severity. Geoecology based prioritisation of watersheds was identified as a holistic approach. This considers several geoecological factors like elevation gradients, geological age, drainage parameters, mean annual temperature and mean annual rainfall of the watersheds for the prioritisation. This study when performed in the Kangra region of Himachal Pradesh, India, Baner river was prioritised for conservation among its 10 watersheds.

For the accuracy assessment of the obtained result a ground truthing of the Baner watershed was done and it was observed that the identified watershed was geoecologically unstable requiring suitable conservation measures.

Automated flower enumeration method developed for the floriculture industries

Estimation of flower yield at the time of their harvesting is an important aspect for post-harvest strategizing for their marketing. Conventionally, flowers are counted manually for their yield estimations, which can be laborious and time-consuming. Therefore, we have developed an automated approach for counting of *Tagetes* flowers from its picture captured at the time of its harvesting using digital image processing techniques (Fig. 3). The process was repeated several times for the robustness of the technique. The validation of the results was done by comparing the manual and automated counting. The obtained result was 96.66% accurate.

Fig. 3 Automatic counting of Tagetes flowers.

Air Pollution Tolerance Ability (APTI) assessment of preferred indoor ornamental potted plants

The Air Pollution Tolerance Index (APTI) of 15 commonly used indoor ornamental plant species was estimated from their foliar portion using their biochemical parameters like chlorophyll (total), pH, relative water content, and ascorbic acid. Among all the plants, *Dracaena deremensis* and *Ficus benjamina* were identified as tolerant; eight species (*Spathiphyllum wallisii*, *Epipremnum aureum*, *Philodendron bipinnatifidum*, *Dieffenbachia seguine*, *Sansevieria trifasciata*, *Hedera helix*, *Chrysanthemum* *indicum*, *Ficus elastica*) were moderately tolerant. The *Chlorophytum comosum* was intermediately tolerant and four were sensitive (*Rhapis excels, Chamadorea seifrizii, Dypsis lutescens, Gerbera jamesonii*) towards air pollution. It was revealed that the APTI can be used as a screening parameter of appropriate indoor plant species for indoor pollution abatement.

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Plant Ecology

Studying Impact of Climate Change on Treeline and Alpine plants

(a) Monitoring of timberline forests

The 04 Long Term Ecological Research (LTER sites) were utilized to study the following: -

- Nutrient Resorption Efficiency (NRE) of macro- and micro-elements during senscence of *Betula utilis*, a key treeline species. NRE was found to be more than 50%.
- Parameterization of BIOME BGC and CENTURY models for estimating changes in Net Primary Productivity (NPP) and nutrient cycling respectively in the timberline forests.

An increase was found in the NPP of timberline forests during the period of study.

(b) Monitoring of alpine vegetation

Field studies and ecological monitoring was undertaken in LTER plots, which were established along an elevation gradient [a total of 4 elevations (3550m, 3850m, 4150m and 4350m)] at Rohtang (32°22' N 77°16' E). We used a random-plot design to manipulate snowmelt timing. At each elevation, we randomly placed 10 plots (2.5 x 5 sq.m) with 5 replicate plots per treatment (control and early snowmelt). The data on phenology of dominant alpine species was collected along with population assessment and recording of vegetative and reproductive traits. It was found that species with acquisitive and conservative strategies give an elevation specific response to increase in growing season length.

Studying adaptation strategies of high altitude plants

(a) Alpine shrub-herb interactions

We studied dominant alpine shrubs interactions with associated herbaceous flora to know the type of interaction, and further how it is influenced under varying environmental conditions along elevation gradient. A representative alpine region of western Himalaya (31.34° to 33.14° latitudes) was targeted to study shrub-herb interactions of three dominant shrubs with distribution in the region.

It was found that the shrub-herb interactions are competitive and the herbaceous communities associated with the alpine shrubs exhibit resource acquisitive functional strategies.

(b) Variability in ecophysiological and anatomical traits of *Rhododendron anthopogon*

Leaves were sampled at an elevation of 3990 m amsl in western Himalaya (at Rohtang), at 10 time-points spanning a period of one year for estimating key ecophysiological (relative water content (RWC), leaf dry matter content (LDMC), specific leaf area (SLA), Nitrogen (N), Phosphorus (P), and sugars content (glucose, sucrose, fructose, raffinose, inositol) and anatomical traits. It was found that there is higher variability in showing specific patterns as a response to seasonality, the anatomical traits, however, were relatively less variable. Further, the plasticity index was highest for sugars (0.52-0.95) and lower for anatomical traits (<0.30).

Ecological studies on high altitude vegetation

Pangi valley was floristically explored to document species diversity in the region. Besides, field surveys were conducted in the high altitude region for knowing the distribution and collection of accessions of targeted medicinal plants. More than 700 species of higher plants were recorded in the region.

Conservation of threatened medicinal plants

The field genebank, established at CSIR-Centre for High Altitude Biology was enriched with 40 threatened plant species and more accessions were added with collection from different locations in Himachal Pradesh.

The information and photographs of 52 high altitude species included in the Plant Conservatory at CeHAB was compiled in the form of a book under *Trek and Learn Series* of CSIR-IHBT and released on 26/09/2021. Out of the total species included in the book, 35 species are reported to be threatened in various assessments, 33 being native and 04 species are endemic to Himalaya.

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Plant Ecology

The work focuses on ecological studies, population assessment along with morphological characterization of threatened, and economically important plant species in the high altitude regions of the Indian Himalaya. Also, involved in field genebank conservatory studies at the Centre for High Altitude Biology (CeHAB of CSIR-IHBT) Ribling, Lahaul and Spiti (HP).

High Altitude Ecological Research

Focused ecological studies on the targeted medicinal and aromatic plants were carried out. A survey was conducted to different habitats in the high altitude areas of Himachal Pradesh (latitude 32°06'–32°54'N and longitude 76°10'–78°19'E), and the Laddakh Union Territory region to observe ecological and phenological parameters. A total of 19 sites were surveyed along with an altitudinal range of 2946 to 4494m amsl. Population assessment of species such as *Angelica glauca*, *Carum carvi*, *Arnebia euchroma*, etc. was conducted (Fig. 1). To develop a field genebank, accession samples of *Angelica glauca*, *Arnebia euchroma*, and *Carum carvi* were collected from the surveyed sites.

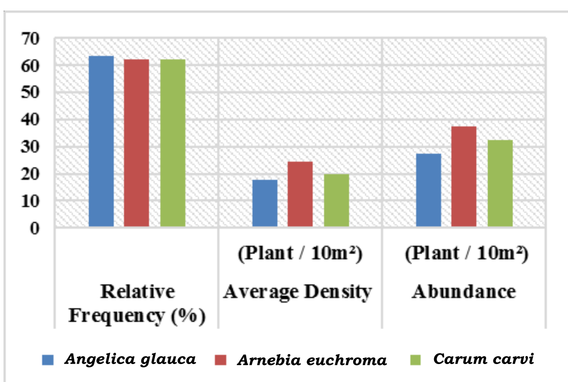
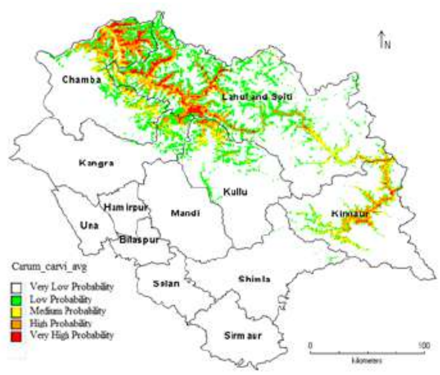


Fig. 1 Distribution pattern of threatened medicinal species in the western Himalaya.

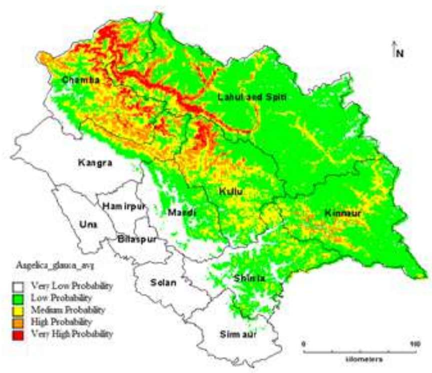
Environmental Niche Modeling

Performed Niche modeling to predict the geographical distribution of the targeted species in the Himachal Pradesh (Fig. 2).

Carum carvi



Angelica glauca



Arnebia euchroma

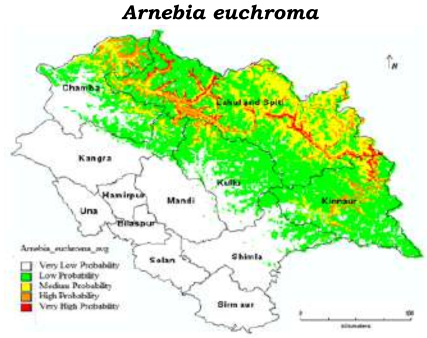


Fig. 2 Habitat suitability and distribution of targeted medicinal plants in Himachal Pradesh.

- Suitable locations for the re-introduction of *Carum carvi* (4.98%), *Angelica glauca* (8.94%), and *Arnebia euchroma* (5.74%) were identified

Field Gene-bank Conservatory

Aimed studies on the conservation of threatened medicinal species were done at CeHAB Ribling, Lahaul & Spiti, HP (3450m amsl), and CSIR-IHBT Palampur (1328m amsl).

- ***Angelica glauca*:** Conserved 23 different accessions collected from Western Himalaya. About 2050 quality plants were successfully raised by seeds and root cuttings in the field gene bank at CeHAB of CSIR-IHBT and CSIR-IHBT Palampur (HP).

- ***Carum Carvi*:** Conserved 16 accessions of *Carum carvi* in the CeHAB farm, farmer's field at Lahaul, and Kullu. Also, conserved 18000 quality plants and harvested 2 Kg seeds from the nursery at CeHAB of CSIR-IHBT Ribling, Lahaul & Spiti (HP).
- ***Arnebia euchroma*:** Conserved 10 different accessions and 500 quality plants in the CeHAB field-gene bank. The plants are being propagated through seeds with conventional and tissue culture methods.
- ***Aconitum heterophyllum*:** Conserved 5 accessions and 7500 quality plants in the field gene bank at CeHAB Ribling, Lahaul-Spiti. Also, harvested seeds (1.0 Kgs) from the CeHAB field genebank.

- ***Sinopodophyllum hexandrum:*** A total of 30 accessions, 1800 quality plants were conserved, and 1.50 Kg seeds were harvested from the field conservatory.

- ***Picrorhiza kurrooa***: Conserved and successfully raised 9000 quality plants of 5 accessions collected from the Chamba, Lahaul & Spiti in the field gene bank at CeHAB.
- ***Rheum australe*:** Conserved 5 accessions and 130 quality plants in the field gene bank at CeHAB Ribling (3450m amsl).

Other important threatened species like *Artemissia maritima, Bunium persicum, Eremurus himalaicus, Inula racemosa, Saussurea costus, Valeriana jatamansi,* were also mass conserved in the genebank of CeHAB/Herbal garden.

Characterization for the selection: Elite accessions of *Arnebia euchroma* from Rarik-

Darcha site in Lahaul; *Carum carvi* from Khangsar site in Lahaul; *Angelica glauca* from Sissu site in Lahaul; *Sinopodophyllum hexandrum* from Hamta site in Kullu, etc. were selected based on their superior physical appearances.

Technology demonstrated

- Medicinal plants like *Aconitum heterophyllum, Carum carvi, Angelica glauca, etc.* were demonstrated in the farmer's field (>100 farmer's) in the Lahaul & Spiti (HP).
- Constructed 20 new dome-shape shade-net houses at CeHAB, Ribling (Lahaul & Spiti) for protective cultivation of medicinal plants in the plant conservatory.

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Herbarium and Plant Taxonomy

Our research group is working on the field exploration, collection and identification of Himalayan plant species. Currently, our research focuses on the taxonomic revision of the genus *Cremanthodium* in Indian Himalaya, elite identification of cryptic species though molecular tools and conservation and management of medicinal and threatened plant species of the Himalayan region.

Floristic survey and collection of plant specimens: For the floristic study and collection of voucher specimens for herbarium enrichment, four field tours were conducted in different parts of western (Rohtang Pass, Lahaul and Spiti, Himachal Pradesh; Chamoli, Uttarakhand) and eastern Himalaya (Tawang, Arunachal Pradesh) during 2021-22, and more than 100 samples were collected of which 85 were identified and processed for herbarium. Besides, more than 600 photographs of plants and landscapes were also clicked.

Taxonomic novelties: During field survey and collection of plant specimens in Himalayan region, four species viz. *Alangium alpinum* (C.B. Clarke) W.W. Sm. & Cave (Cornaceae), *Euphrasia officinalis* L. (Orobanchaceae), *Geranium refractum* Edgew. & Hook.f. (Geraniaceae) and *Sedum filipes* Hemsl. (Crassulaceae) were reported for the first time from Arunachal Pradesh. In addition a zingiber i.e. *Hedychium flavescens* Carey ex Roscoe (Zingiberaceae) was also reported as a new distributional record for Himachal Pradesh (Fig.1).

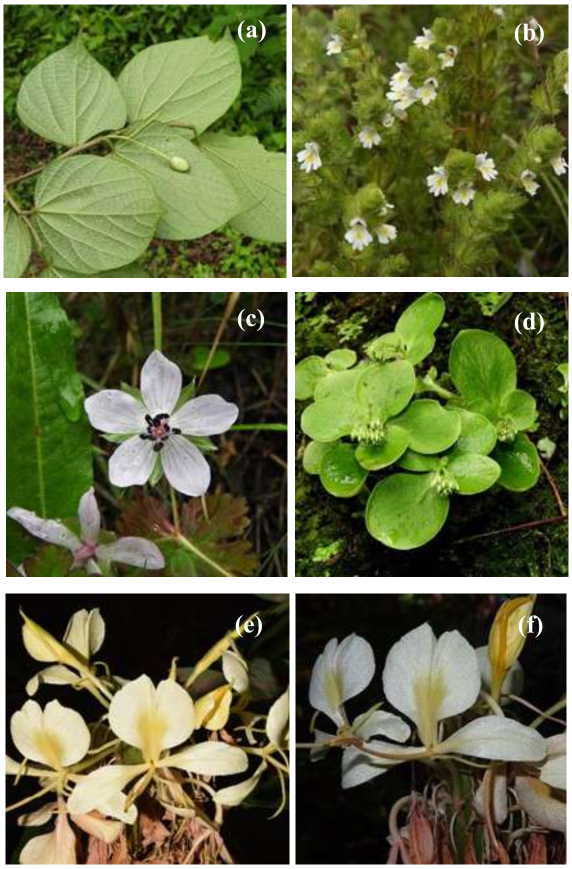

Fig. 1 a. *Alangium alpinum*; b. *Euphrasia officinalis*; c. *Geranium refractum;* d. *Sedum filipes*; e & f. *Hedychium flavescens.*

Taxonomic studies of the genus *Cremanthodium*: For taxonomic revision of genus *Cremanthodium,* a checklist of species distributed in India was prepared. To record the locality and distribution range herbarium specimens from DD, PLP and CAL were also consulted. During field tours, six species were collected and photographs depicting the habit of the plants, close-up view of flowers, landscape vegetation etc. were also taken. Additionally, the leaf samples were collected for molecular study. Some of the photographs of landscape and plant species collected during the field tours are provided in Fig. 2.

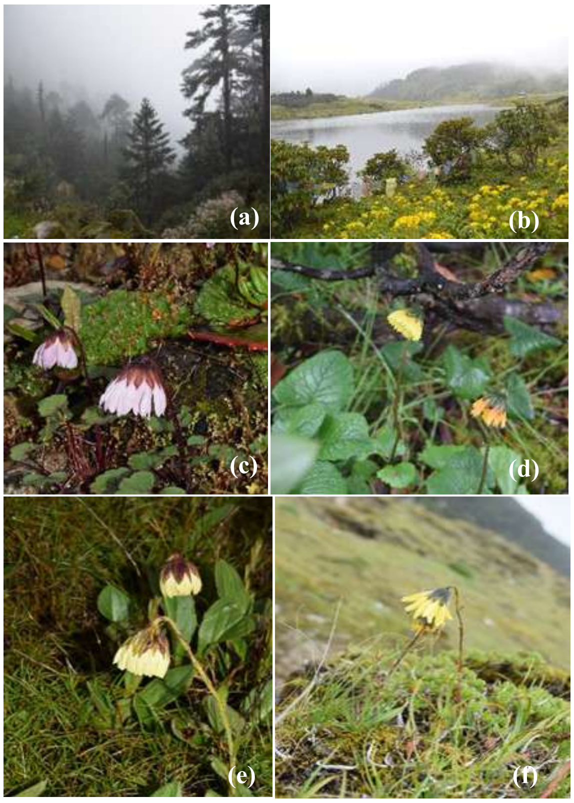

Fig. 2 a. Coniferous forests at Tawang, Arunachal Pradesh; b. PTSO Lake, Tawang; c. *Cremanthodium rhodocephalum*; d. *Cremanthodium reniforme*; e. *Cremanthodium indicum*; f. *Cremanthodium conaense*.

Tagging of trees at CSIR-IHBT campus: After documentation of different tree species at CSIR-IHBT campus, signage board/ name plate of each species were placed for easy identification and knowledge dissemination (Fig . 3).

Fig. 3 Tagging of Trees of CSIR-IHBT campus.

Establishment of Herbal Garden: For conservation of high value Himalayan medicinal plants the establishment of an herbal garden is under process. It is proposed to conserved more than 120 medicinal plants of which, 25 have been planted.

Research group: Mr. Rahul Kumar

CENTRE FOR HIGH ALTITUDE BIOLOGY (CeHAB)

CENTRE FOR HIGH ALTITUDE BIOLOGY (CeHAB)

Location: Tandi, Lahaul and Spiti (Trans Himalaya and cold desert ecosystem) in TRIBAL REGION (32°34ʹ13.9″N, 76°58ʹ32.0″E, 3450 m asl (11,200ft); Area: 20 ha

Mission

To connect to innovate for ecology, economy and societies of higher Himalayas through fundamental and industrial research.

Activities:

- Ecological studies in the high altitude region for elucidating the patterns of vegetation distribution.
- Documentation of biodiversity ethno-ecological knowledge of the high altitude region.
- Monitoring of high altitude vegetation vis-à-vis Long Term Ecological Research (LTER) plots.
- Assessment of distribution of threatened medicinal plants and the factors responsible for the rarity.
- Devising strategies for conservation of these plants by *ex situ* means *viz.*, field banks, nurseries and germplasm repositories
- Standardizing protocols for mass propagation of rare and threatened medicinal plants.
- Bioprospecting of plants and microbes for useful metabolites, processes and value added products.
- Value addition of local traditional crop resources for making commercially important food products, oils *etc.*
- Introduction of high value crops of commercial importance.
- Conducting awareness programmes, popularize science and to provide trainings to farmers as well as other self-help groups and entrepreneur.

Ecological Studies in High Altitude

- Pangi Tehsil of District Chamba was floristically explored and more than 700 species of higher plants were recorded in the region.
- High altitude region was explored for alpine shrubs interactions with associated herbaceous flora were studied to know understand their interactions. These interactions were found competitive in nature and the herbaceous communities associated with the alpine shrubs were observed to exhibit resource acquisitive functional strategies.
- An alpine evergreen shrub, *Rhododendron anthopogon* was studied for understanding the variability in ecophysiological and anatomical traits at different times during the period of its growth. A higher variability was found in all the studied eco-physiological traits which also showed specific patterns as a response to seasonality. The anatomical traits, however, were found to be relatively less variable. Further, the plasticity index was highest for sugars (0.52-0.95) and lower for anatomical traits (<0.30).

Monitoring of high altitude vegetation vis-à-vis Long Term Ecological Research (LTER) plots

Nutrient Resorption Efficiency (NRE) of macro- and micro-elements during senscence of *Betula utilis*, a key treeline species. This was studied in the 04 LTER sites already established in the treeline zone. It was found that NRE was more than 50% during senescence period.

- Parameterizating the BIOME BGC Model revealed increase in NPP of timberline forests during the period of study.
- LTER plots were also established along an elevation gradient (a total of 4 elevations (3550m, 3850m, 4150m and

4350m)) in alpine region at Rohtang (32°22' N 77°16' E) and using a random-plot design to manipulate snowmelt timing, the growing season was altered. It was found that species with acquisitive and conservative strategies give an elevation specific response to increase in growing season length.

Conservation of threatened medicinal plants

Establishment of Field Genebank

- The field genebank, established at CSIR-Centre for High Altitude Biology was enriched with 40 threatened plant species and more accessions were added with collection from different locations in Himachal Pradesh.
- A book entitled "Plant Conservatory at Centre for High Altitude Biology of CSIR-IHBT" was released on 26/09/2021, under the *Trek and Learn Series* of CSIR-IHBT for awareness among the local people, concerned officials and the students in the region. It contains information and photographs of 52 high altitude species. Out of the total species included in the book, 35 species are reported to be threatened in various assessments, 33 being native and 04 species are endemic to Himalaya.

Plant Tissue Culture of threatened medicinal plants

Fritillaria roylei

Fig. 1 Micropropagation protocol established in *F. roylei*.

Fritillaria roylei being a potential but endangered herb, restoration in nature is crucial for rescuing the plant from endangered status (Fig. 1).

- Complete *in vitro* propagation method established in *Fritillaria roylei* for sustainable resource generation and conservation.
- Sustainable regeneration protocol for bulb production achieved as rehabilitation into natural using storage organs is more effective.
- *En masse* proliferation of *Fritillaria roylie* and *Picrorhiza kurrooa* done and transferred to natural habitat for rehabilitation and conservation with an aim to give farmer an alternate option of income generation and minimize the exhaustive & indiscriminate harvesting from wild.

Nardostachys jatamansi

In vitro mass production of *Nardostachys jatamansi* – a critically endangered high value medicinal plant of Himalaya was done (*S.Afr.J.Bot.* 140: 468-477, 2021).

- Low-cost (reduced by 6.4 times) direct and indirect micropropagation protocol was established (Fig. 2)
- Hardening of *in vitro* plantlets achieved with 83% survival in sand and sand plus soil
- Hardened plants transferred to field of a farmer with 60 % survival
- The present micropropagation method developed for *N. jatamansi* can have potential app locations in medicinal plant- based industry

Fig. 2 Indirect and direct propagation methods established in *N. jatamansi*.

Experimental Trials of Heeng and Kala Zeera

Heeng (*Ferula assa-foetida* L.) is a perennial herb belongs to Apiaceae (Umbelliferae) family and is a well-known condiment and medicine in India, Pakistan, and Persia (Iran). Commercially, *Heeng* is extracted from the roots of *F. assa-foetida* plants as an oleo-gum resin. There is no established agro-technique of *F. assa-foetida* to promote its cultivation. Little research has been done to characterize the existing populations of *F. assa-foetida*. It is unclear whether this plant behaves differently due to climatic conditions and agro-technique. Therefore, there is a pressing need to do the agronomic evaluation in cold desert regions of Indian Himalayas. Agronomic trails of *F. assa-foetida* is being conducted at CeHAB, Ribling to standardise its basic agrotechnology. For promoting its large-scale cultivation, planting material was distributed and on-farm training programme on *Heeng* cultivation was organised at villages Keylong, Triloknath, Gondhla and Salgram of Distt. Lahaul & Spiti in which 62 local farmers participated (Fig. 3).

Fig. 3 Seed Production Centre of *F. assa-foetida* at CeHAB.

Kala zeera {*Bunium persicum* (Boiss.) B. Fedtsch.} is another high-value aromatic and medicinal herb of high altitude region extensively used for culinary, flavoring food and beverages, perfumery and carminative purposes. The unsustainable collection of *B. persicum* from forests has made it vulnerable to extinction due to lack of cultivation. Diverse populations of *B. persicum* were collected from Chamba, Kinnaur, Lahaul and J&K and conserved at CeHAB, Ribling for selecting genetically and agronomic superior lines from the existing population coupled with suitable agro-technique for bringing it under cultivation.

