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वार्षिक प्रतिवेदन
Annual Report
2020-21

केसर उत्पादन तकनीक
Saffron Production Technology

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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वार्षिक प्रतिवेदन

ANNUAL REPORT

2020-21

With Best Compliments from

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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, नवोन्मेष, 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 कॉम्प्लेक्स 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, डॉ. 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

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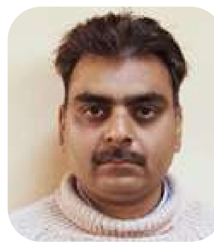

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Controller of Administration
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(23.10.2020 Onwards)
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CSIR-Institute of Himalayan Bioresource Technology,
Palampur– 176061 (HP)

IMPRESSIONS

9/Nov/2020 Shekhar C. Mande

Every time I visit IHBT, I discover a new facet of the Institute. Its work on Asafoetida & Saffron is exemplary. The former has generated plenty of attention worldwide. I wish the entire CSIR-IHBT family success in everything they do. Please keep up bringing smiles on the faces of Hill people!

28/2/2021 Lalit K. Awasthi

Happy Science Day. IHBT is doing great work under dynamic leadership of Dr. Sanjay Kumar. I have seen how scientific knowledge has been used to make friendly products and more than 6000 entrepreneurs have been benefitted. Really very good service to the nation and to Himanchal in particular. I am happy to associate with IHBT by way signing MOU.

1st March 2021
01-03-2021

Honourable minister of state For Finance and Corporate Affairs
Sri Anurag Singh Thakur

CSIR is one of the Premier R&D organisations in the Country today, undertaking innovative and path breaking work.

The organisation's vast network and experience possesses huge innovation potential.

Excellent opportunity for those seeking to pursue a Career or work on innovative solutions in the field of Scientific and industrial research.

My visit to CSIR has been very fruitful & a learning experience. My Best wishes for future

8.3.2021

Dinesh K Aswal
Director, CSIR-NPL

Dr. Sanjay Kumar, Director IHBT has led from the front and made the institution a class of its own. The technologies developed by the IHBT are supporting local farmers. The look of IHBT has become very attractive. The theme song of IHBT shows the vision & mandate. Was lucky to inaugurate the NEW FLAG post at IHBT. Also felt very happy in delivering a talk on leadership on International Women Day. Wish all the success to IHBT.

Dinesh K Aswal

निदेशकीय प्रतिवेदन

मुझे वर्ष 2020–21 के लिए सीएसआईआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान (सीएसआईआर –आईएचबीटी) की प्रमुख उपलब्धियों को आपके समक्ष प्रस्तुत करते हुए अत्यंत प्रसन्नता हो रही है।

इस वर्ष के दौरान, उद्यमशीलता विकास तथा आजीविका उपार्जन हेतु अनुसंधान– अकादमिक–उद्योग संपर्क पर नए सिरे से बल दिया गया। संस्थान ने उद्यमियों के साथ 25 प्रौद्योगिकी हस्तांतरण समझौतों पर हस्ताक्षर किए और 20 स्टार्ट–अप को इनक्यूबेट किया। इसके अतिरिक्त केंट स्टेट यूनिवर्सिटी (केएसयू) और वोल्ट रिसर्च एलएलसी, यूएसए के साथ अंतर्राष्ट्रीय सहयोग सहित संस्थान द्वारा 72 परामर्श समझौतों/ एमओयू/एमटीए पर हस्ताक्षर किए गए। साथ ही, 3.43 के औसत तथा उच्चतम 11. 38 इम्पैक्ट फैक्टर के साथ कुल 135 शोध पत्र भी प्रकाशित किए गए। इसके अतिरिक्त, 29 पुस्तक अध्याय प्रकाशित किए गए और कुल 51 पेटेंट आवेदित किए गए।

इसके साथ ही, सीएसआईआर–आईएचबीटी ने नेशनल इंस्टीट्यूशन फॉर ट्रांसफॉर्मिंग इंडिया (नीति आयोग) द्वारा अनुमोदित ''इंडियन हिमालयन सेंट्रल यूनिवर्सिटीज कंसोर्टियम'' के अन्तर्गत भारतीय हिमालयी क्षेत्र में आजीविका को सुदृढ़ करने की दिशा में एक प्रौद्योगिकी भागीदार के रूप में अपनी महत्वपूर्ण भूमिका को आगे बढ़ाया।

कोविड–19 महामारी से उत्पन्न चुनौती को देखते हुए, संस्थान ने कोविड परीक्षण के लिए अपनी सेवाएं प्रदान की और जीनोम अनुक्रमण और सेरो सर्वेक्षण द्वारा SARS-CoV-2 की आणविक निगरानी में योगदान दिया। साथ ही, संस्थान ने राज्य के स्वास्थ्य विभाग के साथ मिलकर कोविड परीक्षण सुविधाओं को स्थापित किया और स्वास्थ्य कर्मियों को प्रशिक्षण भी दिया।

भारत को आत्मनिर्भर बनाने के अभियान में संस्थान द्वारा भारत में हींग की खेती की शुरुआत एक बहुत बड़ा कदम रहा है। वर्तमान समय में हमारा देश प्रति वर्ष 940 करोड़ रुपये के हींग का आयात करता है। सीएसआईआर–आईएचबीटी ने देश के ठंडे रेगिस्तानी क्षेत्रों में हींग की खेती के लिए इसकी कृषि–प्रौद्योगिकी का मानकीकरण किया। एक और महत्वपूर्ण मसाला जो भारत आयात करता है वह है केसर (*क्रोकस सैटाइवस,* मसालों का लाल सोना) और इस फसल की खेती केवल जम्मू और कश्मीर राज्य में की जाती है, जो देश की मांग का लगभग 7–9% पूरा करता है। संस्थान ने हिमाचल प्रदेश तथा अन्य हिमालयी क्षेत्रों में इसकी खेती को बढ़ावा देने के लिए पहल करते हुए केसर उत्पादन तकनीक विकसित की। हिमाचल प्रदेश सरकार ने बजट सत्र 2020 के दौरान संस्थान के प्रयासों की सराहना की। परिणामस्वरुप राज्य में हींग और केसर की खेती को सहयोगात्मक रूप से बढ़ावा देने के लिए सीएसआईआर–आईएचबीटी और हिमाचल प्रदेश राज्य के कृषि विभाग के बीच समझौता ज्ञापन पर हस्ताक्षर किए गए। भारत में हींग की खेती की शुरुआत करने के लिए 15 अक्टूबर, 2020 को केलांग के पास क्वारिंग गांव में हींग का पहला पौधा लगाया गया और राज्य में केसर की खेती की पहल भी की गई। पुनर्गठित राष्ट्रीय बांस मिशन के अंतर्गत, संस्थान ने गुणवत्तापूर्ण बांस रोपण सामग्री तैयार करने और अगरबत्ती (अगरबत्ती) की स्टिक विकसित करने के लिए कृषि विभाग, हिमाचल प्रदेश के साथ सहयोग कर रहा है, जो अभी तक देश में आयात की जाती रही है।