Night Soil Composting for the benefit of society

The traditional practice of night soil composting has been declining lately and the major limitations associated with night-soil composting were the delayed degradation process due to low ambient temperature and limited microbial load causing foul odor and unhygienic conditions. The night-soil composting process required scientific improvisation to accelerate the degradation process so that the foul odour, heavy metal content, and pathogenicity associated with night-soil composting could be controlled. In our laboratory, we have carried out the quality assessment, safety evaluation, and microbiome analysis of the night-soil compost from Lahaul valley. Based on the fertility and clean indices determined by the fertility and heavy metal parameters, night-soil compost (NSC) was categorized as good quality compost with high fertilizing potential and moderate concentration of heavy metals. With respect to pathogens, the faecal coliform levels in the NSC were categorized as safe according to the U.S. Environmental Protection Agency standards. The bacterial community structure based on 16S rRNA gene amplicons revealed a diverse taxonomy with 14 phyla and 54 genera in NSC. Additionally, pathogenic bacteria with antimicrobial resistance (AMR) genes in the NSC metagenome were determined that revealed 139 pathogenic strains with most pathogens susceptible to antibiotics, indicating lower AMR in the predicted strains. The phytotoxicity of NSC with *Pisum sativum* var. AS-10 seeds showed a germination index of >85%, indicating NSC's non-harmful effects on seed germination and root growth. Overall it was concluded that the NSC from Himalayan dry toilets can be used as a soil amendment for food and non-food plants. Furthermore, indigenous psychrotrophic bacteria with efficient hydrolytic and plant growth-promoting attributes have been recovered from matured night-soil compost. The product called 'Compost Booster' using indigenous bacteria from Lahaul valley has been developed which can efficiently degrade the night soil and produce a humanure rich in nutrients for plants. The product was prepared at the CeHAB center by mixing the bacterial consortia with suitable carrier materials and distributed in Lahaul valley, covering five gram-panchayats (Gushal, Muling, Tandi, Jahlma & Yurnath) and more than 15 villages (Fig. 4). Four societies of Lahaul valley viz. Krishi Seva Sehkari Sabha Samiti, Goushal village, Lahaul & Spiti, HP; Mahila Mandal Mooling village, Lahaul & Spiti, HP; Gram panchayat Tandi village, Lahaul & Spiti, HP and, Life and Heritage of Lahaul, Keylong, Lahaul & Spiti, HP have signed material transfer and consultancy agreement for the procurement of "Compost Booster" for stabilization of night soil.

Fig. 4 Production of "Compost Booster" at CeHAB and its distribution.

PLANNING, PROJECT MONITORING AND EVALUATION - BUSINESS DEVELOPMENT AND MARKETING UNIT

Planning Project Monitoring & Evaluation

Institutional Research Planning

Facilitated formulation of various documents sent to CSIR headquarters, compiled significant achievements of CSIR-IHBT for the society meeting, details of significant achievement (2015 to 2021), prepared PAB document with vision & strategy and action plan, ATR on monthly meeting of DG CSIR with the Directors, information on women specific initiatives, Indian S&T Diaspora-Portal/Database, information for NIRF 2022, institute's interventions on agricultural improvement and in NER etc. and action taken towards achievement of goals were regularly furnished to the competent authority.

For constant updating institutional data on various domain, 112 proforma and report on daily basis were uploaded on to C-DIS portal during 2021-22. PPME recorded initiation of 46 new projects funded by various agencies (DBT, DST, SAC, Indo-French Centre for the Promotion of Advanced Research, NMHS, HIMCOSTE etc.). As a part of routine activity, carried out updation and maintenance of databases pertaining to project, staff, paper, patent, ECF, resource management etc. For facilitating decision making, the Division carried out monitoring of institutional performance with respect to publication, ECF, patent, technology transfer and societal impact. The division also compiled Institutional information for CSIR Annual Report. PPME furnished inputs to 32 parliament questions received form CSIR.

PPME organized the events of national importance as detailed below:

- National Technology Day (11th May, 2021)
- World Environment Day (5th June,2021)
- CSIR-IHBT Foundation Day (2nd July, 2021)
- CSIR Foundation Day (26th Sepetember,2021)
- The Curtain Raiser Ceremony of the Indian International Science Festival (IISF) 2021 (6th December, 2021)
- Swarn Jayanti Tea Fair – 2021 in collaboration with HP State Agriculture Deptt (14th December, 2021)

The Division conducted 61st and 62nd Meeting of Research Council of the Institute on 30th June and 20th December, 2021, respectively.

PPME proactively supported the following programmes organized at the institute:

- Induction programme for newly recruited scientists (39th batch) organized by CSIR-HRDC, Ghaziabad at CSIR-IHBT (23-29th October 2021)
- Visit of Hon'ble Governor of Himachal Pradesh, Shri Rajendra Vishwantah Arlekar ji on the occasion of National Science Day (28th February, 2022)
- Visit of Shri Loknath Sharma, Hon'ble Minister, Agriculture, Horticulture, AH&VS, IPR, Printing & Stationary, Government of Sikkim (17th February, 2022)

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 equipment. To cater to manpower need of the institute, appropriate steps were taken to seek approvals and induct new manpower. Lab strategic Group (LSG) has been formed in accordance with CSIR guidelines and monitoring meeting of major projects are taken-up on weekly basis.

IT based activities: The information related to Institute's activities were promptly posted in social media (Facebook, Tweeter, YouTube etc.) and sent to CSIR headquarters for its inclusion in CSIR in Media news bulletin. Information were regularly updated and flashed in intranet as well as Institute website.

Right to Information: Furnished information on 62 queries under RTI Act and filed quarterly report to RTI portal www.rti.gov.in.

CPGRAMS: Two grievances received during the year for which needful action taken and case have been disposed-off.

Research group: Dr RK Sud, Dr Avnesh Kumari and Mr Jasbeer Singh

BUSINESS DEVELOPMENT AND MARKETING UNIT (BDMU)

This unit is making its all efforts 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 2021-22, BDMU facilitated for signing 316 agreements/MoUs including, ten technology transfers, two hundred sixty-three material transfer agreements (MTAs), one consultancy service for establishment of shiitake cluster, twenty-nine miscellaneous MoUs signed with different farmer societies, academic and R&D collaborations with government institutes/universities, IITs and thirteen MoUs/Agreements under "Chief Minister's Start up Scheme" 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 MoUs with government institutes, responding queries of clients, raising expression of interest (EOI) for different technologies, raising FVC for timely payment of GST related to BDMU, procurement of services related to open / global tenders, socio-economic impact analysis of technologies/ services from third parties and providing inputs for drafting technology specific documents.

Transfer of Technologies

During 2021-22, CSIR-IHBT has signed ten agreements for transfer of technology i.e (i) commercial production of making herbal soap (bars) with Suhavi Producer Company Ltd., Village Kangar P.O. Basali, Tehsil Anandpur Sahib, District Rupnagar, Punjab, (ii) manufacturing/ processing of (i) Granola bars - (millet & cereals based), and (ii) Spirulina peanut bar products with M/s Komal Innovation & Wellness Initiative, Shed No. 4, Industrial Area, Nagrota Bagwan, Kangra (HP), (iii) Technology for cultivation of Shiitake mushroom to its implementation at large scale with M/s Gaurav Agro Foods, Plot no. 28, Industrial Area -2, Nagri, Palampur (HP), (iv) Technology for cultivation and production of medicinal plants (Picrorhiza, Valeriana) under hydroponic system, tissue culture protocols and extraction of the produce with M/s Amar Exports, 6-3-1239/2, 2nd floor, Raj Bhavan Road, Somajiguda, Hyderabad, TG, INDIA, (v) Agreement need based R&D Project with M/s Algareal Nutraceuticals, G3, Vaasthu Nirvaan, No. 26, Railway Parallel road, Nehru Nagar, Bangalore, (vi) Technology transfer agreement for Herbal Formulation for Immunity Modulation with M/s Ras Vaidyashala, Jobner, Jaipur, Rajasthan, (vii) Technology for making, manufacturing, designing and using the distillation units of different capacities with M/s Kontact Consortium India Pvt. Ltd., Sidco Nagar, Villivakkam, Chennai, (viii) Technology for making travel/pocket perfumes (4-5 variants) with M/s The Fragrance, Ward No. 8, M C Palampur, Maranda, District Kangra (HP), (ix) Technology/ process for ready to eat instant seera in the convenience package with M/s Yuktika Biotech Pvt. Ltd., Bharmat Palampur, (x) Making/ preparation of Tea Mouthwash with The Unati Cooperative Marketing-cum-Processing Society Ltd. Talwara, District Hoshiarpur, Punjab.

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Transfer of Technology, Business Development, Techno-economics, Promotion of technologies, Establishing Institute's linkages with Industries/ Startups/ Farmers and R&D Institutes/ Academia

Research Focus: Transfer of technology, business development, techno-economics, promotion of technologies, establishing Institute's linkages with industries/ startups/ farmers and R&D Institutes/ academia. Working as PI in DSIR Sponsored Project, "Studies on Technology and Innovation". Nodal Scientist for Vertical, "Establishing effective domestic and international market linkage" in CSIR Floriculture Mission. Acted as Co-PI in the project, "Agro-ecology in Himalayan States with Special Emphasis on Marketing"

Recognition:

- Officially recognized as Registered Technology Transfer Professional (RTTP) by Alliance of Technology Transfer Professionals (ATTP). https://attp.info/current-rttps/
- Received 'Certificate of Merit' during 'CSIR Technology Awards 2021' in the 'Category of Technology Award for Business Development & Technology Marketing' on the Occasion of 80th CSIR Foundation Day celebrated at CSIR HQs, New Delhi in the presence of Hon'ble Vice President of India, Sh. M. Venkaiah Naidu; Hon'ble Minister (S&T and ES), Dr. Jitendra Singh; and DG, CSIR, Dr Shekhar C. Mande.
- Certificate of Appreciation for Participation in International Workshop on 'Technology Transfer and Commercialization' (A virtual event) from 7-8 December, 2021 at Jakarata-Indonesia. Event was organized by Centre for Science & Technology of the Non- Aligned and Other Developing Countries (NAM S&T Centre), New Delhi, India, and National Research and Innovation Agency (BRIN), Republic of Indonesia

Business Development and Marketing unit is focusing on Transfer of Technologies, Business Development, Techno-economics, Procurement of R&D and technical services, Raising FVC, Promotion of technologies, and Liaison with Industries/ Startups/ Farmers and Institutes.

Transfer of Technologies: Interaction with the interested industries/ entrepreneurs/ startups/ farmers related to transfer the technologies/ materials. Drafted agreements/ MoUs/ MTAs as per mutually decided terms and conditions.

During 2021-22, CSIR-IHBT has signed ten agreements for transfer of technology i.e. one agreement to transfer the knowhow for making herbal soap (bars), one agreement to transfer the knowhow for manufacturing/ processing of (i) Granola bars - (millet and cereals based), and (ii) Spirulina peanut bar products, one agreement to transfer the knowhow for cultivation of Shiitake mushroom, one agreement to transfer the knowhow for cultivation and production of medicinal plants (Picrorhiza, Valeriana) under hydroponic system, tissue culture protocols and extraction of the produce, one agreement to transfer the knowhow for ready to reconstitute oral formulations utilizing microalgae and carry out need based R&D project for development of algae based nutraceuticals and derived food formulations, technology transfer agreement for herbal formulation for immunity modulation, , one agreement to transfer the knowhow for manufacturing, designing and using the distillation units of different capacities, one agreement to transfer the knowhow for making travel/pocket perfumes (4-5 variants), one agreement to transfer the knowhow for ready to eat instant seera in the convenience package and one agreement for making/ preparation of tea mouthwash.

Besides these, two hundred and sixty-three material transfer agreements (MTAs); one consultancy project assigned for Norbu Choelling Shiitake Mushroom and other food processing cluster; twenty-nine miscellaneous MoU's signed with different farmer societies, academic and R&D collaborations with government institutes/universities, IITs and District administration; and Thirteen MoUs/Agreements under "Chief Minister's Start up Scheme" for incubation and facility use of CSIR-IHBT were also signed. Details of agreements/ MoUs signed are provided in Rolled out Technologies.

Business Development: New clients (more than 350 numbers) were added to the organization through ToT/MTA/Consultancy agreement and technical services. More than 2,700 number of queries (related to tea based technologies, shiitake mushroom, herbal soap, medicinal and aromatic plants, floriculture, herbal incense cones, herbal lipstick, essential oils, distillation unit 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 also indulged in to selling Institute's Lab (R&D) products like honey, green tea, black tea and rose water with utmost dedication.

Facilitating industry partners/ startups to market outreach their CSIR-IHBT technology based products. Six industry partners, and Seven startups launched their products (herbal oil, immust Pro (immunity booster), herbal soap, sea buckthorn drinks, Hydroponic vegetables and fruits, ready to eat seera, spirulina bars, and millet and cereals based bars in the market.

Techno- economic feasibility evaluation of technologies: Evaluated the TRL (Technology Readiness Level) of technologies, floating EOI on institutes websites and techno- economic feasibility/ cost of production of technologies as this information is required during deal for transfer of technologies. Also evaluated charges for different consultancy projects, sponsored projects, training programmes, and facility availing.

Promotion of technologies: Participated in national and international exhibitions/ trade fairs to represent CSIR-IHBT for promotion of technologies through virtual platforms. Also participated in India International Science Festival from 10-13 December, 2021 in Goa for showcasing the CSIR-IHBT technology based products.

Linkages amongst Academia/ R&D Institutes and Industry: We are also working on to study the extent linkages amongst different academia/ R&D Institutes and Industry in the state of Himachal Pradesh through DSIR sponsored project. We have purposively selected sample size of 50 each from academia (universities, colleges, R&D Institutes) and Industry (food processing, ayurvedic & herbal, pharmaceuticals industry etc.) for survey to get information. We are covering primary and secondary data from sample universities/ R&D institutes and industries related to quantitative and qualitative information on university-industry linkage, competencies, Institutional mechanism, reasons for collaboration, limitations, Govt. support, lab facility, campus interviews. Further, data will be compiled and analysed through suitable techniques (Descriptive Statistics, Regression Analysis) to find out the results for linkages amongst academia, R&D institutes and industries. Besides this, we also created data base for herbal, food processing and NGO/FPO database of Indian Himalayan Region under NITI Ayog sponsored project.

Procurement of Technical/R&D Services: Procured Technical R&D services through inviting tenders. One global tender and two open tenders awarded in this Financial Year.

PROJECT SCIENTIST, WOS-A INSPIRE FACULTY, CSIR-POOL OFFICER, SERB-NATIONAL POST DOCTORAL FELLOW

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Dietetics and Nutrition Technology Division

Polyphenol encapsulates from waste biomass of *C. sinensis* and their simulated oral, gastric and intestinal stability studies.

Polyphenols are secondary metabolites that function against various diseases, metabolic disorders and serious ailments. In recent times various plants are studied in order to explore bioactive phytochemicals. Polyphenols are one of the bioactive metabolites that are widely studied. Extraction of bioactive metabolites from waste biomass is recent area of research; hence purification and HPLC-DAD based quantification of polyphenols from neglected parts (fruit, flower and coarse leaves) of *Camellia sinensis* was carried out (Fig. 1). Purification of polyphenols was performed via fractionation process and purity was attained up to 77%. While quantified content of catechins attained up to 63.3% with excellent free radical inhibition (78.89-97.20 %). Aiming the controlled release of polyphenols with improved shelf life, microencapsulates were prepared by spray drying and freeze drying process. Maltodextrin and soy lecithin were used as two different wall materials and maximum encapsulation efficiency was attained up to 69.05%. Furthermore, quantification of catechins after *in vitro* oral, gastric and intestinal studies presented maximum release in simulated gastric conditions. Maltodextrin encapsulates indicated higher release of catechins whereas soy lecithin found to be relevant for sustained release. Shelf life stability studies of prepared encapsulates indicated fast degradation of polyphenols in free form. However, HPLC-DAD quantification studies of catechins along with antioxidant activity of encapsulates showed good stability with minute variability in content. In conclusion the study offered an encouraging way to incorporate bioactive molecules from waste biomass to value added product formulations.

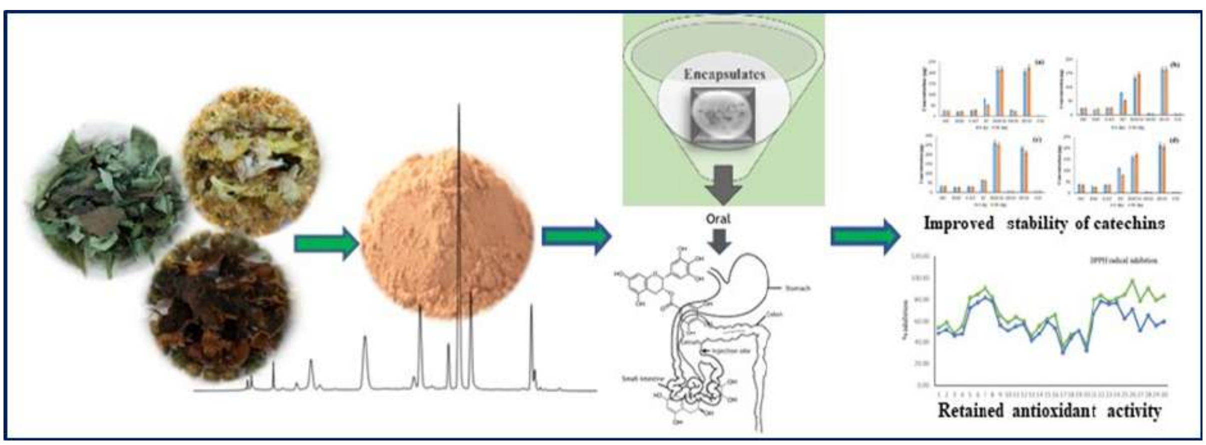

Fig.1 Microencapsulates of catechins extracted from coarse leaves, flower and fruit parts of *Camellia sinensis* and their release profile in simulated digestion model with stability studies.

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Plant Epigenetics and Quantitative Genetics

We are elucidating the role of epigenetics in heat stress adaptation and stress memory in plants. We are also exploring the genomic regions associated with abiotic stress tolerance in plants using multi-locus GWAS and QTL mapping.

Characterization of DNA Demethylase Genes and Their Association with Thermal Stress in Wheat

DNA demethylases (dMTases) are essential proteins in plants that regulate DNA methylation levels. The dMTase genes have been explored in a number of plant species, however, members of this family are not reported in wheat. We identified 12 wheat dMTase genes divided into two subfamilies, repressor of silencing 1 (ROS1) and DEMETER-Like (DML). The TadMTases in the same subfamily or clade in the phylogenetic tree have similar gene structures, and proteins motifs and domains (Fig. 1).

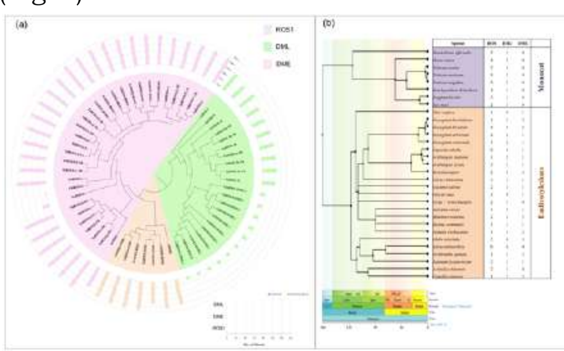

Fig. 1 Evolutionary relationship among various dMTases. (a) Evolution relationship among the 10 plant species (b) Dated phylogeny trees for 31 plant species.

The promoter sequence contains multiple cis-regulatory elements (CREs) that respond to abiotic stress, hormones, and light, suggesting that the majority of *TadMTase* genes play a role in wheat growth, development, and stress response (Fig. 2).

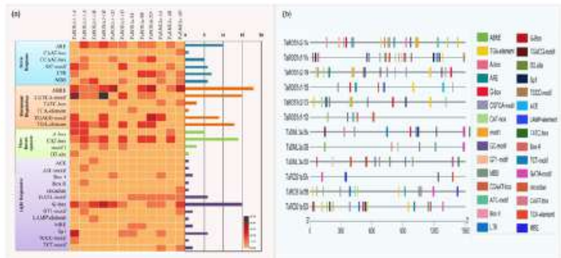

Fig. 2 Cis-regulatory elements (CREs) of wheat dMTases genes.

The NLS and subcellular localization, micro RNA-targeting sites and SRR motifs were also analyzed. The expression profiles analyses revealed that TadMTase genes showed differential gene expression patterns in distinct developmental stages and tissues and under heat stress. Furthermore, the qPCR analysis revealed that TadMTase gene expression differed amongst wheat cultivars with varying degrees of HS tolerance (Fig. 3).

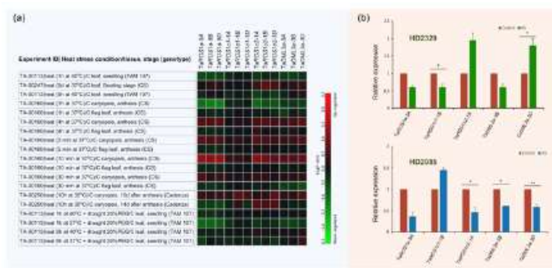

Fig. 3Expression profiles of wheat dMTase genes under heat stress (HS) conditions.

Overall, this work contributes to the understanding of the biological function of wheat dMTases and lays the foundation for future investigations.

Deep Sequencing of Wheat sRNA Transcriptome Reveals Distinct Expression Pattern of miRNAs in Response to Heat Stress During Grain Filling

Assessing plant adaptability to abiotic

stressors has important for plant breeding, particularly in the context of climate change. Micro RNAs and short interfering RNAs play a crucial role in gene regulation. Here, wheat plants were exposed to heat stress at grain filling and grain tissues from three biological replicates were harvested at 10 DAA. A total of four small RNA libraries were sequenced from which 113 conserved and 17 novel miRNAs were predicted. Approximately 55% of the showed differential expression upon heat stress (Fig. 4).

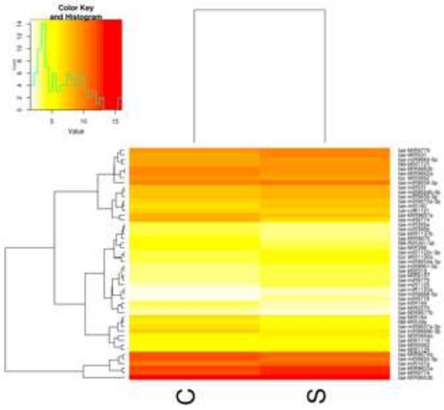

Fig. 4 Differential expression of miRNAs following heat stress.

These mRNAs regulate the stress-responsive genes, involved in the activation of signal transduction pathways and flowering. The above results suggest a temporal miRNA-guided post-transcriptional regulation that enables wheat to respond to abiotic stresses, particularly heat. Such accurate identification and validation of miRNAs and their target genes are essential to develop novel regulatory gene-based breeding strategies.

Multi-Locus GWAS for Grain Weight-Related Traits

In wheat, a multi-locus genome-wide association study (ML-GWAS) was conducted for the four-grain weight-related traits (days to anthesis, grain filling duration, grain number per ear and grain weight per ear) using data recorded under irrigated (IR) and rain-fed (RF) conditions (Fig. 5).

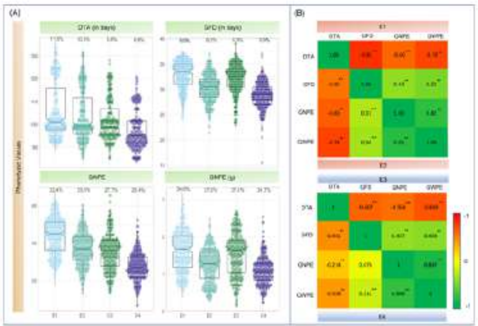

Fig. 5 Boxplots showing the distribution of values for four traits in four environments.

Seven stress-related indices were estimated for these four traits: (i) drought resistance index (DI), (ii) geometric mean productivity (GMP), (iii) mean productivity index (MPI), (iv) relative drought index (RDI), (v) stress tolerance index (STI), (vi) yield index, and (vii) yield stability index (YSI). The association panel consisted of a core collection of 320 spring wheat accessions representing 28 countries. The panel was genotyped using 9627 single nucleotide polymorphisms (SNPs). The ML-GWAS analysis provided 30 significant marker-trait associations (MTAs) for four traits and 153 MTAs were available for the seven stress-related indices (Fig. 6). Five MTAs co-localized with previously reported QTLs/MTAs. Candidate genes (CGs) associated with different MTAs were also worked out. Gene ontology (GO) analysis and expression analysis together allowed the selection of the two CGs, which may be involved in response to drought stress (Fig. 7).

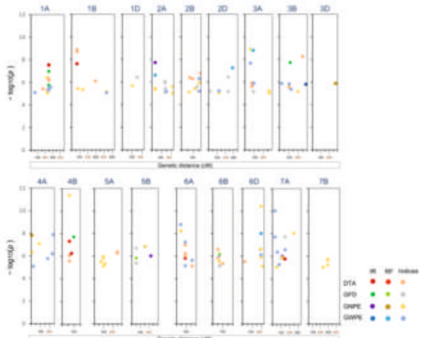

Fig. 6 Significant markers trait associations (MTAs) for four traits and seven indices.