भारत में सेब की खेती आम तौर पर देश के ठंडे क्षेत्रों (हिमाचल प्रदेश, जम्मू एवं कश्मीर और उत्तराखंड) तक ही सीमित रही है। यद्यपि, 2016–2019 की अवधि के दौरान उत्तर पूर्वी राज्य की एजेंसियों और नेरकॉर्म्फ के सहयोग से सेब की कम ठंड (लो चिलिंग) वाली किस्मों को देश के उस क्षेत्र में सफलतापूर्वक लगाना प्रारंभ किया। इस वर्ष में भारत के उत्तर पूर्वी राज्यों से गुणवत्ता वाले लो चिलिंग सेब की सफल फसल पायी गई।

सीएसआईआर द्वारा शुरू किया गए 'अरोमा मिशन' का पहला चरण एक बड़ी सफलता रही, जिससे किसान की आय बढ़ाने तथा भारत को आत्मनिर्भर बनाने की दिशा में काफी सहायता मिली। इस वर्ष के दौरान, हिमाचल प्रदेश, पंजाब, हरियाणा, उत्तर प्रदेश, उत्तराखंड, ओडिशा,

झारखंड, गुजरात, मणिपुर, सिक्किम, मिजोरम, जम्मू और कश्मीर और लद्दाख में सगंध फसलों की खेती को आगे बढ़ाते हुए तथा किसानों को आसवन इकाइयां प्रदान करके ''अरोमा मिशन'' के दूसरे चरण की शुरूआत की गई। संस्थान की सार्थक पहल से, हिमाचल प्रदेश प्रति वर्ष 6.5 टन उत्पादन क्षमता के साथ देश में जंगली गेंदे के तेल का नंबर एक उत्पादक बन गया है। साथ ही संस्थान ने उच्च बायोमास/पुष्प उपज और सगंध तेल सामग्री के लिए सगंध फसलों की पांच किस्में, हिम बसंत (दमस्क गुलाब), हिम सुरभित (भारतीय वेलेरियन), हिम सुगंध (सफेद ड्रैगनहेड), हिम देवसुगंध (सी वर्मवुड), और हिम स्वर्णिमा (जंगली गेंदा) का विमोचन भी किया।

भारतीय फूलों की खेती के बाजार की 16,000 करोड़ रुपये की वार्षिक विशाल संभावना और सीएसआईआर की क्षमताओं को ध्यान में रखते हुए, डॉ हर्ष वर्धन, माननीय विज्ञान और प्रौद्योगिकी मंत्री और उपाध्यक्ष, सीएसआईआर ने सीएसआईआर प्रौद्योगिकियों का उपयोग करते हुए उच्च मूल्यवान पुष्पों की खेती के माध्यम से किसानों की आय बढ़ाने तथा उद्यमिता विकास को प्रोत्साहित करने के उद्देश्य से 4 मार्च 2021 को ''सीएसआईआर–फ्लोरिकल्चर मिशन'' का शुभारंभ किया। सीएसआईआर–आईएचबीटी इस अभियान को हिमाचल प्रदेश, उत्तराखंड, पंजाब, हरियाणा और लद्दाख में क्रियान्वित करेगा। अभियान को पूरा करने के लिए, वर्ष के दौरान गुलदाउदी की पांच किस्में, हिम आदित्य, हिम पुष्कर, हिम शिखर, हिम उज्ज्वला, और हिम श्रृंगार भी नवीन पुष्प रंगों एवं आकृतियों के लिए विमोचित की गई।

संस्थान ने इस वर्ष के दौरान 10 अलग–अलग राज्यों में स्टीविया (एक प्राकृतिक कम कैलोरी वाला स्वीटनर) की खेती को आगे बढ़ाया। इस फसल की खेती अब 400 हेक्टेयर क्षेत्र में की जा रही है।

2018–2020 के दौरान, सीएसआईआर ने ''न्यूट्रास्युटिकल्स एंड न्यूट्रिशनल्स'' पर अपने मिशन के अन्तर्गत एक बड़ा कदम उठाया गया। कोविड–19 महामारी की अभूतपूर्व घटना को ध्यान में रखते हुए, सीएसआईआर ने नोडल संस्थान के रूप में सीएसआईआर–आईएचबीटी के साथ ''स्वास्थ्य और तंदुरुस्ती के लिए पोषकों और न्यूट्रास्यूटिकल्स के इम्यूनोमॉड्यूलेटरी फंक्शन'' विषय पर एक प्रतिरक्षा अभियान की शुरूआत की। इसका मुख्य उद्देश्य न्यूट्रास्युटिकल्स और पोषक तत्वों का अन्वेषण, पहचान एवं विकसित करना है, जो संक्रमण से लड़ने एवं प्रतिरक्षा को बढ़ावा देने में सक्षम हैं। साथ ही इम्युनोस्टिमुलेटरी क्षमता युक्त भारतीय फलों और सब्जियों का दस्तावेजीकरण करना भी शामिल है। इस परियोजना को 2020 में 2021–2022 के दौरान लॉन्च करने की स्वीकृति दी गई है।

इस वर्ष के दौरान हिमालयी जैवसंपदा आधारित न्यूट्रास्युटिकल उत्पादों और प्रौद्योगिकियों की एक श्रृंखला विकसित की गई। मधुमेहरोधी क्षमता के लिए *टाइनोस्पोरा कॉर्डिफोलिया* (गिलोय) के आयुर्वेद–आधारित पारंपरिक फॉर्मूलेशन को प्रीक्लिनिकल अध्ययनों में मान्य किया गया। इसी तरह, फेफड़ों की चोट को कम करने के लिए *वाइटेक्स निगुन्डो* (निर्गुंडी) की पत्ती का अर्क प्रभावी पाया गया। इंस्टेंट नूडल्स को विकसित करने के लिए उच्च तुंगता वाले क्षेत्रों से छिलके रहित जौ का उपयोग किया गया। टाइप 2 मधुमेह में इंसुलिन संवेदनशीलता और ग्लूकोज सुधार करने में सेब के पॉलीफेनोल्स की भूमिका को भी उजागर किया गया। चाय आधारित एक इम्यूनोमॉड्यूलेटरी फॉर्मूलेशन विकसित किया गया, जिसे एनिमल मॉडल पर मान्य किया गया था और प्रौद्योगिकी को एक उद्यमी को हस्तांतरित किया गया है।

हिमालयी पौधों की प्रजातियों, विशेष रूप से जलवायु परिवर्तन और वाणिज्यिक अत्याधिक दोहन से खतरे में पड़ी प्रजातियों के प्रति संस्थान का लगातार ध्यान केंद्रित है। इस दिशा में, लुप्तप्राय और आर्थिक रूप से महत्वपूर्ण पौधों की प्रजातियों जैसे *रोडियोला इम्ब्रिकाटा, वेलेरियाना जटामांसी,* और *पिक्रोरिजा कुरूआ* आदि के लिए एरोपोनिक्स, हाइड्रोपोनिक्स, वर्टिकल हाइड्रोपोनिक्स और टिशू कल्चर–आधारित प्रौद्योगिकियों को विकसित किया गया। उल्लेखनीय है कि हिमालयी औषधीय पौधों और अन्य व्यावसायिक रूप से महत्वपूर्ण प्रजातियों की हाइड्रोपोनिक्स और टिशू कल्चर–आधारित प्रौद्योगिकियों को खेती के लिए उद्यमियों को हस्तांतरित किया गया।

हिमालय में ठंडे रेगिस्तानी क्षेत्र नाइट सॉयल (मानव अपशिष्ट) के क्षरण की समस्या का सामना कर रहे हैं। संस्थान के वैज्ञानिकों ने नाइट सॉयल के तेजी से क्षरण के लिए कुशल माइक्रोबियल कंसोर्टियम विकसित किया, जिसे उस क्षेत्र के मूल निवासियों द्वारा इसके उपयोग की सकारात्मक प्रतिक्रिया मिली। इस वर्ष के दौरान, स्थानीय उपयोग के लिए लाहौल और स्पीति जिले (हिमाचल प्रदेश)

में लाहौल घाटी के निवासियों को 1.6 टन उत्पाद सामग्री वितरित की गई। उत्पाद की उपयोगिता ने भारतीय सेना की 14 कोर तहत '39 माउंटेन डिवीजन' और उत्तरी कमान का ध्यान आकर्षित किया और उत्पाद का उपयोग उनके द्वारा लद्दाख क्षेत्र में तैनात सैन्य कर्मियों के लिए किया जा रहा है।

''एंजाइम मिशन'' पर अपने प्रयासों को जारी रखते हुए, हिमालय के सूक्ष्मजीवों/पौधों से कई व्यावसायिक रूप से महत्वपूर्ण एंजाइमों की पहचान की गई। उदाहरण के लिए, एक थर्मोस्टेबल Fe/Mn सुपरऑक्साइड डिसम्यूटेज, व्यापक तापमान सक्रिय लाइपेस और अद्वितीय लैकेश को विलगित किया गया। इसके अतिरिक्त, हिमालयी बैक्टीरिया से बायोडिग्रेडेबल–बायोप्लास्टिक पॉलीहाइड्रॉक्सी- कैनोएट्स और वायलिन पिगमेंट के लिए एक पेटेंट प्राप्त किया गया।

नैनोटेक्नोलॉजी का उपयोग करते हुए, कार्बन के साथ नैनोजाइम विकसित किया गया। यह पहली बार है जब नैनोजाइम के लिए धातु का उपयोग नहीं किया गया। इसके अतिरिक्त, सेल्यूलोज नैनोनियन को चिकित्सीय क्षेत्र में अत्यधिक प्रभाव के साथ विकसित किया गया है।

पादप रसायनिकी की क्षमता का लाभ उठाते हुए, *सिसाम्पेलोस परेरा* से छह अणुओं को विलगित किया गया एवं शक्तिशाली एंटीमलेरियल के रूप में लक्षणचित्रित किया गया। इसी तरह, *ट्रिलियम गोवेनियानम* राइजोम की पादप रसायनिकी जांच से स्टेरॉइडल सैपोनिन को विलगित कर लक्षण वर्णन किया। इनमें से, बोरसोसाइड ई, प्रोटोडिओसिन और डायोसजेनिन मधुमेह समर्थक एंजाइमों (α-amylase, α-glucosidase, और DPP-IV) को बाधित करने के लिए पाए गए।

अपशिष्ट बायोमास के कुशल उपयोग के लिए एक वैकल्पिक परिवर्तनात्मक दृष्टिकोण के रूप में, न्यूनतम रासायनिक भार के साथ सशोधित क्राफ्ट पल्पिंग प्रक्रिया का उपयोग करके गाय के गोबर से सेलूलोज निकालने के लिए प्रयोगशाला स्तर की प्रक्रिया विकसित की गई।

इसके अतिरिक्त, अच्छे रसायनों और एपीआई के लिए आयात निर्भरता को कम करने के लिए, औद्योगिक रूप से महत्वपूर्ण पैरासिटामोल और ब्रोमहेक्सिन के लिए प्रयोगशाला स्तर की प्रक्रियाएं विकसित की गई। इस वर्ष कार्बनिक रसायन विज्ञान के क्षेत्र को मजबूत करने के लिए कुल 14 नई सिंथेटिक पद्धतियां विकसित की गई। इन पद्धतियों की प्रमुखता दवा–संयुग्म, नैनो–उत्प्रेरण, सी–एच सक्रियण, ऑर्गेनो–/फोटो–उत्प्रेरण, हरित और टिकाऊ रसायन और कार्बन मोनोऑक्साइड निर्धारण प्रतिक्रियाएं रहीं।

महामारी के बावजूद, संस्थान ने सावधानीपूर्वक वनस्पतियों की खोज का कार्य किया। जिसमें संस्थागत पादपालय को समृद्ध करने के लिए उच्च तुंगता वाले क्षेत्रों से 850 से अधिक पौधों के नमूने एकत्र किए गए। इसके अतिरिक्त, 400 प्रजातियों की जानकारी के डिजिटलीकरण को भारतीय जैव संसाधन सूचना नेटवर्क में एकीकृत किया गया। संस्थान को हिमाचल प्रदेश के पुष्प संसाधन के लिए जैव संसाधन सूचना केंद्र के रूप में मान्यता प्राप्त है। साथ ही, संस्थान ने सामुदायिक भागीदारी के माध्यम से 10 हेक्टेयर वन भूमि का जीर्णोद्धार किया और संसाधन संरक्षण में पारंपरिक ज्ञान की भूमिका पर प्रकाश डाला।

नेक्स्टजेन रिमोट सेंसिंग (ड्रोन आधारित और मशीन लर्निंग) तकनीकों का उपयोग प्रजातियों के मानचित्रण और रोजा *डेमेसिना* और *वेलेरियाना जटामांसी* के विकास विभेदन के लिए किया गया। फीनोलॉजिकल और स्नो मेल्ट पैटर्न का अध्ययन करने के लिए स्वचालित टाइम लैप्स कैमरा सेट–अप का उपयोग किया गया। साथ ही, प्रभावी संरक्षण के लिए संकटापन्न पौधों के वितरण और बहुतायत को निर्धारित करने वाले पारिस्थितिक कारकों का मूल्यांकन किया गया। *एंजेलिका ग्लौका, कैरम कार्वी, अर्नेबिया यूक्रोमा, एकोनाइटमटम हेटरोफाइलम, सिनोपोडोफिलम हेक्सेंड्रम, पिक्रोराइजा कुरोआ, फ्रिटिलारिया रॉयली* आदि सहित बीस प्रजातियों को क्षेत्र जीन–बैंक संरक्षक में संरक्षित किया गया है।

कोविड–19 महामारी की स्थिति को ध्यान में रखते हुए, छात्रों को विज्ञान के प्रति प्रेरित करने के लिए जिज्ञासा कार्यक्रम के अन्तर्गत स्कूली छात्रों एवं उनके शिक्षकों को संस्थान की अनुसंधान एवं विकास गतिविधियों को प्रसारित/प्रचारित करने के लिए विभिन्न ऑनलाइन गतिविधियों का आयोजन किया गया। हमने छठे भारत अंतर्राष्ट्रीय विज्ञान महोत्सव (आईआईएसएफ–2020) के सफल आयोजन के लिए सभी जवाहर नवोदय विद्यालयों, केन्द्रीय विद्यालयों एवं हिमाचल प्रदेश के सरकारी तथा पब्लिक स्कूलों के साथ समन्वय स्थापित किया। इस वर्ष वेबिनार, आईआईएसएफ–2020, विज्ञान यात्रा, राष्ट्रीय विज्ञान दिवस समारोह एवं अन्य कार्यक्रमों सहित कुल 9238 प्रतिभागियों ने विभिन्न गतिविधियों में भाग लिया।