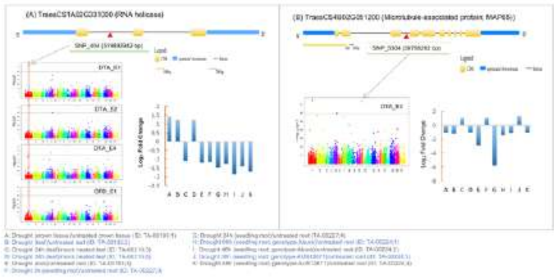

Fig. 7 Structure of the CGs and expression profile of CGs during drought stress.

These two CGs included:

TraesCS1A02G331000 encoding RNA helicase and TraesCS4B02G051200 encoding microtubule-associated protein 65. The results supplemented the current knowledge on genetics for drought tolerance in wheat. The results may also be used for future wheat breeding programs to develop drought-tolerant wheat cultivars.

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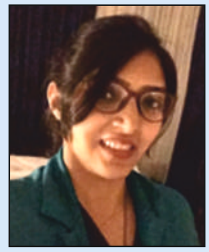
Plant Molecular Physiology



Plants in Himalayas face extremes of environmental conditions in terms of temperature, soil and water availability. They adopt varied survival strategies to adapt these variations. Among the freeze survival strategies, production of antifreeze proteins (AFPs) gained prominence. During freezing, ice forms due to crystallization of water molecules and it grows due to ice recrystallization. Larger molecules of ice are lethal for cells because of physical stress they cause to the plasma membrane. The antifreeze proteins possess ice recrystallization inhibition (IRI) property by which, they bind to the ice crystals and retard their growth during recrystallization. This ice structuring property gives them the name of ice–structuring proteins (ISPs). ISPs are of immense benefit during cryopreservation in food and medical industry. Therefore, my research is focused on identifying ISPs from Himalayan grains and evaluating their application potential in food and medical industries.

Identification of ice structuring proteins from Himalayan grains and their recombinant expression

The Himalayan food grains were screened for IRI activity. Amongst, Himalayan barley variety, *Hordeum vulgare* var. *dolma* exhibited maximum IRI activity. The total protein from grains of *Hordeum vulgare* var. *dolma* with ice structuring properties (ISE) reduced the drip loss and prevented the freeze-induced loss in vitamin B4, vitamin B6 and vitamin C in green peas (Kashyap and Kumar, 2022). To purify ISPs from this crude extract (ISE) of barley, it was fractionated with ammonium sulphate precipitation. An ice-structuring fraction (ISF) was obtained with remarkable IRI properties after 80 % ammonium sulphate cut and showed two major polypeptides (HvISP1 and HvISP2), when resolved on an SDS-PAGE gel (Fig. 1a,b). These were cut from the gel and identified by MALDI-ToF/ToF after in-gel trypsin digestion. The identified HvISP1 was amplified from barley grains and cloned in an expression vector pET47b. After transforming the HvISP1/pET47b in expression host, *E.coli* (BL21 cells), the induction of HvISP1 at 37 kDa was observed (Fig. 1c). However, the recombinant HvISP1 was going into the inclusion bodies of *E.coli.* Therefore, HvISP1 was purified under denaturing conditions by Ni-NTA his tag affinity chromatography and the purified HvISP1 was refolded by dilution and dialysis (Fig. 1d). The purified HvISP1 showed excelled IRI properties (Fig. 1e).

Overall, an ISP with IRI property was purified and is being studied for its industrial applications.

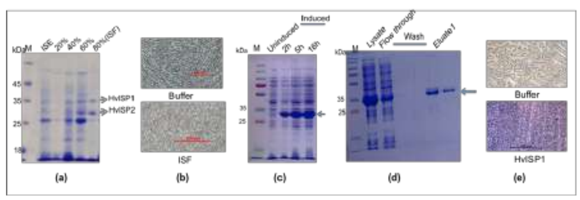


Fig. 1 Purification of HvISP1 form Hordeum vulgare (a) Ammonium sulphate precipitation, (b) IRI activity of HvISF, (c) Prokaryotic expression of HvISP1, (d) Purification of HvISP1, (e) IRI activity of HvISP1.

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Beneficial plant-microbe interactions

Microbial endophytes of *Arnebia euchroma*, a high value medicinal plant, alleviate abiotic stress tolerance in *Arabidopsis thaliana*

Arnebia euchroma (Royle) Johnston, commonly known as Pink Arnebia and Ratanjot (family: Boraginaceae), is an endangered herb of medicinal value which grows naturally on the hilly slopes in cold desert Himalaya at an altitude ranging from 3,200 to 4,500 m above mean sea level. The plant has been reported to possess potential pharmaceutical properties and is commercially exploited for napthoquinones pigments. *A. euchroma* in its natural habitat experiences extreme low temperature, arid conditions, and high light intensity and grows under nutrient-limited soil with reduced water availability. The interplay of plant–microbe interactions in *A. euchroma* might be responsible for the uniqueness of this plant in surviving harsh environmental conditions and in production of specific secondary metabolites. In spite of the valuable aspects of this species, its microbiota and underlying plant-microbe interactions governing cold tolerance to the plant are not yet explored.

Earlier we isolated a yeast endophyte identified as *Naganishia liquefaciens* from the roots of *A. euchroma*. Surprisingly, isolation of a similar yeast species has been reported from Deep Sea environments of Japan Trench (Fig. 1). In our study, we observed that inoculation of this yeast in model plant *Arabidopsis thaliana* mitigated low temperature (LT) stress of 10 °C. The biochemical characterization provided insights of auxin (indole acetic acid) and salicylic acid (SA) production by the yeast candidate which were further supported by genomic evidences. The yeast inoculation improved cold sensitivity of plants as indicated by low oxidative stress (reduced H_2O_2 production, and SOD activity) followed by reduced osmolyte accumulation and electrolyte leakage in the leaves at LT. Furthermore, photosynthetic efficiency of inoculated plants was also found increased as compared to control plants. On further evaluation on phytohormone signaling in roots inoculated with yeast under LT stress, auxin signaling and trafficking was found higher in primary root meristem, lateral root primordia, as well as root vascular tissues as compared to control plants. Gene expression analysis in leaves showed that cold responsive genes were downregulated in the inoculated plants even under cold stress in inoculated plants. However, expression of SA biosynthetic genes *AtSID2* and *AtPBS3* were found >6 fold higher in yeast inoculated plants in LT as compared to control plants under same conditions. In addition, expression of abscisic acid responsive *AtRAB18* and *AtEIN2* (codes for ethylene-insensitive protein 2) was also found higher in inoculated plants under LT. Overall, the data suggested that an interplay if phytohormone signaling on yeast inoculation mediated cold stress response in Arabidopsis leading to reduced cold sensitivity of plants.

In a separate study, a synthetic community (SynCom) of four bacterium was formulated that improved tolerance of Arabidopsis to multiple abiotic stresses including cold, salt and drought. Moreover, the bacterial SynCom also enhanced germination and survival of *A. euchroma* seedlings. Further investigation on molecular level plant-bacterial SynCom interactions are ongoing.

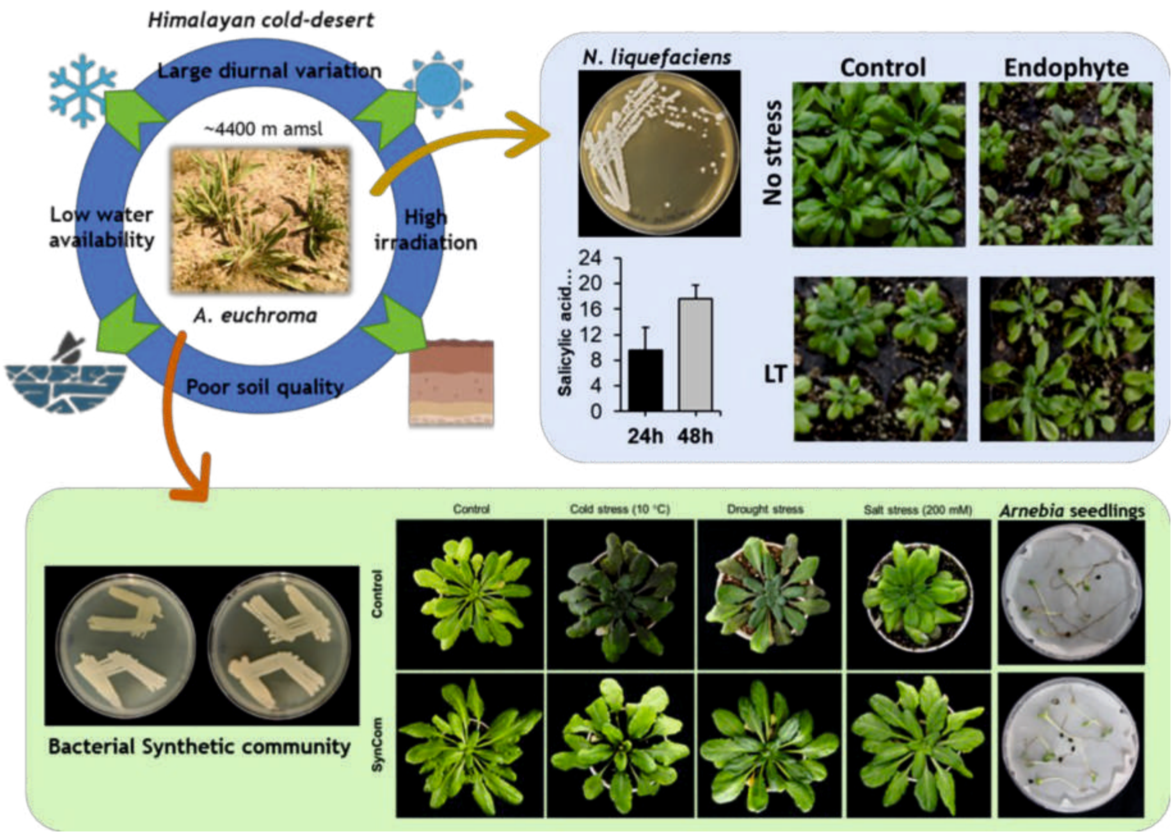


Fig. 1 Isolation of endophytes from *Arnebia euchroma* (left panel) and plant-microbial inoculation studies to investigate contribution of microbes in imparting cold tolerance in Arabidopsis (right panel).

SCIENCE & TECHNOLOGY SUPPORT SERVICES

Engineering Services Unit

Dispensary at CSIR-IHBT Palampur:

Foundation stone of this facility was laid by Sh. Jai Ram Thakur, Hon'ble Chief Minister of Himachal Pradesh, on 30rd July, 2020. The estimated cost of this building is Rs. 100 lacs and is near completion.

Conversion of open scrap yard into central store office:

The scrap yard being used by central store to keep auctionable material was converted into decent office. The new construction was inaugurated by Dr. Sanjay Kumar, Director, CSIR-IHBT Palampur on 04.06.2021. The expenditure on this work was Rs. 25 lacs and covered area is 200sqm.

Floriculture Lab Extension:

The existing field Lab of Floriculture was fully occupied and its extension was required for smooth functioning. Floriculture lab extension work was carried out in Financial year 2021-22. The Building cost is Rs. 30.00 lacs with 150 sqm covered area.

New Lab Block at CSIR-IHBT Palampur: The Foundation stone of New Lab Block was laid by Sh. Rajendra Vishwanath Arlekar, Hon'ble Governor of Himachal Pradesh, on 28th Feb, 2022.

The estimated cost of this building is Rs. 15.22 crore having plinth area of 2500sqm.

120 Rooms Hostel:

The 120 rooms hostel construction was started in Jan, 2021. The work is in progress and expected completion is in Dec, 2022.

ADMINISTRATION

The administration plays the following roles:

- Formulates and implement the policies concerning administrative procedures for smooth functioning of the institute.
- Provide advice to the functional bodies (committees, groups) within the organization.
- Keep liaison with CSIR on matters related to administration.
- Provide healthy working conditions and atmosphere to the institute by correct interpretation of rules and laws.
- Advice Director on matters related to administrative nature for implementation of decision.
- Seek instructions of the Director on matters for implementation.
- Overall in charge of the activities in administrative sections that deal with matters like personnel, maintenance, upkeep and security of the institute's property, logistics support, control of expenditure from administrative angle etc.
- Undertake other tasks assigned by Director.
- To discharge all administrative functions of the institute .
- To ensure overall coordination with various divisions of the institute.
- Execute the power delegated to Administrative Officer.
- To handle all vigilance/ legal cases of the institute.
- Undertake the tasks assigned from time to time of non-routine nature.
- To handle security problems of institute.
- Providing stenographic assistance to the Administrative officer.
- Providing assistance to Administrative Officer in discharging his day to day routine duties.
- General assistance to the Administrative Officers.

- Distribution of Dak of AO's Office.
- Recruitment, Assessment, promotion, legal, vigilance and CR.
- Hindi Section & Official language implementation works.
- Nodal office for Public grievance.
- RTI matters for General administration.
- All Daks.
- Any other matters not covered above as assigned by Director from time to time.
- Head of office for pension and Estt. Matters.
- Establishment matters.
- Bills.
- Security matters.

Administrative Officer

Administrative Officer coordinates all the administrative functions starting from recruitment , and assessment, service matters, payment of salaries, bills general matters, safety, security, vigilance and legal matters, medical services etc.

To act as Member-Secretary of the Management Council, To take active role as one of the members of consultative mechanism Committee and local grievance committee in respect of grievance matters. Administrative Officer is also to sign the legal documents, agreements, contracts etc. on behalf of the CSIR, Any other work assigned by the Director for smooth running of the Laboratory administration.

Security Section:

The security section plays important role for the safety and security inside the premise of this Institute. The security personnel takes care of routine security issues and monitors coming as well exiting from the institute.

The section secures the premises of this Institute by routine checkups and through electronic surveillance system. It reports losses and damages by reporting the incidents to the competent authorities of this Institute. It also briefs the security measures as approved by the competent authority of this Institute.

The section has prevented the violators through continuous attentive vigil. It maintains the record of the movement of visitors as well as materials coming inside and exiting the premise of this Institute. It assists when required at the main entrance of this Institute.

Administration group: Sh. B.P. Saw, Sh. Constan Kujur, Sh. Sanjay Kumar, Sh. Ved Parkash, Sh. Prajwal Rai, Sh. Praveen Singh, Smt. Santosh Kumari, Sh. Baldev, Sh. Kiran Kumar, Smt. Pooja Awasthi, Sh. Sandeep Kumar, Sh. Mukul Sharma, Sh. Ajay Singh Kaundal , Sh. Bony Kumar, Sh. Trilok Nath, Sh. Baleshwar Parsad, Sh. Thaman Bahadur

FINANCE AND ACCOUNTS SECTION

Finance and Accounts Division caters to the financial needs of the Scientific, Technical and Administrative staff of the institute. The Division maintains Accounts of the institute on behalf of the Director. The utilization of the budget allocation received from CSIR Headquarters, New Delhi is monitored and remedial measure for effective utilization is suggested to appropriate authorities by the Division. Apart from Budget Allocation, charges for Technical services, sponsored and Grant- in - aid projects constitute the major sources of income. The revenue received from training programmes is also source of receipt to the institute. F&A Division is handling its duties in time targeted manner in order to fulfil smooth and effective attainment of its goals on the one hand with financial prudence on the other.

The functions of the Finance & Accounts Division are as follows:

FUNCTIONS & DUTIES:

- Preparation and compilation of budget estimates, revised estimates andsupplementary.
- Management of the financial resources received in the form of CSIR Grant and Externally Funded Projects & Lab Reserve of the Institute with the due approval of the Competent Authority.
- Coordination with Head, PPME in Project monitoring and other project-related activities, etc.
- Ensuring that the economy instructions of the Govt. of India are scrupulously followed and also exercising necessary budgetary controls.
- Releasing timely payments to all suppliers/contractors for their services through PFMS portal and commercial bank.
- Making payment to all staff for their personal claims and advances.
- Maintenance of Vouchers and Accounts Audit Registers/Ledgers.
- All matters related to Banks collecting debits, credits, bank statement, DDs, NEFT & RTGS transfers, etc.
- Concurring fixation of pay proposals and other financial matters.
- Monitoring Loans and advances paid to Staff, Govt. departments, Private parties, Hospitals, etc.
- Finalization of pension and issue of Pension Payment Orders, Family pension, Retiring pension, Retiring Gratuity, Gratuity, Commutation, etc.
- Liasioning and 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.
- Ensuring modernization and computerization of Finance & Accounts functions.
- Investment of funds from sponsored projects & lab reserve after obtaining necessary approval.
- To render advice to the Director on all financial matters and providing support services to all Scientific staff and bench level scientists.
- Any other work assigned by CSIR/Director.

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 NKN (National Knowledge Network) Connectivity as a part of CSIR Programme under the premise of Govt. of India's National Programme, in which a dedicated 1GBps WAN link is provided to the institute on optical fiber backbone through which Wired (LAN) & wireless Internet facility has been provided in the campus including hostel and faculty residences with the use of 48 managed switches and 70 indoor and outdoor wireless access points. All the Internet users are managed centrally with the help of authenticator.

Network Security hardware used for LAN & WAN comprises of almost 45 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 managed 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): Library

The KRC continuously contributing to achieve the scientific targets of the Institute through making available the quality knowledge resources to the scientists, scholars, technical and other workforce of the institute. The knowledge resources includes e-journals, databases and other materials such as books, reports, online databases in the field of science and technology. In addition, the library extends reference and consultation, circulation, document delivery, reprographic, resource sharing, information alert, user awareness using latest tools of the ICTs to users. In this way, library contributed in generating new knowledge by the scientists and other researchers working in the institute.

Relevant information on impact factor of journals, publishers' guidelines to authors, publishing policy of journals for selecting quality journals for publication of their research articles as well as online submission of research articles were provided. During the year, 37 books of research value, 191 Hindi books covering scientific and societal issues and 7 thesis were added to the library collection. The database of books, journals and other documents was updated with new additions in KOHA-an open source software of library management. The database is available for access on internet through website http://library.ihbt.res.in.

OPAC- Online Public Access Catalogue: The library holdings database was updated and made available for access on internet. The OPAC is accessible and searchable online through http://14.139.59.218/. It has facilities like, view online checkout status, reservation of books, and recommendation of new books, journals, etc. The records in database can be searched by keywords, author, title, publisher, accession number, subject, ISBN, etc.

Similarity and Grammar Check: The library had continued to check various documents with the iThenticate database for detection of similarity/plagiarism. Similarity reports of the documents checked were provided to the scientist and scholars. The Grammarly software made available and uploaded on individual PCs for grammar checks. Drafts of the documents were also checked by library staff with the database of Grammarly for grammar correction and reports were provided for further improvement by scientist, scholars and staff.

Printing and Photocopying Service: The library continued to coordinate the printing and photocopying activities for the institute. The library staff have assisted S & T staff for layout settings of different types of the documents such as scientific & technical brochures, annual report, manuals, banners, products stickers, advertising materials, flyers of technology developed, official documents, project proposals & reports. The binding of documents was also facilitated through the library.

Press and Media Activities: Press and media activities of the institute for preparation of press notes on various technologies developed and scientific programmes organized in the institute for the communication of new knowledge to society through the print and electronic media were coordinated.

The library continued to subscribe ten newspapers of Hindi and English languages. The dailies were scanned for relevant news items appeared therein related to the R & D programmes of the institute. Relevant news clips scanned and communicated to directorate and related scientists for their information. The news items were uploaded on blog at- http://ihbtinnews.blogspot.in/.

Library group: Sh. Mukhtiar Singh, Sh. Saurabh Sharma, Smt. Jasveer Kaur and Smt. Rujala Devi

PHOTOGRAPHY

Endeavored to make a persistent, diligent and creative effort to achieve the highest standards in: - In all the activities, there was a persistent effort towards learning and applying new developments in the field while striving for excellence in quality and timely delivery of the institute.

Documentation and preservation of official functions

Documentation of various official functions through photography & videography, such as celebration of nationals days, CSIR & IHBT foundation days and impotent visits of important dignitaries.

Continued photography of research activities of the scientists and scholars in the lab and in demonstration plots. It also includes **photography & videography** the medicinal, floriculture, commercial crops and trainings thereon. Extended assistance to improve the photographs for better quality for reproduction in different documents.

Photographic tours of farmer's field: Captured visits to various demonstration plot, field activities and interviews with farmers using still photography and videography.

Designs & layout: Designed cover page of the Annual Report 2021-22, Products profile of CM Stat-up Scheme with text and photographs, CSIR-IHBT history book, R&D posters, label of products, infographics, e-banners, certificates and text details of technologies.

Film making: Assisted in short film making (on going assignment) **for CSIR Jigyasa Portal** (**GIT LAB**, which is coordinated by **IIT Mumbai**). These includes: Conservation of Endangered Plants, Microbial Enzymes from Himalayas, Mapping and Exploring Rich Himalayan Bioresource, Himalayan Medicinal Plants, Soil-less Cultivation to Boost Farmer's Income.

A few samples of photographs and videopgraphy: Lamongrasses (a), Crataegus (b) and video shooting (c).