साथ ही, डीबीटी–हिमकोस्ट द्वारा प्रायोजित कौशल विज्ञान कार्यक्रम के अन्तर्गत गुणवत्ता नियंत्रण जीवविज्ञानी (15) और लैब तकनीशियन /सहायक (10) के पहले बैच को तीन महीने के ऑनलाइन पाठयक्रमों के लिए चुना गया। इसके अतिरिक्त, इस वर्ष 19 स्नातक/स्नातकोत्तर/ पीएचडी. छात्रों को सीएसआईआर–आईएचबीटी में वैज्ञानिकों के कुशल मार्गदर्शन में प्रशिक्षित किया गया।

पौधों के प्रति जागरूकता पैदा करने तथा विज्ञान को लोकप्रिय बनाने के लिए संस्थान में एक 'प्रकृति कुंज' विकसित किया गया, जो अपनी तरह की एक अनूठी पहल है, जहां पौधों की प्रजातियों को क्यूआर–आधारित नेमप्लेट से टैग किया जाता है। मोबाइल उपकरणों के माध्यम से क्यूआर को स्कैन करने से पौधों के बारे में उनके उपयोग के साथ–साथ वानस्पतिक और स्थानीय नामों सहित जानकारी मिलती है। इसके अतिरिक्त, संस्थान ने परिसर की वृक्ष संपदा पर एक सचित्र पुस्तिका का भी विमोचित किया। साथ ही, पौधों के विभिन्न समूहों के संरक्षण की जानकारी युक्त हर्बेरियम तकनीक पर एक मैनुअल भी तैयार किया गया।

ज्ञान साझा करने, संचार और अनुसंधान सहयोग को बढ़ावा देने के लिए, संस्थान के शोधार्थियों ने एमएस टीम के माध्यम से "कोविड 19: ए कैंसिल कल्चर ऑर ए विंडो ऑफ अपॉर्चुनिटीज" विषय पर 5 सितंबर, 2020 को छात्र संगोष्ठी श्रृंखला के चौथे संस्करण का आयोजन किया। सीएसआईआर–आईएचबीटी के छात्रों के अतिरिक्त, आईआईटी, रोपड़, आईआईटी, मंडी, पंजाब विश्वविद्यालय, चंडीगढ़, जैव संसाधन और सतत विकास संस्थान, मणिपुर, राजीव गांधी गवर्नमेंट स्नातकोत्तर आयुर्वेदिक कॉलेज, पपरोला, राजकीय मेडिकल कॉलेज और अस्पताल, मंडी और शूलिनी विश्वविद्यालय, सोलन के प्रतिभागियों ने संगोष्ठी श्रृंखला में भाग लिया।

इस वर्ष के दौरान संस्थान में उपलब्ध व्यापक सुविधाओं को सुधार के माध्यम से स्वच्छ परिसर बनाने की पहल की। इस के अन्तर्गत, कई नई गतिविधियां शुरू की गईं जिनमें राष्ट्रीय ध्वज के साथ एक खुला संबोधन स्थल, भरमात कॉलोनी में कंक्रीट रोड, पांच विभिन्न स्थानों पर जैविक और रासायनिक भंडार शामिल हैं। श्री जय राम ठाकुर, माननीय मुख्यमंत्री, हिमाचल प्रदेश द्वारा उच्च गुणवत्तायुक्त पौधशाला और टिशू कल्चर यूनिट की आधारशिला रखी गई। इसके अतिरिक्त 12 टाइप–IV स्टाफ क्वार्टर की आधारशिला श्री अनुराग सिंह ठाकुर, माननीय केंद्रीय राज्य मंत्री, वित्त मंत्रालय और कॉर्पोरेट कार्य के मंत्रालय द्वारा रखी गई।

संस्थान के प्रयासों को सीएसआईआर मुख्यालय, संस्थान की अनुसंधान परिषद तथा प्रबंधन परिषद द्वारा समर्थित किया गया। किसानों, स्टार्टअप्स, इनक्यूबेटिस और उद्यमियों सहित हमारे हितधारकों ने संस्थान द्वारा विकसित प्रौद्योगिकियों और हमारे कामकाज में बहुत विश्वास दिखाया, जो कि हमारे साथ उनके मजबूत सहयोग से स्पष्ट झलकता है। विभिन्न सरकारी और राज्य के विभागों एवं अन्य वित्त पोषण एजेंसियों ने संस्थान की गतिविधियों को आगे बढ़ाने में सहायता की। मैं इस अवसर पर उन सभी को धन्यवाद देता हूं।

"आत्मनिर्भर भारत" बनाने पर हमारे माननीय प्रधानमंत्री के स्पष्ट अधिदेश के साथ, हम राष्ट्र के विकास में अपना योगदान करने के लिए समर्पित हैं।

जय हिन्द!

(संजय कुमार)

FROM THE DIRECTOR'S DESK

It is a pleasure to have an opportunity again to connect with you by way of presenting the salient achievements of the CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT) for the year 2020-21.

During the year, a renewed emphasis was placed on research-academia-society-industry connect to generate entrepreneurship and guide livelihood. The Institute signed 25 technology transfer agreements with entrepreneurs/industries, and incubated 20 start-ups. Also, 72 consultancy agreements/MoUs/MTAs were signed by the Institute, including international collaborations with Kent State University (KSU), and Volt Research LLC, USA. At the same time, 135 research papers, with an average impact factor of 3.43 and the highest having 11.38, were published during the year. Further, 29 book chapters were published and 51 patents were filed.

Further, CSIR-IHBT continued its pivotal role as a technology partner towards upliftment of livelihood in the Indian Himalayan Region under the "Indian Himalayan Central Universities Consortium" as approved by The National Institution for Transforming India (NITI Aayog).

Addressing the challenge posed by COVID-19 pandemic, the Institute rendered its services to testing and contributed to molecular surveillance of SARS-CoV-2 by genome sequencing and sero surveys. CSIR-IHBT also collaborated with the State Health Department to establish new COVID-19 testing facilities, and to train the health personnel. Aiming to develop therapeutics against COVID-19, natural molecules from the Himalayan botanicals were screened and potential inhibitors of SARS-CoV-2 were identified for further development.

Contributing to the mission of making India self-reliant- "*Aatmanirbhar Bharat*" the Institute took a big leap to introduce *Heeng* (*Ferula assa-foetida* L.) in India. Presently, the country imports *Heeng* worth Rs. 940 crore, annually. CSIR-IHBT standardized agro-technology of *Heeng* for its cultivation in the cold desert regions of the country. Yet another important spice India imports is saffron (*Crocus sativus*; red gold of spices) that is cultivated only in the state of Jammu and Kashmir. The cultivation meets about 7-9% of the country's requirement. The Institute embarked to promote its cultivation in Himachal Pradesh and other Himalayan regions, and therefore developed the saffron production technology for the purpose. The efforts of the Institute were lauded by the Himachal Pradesh Government during the budget session 2020. Consequently, MoUs between CSIR-IHBT and State Department of Agriculture, Himachal Pradesh were signed to promote *Heeng* and saffron cultivation in the State in a collaborative way. The first plant of *Heeng* was planted at village Kwaring near Keylong on October 15, 2020, to mark the initiation of *Heeng* cultivation in India, and the saffron cultivation was also taken up in the state. Under the Restructured National Bamboo Mission, the Institute joined hands with the Department of Agriculture, Himachal Pradesh to generate quality bamboo planting material and to develop *Agarbatti* (incense) sticks that is currently imported in the country.