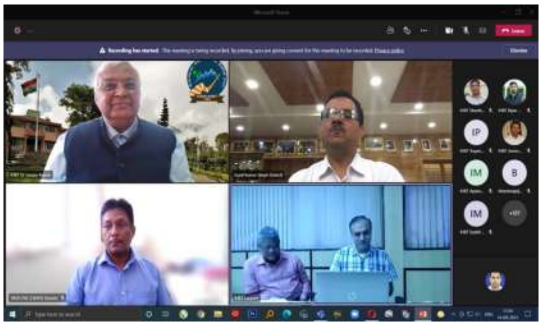
राजभाषा

संघ की राजभाषा नीति, राजभाषा अधिनियम के उपबंधों तथा आदेशों से अधिकारियों एवं कर्मचारियों को अवगत कराना, अनुपालन हेतु सहयोग, राजभाषा तिमाही प्रगति रिपोर्ट, प्रोत्साहन योजनाओं को लागू करना, वातावरण निर्माण हेतु कार्यशाला एवं कार्यक्रमों का आयोजन तथा संस्थान की राजभाषा कार्यान्वयन समिति के निर्देशन में संस्थान में संघ की राजभाषा नीति का अनुपालन सुनिश्चित करना संस्थान के राजभाषा अनुभाग का प्रमुख दायित्व है।

हिंदी सप्ताह समारोह का आयोजन

संस्थान में हिंदी सप्ताह समारोह का मुख्य समारोह दिनांक 14 सितम्बर 2021 को ऑनलाइन माध्यम से बड़े हर्षोल्लास के साथ मनाया गया। समारोह का शुभारंभ संस्थान गान के साथ हुआ।

समारोह के मुख्य अतिथि प्रो. सुनील कुमार सिंह, निदेशक, राष्ट्रीय समुद्रविज्ञान अनुसंधान संस्थान, गोआ ने 'हिंदी महासागर का जैव–भू–रासायनिक अध्ययन' विषय पर संभाषण दिया। अपने संभाषण में उन्होंने बताया कि राष्ट्रीय समुद्रविज्ञान अनुसंधान संस्थान का लक्ष्य आप–पास के समूद्रों की जानकारी में सतत वृद्धि करना तथा इसकी जानकारी सभी के लाभ के लिए परिणत करना है। हिंद महासागर की विशेषताओं का वर्णन करते हुए उन्होंने बताया कि यदि शोध सही दिशा में चलता रहा तो अपार संपदा का उपयोग करना सरल हो जाएगा और उनका संस्थान अत्याधुनिक पोतों एवं सुविधाओं का उपयोग करते हुए इस दिशा में अग्रसर है। उन्होंने पृथ्वी, महासागर और और वायुमंडल की उत्पत्ति पर भी प्रकाश डाला। आगे अपने संबोधन में हिंदी दिवस की बधाई देते हुए राजभाषा से संबन्धित विभिन्न पहलुओं पर भी प्रकाश डाला। उन्होंने कहा कि हम तब तक आगे नहीं बढ़ सकते जब तक अपनी भाषा में विज्ञान को उजागर नहीं किया जाएगा ओर यही समय की मांग है।



संस्थान के निदेशक डा. संजय कुमार ने अपने अध्यक्षीय संबोधन में हिंदी दिवस की शुभकामनाएं देते हुए कहा कि पर्वत व सागर हमारे लिए अक्षय वरदान है। सागर से चल कर जल बादल बन कर हिमालय में बरसते हैं फिर नदियों के माध्यम से पुनः सागर में पहुंच जाता है। इसी से हमारा भरण–पोषण होता है। प्रकृति हमारी अनिवार्य आवश्यकताओं की पूर्ति करती है। प्रकृति अनमोल है। पर्यावरणीय पर्यटन इसी का एक उदाहरण है। उन्होंने अवगत कराया कि संस्थान द्वारा विकसित प्रौद्योगिकियों को उसके उपयोगकर्ता तक पंहुचाने के लिए सरल एवं जन भाषा का उपयोग करते हुए हम आगे बढ़ रहे हैं।

इस अवसर पर निदेशक डा. संजय कुमार ने राजभाषा विभाग, भारत सरकार की ओर से जारी की गई प्रतिज्ञा को संस्थान के कर्मियों को दिलाया। निदेशक की ओर से राजभाषा में कार्य को बढ़ाने के लिए एक अपील भी जारी की गई।

इस अवसर पर संस्थान के वित्त एवं लेखा अधिकारी श्री यशपाल ने हिंदी सप्ताह के अन्तर्गत आयोजित हिंदी प्रतियोगिताओं के विजेताओं की घोषणा की तथा

हिंदी में मौलिक काम करने वाले कार्मिकों को प्रोत्साहित भी किया गया। जिसका विवरण निम्नानुसार हैः

संस्थान के प्रशासनिक अधिकारी श्री बी.पी. साव ने धन्यवाद ज्ञापन किया तथा कार्यक्रम का संचालन हिंदी अधिकारी श्री संजय कुमार ने किया।

विश्व हिंदी दिवस का आयोजन

सीएसआईआर–आईएचबीटी में 10 जनवरी 2022 को विश्व हिंदी दिवस का आयोजन किया गया। इस अवसर पर डा. कृष्ण मोहन पाण्डेय, आचार्य एवं वेद विशेषज्ञ ने 'हिंदी भाषा–व्यापकता एवं महत्व' विषयक अपने संबोधन में राजभाषा हिंदी के राष्ट्रीय, ऐतिहासिक परिदृश्य पर महत्वपूर्ण एवं ज्ञानवर्धक व्याख्यान दिया।

अपने संबोधन में डा. पाण्डेय ने भाषा के उद्भव, क्रमिक विकास, चुनौतियां और संभावनाओं पर प्रकाश डाला। उन्होंने विज्ञान को जनभाषा में प्रचारित एवं प्रसारित करने की दिशा में आत्मचिंतन के लिए प्रेरित किया।

संस्थान के निदेशक डा. संजय कुमार ने अपने अध्यक्षीय संबोधन में कहा कि अपने भावों को जितनी सहजता एवं सरलता से हम अपनी भाषा में अभिव्यक्त कर सकते हैं वो अन्य भाषा से नहीं कर सकते हैं। उन्होंने विज्ञान को जन–जन तक पंहुचाने की दिशा में किए जा रहे प्रयासों की जानकारी दी। उन्होंने अवगत कराया कि संस्थान द्वारा विकसित प्रौद्योगिकियों को उसके उपयोगकर्ता तक पंहुचाने के लिए सरल एवं जन भाषा का उपयोग करते हुए हम आगे बढ़ रहे हैं।

उल्लेखनीय है कि विश्व हिन्दी दिवस का उद्देश्य विश्व में हिंदी के प्रचार–प्रसार के लिये जागरूकता

हिन्दी टिप्पण लेखन प्रतियोगिता

पुरस्कारः	प्रथम पुरस्कार	श्री वेद प्रकाश, सहायक अनुभाग अधिकारी
	द्वितीय पुरस्कार	श्री बलदेव, सहायक अनुभाग अधिकारी
	तृतीय पुरस्कार	श्री बोनी कुमार, आशुलिपिक

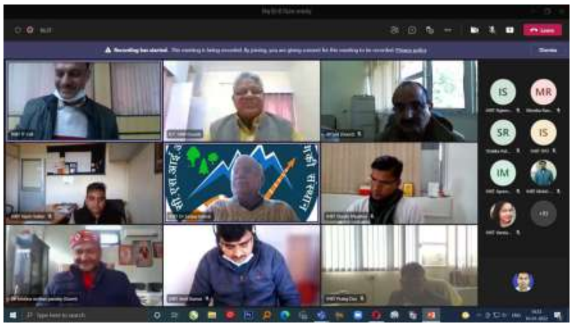
हिन्दी टिप्पण प्रोत्साहन योजना के अन्तर्गत वर्ष 2020–21 के लिए

प्रथम पुरस्कार (2)	श्री संदीप कुमार, वरि. सचिवालय सहायक
	श्री मुकुल शमा, वरि. सचिवालय सहायक
द्वितीय पुरस्कार (3)	श्री बोनी कुमार, आशुलिपिक
	श्रीमती पूजा अवस्थी, वरि. सचिवालय सहायक
	श्रीमती अरुणा कुमारी, सहायक अनुभाग अधिकारी
तृतीय पुरस्कार (5)	श्री बलदेव, सहायक अनुभाग अधिकारी
	श्रीमती संतोष कुमारी, वरि. सचिवालय सहायक
	श्री किरण कुमार, वरि. सचिवालय सहायक
	श्री ईश्वर दास, तकनीशियन
	डा. अशोक गहलोत, वरि. तकनीकी अधिकारी

पैदा करना, हिंदी को अन्तरराष्ट्रीय भाषा के रूप में पेश करना, हिन्दी के लिए वातावरण निर्मित करना, हिन्दी के प्रति अनुराग पैदा करना है।

अन्तर्राष्ट्रीय मातृभाषा दिवस

संस्थान में 21 फरवरी 2022 मातृभाषा दिवस के अवसर पर एक कार्यशाला का आयोजन किया गया जिसमें 14 वैज्ञानिकों को अपने शोध एवं विकास कार्यों को हिंदी के अतिरिक्त अपनी मातृभाषा में भी प्रसारित करने के लिए प्रेरित किया गया।



राजभाषा संबन्धी कार्यान्वय

- संस्थान द्वारा किये जा रहे शोध कार्यो को आम जनता तक पहुंचाने के उद्देश्य से ब्रोशर आदि के लिए सामग्री का अनुवाद, संपादन एवं प्रकाशन में सहयोग किया गया।जिनमें से प्रमुख 'सीएसआईआर–आईएचबीटी की बांस संपदा', 'व्यावसायिक पुष्पीय फसलें–प्रशिक्षण पुस्तिका' सिट्रेनोला, पामारोजा, आदि अनेक प्रकाशन हिंदी में तैयार किए गए।
- केसर प्रशिक्षण मैनुअल
- प्रौद्योगिकी प्रोफाइल I, II हिंदी में तैयार की।
- समझौता ज्ञापनों का अनुवाद
- सभी समारोहों के प्रेस नोट तैयार करना
- 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 तथा प्रशासनिक शब्दावली उपलब्ध कराई गई। 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।
- संस्थान के शोध छात्रों के पीएच.डी. थिसीज की समरी के अनुवाद एवं संपादन में सहयोग।
- प्रबन्ध परिषद के कार्यवृत एवं एजेंडा एवं प्रशासन से संबन्धित विभिन्न प्रकार की सामग्री के अनुवाद एवं संपादन में सहयोग
- संस्थान द्वारा आयोजित किए जाने वाले विभिन्न समारोहों जैसे स्वच्छता पखवाड़ा, सतर्कता जागरुकता सप्ताह, कौमी एकता सप्ताह, सद्भावना दिवस, सीएसआईआर स्थापना दिवस, आईएचबीटी स्थापना दिवस, किसानों एवं उद्यमियों के लिए आयोजित प्रशिक्षण कार्यक्रमों, विभिन्न कार्यशालाओं /समरोहों के आयोजनों में सहयोग किया।

CSIR SKILL DEVELOPMENT PROGRAMS - JIGYASA - INCUBATION CENTRE - AcSIR - IMPORTANT EVENTS

JIGYASA PROGRAM AT CSIR-IHBT, PALAMPUR

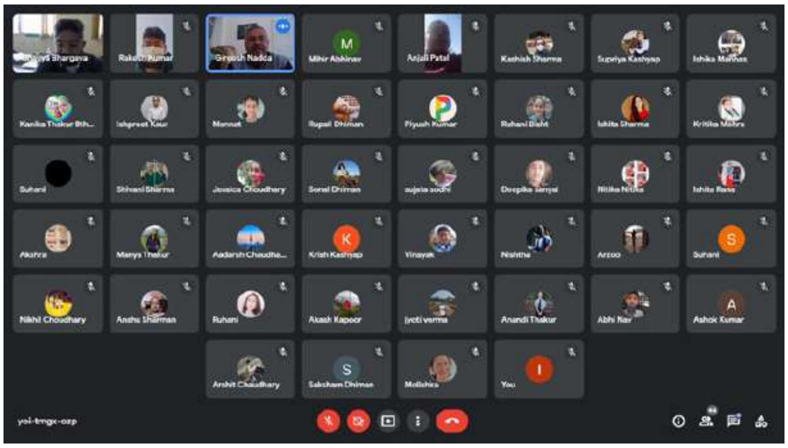
Jigyasa is a student-scientist connect programme inspired by Prime Minister Narendra Modi's vision of a new India and Scientific Social Responsibility (SSR) of Scientific Community and Institutions. Keeping in view the COVID-19 pandemic situation, various activities were conducted through offline and online modes under the Jigyasa 2.0 virtual laboratory program to motivate students towards science. During 2021-22, a total of 2607 school students and their teachers from different schools (Jawahar Navodaya Vidyalaya, Govt. and Public Schools) participated in this programme (Table 1 and 2). They visited to various R&D activities of the Institute through demonstrations, exhibitions, lectures, and hands on training to inculcate scientific temperament in them. They were exposed to different state-of-art facilities in the area of biotechnology, bioinformatics, agrotechnologies of commercial important crops, floriculture especially First Tulip Garden of HP, natural product chemistry, synthetic chemistry, internationally recognized herbarium, remote sensing and mapping facilities, regulatory research facility, pilot plant for nutraceuticals, essential oil and herbals fernery and bamboo museum. Students were guided for making working models for Children Science Congress.

Table 1 Details of the schools that participated in "Jigyasa" Programme

Sr. No.	Name of School	Date	No. of Teachers	No. of Students
1	Green Field Sr. Sec. School, Nagrota Bagwan (HP)	29-10-2021	01	05
2	Viveka Foundation, Mansimbal, Palampur (HP)	01-11-2021	02	9
3	Green Field Sr. Sec. School, Nagrota Bagwan (HP)	23-12-2021	02	2
4	Govt. Sr. Sec. School, Bhareri, Hamirpur, (HP)	23-12-2021	02	4
5	Amar Shanti Nodal Public School Sihati, Khundian, (HP)	04-01-2021	08	59
6	DAV Public School, Bankhandi (HP)	03-03-2022	04	19
7	Udan School KBES Campus Kamlehr, Bankhandi, (HP)	03-03-2022	04	22
8	GSSS Dhaloon (HP)	07-03-2022	03	26
9	GSSS Dhaloon (HP)	08-03-2022	03	34
10	GSSS Dagoh (HP)	08-03-2022	02	26
11	GSSS Khera (HP)	08-03-2022	03	44
12	Crescent Public Sr. Sec. School, Banuri (HP)	11-03-2022	13	262
13	GSSS Tihri (HP)	14-03-2022	03	50
14	Crescent Public Sr. Sec School, Banuri (HP)	14-03-2022	15	227
15	Anuradha Public Sr. Sec. School, Maranda (HP)	15-03-2022	09	245
16	Govt. Co-Edu. Sr. Sec. School, Palampur (HP)	15-03-2022	05	30
17	Neugal Public Sr. Sec. School, Andretta (HP)	16-03-2022	05	20
18	Anuradha Public Sr. Sec. School, Maranda (HP)	16-03-2022	11	213
19	Asian Public School, Dheera (HP)	16-03-2022	04	29
		Total	**99**	**1326**
		Grand Total	**1425**	

Table 2. Online activities conducted under "Jigyasa" Programme

S. No.	Webinar on	Speaker Name	Speaker Designation	Organized on	Platform	No of Participants
1	"Benefits of Gardening" under CSIR Floriculture Mission & JIGYASA program	Dr. Bhavya Bhargav	Senior Scientist, CSIR-IHBT	11-11-2021	Google Meet	46 students and 4 teachers
2	"Curtain Raiser Ceremony" of the 7th IISF 2021	Prof. Annpurna Nautial	Vice-Chancellor,-Hemvati Nandan Bahuguna Garhwal University, Garhwal, Uttrakhand	06.12.2021	(Youtube) https://youtu.be/hcwuZh3_law	1132 (Based on views)
					Total	**1182**



Online activities conducted under "Jigyasa" Programme

In addition to this, 405 students and teachers of various Universities, Institutes and Colleges visited the institute.

Table 3. Visits of College/ University & Institute students to CSIR-IHBT, Palampur

Sr. No.	Name of College, University, Institute	Date	No. of Students	No. of Teachers	State/ UT
1	Govt. Mohindra College, Patiala (Punjab)	20-10-2021	23	03	Punjab
2	Shanti Devi Arya Mahila College, Dinanagar (Punjab)	13-12-2021	33	02	Punjab
3	Sri Sai University, Palampur (HP)	15-12-2021	20	02	Himachal Pradesh
4	GGDSD College, Rajpur, Palampur (HP)	16-12-2021	25	02	Himachal Pradesh
5	GGDSD College, Rajpur, Palampur (HP)	17-12-2021	58	03	Himachal Pradesh
6	PSR Govt. College, Baijnath (HP)	10-03-2022	13	02	Himachal Pradesh
7	Swami Vivekanand Govt. College, Ghumarwin (HP)	10-03-2022	51	04	Himachal Pradesh
8	Sri Sai University, Palampur (HP)	15-03-2022	22	05	Himachal Pradesh
9	Guru Nanak University, Amritsar (Punjab)	16-03-2022	35	04	Punjab
10	IARI, New Delhi	17-03-2022	10	02	Delhi
11	Career Point University, Hamirpur (HP)	22-03-2022	-	12	Himachal Pradesh
12	Doaba College Jalandhar, (Punjab)	25-03-2022	58	04	Punjab
13	Govt. Degree College Naura, Distt. Kangra (HP)	28-03-2022	11	01	Himachal Pradesh
Total			359	46	
Grand Total		**405**			

Virtual Tour of CSIR-IHBT. A Virtual Tour of CSIR-IHBT followed by a lecture on "Plant Adaptation to Climate Change" by Dr. Gaurav Zinta, Senior Scientist CSIR-IHBT to College of Horticulture and Forestry NEERI, Hamirpur (HP) was conducted on 22-01-2022. In this event, 29 B. Tech., Biotechnology students and one faculty member participated.

SKILL DEVELOPMENT ACTIVITIES

This year, CSIR-IHBT, Palampur is registered as "Training Provider" (TP) and Training Center (TC) at National Skill Development Council (NSDC)-Skill India Portal (Pradhan Mantri Kaushal Vikas Yojna-PMKVY). Besides, CeHAB, Keylong is registered as an another Training Center (TC) of CSIR-IHBT.

Following guidelines in order to combat Covid-19 pandemic, this year different skill development programmes were conducted under CSIR Integrated Skill Initiative (Phase II) and other skill programs (Table 1 and 2). Some of the these are as: A five days' capacity building programme was conducted for Ph.D. students and faculty members from Maharshi Dayanand University, Rohtak, Haryana on "Bioprospecting natural products for human health and socio-economic development" under UGC-STRIDE Programme (Scheme for Tran-disciplinary Research for India's Developing Economy). A eight days skill development programme was conducted for students from Sant Baba Bhag Singh University, Khiala, Jalandhar, Punjab on "Protected cultivation of flower crops".

Table 1. Details of Skill Development programmes

S. N.	Date (s)		Title of Skill Development Program	Sector/ Discipline	Name(s) of Faculty	No. of Trainees
	From	To				
1	03.04.2021	12.04.2221	Hands-on training on chromatographic techniques	Genetic and Plant breeding	Dr. Dinesh Kumar & Dr. Robin Joshi	1
2	22.10.2021	01.11.2021	Hands-on training in analytical techniques	Nano-Technology	Dr. Amitabha Acharya	1
3	22.11.2021	29.11.2021	Protected cultivation of flower crops	Floriculture	Dr. Bhavya Bhargava	9
4	05.01.2022	04.03.2022	Basic aspects of plant based natural products extractions and isolation	Chemistry	Dr. Upendra Sharma	1
5	07.03.2022	11.03.2022	Capacity building programme on "Bioprospecting natural products for human health and socio-economic development" under UGC-STRIDE	Biological and Chemical Sciences	Faculty of CSIR-IHBT	34
6	21.03.2022	21.03.2022	Hands-on training on Beekeeping	Biological Sciences	Dr. SGE Reddy	18
					Total	**64**

Research Internship at CSIR-IHBT

This year, 55 UG/PG/ Ph.D. students from different educational and research institutes of Pan India completed their trainings for different time durations (1-12 months) for fulfil of their degree, under the able supervision of CSIR-IHBT scientists. Besides, 48 trainees are enrolled and continuing their training.

Table 2. Details of trainings provided to Graduate/ Post Graduate/ Ph.D. students (April, 2021-March, 2022)

S. N.	Trainee	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
1	Ms. Aayushi	GGDSD College Chandigarh	M.Sc. Applied Chemistry	1	Dr. Pamita Bhandari	Isolation of lutein from *Tagetes erecta*
2	Ms. Shilpa Bhardwaj	IGNOU, New Delhi	M.Sc. D&FSM	1	Dr. Vidyashankar	Development an nutritional characterization of herbal spice mixes
3	Ms. Reetika	Maharaja Agarasen University, Baddi	M.Sc. Biotechnology	3	Dr. Ashish Warghat	Basic Techniques in Plant Tissue Culture
4	Ms. Simran Chaudhary	Maharaja Agarasen University, Baddi	M.Sc. Biotech nology	3	Dr. Rohit Joshi	Micropropagation of *Phyllostachys pubescens* through nodal segments and understanding the basics of transcriptomics
5	Ms. Reetika Aggrawal	JUIT, Solan, HP	B.Tech Biotechnology	1.5	Dr. Shiv Shankar Pandey	Isolation of endophytic microbes from plant tissue
6	Mr. Mrigank Sharma	Rajiv Gandhi Government Engineering College Kangra, HP	B.Tech Civi Engg.	1	Sh. Anil Kumar	Practical exposure to Civil Engineering works at CSIR-IHBT, Palampur
7	Ms. Radhika Dhawan	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Biotechnology	4	Dr. Arun Kumar	Identification of natural molecules as inhibitors of Main Protease (M^{pro}) of SARS-CoV-2
8	Ms. Garima	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Biotechnology	4	Dr. Poonam Kumari	*In-vitro* seed germination, multiple shoot induction and callus induction in three Indian Himalayan plants
9	Ms. Tania Dadwal	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Biotechnology	4	Dr. Sarita	Isolation and characterization of potential probiotics from milk and milk based products from Western Himalaya

S. N.	Trainee	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
10	Ms. Isha Dogra	Chandigarh University, Gharuan, Mohali, PB	M.Sc. Biotechnology	4	Dr. Jermey Dhankar	*In-vitro* seed germination, multiple shoot induction and callus induction in three Indian Himalayan plants
11	Ms. Bhagya Shri Trivedi	Jaipur National University, Jaipur, RJ	B.Tech Biotechnology	5	Dr. Poonam Kumari/Dr. Arun Kumar	*In vitro* induction of callus from *Calendula officinalis* explants in response to various growth regulators Heterologous expression and purification of recombinant protein
12	Ms. Indu	Bansthali Vidyapith University, RJ	M.Sc. Food Tech	1	Dr. Mahesh Gupta	Development of ready to eat convenient food formulation and its quality evaluation
13	Ms. Akshita Saraswat	Jaipur National University, Jaipur, RJ	B.Tech Biotechnology	5	Dr. Probir Kumar Pal	Effect of salinity and seaweed extract on germination behaviours and growth of *Stevia rebaudiana* Bertoni
14	Ms. Neha	Govt. PG College, Dharamshala (HP)	B.Sc. Biotechnology	3	Dr. Kunal Singh	"Characterization of plant growth promoting activities of endophytic fungi"
15	Mr. Parvesh Kumar	Chandigarh University, Gharuan, Mohali, PB	M.Sc.Indust. Microbiology	3	Dr. Vipin Hallan	Basic techniques in biotechnology
16	Ms. Divyanshi thakur	SLIET, Sangrur, PB	M.Sc. Food tech	1	Dr. Ankit Saneja	Handling of basic laboratory instruments for nutraceutical formulations
17	Mr. Munish Daroch	SLIET, Sangrur, PB	M.Tech CSE	1	Dr. Vishal Acharya	Development and selection of various Machine Learning algorithms to reduce false-hits in large scale virtual screening

S. N.	Trainee	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
18	Ms. Ashmita Uppal	SLIET, Sangrur, PB	M.Sc. Food tech	1	Dr. Ankit Saneja	Handling of basic laboratory instruments for nutraceutical formulations
19	Ms. Gunjan Bhargava	MMU, Mullana, HR	M.Sc. Biotechnology	3	Dr. Vandana Jaiswal	Basic bioinformatics analysis of BES1 gene family in rose
20	Ms. Rupali	Banaras Hindu University, Varanasi, UP	M.Tech Food Tech	1	Dr. Mahesh Gupta	Nutritional facts protocol study and training on analysis of samples for nutrition and shelf life
21	Ms. Muskan Thakur	Govt. PG. College, Dharmashala, HP	B.Sc. Biotechnology	3	Dr. Rakshak Kumar	Basic techniques in Microbiology
22	Ms. Aanchal Prabhakar	Panjab University, Chandigarh	B.Sc. Biophysics	3	Dr. Arun Kumar/ Dr. Anish Kachara	Molecular characterization of transgenic lines of *Arabidopsis thaliana*
23	Ms. Rupika Arya	MCM DAV College, Chandigarh	B.Sc. Microbial & Food Tech	1	Dr. Mahesh Gupta	Nutritional facts analysis for food samples/ products
24	Ms. Sakshi Sharma	DAV University, Jalandhar, PB	M.Sc. Chemistry	3	Dr. Sushil Maurya	Synthesis of carbohydrate-derived olefin and enyne building blocks
25	Ms. Sujata	IISER, Mohali, PB	BS-MS completed	3	Dr. Damanpreet Singh	Hands on training in molecular biology techniques
26	Ms. Anchal Chandel	Shoolini University, Solan, HP	M.Sc. Biotechnology	3	Dr. Vivek Dogra	Prickle morphogenesis in rose is coupled with secondary metabolite accumulation and governed by canonical MBW transcriptional complex
27	Ms. Anchal	Chandigarh University, Gharuan, Mohali, PB, Chandigarh	B.Sc. Agriculture	2	Dr. Satbir Singh	Wet-lab techniques for crop improvement

S. N.	Trainee	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
28	Ms. Shivanshi chauhan	Kurukshetra University, Kurukshetra	M.Sc. Microbiology	3	Dr. Sarita Devi	Screening and characterisation of microorganisms present in traditional fermented beverages (Chhang) and its starter culture (Phab) of Western Himalayas
29	Ms. Sarita Maurya	University of Allahabad, UP	M.Sc. Bioinformatics	4	Dr. Ravi Shankar	Using NGS data for deciphering transcription factors based gene regulation
30	Mr. Amandeep Singh	Panjab University, Chandigarh	B.Sc. Biotech	3	Dr. Vandana Jaiswal	Genome-wide identification and characterization of important genes involved in abiotic stress
31	Mr. Badgujar Shreyas P.	SVKM, Institute of Pharmacy, MH	B. Pharmacy	3	Dr. Ankit Saneja	Exposure of pre - formulation strategy for nutraceuticals delivery
32	Ms. Riya Jaswal	Panjab University, Chandigarh	B.Sc. Microbiology	4	Dr. Dharam Singh	Exploration and characterization of bacteria from high altitude niches
33	Ms. Rupali Katoch	GNDU, Amritsar, PB	M.Sc. Microbiology	3	Dr. Kunal Singh	Characterization of plant growth promoting activities of Arthrobacter under *in-vitro* conditions
34	Ms. Indu Bala	GNDU, Amritsar	M.Sc. Microbiology	3	Dr. Aparna Maitra Pati	Development of Biofertilizer using PGPR
35	Ms. Neha	Punjabi University, Patiala	Ph.D.	3	Dr. Vivek Dogra	Study of gene expression of BR -receptors & antioxidant enzymes of *Brassica juncea* cv RLC 3 seedlings treated with Brassinosteroids and grown under different temperature conditions