Apple cultivation in India has generally been restricted to the cooler regions of the country (Himachal Pradesh, Jammu & Kashmir and Uttarakhand). Low-chilling varieties of apples, in association with North Eastern State Agencies and NERCORMP were successfully introduced Mizoram, Meghalaya, Manipur and Arunachal Pradesh during the period of 2016-2019. The current year witnessed a successful harvest of quality apples from Mizoram, Meghalaya and Manipur.

The first phase of "Aroma Mission" launched by the CSIR had been a great success that helped to increase farmer's income and make India self-reliant. During the current year, the second phase of the "Aroma Mission" was launched by further extending the cultivation of aromatic crops and providing distillation units to farmers in Himachal Pradesh, Punjab, Haryana, Uttar Pradesh, Uttarakhand, Odisha, Jharkhand, Gujrat, Manipur, Sikkim, Mizoram, Jammu & Kashmir, and Ladakh. After the Institute's interventions, Himachal Pradesh has become the number one producer of wild marigold oil in the country with a production potential of 6.5 tonnes, annually. Concomitantly, 5 varieties of aromatic crops *viz.*, *Him Basant* (damask rose), *Him Surbhit* (Indian valerian), *Him Sugandh* (white dragonhead), *Him Devsugandh* (sea wormwood), and *Him Swarnima* (wild marigold) were released for high biomass/ flower yield and essential oil content.

Keeping in view the huge potential of Indian Floriculture market to a tune of ~Rs. 16,000 crore annually, and the capabilities of the CSIR, Dr. Harsh Vardhan, Hon'ble Minister of Science & Technology and Vice President of CSIR launched "CSIR-Floriculture Mission" on 4th March 2021, with an objective to enhance farmers' income and entrepreneurship development through high value floriculture utilizing CSIR technologies. The CSIR-IHBT will implement the Mission in Himachal Pradesh, Uttarakhand, Punjab, Haryana and Ladakh. Further, to cater to the mission, 5 varieties of chrysanthemum *viz.*, *Him Aditya*, *Him Pushkar*, *Him Shikhar*, *Him Ujjwala*, and *Him Shringar* were also released for novel flower colours and shapes during the year.

The Institute further extended stevia (a natural low-calorie sweetener) cultivation in 10 different states, during the current year. The crop now covers a total area of 400 ha.

During 2018-2020, CSIR had taken a big stride under its Mission on "Nutraceuticals and Nutritionals". Considering the unprecedented occurrence of COVID-19 pandemic, CSIR launched "Immunity Mission" under the theme "Immunomodulatory Function of Nutritionals and Nutraceuticals for Health and Wellness", with CSIR-IHBT as the nodal Institute. The key objectives of the mission are to explore, identify and develop nutraceuticals and nutritionals, capable to boost immunity to fight infections, and to document Indian fruits and vegetables, those having immunostimulatory potential. The project was approved in 2020 to be launched during 2021-2022.

An array of Himalayan bioresource-based nutraceutical products and technologies were developed during this year. The Ayurveda-based traditional formulation of *Tinospora cordifolia* with antidiabetic potential was validated in the preclinical studies. Similarly, the leaf extract of *Vitex negundo* was found to be effective to alleviate lung injury. The hull-less barley of high altitude was utilized for the development of instant noodles. The role of apple polyphenols in improving insulin sensitivity and glucose uptake in type II diabetes was also uncovered. A tea-based immunomodulatory formulation was developed, validated in animal system, and the technology was transferred to an entrepreneur.

The Institute has a consistent focus around Himalayan plant species, particularly those threatened by climate change and commercial over-exploitation. In this direction, aeroponics, hydroponics, vertical hydroponics and tissue culture-based technologies were developed for several endangered and economically important plant species, such as *Rhodiola imbricate, Valeriana jatamansi,* and *Picrorhiza kurrooa* etc. Importantly, hydroponics and tissue culture-based technologies were transferred to enterpreneurs for *ex situ* cultivation of important Himalayan medicinal plants and other commercially important species.

Cold desert regions in Himalaya is confronted with a major issue of night soil (human waste) degradation. Scientists at the Institute developed efficient microbial consortium for faster degradation of night soil, that received positive feedback of its application by the natives in that region. During the current year, 1.6 tonnes of the material was distributed to inhabitants of Lahaul valley in Lahaul and Spiti district (Himachal Pradesh) for local use. The utility of the product attracted the attention of '39 Mountain Division' under 14 Corps and Northern Command of Indian Army and the product is being used by them for the army personal deployed in Ladakh region.

Continuing our efforts on "Enzyme Mission", several commercially important enzymes were identified from the microbes/plants of the Himalaya. For instance, a thermostable Fe/Mn superoxide dismutase, broad temperature active lipase and unique laccase were isolated. Also, a patent was obtained for biodegradable-bioplastic polyhydroxyalkanoates and violacein pigment from Himalayan bacteria.

Using the power of nanotechnology, nanozyme was developed with carbon. This is the first time when metal was not used for nanozyme. Also, cellulose nanonion were developed with immense implications in therapeutics.

Leveraging the potential of phytochemistry, six molecules were isolated and characterized as potent antimalarials from *Cissampelos pareira*. Similarly, phytochemical investigation of *Trillium govanianum* rhizomes led to the isolation and characterization of steroidal saponins. Among these, borassoside E, protodioscin and diosgenin were found to inhibit pro-diabetic enzymes (α-amylase, α-glucosidase, and DPP-IV).

As an alternate, innovative approach for the efficient utilization of waste biomass, process was developed to extract cellulose from cow dung by using a modified kraft pulping process with minimal chemical load. Extracted cellulose was further converted into alpha-nanocellulose with excellent surface charge.

Further, to reduce the import dependency for the fine chemicals and APIs, lab scale processes were developed for the industrially important paracetamol and bromhexine. This year a total of 14 new synthetic methodologies were developed to strengthen the area of organic chemistry. The emphases of these methodologies were drug-conjugates, nano-catalysis, C-H activation, organo-/photo-catalysis, green and sustainable chemistry and carbon monoxide fixation reactions.

Despite pandemic, the CSIR-IHBT cautiously conducted floristic explorations wherein more than 850 plant samples were collected from high altitude regions to enrich Institute's Herbaria. Further, the digitization of information of 400 species was integrated into the Indian Bioresource Information Network. The Institute continues to be identified as a Bioresource Information Centre for the Floral Resource of Himachal Pradesh. The Institute rejuvenated 10 ha of forest land through community involvement and highlighted the role of traditional knowledge in resource conservation.

NextGen remote sensing (drone based and machine learning) techniques was utilized for species mapping and growth discrimination of *Rosa damascena* and *Valeriana jatamansi*. The automated time lapse camera set-up was used to study the phenological and snow melt patterns. Also, the ecological factors determining the distribution and abundance of threatened plants were assessed for effective conservation. Twenty species including *Angelica glauca, Carum Carvi, Arnebia euchroma, Aconitum heterophyllum, Sinopodophyllum hexandrum, Picrorhiza kurrooa, Fritillaria roylei*, *etc.,* were conserved in our field gene-bank conservatories.

Keeping in view the COVID-19 pandemic situation, different online activities were conducted to disseminate R&D activities of the Institute to school students and teachers under the Jigyasa programme to motivate young minds towards science. We coordinated with all Jawahar Navodaya Vidyalaya, Kendriya Vidyalaya, Government and Public schools within the state for the successful organization of the 6th India International Science Festival (IISF-2020). This year, a total of 9238 participants took part in different activities *viz.* webinar, IISF-2020, Vigyan Yatra, National Science Day Celebration and other events.

The first batch of quality control biologist (15 No.) and lab technician/assistant (10 No.) were selected for 3 months online courses under the Skill Vigyan programme sponsored by the DBT-HIMCOSTE. Besides, this year 19 graduate/ post graduate/ Ph.D. students were trained under the able guidance of scientists at CSIR-IHBT.

Further, to create awareness about plants and science popularization, a 'Prakriti Kunj' was developed. It is a one-of-its kind initiative, where QR-based nameplates are tagged to the plant species. Scanning the QR through mobile devices provides information on the plants including botanical and vernacular names along with their uses. Besides, the Institute came out with a pictorial handbook of tree resources of the campus. Also, a manual on herbarium techniques covering the preservation of different groups of plants was prepared.

To foster knowledge sharing, communication and research collaboration; research scholars of the Institute organized the fourth edition of the Student Seminar Series on 5th Sept, 2020 on the theme "COVID 19: A Cancel Culture or a Window of Opportunities" via MS Team. Herein, in addition to the students from the CSIR-IHBT, participants from IIT, Ropar; IIT, Mandi; Panjab University, Chandigarh; Institute of Bioresources & Sustainable Development, Manipur; Rajiv Gandhi Government Post Graduate Ayurvedic College, Paprola; Government Medical College and Hospital, Mandi; and Shoolini University, Solan also participated in the event.

This year perceived an emphasis on clean campus initiative through the advancement and improving the wide ranging facilities within the Institute.

Under this vision, several new developments were made that included an open address terrace with National Flag, concrete road in Bharmat colony, biological and chemical stores at five locations. The foundation stones of high tech nursery and tissue culture unit were laid by Sh. Jai Ram Thakur, Hon'ble Chief Minister, HP. Also, the foundation stone of type-IV staff quarters (12 numbers) was laid by Sh. Anurag Singh Thakur, Hon'ble Union Minister of State, Ministry of Finance and Ministry of Corporate Affairs. The endeavours of the Institute were ably supported by the CSIR headquarter, the Institute's Research Council and the Management Council. Our stakeholders including farmers, startups, incubatees and the entrepreneurs exhibited enormous faith in the technologies developed by the Institute and its functioning, as evident from their strong association with us. Various Government and State departments and other funding agencies rendered help to the Institute in furthering its activities. I take this opportunity to thank them all.

With the clear mandate from our Hon'ble Prime Minister on making *Aatmanirbhar Bharat* (self–reliant India), we remain dedicated to contribute for national development.

Jai Hind!

(Sanjay Kumar)

TECHNOLOGIES AVAILABLE AND ROLLED OUT

TECHNOLOGIES AVAILABLE WITH CSIR-IHBT

	Agrotechnology
S.No.	**Technology/ Products Name**
1	Stevia: agro- and processing technology
2	Monk fruit *(Siraitia grosvenorii):* low calorie natural sweetner
3	*Heeng (ferula assa-foetida):* agrotechnology
4	China hybrid tea (*Camellia sinensis*): agrotechnologypacakage
5	Damask rose (*Rosa damascene*): agro-and processing technology
6	Wild marigold (*Tagetus minuta*): agro-and processing technology
7	Lavender (*Lavandula officinalis*): agro- and processing technology
8	Rosemary (*Rosmarinus officinalis* L.): agro and processing technology
9	Agro-technology for mass production of saffron (*Crocus sativus* L.)
10	German chamomile (*Matricaria chamomilla* L.): agro and process technology
11	Improved bee hive for quality and hygienic extraction of honey
12	Lilium: agrotechnology
13	Calla lily: agrotechnology
14	Gerbera: agrotechnology
15	Agro-technology of carnations
16	Alstroemeria: agrotechnology
17	Cut-roses: agrotechnology
18	Chrysanthemum: agrotechnology
19	Vertical gardening
20	Indoor air pollution abatement plants
21	Micropropagation protocols: industrially important crop plants
22	Micropropagation protocols for *Picrorhiza kurrooa*
23	Production technology for quality rootstock for apple
24	Biofertilizers
	Biotechnology
25	Superoxide dismutase: an enzyme for diversified industrial applications
26	L-Asparaginase (HimAsnase™): an enzyme with application in food processing
27	DNA barcode technology for plant authentication
28	(GEPROTED)™: gel processing and transfer device
29	iRIS™: a solution for easy isolation of RNA
30	Steriflow™: mini laminar flow unit
31	Culture vessel for rooting of microshoots
32	*In vitro* production system for naphthoquinones (red colour) from *Arnebiaeuchroma*
33	Simultaneous production of biodegradable bioplastic polyhydroxyalkanoates (PHA) and violacein pigment from Himalayan bacteria
34	Tissue culture protocol for mass production of quality corms of saffron
35	Mass production of *Nardostachys jatamansi*– a critically endangered high value medicinal plant of Himalaya
36	Technology with short cultivation cycle for production of adventitious roots as a source of valepotriates
37	Compost booster for cold regions

Biotechnology	
S.No.	**Technology/ Products Name**
38	Technology for shortened flowering cycle and year round production of lilium and tulip
39	Technology for year round cultivation of quality spice crops
40	Mass production of *Diplazium maximum*: A nutritious ethnic food of Himachal Pradesh
Chemical Technology	
41	Technology for the production of aescin from horse-chestnut
42	Process for cyclohexane-1, 3- dionesynthesis
43	Process for 5-hydroxymethylfurfural (5-HMF) production from biomass
44	Natural colours from plants/vegetable sources
45	Green process for nanocurcumin synthesis with increased solubility
46	Bamboo charcoal
47	Formulation of herbal incense cones from herbs and flowers
48	Tea based hand sanitizer
49	Tea based mouthwash
50	Process for 5-methylfurfuryl alcohol (MFA) production from biomass derived 5-HMF
51	Scalable process for production of 4-alkyl resorcinols
52	Eco-friendly process for textile fibre from plant resources for various applications
53	Herbal based liquid hand wash
54	Chemical free herbal soap
55	Herbal oil for dandruff prevention
56	Herbal lipsticks
57	Formulation promoting cartilage health
58	Natural perfumes
59	Lip balm
60	Air fresheners
61	Mosquito repellents
Food Technology	
62	*Shitake* mushroom: vitamin D_2 enriched
63	Gluten-free foods from buckwheat
64	Iron and zinc enriched spirulina based bars
65	Iron enriched fruit bars and candies
66	Multigrain high protein mix
67	Protein and fibre enriched cereal bars
68	Tea catechins
69	Tea wine
70	Ready to serve tea concentrates
71	Ready to eat crispy fruits & vegetables
72	Canning technology for ready to eat (RTE) foods
73	Food products from bamboo
74	Technology for dietary fibre extraction from apple pomace