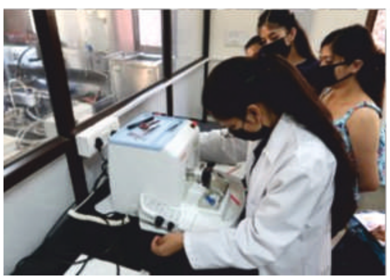
S. N.	Trainee	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
36	Mr. Umesh Kumar	Vinoba Bhave University, Jharkhand	M.Sc. Biotechnology	6	Dr. Kunal Singh	Screening for potential phosphate solubilizer from rhizospheric soil of Rothang Pass as effective bio-inoculant
37	Ms. Priya Thakur	Panjab University, Chandigarh	B.Sc. Microbiology	3	Dr. Dharam Singh	Exploring high altitude bacteria for enzymatic activity
38	Ms. Chhaya Thakur	Sri Sai University, Palampur, HP	M.Sc. Zoology	3	Dr. Narendra Tripude	Sensitization training on molecular techniques involved in validating prophylactic mechanism (s) of herbal preparations
39	Mr. Gaurav Moudgil	Panjab University, Chandigarh	M.Sc. Microbiology	3	Dr. Shivshankar Pandey	Media optimization for efficient isolation of endophytes from medicinal plants
40	Ms. Neetu Sharma	Mahatma Jyotiba Phule Rohilkhand University, UP	M.Sc. Zoology	3	Dr. Damanpreet Singh	Hands on training in different molecular biology & biochemical techniques used in Pharmacology & Toxicology Laboratory
41	Ms. Neha Thakur	Sri Sai University, Palampur, HP	M.Sc. Zoology	3	Dr. Narendra Tripude	Sensitization training on techniques in pre-clinical screening and efficacy evaluation of standardized extracts
42	Ms. Aastha Kumari	SILB, Solan, HP	M.Sc. Microbiology	1	Dr. Arun Kumar	Basic techniques in Microbiology and Plant Molecular Biology
43	Ms. Amanpreet Kaur	HPU, Shimla, HP	M.Sc. Microbiology	3	Dr. Gireesh Nadda	“Basic techniques in microbiology and molecular biology
44	Ms. Priyanka	SILB, Solan, HP	M.Sc. Microbiology	3	Dr. S.G.E. Reddy	Multiplication and evaluation of IHBT strains of entomopathogenic fungi against insect pests

S. N.	Trainee	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
45	Ms. Nidhi Ghaneera	SILB, Solan, HP	M.Sc. Microbiology	3	Dr. Sarita Devi	Hands on training for various microbiological and biotechnological techniques for characterization of fermented foods
46	Ms. Srishti Puri	SILB, Solan, HP	M.Sc. Microbiology	3	Dr. Vidyashankar	Studies on cultivation techniques and biochemical characterization of nutraceuticals from *Spirulina platensis*
47	Ms. Pallavi Sharma	Shoolini University, Solan (HP)	M.Sc. Microbiology	3	Dr. Arun Kumar	Heterologous expression and purification of recombinant protein
48	Ms. Hiteshi Vaidya	Panjab University, Chandigarh	M.Sc. Zoology	3	Dr. Gireesh Nadda	Entomology and pest management
49	Ms. Shafali	HPU, Shimla, HP	M.Sc. Microbiology	3	Dr. Sarita Devi	Hands on training for microbiological and biotechnological laboratory practices related to food technology
50	Ms. Krishma Devi	A.P.G. Shimla, University, HP	M.Sc. Chemistry	6	Dr. Dinesh Kumar/ Dr. Robin Joshi	Hands on training on analytical techniques
51	Ms. Pallavi Sharma	Shoolini University, Solan, HP	M.Sc. Biotechnology	6	Dr. Rakshak Kumar	Isolation, screening and characterization of psychrotrophic plant growth promoting bacteria from Lahul region for application ion agriculture at cold climate
52	Ms. Shifali Choudhary	Vellore Institute of Technology, Tamil Nadu	M.Sc. Biotechnology	6	Dr. Dharam Singh	Fundamentals in molecular microbiology for bacterial cellulolytic enzymatic activities
53	Ms. Rupinder Kaur	Kumaun University, UK	M.Sc. Zoology	3	Dr. Gireesh Nadda	Basic techniques in entomology and peat management

S. N.	Trainee	Affiliation	Class/ Course	Duration (in months)	Supervisor	Title
54	Ms. Tanya Bhatti	Kanya Mahavidyalaya, Jalandhar, PB	B.Sc. Biotechnology	3	Dr. Damanpreet Singh	Investigating the effect of IHBT -B.A-001 in pilocarpine induced epilepsy model of zebrafish
55	Ms. Rashmi Kumari	DAV University, Jalandhar, PB	M.Sc. Zoology	6	Dr. Vikram Patial	Hands on training in different molecular biology and biochemistry techniques used in Pharmacology and Toxicology Lab

"Skill Vigyan Program" of DBT-HIMCOSTE

During this year, two LSSSDC courses *viz.* Quality Control Biologist (QCB) and Lab Technician/ Assistant (LTA) of 3 months' duration were initiated under "Skill Vigyan Progam". All the 22 persons of first batch, who appeared for third party evaluation have successfully completed these courses. The second batch of Quality Control Biologists (15 no.) and Lab Technicians/ Assistants (09 no.) is going on.



Glimpses of Skill Development Programme

START-UP AND INCUBATEES

INCUBATION CENTRE AT CSIR-IHBT

Department of Industry, Himachal Pradesh signed an MoU for implementation of HP state chief minister start-up incubation scheme at CSIR-IHBT, Palampur. Under this scheme, incubates shown interest to establish new start-up/enterprise in the state.

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, aware-ness and up-scaling in various areas of their interest.

Total 50 startups joined CSIR-IHBT, Palampur and 33 startups already completed the tenure and developed their prototypes. Currently 17 startups are actively working in the area of process development, food processing, tissue culture, aeroponics, floriculture, aromatic crops and herbal products 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 startups.

List of the start-ups joined during April 2021 to March 2022 at incubation facility at CSIR-IHBT, Palampur with their information as below:

S. No	Name of Incubatees	Idea of Start-up and Start date	Mentor
1	**Ankit Shandil** Village Jahri, Post Office- Naswal Tehsil- Ghumarwin, District Bilaspur (HP) 174021 Cont. No. 9816757642 Email: shandilankit999@gmail.com	Establish plant tissue culture lab for production of diseases free, elite planting material (blueberry, apple and saffron) at minimum cost. **1st Apr 2021**	Name: Dr. Rohit Joshi Email: rohitjoshi@ihbt.res.in
2	**Tanmay Sharma** C/O Sh. Devi Sharma, V.P.O. Khaira, Tehsil Palampur, District Kangra. (HP) 176 086 Cont. No. 8091746060 Email: tanmaysharma1@gmail.com	Establishment of facility for organic incense sticks with/ without bamboo sticks **19th Jul 2021**	Name: Dr. Robin Joshi Email: robinjoishi@ihbt.res.in
3	**Nitika Bhandari** C/O Khadi Gramoudhyog Sansthan, Nagrota Bagwan, Distt. Kangra (HP) Cont. No. 9805347466 Email: aasrafoundation111@gmail.com	Establishment of facility for various types of value added products from *Tinospora cordifolia* (Giloe) **19th Jul 2021**	Name: Dr. Dinesh Kumar Email: dineshkumar@ihbt.res.in

S. No	Name of Incubatees	Idea of Start-up and Start date	Mentor
5	**Rohit Kalia** Plot No. 28, Phase 2, Industrial Area, Nagri, Palampur, Distt. Kangra (HP) Cont. No. 9780599369 Email: mishra.eshika26@gmail.com	Develop packaging material utilising available agricultural wastes and Mushroom Mycelium **26th Jul 2021**	Name: Dr. Rakshak Kumar Email: rakshak@ihbt.res.in
6	**Aditi Sharma** Amravati Niwas, Tika Aima, Ghuggar, Near SSB Chowk, Palampur, Distt. Kangra (HP) Cont. No. 9988053161 Email: aditi.sharma203@gmail.com	We are determined to use the plant's healing properties to promote good health and lifestyle without any physical contact with skin **22nd Nov 2021**	Name: Dr. Dinesh Kumar Email: dineshkumar@ihbt.res.in Name: Dr. Robin Joshi Email: robinjoishi@ihbt.res.in
7	**Abhishek Gautam** Block No- 18, Flat No- 4, Phase-3, New Shimla, Shimla (HP)171009 Cont. No. 9871860115 Email: abhishekgaumzi99@gmail.com	Project in concentrated on growing different types of mushrooms used for medicinal and nutritional values, **15th Nov 2021**	Name: Dr. Rakshak Kumar Email: rakshak@ihbt.res.in
8	**Akash Deep Rehan** Ward No- 5, Near Yamini Hotel, Palampur (HP) -176061 Cont. No. 7651093555 Email: akkashrehan@gmail.com	Plants are high in market demand and used in pharma comp Growth period can be shorten by soilless farming result in continuous cash flow Herbs are expensive that can make hi tech farming to profit **18th Nov 2021**	Name: Dr. Ashish Wargat Email: ashishwarghat@ihbt.res.in

The Academy of Scientific and Innovative Research (AcSIR) was established in 2010 (by a resolution of GOI on July 17, 2010) and formalized by an Act of Parliament vide The Gazette of India (dated February 7, 2012). Later on 3rd April, 2012 it was notified as an Institution of National Importance with mandate to undertake high quality teaching and research in frontier areas of Science and Technology. The CSIR-IHBT started Ph.D. programme in January 2011 in Biological and Chemical Sciences under the banner of AcSIR. As on date, 349 students are enrolled for Ph.D. under AcSIR at CSIR-IHBT in the faculty of Biological Sciences and Chemical Sciences (Fig. 1) and 94 students have been awarded with their doctoral degrees.

During the year 2021-22, various academic activities of AcSIR, CSIR-IHBT, like interviews, classes, examinations, DAC meetings, comprehensive examinations and Viva-Voce, were conducted digitally through electronic communication mode following COVID-19 containment guidelines.

Online interviews were conducted for 166 students who had applied for Ph.D. admissions. Out of these 51 students were selected for Ph.D. admissions in AcSIR at CSIR-IHBT for August 2021 and January 2022 sessions.

Total 16 students successfully defended their thesis in their Viva Voce examinations and were awarded with doctoral degree as per the details provided in the following table:

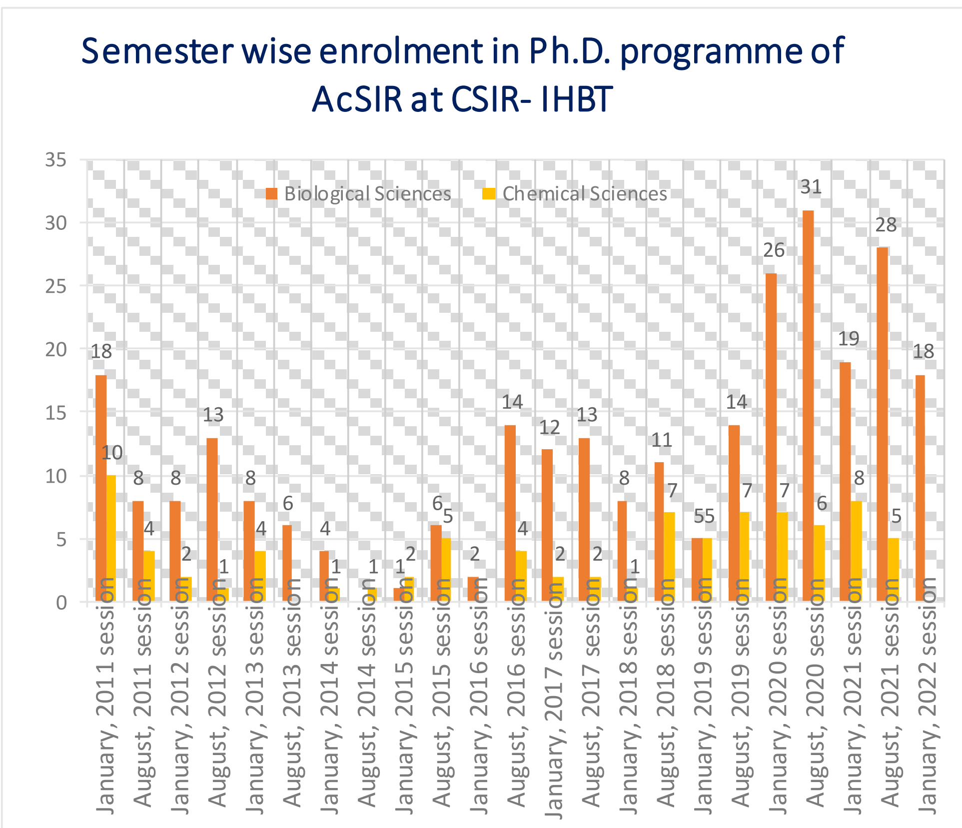


Fig. 1 Semester wise enrolment in Ph.D. programme of AcSIR at CSIR- IHBT

Sr.	Registration No.	Name of the Student	Faculty	Supervisor
1	10BB13J33002	Bharti Lalhal Barsain	Biological Sciences	Dr. Vipin Hallan
2	10BB15A33002	Mitali Mahajan	Biological Sciences	Dr. Probir Kumar Pal
3	10BB15A33004	Supriya Sharma	Biological Sciences	Dr. Damanpreet Singh
4	10CC15A33011	Inder Kumar	Chemical Sciences	Dr. Upendra Sharma
5	10BB16A33002	Nikita Rathore	Biological Sciences	Dr. Amit Chawla
6	10BB16A33003	Himani Agrawal	Biological Sciences	Dr. Mahesh Gupta
7	10BB16A33008	Swati Walia	Biological Sciences	Dr. Rakesh Kumar
8	10CC16A33015	Rohit Rana	Chemical Sciences	Dr. S. K. Maurya
9	10CC16A33017	Shaifali	Chemical Sciences	Dr. Pralay Das
10	10CC16A33018	Shruti Sharma	Chemical Sciences	Dr. Dinesh Kumar
11	10CC17J33013	Ranjana Sharma	Chemical Sciences	Dr. Dinesh Kumar
12	10BB17A33015	Vikram Patial	Biological Sciences	Dr. Y. S. Padwad
13	10BB18J33005	Tirpude Narendra Vijay	Biological Sciences	Dr. Vishal Acharya
14	10CC18J33009	Antim Kumar Maurya	Chemical Sciences	Dr. V. K. Agnihotri
15	10BB18A33005	Patil Shivprasad Suresh	Biological Sciences	Dr. Y. S. Padwad
16	10CC18A33022	Ankit Kumar Dhiman	Chemical Sciences	Dr. Upendra Sharma

National Technology Day

CSIR-Institute of Himalayan Bioresource Technology, Palampur (HP) celebrated National Technology Day on 11th May, 2021 through MS Teams in virtual mode. This year the theme of the National Technology Day was "Science and Technology for a Sustainable Future". Dr. Sanjay Kumar, Director, CSIR-IHBT welcomed the guests and reiterated the importance of National Technology Day. He briefed about the different research and developmental activities of the institute that led to various technological breakthroughs and contributed significantly to catalyzing the Himalayan Bioresources-based bioeconomy. He also highlighted the contribution of team CSIR-IHBT for developing testing facilities and scientifically validated products such as hand sanitizers and immunity-boosting tea formulation for the management of the COVID-19 pandemic. On this occasion, the chief guest Prof. Kuldeep Singh, Director, ICAR-NBPGR, New Delhi delivered a National Technology Day Lecture on "Conservation of Agrobiodiversity for Ensuring Food and Nutritional Security in India". He emphasized the role of NBPGR in the management and conservation of national agrobiodiversity and summarized the activities of the bureau. The program was attended by CSIR-IHBT staff, scholars as well as former employees, press and media persons, and other dignitaries of the region.

World Environment Day

CSIR-IHBT celebrated World Environment Day on 5th June, 2021. On this occasion, CSIR-IHBT scientists, Dr. Sanjay Uniyal and Dr. Gaurav Zinta delivered the talks on ecosystem restoration and technological solutions to global climate change. Director CSIR-IHBT, Dr. Sanjay Kumar, highlighted the institute's contributions to protect the environment and administered the Environment Day pledge to staff and research scholars. In addition, plants for

Sh. Virender Kanwar, Hon'ble Minister of Rural Development, Agriculture, Panchayati Raj, Animal Husbandry and Fisheries, Govt. of HP

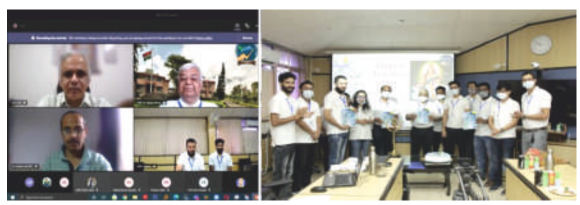
Sh. Virender Kanwar, Hon'ble Minister of Rural Development, Agriculture, Panchayati Raj, Animal Husbandry and Fisheries, Govt. of HP, visited CSIR-IHBT on June 17, 2021. On this occasion, the Hon'ble Minister was briefed about the development made by CSIR-IHBT on Hing and Saffron cultivation in HP along with other research activities and technologies of the institute. He was pleased with the work and achievements of the institute. He appreciated the institute's efforts on increasing farmer's income and making them self-reliant. He assured full support from the state government on relevant activities of mutual interest. The Hon'ble minister visited the institute facilities and planted a tree. He was accompanied by Dr. Ajay Kumar Sharma (Secretary Agriculture), Sh. Rakesh Kanwar (Special Secretary, Agriculture), Sh. Naresh Thakur (Director, Agriculture), Dr. Ajmer Singh Dogra (Director, Animal Husbandry), Dr. Rajeshwar Chandel (Program Director, Natural Farming), and Prof. H. K. Chaudhary (VC, CSKHPKV, Palampur).

CSIR-IHBT Foundation Day Celebrations

CSIR-IHBT celebrated its 39th Foundation Day on 2nd July, 2021. Chief Guest of the function, Hon'ble Prof. R.A. Mashelkar, Padam Vibhushan, National Research Professor, Chairman, National Innovation Foundation, and Former, Director General CSIR delivered the Foundation Day Lecture on "Innovation Leadership: Learnings from a Personal Journey". Dr. Shekhar C. Mande, Secretary DSIR and Director General CSIR, Govt. of India presided over the function. On this auspicious occasion, Prof. R.A. Mashelkar inaugurated an incubation facility for Vitamin D_2 enriched Shiitake mushroom and released the institute's Annual Report 2020-21 along with saffron manual "गैर पारंपरिक क्षेत्रों में केसर की उन्नत कृषि प्रोद्योगिकी पर प्रशिक्षण मैनुअल". Dr. Shekhar C. Mande laid the foundation stone of CSIR-IHBT dispensary. Nine MoUs/ Agreements were signed online in the presence of Prof. Mashelkar and Dr. Mande. Tree plantation was also done.

STUDENTS' SEMINAR SERIES - 2021

Theme: Scientific Innovation and Digital Transformation: Bridging interdisciplinary Perspective

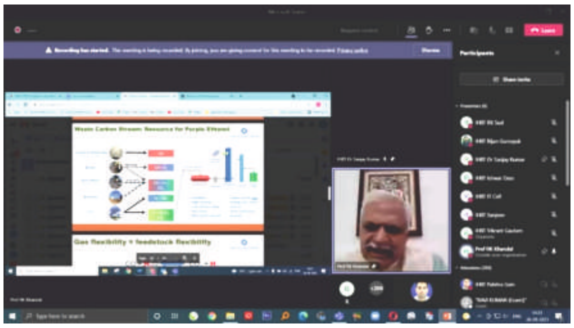


Fifth annual seminar on the theme was organized at the Institute on the Teachers' Day, 5th Sept 2021. Dr Shekhar C Mande, DG CSIR graced the occasion virtually. Dr Ashish K Lele, Director CSIR-NCL, Pune, delivered "talk on" Hydrogen Economy.

हिंदी सप्ताह समारोह का आयोजन

संस्थान में हिंदी सप्ताह समारोह का मुख्य समारोह दिनांक 14 सितम्बर 2021 को ऑनलाइन माध्यम से बड़े हर्षोल्लास के साथ मनाया गया। समारोह के मुख्य अतिथि प्रो. सुनील कुमार सिंह, निदेशक, राष्ट्रीय समुद्रविज्ञान अनुसंधान संस्थान, गोआ ने `हिंद महासागर का जैव-भू-रासायनिक अध्ययन' विषय पर संभाषण दिया।

CSIR Foundation Day Celebrations



Institute celebrated CSIR Foundation Day on 26th September, 2021 through virtual mode. Chief Guest of the function Prof RK Khandal, Fellow, Royal Society of Chemistry, London, President R&D and Business Development, India Glycols Limited, Noida delivered the Foundation Day lecture on "Changing Industrial Trends: Increasing Demand for Renewable Chemicals". At the outset, Director of the institute, Dr. Sanjay Kumar, welcomed the guests and presented a brief description of the key activities and achievements of the institute. He also congratulated the scientists of the institute who received the CSIR Technology Award for achievements in the field of biology and technology dissemination. On this occasion, a booklet on plant protection was released and MoUs on biodegradation was signed with three different groups of Lahaul and one MoU was signed with ICICI Foundation for inclusive growth, ICICI Bank Towers, Bandra East, Mumbai. Plantation was also done by the chief guest through online medium. The programme was attended by scientists from other CSIR institutes, former scientists of the institute, dignitaries from the adjoining areas, scientists of CSIR-IHBT, research students, personnel and media representatives through MS-Team.

Vigilance Awareness Week

CSIR-IHBT celebrated vigilance awareness week from 26th October to 1st November, 2021. The week was started by administering "Integrity Pledge" by Dr Sanjay Kumar, Director, to all the scientists, researchers and employees, followed by "walkathon",

debate and quiz competition, awareness against corruption programme "Gram Sabha" at 4 panchayats in Kangra district, and "Vendors Meet" and "Contractors Meet" at the institute with Integrity Pledge for Organizations.

Curtain Raiser Event for Indian International Science Festival (IISF), 2021

The Curtain Raiser Ceremony of IISF was held at the institute on 6th December, 2021 through hybrid mode. Prof. Annapurna Nautiyal, Vice Chancellor, Dr. Hemvati Nandan Bahuguna Garhwal University, was the Chief Guest. Dr. Ashwini Rana, President, Vijnana Bharati, Himachal Pradesh Chapter and Associate Professor, National Institute of Technology, Hamirpur, was Guest of Honour.

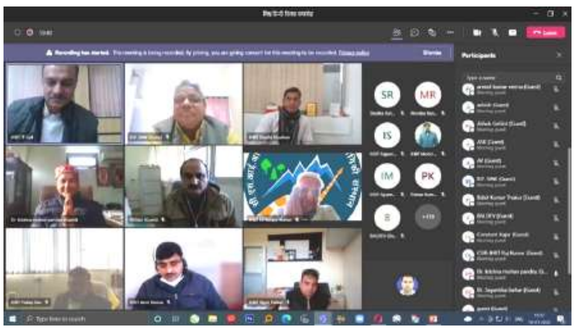
Sawaran Jayanti Tea Fair – 2021

"Swaran Jayanti Tea Fair" was organized on

14th December, 2021 at CSIR-IHBT,

Palampur. Shri Virendra Kanwar, Minister Agriculture, Rural Development, Panchayati Raj, Fisheries and Animal Husbandry, Govt. HP was the Chief Guest.

विश्व हिंदी दिवस



हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर में 10 जनवरी, 2022 को विश्व हिंदी दिवस का आयोजन किया गया। इस अवसर पर डा. कृष्ण मोहन पाण्डेय, आचार्य एवं वेद विशेषज्ञ ने `हिंदी भाषा-व्यापकता एवं महत्व' विषय पर अपने संबोधन में राजभाषा हिंदी के राष्ट्रीय, ऐतिहासिक परिदृश्य पर महत्वपूर्ण एवं ज्ञानवर्धक व्याख्यान दिया। अपने संबोधन में डा. पाण्डेय ने भाषा के उद्‌भव, क्रमिक विकास, चुनौतियां और संभावनाओं पर प्रकाश डाला

Shri Loknath Sharma Hon'ble Minister, Agriculture, Horticulture, AH&VS, IPR, Printing & Stationary, Government of Sikkim

Shri Loknath Sharma Hon'ble Minister, Agriculture, Horticulture, AH&VS, IPR, Printing & Stationary, Government of Sikkim visited CSIR-IHBT, Palampur on 17-18th February, 2022. Hon'ble Minister appreciated the work being done and desired to extend the technologies of institute of the aeroponics and hydroponics, low chilling varieties of Apple, Heeng, Saffron, Aromatic crops, Floriculture crops and monk fruit in Sikkim for the benefit of the people there.