Food Technology	
S.No.	**Technology/ Products Name**
75	Roasted barley grain based beverages
76	Low calorie herbal mukhwash
77	Value added food products based on honey
78	Value added food products and technologies based on sohiong (*Prunusnepalensis*)
79	Value added food products and technologies based on seabuckthorn (*Hippophaerhamnoides*)
80	Protein and micronutrients enriched ready to cook foods
81	Tea based synbiotic nutraceutical
82	Tea vinegar
83	Herbal formulation for immunity modulation

TECHNOLOGIES ROLLED OUT AND MoUs/AGREEMENTS SIGNED 2020–21

TECHNOLOGY TRANSFER AGREEMENTS

S. No	Title of agreement	Name of party	Date of signing
	Agrotechnology		
1	Agreement for ToT of newly developed agro technologies of *Heeng* & Saffron	Directorate of Agriculture, Government of Himachal Pradesh, Krishi Bhawan, Boileauganj, Shimla-171005	06.06.2020
	Biotechnology		
2	Lab scale technology on development of efficient psychrotrophic bacterial formulation for preparation of enriched compost/ vermicompost in cold hilly region for its implementation at large scale	Moonew Tareybhir Enriched Composting/ Vermicomposting Cluster (MECC), West District, Sikkim – 737 121	19.08.2020
3	Preparation of enriched compost/ vermicompost in cold hilly region for its implementation at large scale	Triloki Enriched Composting/ Vermi Composting Cluster (TECC), Sirmour District, Himachal Pradesh	27.08.2020
4	Agreement for establishment of hydroponic facility for production of Lilium and Tulip plants	Sh. Akshat Goel 172, Sukhdev Vihar, New Delhi- 110025	01.01. 2021
5	Cultivation and Production of Kutki and Jatamansi plant under hydroponic system	Hydrocrops India Pvt. Ltd., Jalandhar (Punjab)	17.03. 2021
	Chemical Technology		
6	Technology for commercial production of hand sanitizer	M/s Nature Green Chamba Herbs, Village Sutrar, Tehsil Nurpur, Dist. Kangra (H.P.)	01.04.2020
7	Technology for commercial production of hand sanitizer	M/s VLCARE HEALTH, 53, Gurudwara Area, Bistupur, Jamshedpur, 831001, District: East Singhbhum, State: Jharkhand	01.04.2020
8	Technology for commercial production of hand sanitizer	M/s Baijnath Pharmaceuticals Pvt. Ltd., Paprola, Tehsil Baijnath, District Kangra–176115 (H.P.)	03.04.2020
9	Technology for hand sanitizer	M/s Mount leaf, Ghurkari khas, Kangra, (H.P)	19.05.2020
10	Technology for Tea Vinegar	M/s Kash I wish, Sidhbari Dharmshala (H.P.)	21.05.2020
11	Technology for making Herbal Soaps, liquid hand wash and Incense Cone	M/s Geo Care, V.P.O BhethJhikli, Tehsil Baijnath, District Kangra (H.P.) – 176 081	02.06.2020
12	Technology transfer agreement to make herbal soap and herbal oil	Ras Vaidyashala, Jobner, Jaipur (Rajsthan)- 303 329	09.03. 2021
13	Lab scale technology on formulation promoting cartilage health at large scale	M/s Carol's Formulations, C/o Noble Product, 39, Kanganiwal Industrial Area, Jandu Singha Road, Jalandhar (Punjab) – 144 025	09.02. 2021
	Food Technology		
14	Technology for manufacturing/ processing of Spirulina Peanut Bar PRODUCTS	M/s Daziran Health Products, 31, LGB Nagar, Sivanandhapuram, Ganapathy, Coimbatore	05.05.2020
15	Technology for manufacturing/ processing of multigrain protein powder	Lok Seva Trust (NGO), Meerut (U.P.)	05.05.2020

16	Ready to eat (RTE) Free from additives & Chemical preservatives	M/s Singh Agritech, Plot No. 115-A, Mauakheraganj, Nandnanagar Ind. Estate, Phase II, Kashipur (U.K.) 244713	23.05.2020
17	Technology of rice puffed bars	M/s SS Vitran Healthcare Pvt. Ltd., Opposite Arya Vanprastha Ashram, Arya Nagar, Jwalapur, Haridwar	24.06.2020
18	Manufacturing/ processing facility for manufacturing/ processing of (i) Granola bars - (millet and cereals based), and (ii) Spirulina peanut bar products	M/s Sumati Foods, Village Juddi Kalan, Baddi, Tehsil Baddi, District Solan, H.P.	01.09.2020
19	Lab scale technology on cultivation of Shiitake mushroom to its implementation at large scale	M/s Taqgene Training and Research Enterprise (TGTRE), Near Subhatri Hospital, Kotda Santoor, Nanda Ki Chowki, Prem Nagar (Uttarakhand) – 248 001	18.09.2020
20	Lab scale technology on cultivation of Shiitake mushroom to its implementation at large scale	Norbu Choeiling Shiitake Mushroom and Other Food Processing Cluster (NCSMC), South Sikkim, Block Namthang–737 121	17.12.2020
21	Lab scale technology on cultivation of Shiitake mushroom to its implementation at large scale	Sumbuk Shiitake Mushroom and Other Food Processing Cluster (SSMC), Sumbuk South Sikkim	17.12.2020
22	Lab scale technology on cultivation of Shiitake mushroom to its implementation at large scale	West Sikkim Shiitake Mushroom & Other Food Processing Cluster (WSSMC), Sikkim District: West-East Pin-737 121	17.12.2020
23	Transfer manufacturing/ processing of (i) Energy/Granola bars - (millet and cereals, protein based) products, and (ii) instant beverage mixes products/ variants	The Mak Biotek, K-22, Sawan Park Ashok Vihar, Phase-3, New Delhi 110052	22.02. 2021
24	Agreement for cultivation of Shiitake mushroom to its implementation at large scale	TAKE Farms, Proprietor Name - Abhimanyu Dhakal, 'Abhilasha', Next To Nepali Sahitya Parishad, Development Area, Gangtok – 737101, Sikkim	01.03. 2021
25	Herbal Formulation for Immunity Modulation	M/s Vigada Care Private Limited Ground Floor, K-19A, Kalkaji, New Delhi, South East Delhi- 110019	01.01. 2021

CONSULTANCY AGREEMENTS

Agrotechnology			
1	Consultancy for establishment of drying sheds and storage godowns for medicinal herbs at Jogindernagar (H.P.)	Department of Ayurvedic Pharmacy, Jogindernagar, District Mandi (H.P.)	28.05.2020
2	Consultancy agreement for core support program of DST for S&T interventions in Chowari Block of Chamba (H.P.)	Society for Technology & Development, Village Malori, P.O. Behna, Distt. Mandi (H.P.)	12.06.2020
3	Consultancy project to undertake the assessment of availability of different NTFPs (Medicinal and Aromatic Plants) of 20 VFDS in Mandi District of HP	Chief Project Director (JICA) Project for Improvement of Himachal Pradesh Forest Ecosystems Management & Livelihoods and Himachal Pradesh Forest Department (HPFD)	26.09.2020
4	Consultancy agreement to construct one drying shed and one storage godown at Jangal Jhalera, Bilaspur (H.P.)	Director Ayurveda-cum-Member Secretary State Medicinal Plant Board, SDA Complex, Block No. 26, Kasumpti Shimla (H.P.)	15.01.2021