Visit of Hon'ble Governor of Himachal Pradesh Rajendra Vishwanth Arlekar

Hon'ble Governor of Himachal Pradesh Shri Rajendra Vishwanath Arlekar visited CSIR-IHBT, Palampur on 28th February, 2022 on the occasion of National Science Day. Hon'ble Governor laid the foundation stone of the new building block of the institute and also inaugurated the "First Tulip Garden" in the state.

Visit of Hon'ble Minister Rural Development, Govt. of Himachal Pradesh

Hon'ble Minister Rural Development, Panchayati Raj, Agriculture, Animal Husbandry & Fisheries, Govt. of Himachal Pradesh, Sh. Virender Kanwar visited Himachal's first Tulip Garden at CSIR-IHBT on 06th March, 2022.

STUDENT SEMINAR SERIES

STUDENT SEMINAR SERIES

The research scholars of CSIR-IHBT organized a scientific program named as Student Seminar Series (SSS), wherein they shared their research interests, ideas, and achievements to foster collaborations and enhance communication. The SSS was incepted in 2017 to celebrate Teachers' day (5^{th} September) scientifically.

In continuation to previous years, the 5^{th} edition of SSS was organized by the research scholars on 5^{th} September 2021 in a virtual mode. The theme of 5^{th} edition was "*Scientific innovations and digital transformation: Bridging interdisciplinary perspectives*". Besides oral presentations scientific writing for articulating research (SWAR) & scientific photography, new events namely videography & e-poster were included in this year. Besides the students of CSIR-IHBT, students from many other institutions, including CSIR-IIIM, Jammu; CSIR-NEERI, Nagpur; IIT, Mandi; Shoolini University, Solan; Department of Animal Husbandry, Himachal Pradesh; Central University of South Bihar, Indian Institute of Management, Jammu; Ramakrishna Mission Vivekananda Centenary College, West Bengal; Chaudhary Bansilal University, Bhiwani; Punjabi University, Patiala; and Panjab University, Chandigarh, participated and presented their work. In addition, this year, alumni of CSIR-IHBT were also invited, and five alumni gave invited talks to motivate the young generation. The program was presided over by the honorable Dr. Shekhar C. Mande, Director General of CSIR & Secretary DSIR, while Dr. Ashish Lele, Director CSIR-NCL Pune, delivered the keynote address.

The credit for the successful organization of SSS goes to young and dynamic scholars of CSIR-IHBT, that include Abhishek Goel, Aman Verma, Amit Kumar, Anil Kumar, Anish Tamang, Rishabh Kaundal, Namo Dubey, Pallavi Sharma, Subhash Thakur, Sumanta Mohapatra, Twinkle and Vikas Dadwal.

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2. Agnihotri VK, Kumar B and Gautam HK (2020) A synergistic formulation against acne and a process for the preparation thereof. (Patent Application No.NFNO. 0041NF2020/WO, Application No. 17/598277, Comp. Filing Date 26/Sep/2021. Patent Application No.NFNO. 0041NF2020/WO, Application No. 17/598277, Comp. Filing Date 26/Sep/2021. Patent Application No.NFNO. 0193NF2018/JP, Application No. 2021-557843, Comp. Filing Date 28/Sep/2021 and Patent Application No.NFNO. 0193NF2018/EP, Application No. 20784262.6, Comp. Filing Date 04-October-2021)

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5. Dass P, Yamini, Richa B, Shankar R, Bhardwaj K, Rituraj P, Singh D, Anand P and Padwad SY (2020) Bioactive benzocycloheptane analogues from Himachalenes useful for the treatment of PI3K and MK2 related disorders. (Patent Application No.NFNO. 0053NF2020/WO, Application No. PCT/IN2021/050993, Comp. Filing 19-October-2021)

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10. No. 202111045079, Comp. Filed on 04-October-2021)

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No. NFNO. 0086NF2020/IN, Application No. 202011048468, Prov. Filing Date 04-November-2020 Comp. Filing Date 21-October-2021)

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Bioreactor vessel or large scale growing of plants under aseptic conditions. (Patent Application No. NFNO. 0013NF2012/IN, Application No. 2445DEL2012, Patent No. 372301 Granted on 20-July-2021)

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Purohit R (2021) Plant-based analogues identified as potential inhibitor against tobacco mosaic virus: A biosimulation approach. Pesticide Biochemistry and Physiology, 175, 104858.

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BOOKS/BOOK CHAPTER

1. Baliyan N, Kumari M, Kumari P, Dindhoria K, Mukhia S, Kumar S, and Kumar R (2022) Probiotics in fermented products and supplements. In: Developments in Biotechnology and Bioengineering. (Ed. Rai AK, Singh SP and Socco, CR, Elsevier) p. 73-107.

2. Borker, SS, Prashant SP, Kumari A, Kumari S, Devi R and Kumar R (2021) Metabolic pathways in biodegrading psychrotrophic bacteria under cold environments. in: extreme environments: unique ecosystems–amazing microbes (Ed. Pandey A and Sharma A,Press) p. 217-233.

3. Dkhar J and Joshi R (2022) Bamboo resources at CSIR-IHBT (Vol. II). CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal

Pradesh. p. 76.

4. Jaiswal V, Gahlaut V, Kumar N and Ramchiary N (2021) Genetics, genomics and breeding of chili pepper *Capsicum frutescens* L. and other capsicum species. in: advances in plant breeding strategies: vegetable crops. (Ed. Al-Khayri J.M., Jain S.M., Johnson D.V. Springer, Cham.).

5. Kundu P, Goel K and Zinta G (2022) Nutritional imbalance in plants under rising atmospheric CO_2, in*Plant Nutrition and Food Security in the Era of Climate Change*513-536, Academic Press, https://doi.org/10.1016/B978-0-12-822916-3.00006-8.

6. Kumar A, Kumari S, Dindhoria K, Manyapu V and Kumar R (2021) Efficient utilization and bioprocessing of agro-industrial waste. In:Agriculture Reviews 56 (Ed. Lichtfouse E, Ranjan S and Dasgupta N, Springer). 1-37.

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9. Maurya A and Agnihotri, VK (2022) *Juniperus communis*, *Hedychium* spicatum and *Valeriana jatamansi* from India. LAP LAMBERT Academic Publishing (Omni Scriptum Gmbh & Co. KG), Saarbrucken, Germany. (ISBN-13: 978-620-4-73395-1, EAN: 9786204733951), p. 384

10. Panwar S, Gupta YC, Kumari P, Thakur N and Mehraj U (2021) Carnation. In: Floriculture and ornamental plants. Handbooks of Crop Diversity: Conservation and Use of Plant Genetic Resources. (Ed. Datta S.K., Gupta Y.C. Springer, Singapore). https://doi.org/10.1007/978-981-15-1554-5.

11. Rathore N, Thakur D, Hopak NE and Chawla A (2022) Intra-annual variation in leaf anatomical traits of an overwintering shrub of high elevations of himalaya. In: Kimatu, J.N. (Ed.). Plant Defence Mechanisms. IntechOpen Ltd., U.K. Pp.1-14. ISBN: 978-1-83969-771-5. DOI: 10.5772/intechopen.102016.

12. Sharma C, Verma M, Randhawa S and Acharya A (2022) Nanotechnological interventions for the detection of pathogens through surface marker recognition. In: Handbook of Microbial Nanotechnology. (Ed. Hussain C.M, Elsevier, U.K) p. 45-77.

13. Singh A and Chawla A (2021) Plant Conservatory at Centre for High Altitude Biology of CSIR-IHBT. Trek and Learn Series Vol. 1. Published by Director, CSIR-Institute of Himalayan Bioresource Technology, Palampur, HP, India.

14. Singh Ashok and Chawla Amit (2021) Plant Conservatory at Centre for High Altitude Biology of CSIR-IHBT. Vol.1.

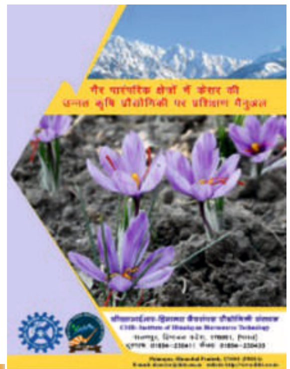
15. भागर्व,भव्य, कुमारी पूनम, विकास सोनी, सनतसुजात सिंह एवं अशोक कुमार (2022) व्यावसायिक पुष्पीय फसलें प्रशिक्षण पुस्तिका, सी.एस.आई.आर- हिमालय जैवसंपदा प्रौद्योगिकी संस्थान, पालमपुर.

16. रोहित जोशी, जेरेमी ड्खार एवं अमिता भट्टाचार्य

(2021) सीएसआईआर-आईएचबीटी की बांस सम्पदा। Palampur, Himachal Pradesh. Pp-104.

TECHNICAL BROCHURES/MANUAL

कुमार राकेश (2021) प्रशिक्षण मैनुअल गैर परम्परागत क्षेत्रों में केसर की उन्नत कृषिप्रौद्योगिकी, पेज 56.



राकेश कुमार (2021) गैर परम्परागत क्षेत्रों में केसर की उन्नत कृषि प्रोद्योगिकी पर प्रशिक्षण मैनुयल. प्रोफेसर आर ए माशेलकर पूर्व महानिदेशक सीएसआईआर द्वारा जारी। जुलाई 2, पी56.

THESIS/ DISSERTATIONS

PhDs.

1. Swati Walia (2021) Nutrient, weed management and altitude effect on biomass, essential oil yield and quality traits of *Tagetes minuta* L. AcSIR program. Supervised by Dr. Rakesh Kumar.

2. Antim Kumar Maurya (2021) Phytochemical investigation of *Juniperus communis*, *Hedychium spicatum* and *Valeriana jatamansi* from North-Western Himalaya. Supervised by Dr. Vijai Kant Agnihotri.

3. Supriya Sharma (2021) Identification and validation of molecular targets for the management of seizure-associated cardiac complications in chronic epilepsy models. Supervised by Dr. Damanpreet Singh.

4. Nikita Rathore (2021) Studies on adaptive responses of *Rhododendron anthopogon* to high altitude alpine environment of Himalaya. Supervised by Dr. Amit Chawla.

M.Sc./M. harma/B.Sc./B.Pharma/B.Tech

Training Imparted

1. Sujata (2021) Hands on training in molecular biology techniques, Supervised by Dr. Damanpreet Singh (12.07.2021-11.10.2021).

2. Neety Sharma (2021) Hands on training in different molecular biology techniques used in pharmacology and toxicology laboratory, Supervised by Dr. Damanpreet Singh (21.09.2021-20.12.2021).

3. Rashmi Kumari (2022). MSc Zoology hands on training in pathology and toxicological techniques Supervised by Dr. Vikram Patial (September 2021 - March 2022).

4. Simran Katle (2020) Optimization of axillary shoot proliferation and biochemical characterization of giant bamboo, *Dendrocalamus giganteus* Wall. Ex Munro. From D.Y. Patil University, Mumbai, Supervised by Dr. Rohit Joshi (11-11-2019 to 10-07-2020).

5. Dipaknashi Patel (2021) Comparative analysis of micropropagation, physiochemical properties, anatomical structure and transcript abundance of five bamboo species. School of Engineering and Technology, Jaipur National University, Jaipur, Supervised by Dr. Rohit Joshi (11-08-2020 to 23-02-2021).

Conference/Training/Workshop/Symposium Presentations

Pal PK (2021) Monk fruit (a non-caloric new natural sweetener) cultivation details and market demand. In: A online meeting with farmers, entrepreneurs, academic experts, young professionals, trade body representatives, policy makers, and political leaders (Organized by Agriculture Information, Vadamalai Media Group, C-2/286, 2 C Cross, Domlur II Stage, Bangalore 560071), May 7.

Conference/Training/Workshop/Meeting Attended

Dhrek, Singh M, Kumar R, Devi J, Gehlot A and Bhushan S (2021) Cryopreservation of *in vitro* leaf induced callus cultures from *Arnebia benthamii* (Wall. ex G. Don) Johnston– a critically endangered Himalayan plant. In 42nd Annual Meeting of PTCA (I) & International Symposium on APBGE-2021, organized by ICAR-Indian Institute of Agricultural Biotechnology (IIAB), Ranchi, Jharkhand (Virtual mode), April 8-10.

Patial V (2021) Digital Colloquium on Avenues for Veterinarians in Pharma Industries: Drug Development and Validation, organized by the Department of Veterinary Pharmacology and Toxicology, COVAS, Mannuthy, Thrissur, Kerala, Kerala Veterinary and Animal Sciences University, September 14-18.

Patial V (2021) Indian Association of Veterinary Pathologists 4th Zonal (Central) Conference-2021 & National Symposium on Livestock Diseases and their Impact on Sustainable Production", organized by Department of Veterinary Pathology, College of Veterinary Science & A.H., NDVSU, Rewa, M.P-486001, October 05-06.

Patial V (2021) Online Short Term Training Course on Current Scenario and Future Challenges of Animal Health and Production in the North Western Himalayan Region, organized by ICAR-IVRI Regional Station, Palampur, November 08-13.

Dutta M, Raturi V, Sharma P, Goel K, Kundu P, Sood S and Zinta g (2021) Assessing thermal sensitivity in potato (Solanum tuberosum) by comparative analysis of sensitive and tolerant potato genotypes. International Potato e-Conference "New Paradigms in Food Security and Industrial Applications, November 23-26.

Nadda G (2021) Attended training on "Freshwater Pearl Culture for entrepreneur Development" organized by ICAR-Central Institute of Freshwater Aquaculture (CIFA), Bhuvneshwar, (online mode), December 1-3.

Patial V (2021) International Veterinary Pathology Congress, jointly organized by Department of Veterinary Pathology, College of Veterinary and Animal Science Rajasthan University of Veterinary and Animal Sciences-Bikaner, IAVP and ICVP, December 17-19.

Kumari A (2022) National webinar on promotion of the farmer producer organizations (fpos) in floriculture sector: opportunities and challenges, organized by ICAR-IIFR, Pune, January 07.

Kumari A (2022) International webinar on biotechnology for crop tolerance to low and high temperature stresses, organized by Department of Agriculture, MM(DU), Mullana- Ambala, January 15.

Kumari A (2022) International virtual conference on Biological Innovations and Computational Exploration for Pandemic Challenges (BICPAC 22) organized by Department of Biotechnology and Bioinformatics, Bishop Heber College, Tiruchirappalli, February 24-25.

Conference/Training/Workshop/Meeting Organized

Ramesh and Singh S (2021) Organized a training program on “Cultivation of Heeng” at Village Triloknath, Kishori, Khangsar and Yurnath, Lahaul Block, Lahaul & Spiti, HP, April 14-17.

Kumar R and Bhargav B (2021) Organized a training program on “Potential of Floriculture and Aromatic Plants in Ladakh”. Industry and Commerce Leh, May 5.

Ramesh and Singh S (2021) Organized a training program on “Cultivation of Heeng and Aromatic Crops” at Village Salgram, Lahaul Block, Lahaul & Spiti, HP, June 06.

Kumar R (2021) Organized a training program on Cultivation of saffron in non-traditional areas training program for the agriculture officers of Department of Agriculture, Govt of HP), June 18.

Kumar R (2021) Organized a training program on Process technologies of aromatic marigold for the farmers of Mandi district. Organized by EWOK (NGO), Mandi, HP, June 19.

Poonam (2021) Organized a training program on in vitro induction of callus from *Calendula officinalis* explant in response to various growth regulators March 23 to June.

Pal, PK and Ramesh (2021) Organized a training program on Cultivation of Monk fruit at Village Raison, Kullu Block, Kullu (HP), July 12.

Kumar R (2021) Organized a training program on Cultivation techniques of saffron in non-traditional areas at village Baga Srahan, Tehsil Nirmand, Kullu, HP, July 23.

Kumar R (2021) Organized a training program on Cultivation techniques of saffron in non traditional areas” at Village Kupa, Tehsil, Sangla and Reckong Pio, Kinnaur, HP, July 25-26.

Poonam (2021) Organized a training program on Micro-propagation of rose (*Rosa* x hybrida) March 15 to July 30.

Ramesh and Kumar A (2021) Organized a training program for the farmers of Tehsil Balichowki, Siraaj Block, Mandi (HP) on Cultivation of Heeng at CSIR-IHBT, Palampur, July 30.

Kumar R, Sharma M, Bhargav B and Soni V (2021) Organized a training program on cultivation and processing of aromatic plants for farmers of Leh, Industry and Commerce Ladakh, August 8.

Ramesh and Kumar A (2021) Organized a training program for the farmers of UT Ladakh on Cultivation of Heeng at CSIR-IHBT, Palampur, August 08.

Ramesh and Kumar A (2021) Organized a capacity building programme for Officers of Agriculture Department at CSIR-IHBT, Palampur, September 21.

Kumar R and Kumar A (2021) Organized a training program on Capacity building program of agriculture officers of production technology of saffron and heeng at CSIR-IHBT Palampur, September 20-24.

Ramesh and Singh S (2021) Organized a training program on Cultivation of Dalchini at Village Kholin, Bangana Block Una, HP, September 29.

Ashok Singh (2021) Organized three training programs on the topic “Ex-situ conservation and development of gene bank of commercially important threatened medicinal plants in the high altitude areas, Himachal Pradesh" sponsored by NMHS-PMU funded project venue at Sissu, Jispa, Mooling villages of Himachal Pradesh, October 07-09.

Ramesh and Singh S (2021) Organized a

training program on Cultivation of Dalchini at Village Sakrala, Nadaun Block, Hamirpur and Nandpur Bhatoli, Nagrota Surian Block, Kangra, HP, October 13.

Ramesh and Singh S (2021) Organized a training program on Cultivation of Dalchini at Village Dadahu and Bhajon, Dadahu Block, Sirmaur, HP, October 14.

Ramesh and Singh S (2021) Organized a training program Cultivation of Dalchini at Village Kosarian, Bilaspur Block, Bilaspur, HP, October 15.

Ramesh and Kumar A (2021) Organized a training program for the farmers of Janskar Valley, UT Ladakh on Cultivation of Heeng at CSIR-IHBT, Palampur, October 16.

Kumar Rakesh and Bhargav B (2021) Organized a training cum awareness program for the representatives for 50 cooperative societies, BDC members, panchayat Pradhan and farmers of Palampur tehsil, distt. Kangra, HP. November 18.

Kumar R and Bhargav Bhavya (2021) Organized a training program on cultivation of aromatic and floriculture crops for the tribal farmers residing in lower areas of Kangra at Sukeri, Rakh, Palampur. December 3.

Kumar R and Bhargav B (2021) Organized a training program for the cooperative societies of Kangra district at CSIR-IHBT Palampur, December 6.

Ramesh and Singh S (2021) Organized a training program on Cultivation of Dalchini at IISF Panaji, Goa, December 12.

Ramesh (2022) Organized a training program on Cultivation of Heeng and aromatic crops at Village Kutahachi, Gohar Block, Mandi, HP, February 19.

Kumar R (2022) Organized a training program on improved cultivation of saffron for the tribal farmers and agricultural officers at Chamba, HP, February 22-23.

Ramesh and Singh S (2022) Organized a training program on Cultivation of Dalchini at Village Kherian, Dehra Block, Kangra, HP, March 06.

Kumar R and Sharma M (2022) Organized one-day workshop on revival of lavender cultivation in Salooni, Chamba, on March 21.

Ramesh and Singh S (2022) Organized a training program on cultivation of Dalchini at Village Barnoh, Una Block, Una, HP, March 23.

Sharma M (2021) Two days training cum demonstration of essential oil distillation of rose flowers was imparted to 3 farmers of Barnala in different types of distillation units i.e. Clevenger type apparatus, Herbostill, steam distillation units. All the steps of distillation which includes plucking of flowers, loading of flowers, distillate/ water, processing of flowers, collection of essential oil, filtration of oil and storage of same had been demonstrated to them. Supervised by Er. Mohit Sharma, (12.04.2021 - 13.04.2021)

Sharma M (2021) One-day training cum demonstration on essential oil distillation was given to 2 representatives of Leela Worldwide group, Delhi and consequently 10 farmers came from Chamba. A batch of 7.0 kg fresh lemongrass was distilled in Herbostill for the same which yield 36 ml essential oil. Supervised by Er. Mohit Sharma, (10.09.2021).

Sharma M (2021) One-day training cum demonstration on essential oil distillation was given to 4 farmers of Bilaspur and Hamirpur district. A batch of 5.0 kg semi-dried lemongrass was distilled in Herbostill for the same which yields 42 ml essential oil.

Supervised by ER. Mohit Sharma, (13.09.2021).

Sharma M (2021) Training cum demonstration on essential oil distillation was given to 20 farmers of Ghallour (Jwalamukhi) in Mobile Essential Oil Distillation Unit (MeDU) at their place. A batch of 200 kg Tulsi was distilled in MeDU for the same which yield 380 ml essential oil and 90 litres ark Supervised by ER. Mohit Sharma, (06.10.2021).

Sharma M (2021) Training cum demonstration of essential oil distillation was given to 25 farmers of Chuwari (Chamba) in the 200 kg/ batch capacity distillation unit established at the site. A batch of 150 kg Tagetes minuta was distilled in the same for the training. Supervised by ER. Mohit Sharma, (26.10.2021).

Sharma M (2021) Training cum demonstration of essential oil distillation was given to 25 farmers of Ghogardhar (Mandi) in the 500 kg/ batch capacity distillation unit established at the site. A batch of 400 kg Tagetes minuta was distilled in the same for the training. Supervised by ER. Mohit Sharma, (18.11.2021).

Sharma M (2021) Training of stevia leaves processing was given to two farmers of Bharatgarh District of Rajasthan. Different steps of stevia leave processing was briefed to them to produce stevia powder, formulated stevia powder and liquid. (08.12.2021).

Sharma M (2022) Training cum demonstration of different equipments and unit operations had been done to 30 Ph.D. students and 4 faculty members of Maharishi Dayanand University (MDU), Rohtak under STRIDE program. Supervised by ER. Mohit Sharma, (08.03.2022).

Sharma M (2022) Training cum demonstration of different equipment and unit operations had been done to 46 Forest Range Officers of Himachal Pradesh Supervised by ER. Mohit Sharma, (21.03.2022).

Lectures Invited/Delivered

Dr. Damanpreet Singh (2021) Delivered a lecture on "Zebrafish (*Danio rerio*): A real-time experimental model in biomedical research" in in a webinar at Department of Pharmacology, Central University of Punjab, Bathinda, April 16.

Dr. Damanpreet Singh (2021) Delivered a lecture on "Novel techniques in drug discovery" in a webinar organized by Govt. Pharmacy College Kangra, Nagrota Bagwan, Himachal Pradesh, May 28.

Dr. Poonam Kumari (2021) Status and scope of floriculture in College of Horticulture and Forestry Neri, Dr Y.S. Parmar university of Horticulture and Forestry, District Hamirpur (HP), July 03.

Dr. Damanpreet Singh (2021) Delivered a lecture on "therapeutic switching in drug discovery: a special reference to epilepsy" in in a faculty development programme (FDP) organized by Chitkara University, Punjab, July 06.

Dr. Damanpreet Singh (2021) Delivered a lecture on "Food as a medicine: Regulatory and safety issues" in UGC sponsored Faculty Induction Programme (FIP) at the UGC-Human Resource Development Centre, Guru Nanak Dev University, Amritsar, Punjab, August 04.

Dr. Damanpreet Singh (2021) Delivered a lecture on "Academic integrity: Duties and responsibilities as a mentor" in UGC sponsored Faculty Induction Programme (FIP) at the UGC-Human Resource Development Centre, Guru Nanak Dev University, Amritsar, Punjab, August 13.

Dr Sukhjinder Singh (2021) Delivered a lecture 'General reporting process, protocol and escalation policy,reports and testing related documents as per SOP, and Explaining how to report deviations to the reporting supervisor' during QCB Course under "Skill Vigyan Programme" sponsored by DBT-HIMCOSTE, September 16.

Dr Sukhjinder Singh (2021) Delivered a lecture on 'Agriculture and value added Technologies of CSIR-IHBT' during Review Meeting of Expert Group on Agriculture Sector held at CSK HPKV, Palampur under the Chairmanship of Dr. Ramesh Chand, Member NITI Ayog, Govt. of India, October 08.

Dr. Damanpreet Singh (2022) Delivered a lecture on "Zebrafish as an alternative animal model in pharmacology Research" in UGC-Networking Resource Centre training course on "Emerging Trends and Alternatives in Pharmacological Research" organized by University Institute of Pharmaceutical Sciences, Panjab University, Chandigarh, February 15.

Dr. Damanpreet Singh (2022) Delivered a lecture on "Safety and Efficacy Evaluation of Natural Products" as a resource person in UGC-STRIDE program at the CSIR-IHBT, Palampur (HP), March 10.

Dr. Poonam Kumari (2022) Delivered a lecture on Cultivation of rose and gladiolus in GSSS, Jaree, District Kullu (HP), February 22.

Dr Sukhjinder Singh (2022) Delivered a lecture about CSIR-IHBT technologies relevant for Mizoram during virtual Technology Expo, a part of Azadi Ka Amrit Mahotsav organized by Scheduled Tribe Cell, Mizoram Science, Technology & Innovation Council (MISTIC), March 10.

Dr Sukhjinder Singh (2022) Delivered a lecture on 'a part of Azadi Ka Amrit Mahotsav organized programme entitled"Bioprospecting natural products for human health and socio-economic development"by MD University,UGC-STRIDE Programme,-IHBT, Palampur, March 11.

Dr. Vijai Kant Agnihotri (2022) A invited lecture "Phytochemistry: An integrated approach with out-of-the-box thinking". Delivered in national seminar on Fundamental and Applied Dimensions in Plant Sciences on. Organized by KSCSTE-Jawaharlal Nehru Tropical Botanic Garden and Research Institute, Palode, Thiruvananthapuram, Kerala, India on March 25.

Kumar R (2021) Virtually delivered a lecture on participated and delivered a lecture on "Low chilling varieties of apple suitable for North East" in Conclave on Transforming Meghalaya state through science and technology interventions. on April 10.

Kumar R (2021) Delivered a lecture on International Conference on Saffron and seed Spices-Innovative Technologies for Sustainable Development at SKAUST, Kashmir, India, on November 7-8.

Kumar R (2021) Delivered a lecture in Fifth International Agronomy Congress on "Agri Innovations to Combat Food and Nutrition Challenges" at Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, Telangana, India, on November 23-27.

Kumar R and Sud R K (2021) Delivered a lecture on medicinal and aromatic plants at village Chauki Maniar, Una, HP. on November 14.

Online Talk

Kumar R (2021) Delivered a radio talk on the topic entitled "Sugandhit Aushdhiye paudhon ki khetibari kaise bana sakti hai faydemand" on All India Radio Dharamshala, at 6:30 to 7:40 pm, June 25.

Abstract Presented

Patel D, Kumari A and Joshi R (2021) Comparative analysis of micropropagation, physiochemical properties, anatomical structure and transcript abundance of five bamboo species. 42nd Annual Meeting of Plant Tissue Culture Association-India (PTCA-I) and International Symposium on "Advances in Plant Biotechnology and Genome Editing" (APBGE-2021), ICAR-Indian Institute of Agricultural Biotechnology, Ranchi, April 8-10.

Sharma I, Kumari A and Joshi R (2021) Commercial scale micro-propagation of industrially important bamboo species at CSIR-IHBT. 42nd Annual Meeting of Plant Tissue Culture Association-India (PTCA-I) and International Symposium on "Advances in Plant Biotechnology and Genome Editing" (APBGE-2021) ICAR-Indian Institute of Agricultural Biotechnology, Ranchi, April 8-10.

Patial V, Katoch S, Chhimwal J, Singh P Pal, Patil SS and Padwad Y (2021) Tinospora cordifolia ethanolic extract mitigates the glomerular and tubular cell injury in diabetic rats. International Veterinary Pathology Congress 2021, jointly organized by Department of Veterinary Pathology, College of Veterinary and Animal Science Rajasthan University of Veterinary and Animal Sciences-Bikaner, December 17-19.

Award and Recognitions

Dr. Pralay Das, et al. (2022) Awarded the CRSI Bronze Medal of 2022 by the Chemical Research Society of India (CRSI). This honor is given to young researchers who have contributed well to research in Chemistry declared on October 13, 2021.

Dr. Pralay Das (2021) Expert reviewer for the DBT-BIRAC BIG project on October 6, 2021 at Start-up Incubation and Innovation Centre (SIIC), IIT, Kanpur (through online mode).

Team CSIR-IHBT was awarded Certificate of Appreciation by Enabling Women of Kamand valley (EWOK) Mandi, HP for training of women farmers, establishment of market linkages, value addition of aromatic plants and ultimately enhancing the income of hilly farmers during 2018-2022 under CSIR Aroma mission.

Sud RK, Expert member for appointment of Head of Deptt., Tea Science in CSK HP Krishi Vishvavidyalaya, Palampur.

Sud RK, Chairman for the Selection Committee Group III staff of CSIR-IIIM, Jammu.

Sud RK, Expert member for the assessment of technical staff of CSIR-CMCRI, Bhavnagar.

Sud RK, Expert member in the meetings of Kangra Valley Tea Planters Association.

Sud RK, Expert member in the meeting of Tea Office (Tea) of State Agriculture Department.

Sud RK, Member, Annual Review Meeting of Tea Board of India.

Best Poster Award

Dr. Rakesh Kumar (2021) Awarded best poster award in the Fifth International

Agronomy Congress on "Agri Innovations to Combat Food and Nutrition Challenges" under the theme of Agronomic Innovations for Tapping Genetic Potential at Professor Jayashankar Telangana State Agricultural University (PJTSAU), Hyderabad, Telangana, India, November 23–27.

Certificate of Appreciation 2022

Dr. Poonam Kumari (2022) Paper entitled "Role of biotechnology for improving floral attributes in floricultural crops" in International virtual conference on Biological Innovations and Computational Exploration for Pandemic Challenges (BICPAC 22) organized by Department of Biotechnology and Bioinformatics, Bishop Heber College, Tiruchirappalli, February 24-25.

Swati Walia and Dr. Rakesh Kumar (2021) Poster entitled "Elucidating the response of nitrogen, sulphur, and their interaction on growth, biomass and quality traits of *Tagetes minuta* L." authored by won second prize in e-International conference on plant biodiversity and environment conservation (ICPBEC-2021).

Dr. Sukhjinder Singh (2021) Certificate of Appreciation for Participation in International Workshop on 'Technology Transfer and Commercialization (A virtual event) at Jakarata- Indonesia. Event was organized by Centre for Science & Technology of the Non- Aligned and Other Developing Countries (NAM S&T Centre), New Delhi, India, and National Research and Innovation Agency (BRIN), Republic of Indonesia, December, 7-8.

CSIR TECHNOLOGY AWARD 2021

Dr. Ashok Kumar (2021) Certificate of Merit for Life Sciences – 2021 for developing Rebaudioside-A rich cultivar of Stevia at CSIR-IHBT, Palampur.

Dr. Mohit Sharma (2021) "Certificate of merit" as team member for prestigious CSIR technology award in life sciences 2021 for developing rebaudioside-A rich cultivar of 'Him stevia', advanced agro-technology with 28% yield improvement, and green process technology for converting dry leaf into stevia glycosides powder with a purity of more than 95%. CSIR Technology Awards seek to foster and encourage multi-disciplinary in-house team efforts and external interaction for technology development.

Dr. Sukhjinder Singh (2021) Received 'Certificate of Merit' during 'CSIR Technology Awards 2021' in the 'Category of Technology Award for Business Development & Technology Marketing' on the Occasion of 80th CSIR Foundation Day celebrated at CSIR HQs, New Delhi in the presence of Hon'ble Vice President of India, Sh. M. Venkaiah Naidu; Hon'ble Minister (S&T and ES), Dr. Jitendra Singh; and DG, CSIR, Dr Shekhar C. Mande.

Special invitee member of Executive Committee of Essential Oil Association of India

Dr. Vijai Kant Agnihotri. As a special invitee member of executive committee of essential oil association of India, attended Executive committee meetings.

POSTER PRESENTED

Rathore S, Singh S, Sharma M and Kumar R (2021). Wild marigold (Tagetes minuta L.) cultivation: Initiative towards crop diversification and doubling farmers' income. Fifth International Agronomy Congress on Agri Innovations to Combat Food and Nutrition Challenges. November 23–27.

Thakur M and Kumar R (2021) Economic empowerment of women through crop diversification: An effort to doubling farmer's income. Fifth International Agronomy Congress on Agri Innovations to Combat Food and Nutrition Challenges, November 23–27.

D. Parmar and U Sharma (2022) C(sp3)-H Monoarylation of 8-Methylquinolines through Ru(II)-Catalysed C-H Activation. Chemical Research Society of India 28th National Symposium in Chemistry (CRSI NSC-28), IIT Guwahati, March 25-27.

Kumar R and Sharma U (2022) Transient Directing Group Assisted Atropeselective Olefination of Biaryls. Chemical Research Society of India 28th National Symposium in Chemistry (CRSI NSC-28), IIT Guwahati, March 25-27.

Manisha and Sharma U (2022) Selective C(7)-H Halogenation of N-Pyrimidylindolines. Chemical Research Society of India 28th National Symposium in Chemistry (CRSI NSC-28), IIT Guwahati, March 25-27.

Sumit and Sharma U (2022) Regioselective C(sp3)-H Trifluoromethylthiolation of 8-Methylquinoline. Chemical Research Society of India 28th National Symposium in Chemistry (CRSI NSC-28), IIT Guwahati, March 25-27.

Thakur A and Sharma U (2022) Regioselective C(sp2)-H Alkylation of Quinoline N-Oxides. Chemical Research Society of India 28th National Symposium in Chemistry (CRSI NSC-28), IIT Guwahati, March 25-27.

Sharma Ajay Kumar, Das Pralay (2021) Best oral presentation award for research paper entitled, “Polystyrene supported bimetallic Pd-Au as catalyst development and its application for CO fixation reactions in combination with oxalic acid as CO source” presented in two days virtual National Conference on “Innovative materials for environmental & health remediation (IMEHR-2021)” organized by Department of Chemistry and Centre for Nano-Science and Technology (CNST), Career Point University, Hamirpur (HP), October 16-17.

Kumar Ajay, Das Pralay (2022) Best oral presentation award for research paper entitled, “Agro Waster Conversion to Furans as potent Molecules for Industry” presented in International Seminar on Advance research in molecular & material science (ARM2S-2022) jointly organized by Department of Chemistry, Sitananda College, West Bengal and Department of Chemistry, Sikkim Manipal University of Technology, Sikkim during March 1-2.

Rohit Bains and Pralay Das (2022) Best Poster Award to Mr. Rohit Bains for poster “Utilization of agro-waste as initial feedstock for the production of 5-hydroxymethylfurfural and furfural” presented in the 28th CRSI National Symposium in Chemistry held at Indian Institute of Technology, Guwahati during March 25-27.

LINKAGES

International Linkages:

- Plant Health Institute of Montpellier, Montpellier, France

Government Organisation/Institution:

- Indian Institute of Technology, Kamand, District Mandi (HP)
- Jawahar Navodaya Vidyalaya Petrol Pump, Teh - Baijnath, District Kangra (HP)
- NMPB, Ministry of Ayush, Government of India at IRCS, Annexe Building, 1 Red cross road, New Delhi (Delhi)
- HP Agro Industries Corporation Limited (HP) AIC), Nigam Vihar, Shimla (HP)
- Sher-e-Kashmir University of Agricultural Sciences and Technology of Jammu, Chatha, Jammu (J&K)
- ICAR Indian Institute of Spices Research (IISR), P. B. No. 1702, Marikunnu, P.O. Kozhikode (Kerala)
- HemvaiNandan(Central University), Srinagar, Dist. Garhwal (Uttrakhand)
- JSS College of Pharmacy, Post Box No.20, Rocklands, Ooty, The Nilgiris (Tamil Nadu)
- Dr. Balasaheb Sawant Konkan Krishi Vidyapeeth (DBSKKV), Tal. Dapoli, Dist. Ratnagiri (Maharashtra)
- Himachal Pradesh Forest Department (H.P.F.D), Society for improvement of Forest Ecosystem management and Livelihoods in HP, Potters Hill, Shimla (HP)
- Deputy Commissioner, Lahaul & Spiti, Himachal Pradesh, Deputy Commissioner Office Lahaul & Spiti at Keylong (HP)
- Department of Horticulture, Govt. of Sikkim, Horticulture Department Krishi Bhawan, East Sikkim (Sikkim)
- ICAR CPRI, Shimla (HP)

Private Industries:

- Suhavi Producer Company Ltd., Village Kangar P.O. Basali, Tehsil Anandpur Sahib, District Rupnagar (Punjab)
- M/s Komal Innovation & Wellness Initiative, Shed No. 4, Industrial Area, Nagrota Bagwan, Kangra (HP)
- M/s Gaurav Agro Foods, Plot no. 28, Industrial Area -2, Nagri, Palampur (HP)
- M/s Amar Exports, 6-3-1239/2, 2nd floor, Raj Bhavan Road, Somajiguda, Hyderabad (Telangana)
- M/s Algareal Nutraceuticals, G3, Vaasthu Nirvaan, No. 26, Railway Parallel road, Nehru Nagar, Bangalore (Karnataka)
- M/s Ras Vaidyashala, Jobner, Jaipur (Rajasthan)
- M/s Kontact Consortium India Pvt. Ltd., Sidco Nagar, Villivakkam, Chennai (Tamil Nadu)
- M/s The Fragrance, Ward No. 8, M C Palampur, Maranda, District Kangra (HP)
- M/s Yuktika Biotech Pvt. Ltd., Bhrmat Palampur, (HP)
- The Unati Cooperative Marketing-cum-Processing Society Ltd. Talwara, District Hoshiarpur (Punjab)

Farmer Societies and NGO:

- M/s Gan Eden Biotic, 20/371/A, Ottaplackal, Nedumgadu, Panacheppally Post, Kottayam (Kerala)
- M/s Maf India Pharmaceuticals,194, New rattan Garh Colony, Jalbhera Road, Ambala City (Haryana)
- Innoveo Exports, B-92, Chitrakut Society, Sanand Ahmedabad (Gujrat)
- Rise Up Foundation Mandi and Rotary Club of Mandi, First Floor, Near M.C. Office (Opposite Police Chowki), Mandi, (HP)
- Mani Trust, Mani Bhawan, Relli Road, Kalimpong (West Bengal)
- M/s Riser Saffron, 110/7 Nanda Nagar,

Indore, (Madhya Pradesh)

- M/s Join Flora Pvt. Ltd., 313, 3rd Floor, Udyog Mandir, Industrial Estate No. 1, Bhagoji Keer Marg, Mahim West, Mumbai (Maharashtra)
- M/s farm Grocer Products Pvt. Ltd., 58, Sarswati Nagar, Ambala City, (Haryana) M/s Mount leaf, Ghurkari khas, Kangra, (HP)
- Vishavpujita Gram Sangathan, Chameti, P.O. Kuhna Block Pragpur, Tehsil Rakkar, District Kangra (HP)
- The Jakh Devta Kisan Cooperative Society, Dodra, Gopan Niwas, Dodra, Tehsil Dodra Kawar, District Shimla (HP)
- M/s Manish Flowers, A-28, Gazipur Flower Market (New Delhi)
- Own War Farmer Producer Company Limited, Khasra No. 23/24, Village Mubarakpur, Nawashahr to Garhshankar Road, Adjoining Royal Marriage Palace, Tehsil Nawanshahr, District Shaheed Bhagat Singh Nagar (Punjab)
- The Laughing Flower Co-operative Multipurpose Society Ltd. Madina, Village Madina, House No. 881, Madina Gindhran District Rohtak (Haryana)

Start-up Incubation

- Mr. Ankit Shandil, Jahri, PO Naswal, Tehsil Ghumarwin District Bilaspur (HP)
- Innotech AgroPostikam Pvt Ltd, Indigram Labs, B1, Mohan Cooperative, Industrial Estate, Badarpur (New Delhi)
- M/s Gaurav Agro Foods, Plot no. 28, Industrial Area-2, Nagri, Palampur (HP)
- Mr. Tanmay Sharma, C/o Sh. Devi Sharma, V.P.O Khaira, Tehsil Palampur, District Kangra (HP)
- Ms. Nitika Bhandari c/o Khadi Gramoudhyog Sansthan, Nagrota Bagwan Distt. Kangra (HP)
- Mr. Ajay Kumar Thakur,C/o Shri Sarbjeet Singh V.P.O. Biara Tehsil Palampur, District Kangra (HP)
- Mr. Rohit Kalia, Plot no. 28, Industrial Area -2, Nagri, Palampur (HP)
- M/s USAS natural and herbal products Pvt. Ltd., Village Pantehar, Post office Patti, Tehsil Palampur District Kangra (HP)
- M/s Agri Natural India, 107, New Model Town, Ludhiana (Punjab)
- M/s Relsus India Pvt. Ltd. Ltd., TG-6/6A Orchid Garden, Suncity, Sector-54, Gurugram (Haryana)
- Mr. Abhishek Gautam, Block No. 18, Flat No. 4, Phase No. 3, New Shimla (HP)
- Mr. Akash Deep Rehan,Rehan Niwas, 1st Floor, Near Yamini Hotel, Palampur, District Kangra (HP)
- Mrs. Aditi Sharma, A-2491, Ground floor, Green Field Colony, Faridabad (Haryana)

STAFF

Staff

Director
Dr. Sanjay Kumar
Chief Scientist
Dr. R.K. Sud
Dr.(Mrs.) Aparna Maitra Pati
Sr. Principal Scientist
Dr. Vipin Hallan
Dr. Sanjay Kumar Uniyal
Dr. Ram Kumar Sharma
Dr. Amit Kumar
Dr. Rakesh Kumar
Dr. Sanatsujat Singh
Dr. Shashi Bhushan
Principal Scientist
Dr. Pralay Das
Dr. Vijai Kant Agnihotri
Dr. Ravi Shankar
Dr. Probir Kumar Pal
Dr. Gireesh Nadda
Dr. Mahesh Gupta
Dr. Rituraj Purohit
Dr. Sushil Kumar Maurya
Er. Mohit Sharma
Dr. Amit Chawla
Dr. Ashok Kumar
Dr. S.G.E. Reddy
Dr. Dharam Singh
Dr. Y.S. Padwad
Senior Scientist
Dr. Upendra Sharma
Dr. Pamita Bhandari
Dr. Amitabha Acharya
Dr. Dinesh Kumar
Dr. Vikram Patial
Dr. Damanpreet Singh
Dr. Vishal Acharya
Dr. Ashok Singh
Dr. Bhavya Bhargava
Dr. Kunal Singh
Dr. Sukhjinder Singh
Dr. Jeremy Dkhar
Dr. Rohit Joshi
Dr. Shiv Shankar Pandey
Dr. Ashish Rambhau Warghat
Dr. Rajiv Kumar
Dr. Narender Vijay Tirpude
Dr. Arun Kumar
Dr. Vivek Dogra
Dr. Gaurav Zinta
Dr. Rajesh Kumar Singh
Scientist
Dr. Rakshak Kumar
Dr. Vidyashankar Srivatsan
Dr. Ankit Saneja
Dr. Poonam Kumari
Dr. Vandana Jaiswal
Er. Amit Kumari
Dr. Satbeer Singh
Dr. Ramesh
Dr. Vikas Kumar
Dr. Sarita Devi
Principal Technical Officer
Sh. Mukhtiar Singh
Senior Technical Officer (3)
Dr. Robin Joshi
Senior Technical Officer (2)
Dr. Kiran Devi
Sh. Vikrant Gautam
Dr. Avnesh Kumari
Sh. Ramdeen Prasad
Sh. J. S. Bisht
Dr. Kiran Singh Saini
Dr. Anish Kaachra
Sh. Shiv Kumar
Dr. Rajneesh
Sh. Rakesh Verma
Sh. Anil Kumar
Senior Technical Officer (1)
Sh. Ramjeelal Meena
Sh. Vivesh Sood
Sh. Mahesh S.
Sh. Bijan Bihari Garnayak
Sh. Mohit Kumar Swarankar
Sh. Jasbeer Singh
Sh. Mukesh Gautam
Sh. Om Prakash

Sh. Ashok Gehlot
Sh. Kunjan Saxena
Smt. Vijaylata Pathania
Sh. Pabitra Gain
Sh. Aman Kumar

Technical Officer

Smt. Meenakshi
Dr. Arvind Kumar Verma
Sh. Anil Chaudhary
Sh. Pawan Kumar
Dr. Rimpy Diman
Sh. Virat Abhishek
Sh. Saurabh Sharma

Technical Assistant

Sh. Rajeev Kumar Koundal
Sh. Vikas Soni

Senior Technician (2)

Sh. Karandeep Sood
Sh. Dhruv Kumar

Senior Technician (1)

Sh. Ramesh Kumar
Sh. Kuldip Singh
Sh. Parveen Kumar
Sh. Sanjay Kumar
Sh. Avinash Chander Rana
Sh. Sandeep Sood
Sh. Ranjeet Singh
Sh. Ajay Kumar
Sh. Arvind Kant

Technician (2)

Sh. Surjeet Singh
Smt. Jasveer Kaur
Sh. Vikas Kumar

Technician (1)

Sh. Sanjeev
Sh. Sanjeet Kumar
Sh. Monu Kumar
Sh. Ishwar Dass

Lab. Assistant

Sh. Rakesh Chand
Mrs. Anupama Saini
Sh. Shamsher Singh

Lab. Attendant (2)

Sh. Uttam Chand
Sh. Balak Ram
Sh. Kuldip Singh
Sh. Balwant Raj
Sh. Girja Nand
Sh. Deepak Sood

Administration Officer

Sh. B.P. Saw

Finance & Accounts Officer

Sh. Yash Pal

Store and Purchase Officer

Sh. Sanjay Rawat

Principal Private Secretary

Sh. Ram Gopal Meena

Hindi Officer

Sh. Sanjay Kumar

Private Secretary

Sh. Didar Singh Patial

Section Officer (Gen.)

Sh. Constan Kujur
Sh. Ved Prakash
Sh. Prajwal Rai

Section Officer (F&A)

Sh. Mahabir Singh

Section Officern (S&P)

Sh. Ravinder Singh

Assistant Section Officer (G.)

Sh. Parveen Singh
Smt. Santosh Kumari
Sh. Baldev
Sh. Kiran Kumar
Smt. Pooja Awasthi

Assistant Section Officer (F&A)

Smt. Aruna Kumari

Assistant Section Officer (S&P)

Sh. Rajeev Sood

Security Assistant

Sh. Trilok Nath

Sr. Stenographer

Sh. Boni Kumar

Senior Secretariat Assistant (G.)

Sh. Praveen Kumar
Sh. Sandeep Kumar
Sh. Mukul Sharma
Sh. Ajay Singh Kaundal

Senior Secretariat Assistant (S&P)

Sh. Rajinder Singh

Junior Stenographer

Coupon Clerk (Canteen)

Sh. Anand Sharma

Cook

Sh. Oman Singh

Sh. Karan Singh

Driver

Sh. Partap Chand

Sh. Braham Dass

Sh. Lakhwinder Singh

Sh. Nitesh Bhardwaj

Bearer (Canteen)

Sh. Bipan Kumar

Tea & Coffee Maker

Sh. Bipan Gurang

MTS

Sh. Baleshwar Prasad

Sh. Thaman Bahadur

Sh. Devender Kumar

Smt. Rujala Devi

Staff Joined CSIR-IHBT between 01.04.2021-31.03.2022

Sr. No.	Name	Designation	Date of Joining
1	Sh. B.P. Saw	Administrative Officer	24.08.2021
2	Sh. Sanjay Rawat	Section Officer (S&P)	31.08.2021
3	Sh. Constan Kujur	Section Officer (Gen.)	20.09.2021
4	Sh. Mahabir Singh	Section Officer (F&A)	20.09.2021
5	Sh. Prajwal Rai	Section Officer (Gen.)	30.12.2021
6	Sh. Ravinder Singh	Section Officer (S&P)	31.12.2021
7	Sh. Ram Gopal Meena	Principal Private Secretary	31-01-2022

Staff Superannuated

Er. K.K. Singh
Chief Scientist: 31.12.2021

Sh. Amarjeet
Administrative Officer: 31.03.2022

Staff Resigned

Dr. Kuldeep Singh, Scientist on 06-09-2021

Staff Transferred to other CSIR Labs/ Institutes between 01.04.2021-31.03.2022

1. Sh. Alok Sharma, COA, CSIR-CIMFR, Dhanbad: 18-08-2021
2. Sh. Amarjeet, AO, CSIR-CCMB, Hyderabad: 28.08.2021
3. Sh. S. Gnanaprakasam, Sr. COSP, CSIR-CCMB, Hyderabad: 18.08.2021
4. Sh. Ram Singh, Section Officer (S&P), CSIR-IMT, Chandigarh:18.08.2021
5. Dr. Pankaj Markand Kulurkar, STO (2) CSIR-NEERI, Nagpur: 03.09.2021

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Late Sh. Baldev Singh
Lab Assistant: 28.11.2021

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Dr. Satish Singh
Young Scientist
Dr. Virender Kumar
Dr. Vijay Kumar
Dr. Prakriti Kashyap
Senior Research Associate (Pool)
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Women Scientist
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Ms. Usha Kumari Rattan
Ms. Rashim Kumari
Ms. Ujala
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PDF & NPDF
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Ms. Kanishika Sharma
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Ms. Neetu Saini
Ms. Nandita Sharma
Ms. Diksha Thakur
Mr. Shubham Rana
Mr. Ravi Kumar
Ms. Neeraj Bala
Mr. Aman Thakur
Mr. Vikrant Chandel

CSIR-IHBT in Print and Electronic Media


Palampur-based IHBT aiming to promote saffron production in HP
EXPERTS SAID CURRENT SAFFRON PRODUCTION IS
domestic demand, most of the saffron is being imported from Iran, he said. Dr Kumar said the IHBT is
वर्ष 1 हैक्टेयर में केसर और 3 हैक्टेयर क्षेत्र में होगी हींग की खेती
सीएसआईआर-आईएचबीटी में केसर व हींग की कृषि तकनीकों पर दक्षता विन्यास कार्यक्रम संपन्न
Dainik Jagran Pg.. 4, dt. 30.08.2021
सराहनीय
सीएसआइआर-आइएचबीटी पालमपुर ने भेजे केसर और हींग के पौधे
केसर से महकेगा किन्नौर जिला
किन्नौर में 0.24 हेक्टेयर में केसर व 0.5 हेक्टेयर क्षेत्रफल में की जाती है की हींग की खेती, किसानों को दिया गया है बकायदा प्रशिक्षण
Palampur-based IHBT aiming to promote saffron production in HP
Palampur-based Institute of Himalayan Bioresource Technology (IHBT) is aiming to promote saffron farming and identify new fields for cultivation, beyond Kashmir, to make India self-reliant in the production of the world's costliest spice, IHBT director Dr Sanjay Kumar said on Saturday.
By HT Correspondent, Dharamshala
PUBLISHED ON JUN 19, 2021 10:55 PM IST
जिला चंबा में केसर की खेती को बढ़ावा देने के प्रयास किए जा रहे है : कृषि उप निदेशक
सालों में सरताजः देश में हिमाचल ने उगाई सबसे पहले हींग, फूलों की खेती में भी आत्मनिर्भर बनेगा
नहीं मंगवानी पड़ेगी विदेशों से 909 करोड़ की दालचीनी
12,500 फुट की ऊंचाई पर लाहौल घाटी के गांवों में ट्यूलिप गार्डन तैयार
INC - Himachal State News
Use of science must be in interest of society: Governor
Shimla-28th February, 2022- Governor Rajendra Vishwanath Arlekar said that the real use of science should be in the interest of the society. The Governor was speaking in a program organized on National Science Day at CSIR-Institute of Himalayan Bioresource Technology, Palampur in Kangra district today.
The Governor said that the world had recognized the scientific discovery of eminent scientist C.V. Raman on this day and the country was proud of the "Raman Effect" given by him. He said that science was a part of life, even today many scientific discoveries match with the ideas of our ancestors. "Somewhere our mental slavery compels us to think that this is the research of today itself. But, the
In a first, Hamirpur farmer grows saffron
Experts say Chamba, Kinnaur, Kangra suitable
RAVINDER SOOD
केसर की खेती कर चमकाएं किस्मत
कुठेर में किसान-वैज्ञानिक संवाद कार्यशाला का किया आयोजन, सितंबर-अक्तूबर में केसर के कंद लगाने का सही समय
प्राकृतिक खेती अपनाने का किया आह्वान
ट्यूलिप गार्डन निहारने के लिए श्रीनगर जाने की जरूरत नहीं, प्रदेश का पहला ट्यूलिप गार्डन पालमपुर में स्थापित
विदेशों से प्रतिवर्ष 50
और अब 'टी माउथवॉश'-'रेडी टू ईट इंस्टेंट सीरा'
सीएसआईआर-आईएचबीटी में राष्ट्रीय विज्ञान दिवस पर हिमाचली स्वीट का प्रौद्योगिकी हस्तांतरण
हींग व केसर की खेती से साकार होगा आत्मनिर्भर भारत का सपना : डा. मांडे
सीएसआइआर आइएचबीटी पालमपुर ने मनाया 39वां स्थापना दिवस
आयोजन
सीएसआइआर ने कोरोना में आपदा को अवसर में बदला : डा. माशेलकर
महानिदेशक ने संस्थान के प्रस्तावित औषधालय का शिलान्यास किया
नौ एमओयू भी हुए
प्रदेश को मिला पहला ट्यूलिप गार्डन
सीएसआईआर-आईएचबीटी में राष्ट्रीय विज्ञान दिवस पर राज्यपाल ने किया उद्घाटन

प्रधानमंत्री मोदी की मन की बात में गूंजी सीएसआईआर के सेब की गूंज

हिमाचल के सेब की मणिपुर तक पहुंची महक का किया जिक्र

मणिपुर में तैयार हुआ सेब सीएसआईआर पालमपुर की देन

प्रधानमंत्री नरेंद्र मोदी ने सराहे पालमपुर में प्रशिक्षण लेकर उखरूल में सेब उगा रहे नौजवानों के प्रयास

आईएचबीटी ने बदल दी मणिपुर के युवाओं की सोच

इम्युनिटी बढ़ाएगा, रोगों से बचाएगा हर्बल पाउडर

सीएसआइआर-आइएचबीटी पालमपुर ने जड़ी-बूटियों से किया तैयार

अच्छी खबर

दिल्ली की कंपनी तैयार करेगी पाउडर

कुल्लू जिले में भी होगी औषधीय हींग की खेती

जिले के बंजार, कुल्लू और नग्गर में रोपे गए हींग के 350

Minister lauds works of CSIR

PALAMPUR, JUNE 17

Virendra Kanwar, Minister for Rural Development, Panchayati Raj, Agriculture, Animal Husbandry, today visited the CSIR-Himalayan Institute of Bioresource Technology.

He appreciated works and achievements of the institute and expressed hope that along with rural development, the CSIR-IHBT would work towards increasing the income of farmers and making them self-reliant.

"The institute is playing active role in increasing the income of farmers by cultivating and processing aroma crops such as wild marigold, damask rose, lemon grass, sugandhabala etc. This will help farmers earn more compared to traditional crops," said the minister.

The Tribune Fri, 18 June 2021 https://epaper.tribuneindia

PM lauds CSIR-IHBT for apple cultivation in Manipur

सुगंधित पौधे कई उपयोगी घटकों का भंडार, जंगली गेंदा की खेती को दिया जा रहा बढ़ावा

किसानों की आजीविका सुधारेगा जंगली गेंदा

700 क्विंटल से अधिक जंगली गेंदा बीज वितरित

सेब की खेती पर सीएसआईआर आईएचबीटी पालमपुर की पहल

भास्कर न्यूज़ | पालमपुर

रविवार को मन की बात कार्यक्रम में प्रधान मंत्री नरेंद्र मोदी जी ने सेब की खेती के लिए मणिपुर के उखरूल जिले के किसानों के प्रयासों की

वैज्ञानिक नेतृत्व के लिए दूरदर्शी दृष्टि के साथ समझ भी जरूरी: माशेलकर

एस.आई.आर.-आई.एच.बी.टी. ने मनाया स्थापना दिवस

मशरूम इंक्यूबेशन सुविधा का उद्घाटन

हिमालय की औषधीय जड़ी-बूटी अब मैदान में भी होगी पैदा

वैज्ञानिकों ने तकनीक विकसित कर असंभव को कर दिखाया संभव, अब हैदराबाद में भी उगेगी कुटकी

भारत में 70 टन उत्पादन

चीन की दालचीनी से छुटकारा दिलाएगा हिमाचल

सीएसआईआर और कृषि विभाग ने प्रदेश के पांच जिलों सिरमौर-हमीरपुर-बिलासपुर-ऊना-कांगड़ा में शुरू की खेती

पालमपुर में तीमारदारों को नाश्ते में मिलेगी आइएचबीटी की खिचड़ी

ट्यूलिप गार्डन निहारने के लिए श्रीनगर जाने की जरूरत नहीं, प्रदेश का पहला ट्यूलिप गार्डन पालमपुर में स्थापित

A first, monk fruit cultivation begins in Kullu

OUR CORRESPONDENT

PALAMPUR, JULY 15

The cultivation of monk fruit (Siraitia grosvenorii) from China has been taken up for the first time in India by the Palampur-based CSIR-IHBT.

The monk fruit is known for its properties as non-calorie natural sweetener. Its sweet taste is attributed to cucurbitane-type triterpene glycosides known as mogrosides, which is about 300 times sweeter than sucrose or cane sugar.

In spite of its high demand, this crop is only cultivated in China. However, suitable agro climatic conditions are also available in India, particularly in Himachal. Keeping in mind the importance and essentiality of non-nutritive natural sweetener and diverse agro-climatic conditions in India, Dr Sanjay Kumar, Director, CSIR-IHBT, Palampur, brought monk fruit seeds for the first time in the country from China through ICAR-NBPGR, New Delhi, in March 2018.

Dr Probir Kumar Pal, Principal Scientist, along with other team members, developed a technology for the generation of quality planting material, its basic agronomic cultivation practices, fruiting technique and post-harvest management. At present, monk fruit is successfully being cultivated at the CSIR-IHBT with good quality fruits under farm conditions. The plant prefers mountainous area with an annual mean temperature of about 16-20°C and humid conditions, hence Himachal is a suitable place for its large-scale cultivation.

Dr Sanjay Kumar, Director, CSIR-IHBT, initiated the monk fruit cultivation programme by planting its seedlings in the field of progressive farmer Manav Khullar at Raison in Kullu yesterday. Nishant Thakur, member secretary, HIMCOSTE, was also present.

लेमन ग्रास व गेंदा की खेती बदलेगी तकदीर

संवाद सहयोगी, पालमपुर : विज्ञानी एवं औद्योगिक अनुसंधान परिषद (सीएसआईआर)-हिमालय जैवसंपदा प्रौद्योगिकी संस्थान (आइएचबीटी) पालमपुर और देव सूर्य हिमालयन आर्गेनिक प्राइवेट लिमिटेड (एफपीओ) शिमला के बीच क्षेत्र में लेमन ग्रास और सुगंधित गेंदा की खेती को बढ़ावा देने के लिए समझौता ज्ञापन पर हस्ताक्षर (एमओयू) किए। अरोमा मिशन के तहत सीएसआईआर-आइएचबीटी की ओर से किसानों को दस लाख लेमन ग्रास पौधे और सुगंधित गेंदा के 75 किलोग्राम बीज प्रदान किए जाएंगे। इससे इन उच्च मूल्य वाली फसलों के तहत 336 एकड़ क्षेत्र को कवर करने और क्षेत्र के 1200 से अधिक किसानों को लाभान्वित करने का लक्ष्य रखा है।

सीएसआईआर-आइएचबीटी के निदेशक ...

लेमनग्रास और सुगंधित गेंदा की खेती दौरान पदाधिकारी। ● जागरण

किसानों के सामाजिक-आर्थिक उत्थान और रोजगार सृजन के उच्च मूल्य वाली सुगंधित फसल खेती को बढ़ावा देने का काम किया था। मिशन के दूसरे चरण सीएसआईआर-आइएचबीटी सुगंधित फसलों की खेती के तहत तीन हेक्टेयर क्षेत्र लाने के लिए प्रतिबद्ध दुनिया में सुगंधित फसलों की ...

epaper.jagran.com

कांगड़ा कसरा

उत्तराखंड के कृषकों को सगंध फसलों की खेती के लिए आई.एच.बी.टी. ने बढ़ाए हाथ

पालमपुर : सगंध फसलों की खेती और प्रसंस्करण पर जागरूकता एवं प्रशिक्षण कार्य में भाग लेते किसान।

देश में पहली बार होगी मांक फल की खेती

मधुमेह रोगी भी ले सकेंगे मीठे स्वाद का स्वाद, गन्ने व चीनी से 300 गुना मीठा है मांक फल से बना मिश्रण सुरक्षित

संवाद सहयोगी, पालमपुर

क्या है मांक फल

हींग-केसर के बाद अब आईएचबीटी की मोती पर नजर

फूलों की खेती में अग्रणी भूमिका निभा रहा आईएचबीटी

सेब की खेती की चर्चा आने से आइएचबीटी गदगद

संवाद सहयोगी ...

प्रधानमंत्री की ... में रविवार ... लिए मणिपुर ... किसानों के प्र... पर हिमालय ... संस्थान पालम... है। पूर्वोत्तर रा... पर आइएचब... कर रहा है। ... एनईआरसीओ... संस्था के सा... हस्ताक्षर क... मिंजोरम औ... में सेब की ... करने के लि... आपूर्ति की थी ... निदेशक ...

India's first monk fruit cultivation exercise begins in HP's Kullu

NAVJEEVAN GOPAL

CHANDIGARH, JULY 14

THE 'MONK fruit' from China, which is known for its properties as non-caloric natural sweetener, was Monday introduced for field trials in Himachal Pradesh by the Palampur-based Council of Scientific Research and Industrial Technology-Institute of Himalayan Bio-resource Technology (CSIR-IHBT) in Kullu.

The field trials have begun three years after the CSIR-IHBT imported its seeds from China and grew it in the house.

Fifty seedlings were planted in the fields of progressive farmer Manav Khullar from Raison village for field trials and

CSIR-IHBT signed a 'Material Transfer Agreement' with Manav. The economic benefits of the new crop are estimated to be between Rs 3 lakh to Rs 3.5 lakh per hectare.

This, as per CSIR-IHBT, is the first ever monk fruit cultivation exercise in India.

NATURE'S SWEET SUPERFOOD: THE MONK FRUIT

The monk fruit (siraitia grosvenorii), is known now throughout the world for its intensely sweet taste, and it has been used as a non-caloric natural sweetener. The sweet taste of monk fruit results primarily from the content of a group of cucurbitane-type triterpene glycosides known as mogrosides, and the extracted mixture of mogrosides is about 300 times sweeter than sucrose or cane sugar. The purified mogroside, has been approved as a high-intensity sweetening agent in Japan and the non-caloric sweet taste extract is a generally recognized as

high demand, this crop is cultivated only in China. However, suitable agroclimatic conditions are available in India, particularly in Himachal Pradesh.

As per a note by CSIR-IHBT "Intake of added cane sugars can lead to life-threatening diseases such as insulin resistance, Type 2 diabetes, liver problems, metabolic syndrome, heart disease, etc. As per the world health organization (WHO) report, worldwide 346 million people are diabetic. Several synthetic sweeteners of low calorific value have recently been appeared in the pharmaceutical and food industries, but their

Hindustan Times

[EXOTIC DELICACY]

Scientists introduce China's monkfruit in HP

Naresh K Thakur

DHARAMSHALA : In a first, scientists of CSIR's Institute of Himalayan Bioresource Technology (IHBT), Palampur, have introduced the cultivation of monkfruit in Kullu district of Himachal Pradesh.

IHBT director Sanjay Kumar said monkfruit cultivation was initiated on a trial basis by planting 50 seedlings in farmer Manav Khullar's fields at Raison in Naggar tehsil of Kullu on Monday. If successful, the fruit will be grown commercially.

Monkfruit (Siraitia grosvenorii) was originally grown only in

Monkfruit was originally grown only in China. HT PHOTO

... over for its sweetness and is used as a non-caloric natural sweetener. "Suitable agro-climatic conditions are also available in India, particularly in Himachal ... fruit in Kullu," Kumar said.

Seeds brought in 2018

He said the monkfruit seeds were brought to India from China through Indian Council of Agricultural Research's National Bureau of Plant Genetic Resources, New Delhi, in March 2018.

Principal scientist Probir Kumar Pal and his team developed the technology for generating quality planting material, its basic agronomic cultivation practices, fruiting technique and post-harvest management.

At present, monkfruit is being cultivated at the Council of Scientific and Industrial Research (CSIR)-run IHBT with good qual... and humid conditions. Himachal Pradesh is a suitable for its large-scale cultivation," said Kumar.

Pal said the plant starts bearing fruit in eight months if the atmosphere is conducive. Experiments have shown that the average life of the plant is four to five years. The fruit weighs 60-65g and in some cases 100g. The average yield is 1kg from each plant.

Sugar alternative

Kumar said intake of added cane sugar can lead to lifestyle diseases such as insulin resistance, Type-2 diabetes, liver problems, metabolic syndrome, and heart disease. Monkfruit offers a

एस्पिरेशनल चंबा में जिन्कगो बाइलोबा की खेती के लिए सामग्री हस्तांतरण समझौता

कार्यक्रम दौरान उपस्थित गणमान्य।

पालमपुर (जसवंत कटियाल): सीएसआईआर हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर, हिमाचल प्रदेश में 1 अप्रैल को क्षेत्रीय-सह-सुविधा केंद्र, उत्तरी क्षेत्र, भारतीय चिकित्सा प्रणाली अनुसंधान संस्थान, आयुष मंत्रालय, जोगिंदर नगर, मंडी, हिमाचल प्रदेश के साथ एक सामग्री हस्तांतरण समझौते पर हस्ताक्षर किए। इस समझौते के तहत, सीएसआईआर- आईएचबीटी राष्ट्रीय पोषन पखवाड़ा अभियान के तहत हिमाचल प्रदेश के एस्पिरेशनल जिला चंबा के भरमौर और पांगी विकास खंडों में आंगनबाड़ी के माध्यम से इस संगठन को जिन्कगो बाइलोबा पौधे प्रदान करेगा। भरमौर में 144 3...

हिमाचल प्रदेश विज्ञान, प्रौद्योगिकी और पर्यावरण परिषद के सहयोग से आईएचबीटी ने शुरू किए प्रयास

देश में पहली बार उगेगा मॉन्क फ्रूट

कार्यालय संवाददाता-पालमपुर

क्या है मॉन्क फ्रूट

जागरूकता सीएसआईआर-आईएचबीटी पालमपुर ने 53 किसान ने लिया प्रशिक्षण

किसानों को फूलों की खेती पर टिप्स

कार्यालय संवाददाता- पालमपुर

सीएसआईआर-आईएचबीटी पालमपुर ने आईसीआईसीआई फाउंडेशन मुंबई के सहयोग से दो प्रशिक्षण और जागरूकता कार्यक्रम आयोजित किए। मंडी

इस कार्यक्रम में किसानों को आधुनिक मधुमक्खी पालन के विभिन्न पहलुओं जैसे मधुमक्खी कालोनियों के प्रबंधन, मधुमक्खियों के कीट एवं रोग प्रबंधन और शहद के साल भर उत्पादन के लिए अमृत

सिक्किम के कृषि मंत्री ने मोती की खेती पर सीएसआईआर,आईएचबीटी के प्रयासों को सराहा

पालमपुर सिक्किम के कृषि मंत्री ने मोती की खेती पर सीएसआईआर-आईएचबीटी द्वारा ग्रामीण अर्थव्यवस्था को उच्च-स्तर अनुसंधान आधारित प्रौद्योगिकियों के विकास से बढ़ावा देने के लिए संस्थान द्वारा किए गए योगदान की सराहना की। उन्होंने अपने संबोधन के दौरान, सिक्किम में एक सीएसआईआर-आईएचबीटी केंद्र स्थापित करने के लिए गहरी रुचि दिखाई, ताकि संस्थान द्वारा विकसित प्रासंगिक प्रौद्योगिकियों को जल्द से जल्द प्रयोग में लाया

कहा कि सीएसआईआर-आईएचबीटी की उनकी यात्रा हाइड्रोपोनिक्स और एरोपोनिक्स, हींग, केसर, सुगंधित औषधीय पौधों एवं फूलों की खे तथा खाद्य प्रसंस्करण सहित विभि

सीएसआईआर-आईएचबीटी में रिसर्च स्कॉलर्स शिक्षक दिवस पर 'छात्र संगोष्ठी' आयोजित

प्रदेश की अप्रैल तोड़ चाय का जवाब नहीं

कभी रॉयल फैमिली ही करती थी फर्स्ट फ्लश चाय का उपयोग, पिछले साल पड़ी थी कोरोना की मार

खास मुहूर्त में पूजा-अर्चना

Sikkim Agri Minister lauds CSIR-IHBT's research work

Lok Nath Sharma, Agriculture and Horticulture Minister of Sikkim, today visited the CSIR-Institute of Himalayan Bio-resource Technology (IHBT). He appreciated the work the institute in development of high-end research-based technologies and their deployment boosting the rural economy. He showed a keen interest to establish a CSIR-IHBT centre in Sikkim for fast deployment of relevant technologies, training and skill development to strengthen their ongoing development programmes.

He sought assistance from the CSIR for cultivation of heeng, saffron, monk fruit and cinnamon. The minister lauded the efforts of the CSIR-IHBT initiating the cultivation of pearl integrated with aquaculture. He said his visit to the CSIR-IHBT would further strengthen cooperation on hydroponics and aeroponics, cultivation of asafoetida, aromatic and medicinal plants, floriculture and food processing, which would help in capacity building among farmers. Dr Sanjay Kumar, Director, CSIR-IHBT, talked about the major achievements and research activities of the institute. He said the institute played a significant role through judicious utilisation of available resources. Cultivating and processing aromatic crops such as wild marigold, damask rose, lemon grass enabled farm-

Lok Nath Sharma, Agriculture and Horticulture Minister of Sikkim, at the CSIR-IHBT, in Palampur

VISIT TO STRENGTHEN COOPERATION

My visit to the CSIR-IHBT will strengthen cooperation on hydroponics and aeroponics, cultivation of asafoetida, aromatic and medicinal plants, floriculture and food processing, which will help in capacity building among farmers

Lok Nath Sharma, AGRICULTURE AND HORTICULTURE MINISTER

आईएचबीटी-कृषि विवि में मनाया योग दिवस

पालमपुर। सीएसआईआर-आईएचबीटी और प्रदेश कृषि विवि योग दिवस पर कार्यक्रम का आयोजन किया गया।

Lahaul farmers trained in 'heeng' cultivation

FIRST DIST IN COUNTRY TO BEGIN SOWING

To improve the livelihood of farmers and utilise the land, the CSIR-IHBT is making an endeavour to introduce heeng, which is suitable for cultivation in cold desert conditions. Lahaul and Spiti is the first district in India to start 'heeng' cultivation — Sanjay Kumar, DIRECTOR, CSIR-IHBT

'Heeng' cultivation being monitored at Madgram in Lahaul & Spiti

94 किसानों को दिए फूलों की खेती-मधुमक्खी पालन के टिप्स

कार्यालय संवाददाता—पालमपुर

फरवरी में आएगी प्रदेश में चाय नीतिः कंवर

कृषि उपकरणों के लिए अनुदान का प्रावधान करेंगे, अप्रैल में चाय पर होगा बड़ा उत्सव

...इएचबीटी में केसर व हींग की कृषि तकनीकों पर दक्षता विन्यास कार्यक्रम संपन्न

पालमपुर, 25 सितंबर (जसवंत कठियाल): सीएसआईआर-आईएचबीटी पालमपुर में केसर व हींग की उत्पादन तकनीक पर कृषि विभाग, प्रदेश के कृषि अधिकारियों हेतु पांच दिवसीय दक्षता विन्यास कार्यक्रम संपन्न

फसलों, केसर और हींग के उत्पादन के महत्व के बारे में चर्चा की।

उन्होंने कहा कि भारत में केसर की वार्षिक मांग लगभग 100 टन जबकि जम्मू-कश्मीर में केवल 6-7 टन का उत्पादन होता है। वर्तमान

दिव्य हिमाचल

फरवरी में आएगी चाय नीति

पालमपुर के आईएचबीटी में एकदिवसीय राज्य स्तरीय चाय मेले में पंचायती राज मंत्री वीरेंद्र कंवर ने किया खुलासा

ब्लैक-ग्रीन टी ही नहीं, और भी बहुत कुछ

CSIR-IHBT
1983

परिकल्पनाः जैवार्थिकी के उन्नयन हेतु प्रौद्योगिकीय उद्भवता एवं विकास में हिमालयी जैवसंपदा के संपोषणीय उपयोग द्वारा विश्व स्तर पर अग्रणी होना

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

उद्देश्यः सामाजिक, औद्योगिक, पर्यावरणीय और अकादमिक हित हेतु हिमालयी जैवसंपदा से प्रक्रमों, उत्पादों और प्रौद्योगिकियों की खोज, नवोन्मेश, विकास एवं प्रसार

MISSION: To discover, innovate, develop and disseminate the processes, products and technologies from Himalayan bioresources for society, industry, environment and academia