5	Consultancy agreement for Gondla Cut Flower Cluster	Foundation for MSME Industries, New Delhi	23.02.2021
6	Consultancy agreement to construct one drying shed and one storage godown at Ayurvedic Pharmacy Paprola (H.P.)	Director Ayurveda-cum-Member Secretary State Medicinal Plant Board	23.02.2021

MATERIAL TRANSFER AGREEMENTS

	Agrotechnology		
1.	MTA under CSIR Aroma Mission for 20Kg seed of wild marigold variety " Him Swarnima"	Himalayan Phytochemical & Grower Association, V.P.O Baggi, District Mandi (H.P.)	11.06.2020
2.	MTA under CSIR Aroma Mission for 12 Kg seed of wild marigold variety " Him Swarnima"	Society for Technology & Development, Village Malori, P.O. Behna, Distt. Mandi (H.P.)	12.06.2020
3.	MTA under CSIR Aroma mission for 3 kg seed of wild marigold variety Him Swarnima	Shiva Kisan Samiti, Village Bhatera, PO Jol Lambri, Tehsil Sujanpur, District Hamirpur (H.P.)	16.06.2020
4.	MTA under CSIR Aroma mission for 3 kg seed of wild marigold variety Him Swarnima	Mr. Umesh Singh V.P.O Pukhri Tehsil and District Chamba (H.P.)	19.06.2020
5.	MTA for 3 Kg Variety Him Swarnima of Wild Marigold	M/s UTL, Kanta Complex, Tehsil Road, Derabassi, District SAS Nagar, Mohali, Punjab	01.07.2020
6.	MTA for *Valeriana jatamansi* seeds (100 gm)	Professor Sheikh Bilal Ahmed, Regional Director, RCFC North II-NMPB, SKUAST, Kashmir, Wadura, Sopore, J&K	14.07.2020
7.	MTA for 60,000 lemongrass slips (FOC) under CSIR Aroma Mission	Mr. Raj Kumar, Village & Post Office Saloh, Ward No., Saloh Uperla (198), Una (H.P.)	14.07.2020
8.	MTA for 1000 gm stevia seeds for cultivation	Ms. Preeti Abbi (Director, GLT Infrastructure Private Limited), 758 – Ekta Nagar, Roorkee Road, Meerut, U.P.	16.07.2020
9.	MTA for stevia seeds (150 gm) and plants raised through seeds in nursery 200 plantlets) and plantlets raised through tissue culture of “Him stevia” (22 plantlets)	Mr. Nishant Bansal, House No. 4, Gian Colony, Patiala (Punjab)	17.07.2020
10	MTA for 4,000 lemongrass slips, 20 rooted plants of rose geranium, 20 rooted plants of damask rose variety “Jwala” and one oregano seedling packed in polysleeves.	Mr. Chirag Sharma, Village Dohg, Post Office Lower Ghallour, Tehsil Jwalamukhi, District Kangra (H.P.)	19.08.2020
11	MTA for 10,000 lemongrass slips free of cost (FOC) under CSIR Aroma Mission.	Nirmal Society, Village Tanda, Post Office Rajpur, Tehsil Palampur, District Kangra (H.P.)	20.08.2020
12	MTA for 1,000 rooted plants of damask rose variety “Jwala” under CSIR AROMA MISSION and 1,000 rooted plants of damask rose on charge basis	Colonel Rajesh Sharma, S/o Major O.P. Sharma, Village Bhavetar. P.O. Kohala, Tehsil Jwalamukhi, Kangra (H.P.)	25.08.2020
13	MTA for Cultivation of medicinal and aromatic plants, floriculture plants (Bulbous plants, Flower crops), Indoor Air Pollution Abating Plants and Outdoor Air Pollution Abating Plants	Mr. Rajiv Arora, Jia Khas, Tehsil Palampur, Distt. Kangra (H.P.)	28.08.2020
14	MTA for 100 gm seeds of *Matricaria chammomilla* (German Chamomile) CSIR-IHBT selection (IHBT/MC-1) from CSIR-IHBT	The Director, ICAR– Central Potato Research Institute, Shimla (H.P.)	05.09.2020

15	MTA for stevia seeds	AFORD (Action Society for development), Bramhapuri, District Chandrapur, MH	16.09.2020
16	MTA for *Ginkgo biloba* plants and dry leaves	M/s Taqgene Training and Research Enterprise (TGTRE), Near Subhatri Hospital, Kotda Santoor, Nanda Ki Chowki, Prem Nagar (Uttarakhand)	18.09.2020
17	MTA for plants bamboo genotypes	Department of Forestry and Natural resources college of Horticulture and Forestry, PAU Ludhiana	24.09.2020
18	MTA for medicinal and aromatic plants, floriculture plants for research and extension activities by GBPNIHE, Kullu	G.B. Pant National Institute of Himalayan Environment (GBPNIHE), Himachal Regional Centre, Mohal, Kullu (H.P.) – 175126	15.10.2020
19	MTA to exchange the bamboo planting material	Jawaharlal Nehru Tropical Botanic Garden and Research Institute, KSCSTE - JNTBGRI, Karimancode P.O. Palode, Thiruvananthapuram, Kerala	21.10.2020
20	MTA for 1 kg seeds of Chamomile (*Matricaria chammomilla*) for cultivation under “CSIR Aroma Mission”.	Dr. Hitesh Kumar, Village Bhoor, PO Jhangi, Tehsil Sandhol, District Mandi (H.P.) – 176 090	28.10.2020
21	MTA for 1 kg seeds of Chamomile (*Matricaria chammomilla*) for cultivation under “CSIR Aroma Mission”.	Ms. Swaroop Sharma w/o Mr. Vinod Sharm, Teeka Garhi, V.P.O Thana Bargram, Baroh, District Kangra (H.P.)	09.11.2020
22	MTA for rooted plants of lavender, rooted plants of mushkbala (*Valeriana jatamansi*), and Damask rose “Himroz variety”	Farmalogist Essence and Organic LLP, A-200, Lower Ground Floor, Lajpat Nagar, Part- 1 New Delhi	7.12.2020
23	MTA for seeds and planting material of Lavander, Damask Rose, Rosemary, Wild marigold and Lemongrass for cultivation under “CSIR Aroma Mission”	Ms. Reena Thakur, V.P.O Averi, Tehsil Baijnath, District Kangra, (H.P.)	07.12.2020
24	MTA for 1.5 kg stevia seeds for cultivation	M/s DL Herbal Farms Group, E-45, 2nd Floor, Masjid Moth, G.K. 3, New Delhi	16.12.2020
25	MTA for stevia seeds 200 gm for cultivation	Ms. Supriya Sharma, Village Gural, Post office Bharwai, Tehsil Dehra, District Kangra (H.P.)	18.12.2020
26	MTA for 1Kg Stevia seeds	M/s Sivani Stevia Industry, Ward no. 10, Green Road, Chandmari, Golaghat, Assam	05.01.2021
27	MTA for 2000 rooted plants of damask rose variety	Mr. Rattan Singh Guleria, VPO Sidhpurghar, Tehsil, Jawali. Kangra (H.P.)	07.01.2021
28	MTA for damask rose rooted plants " Jwala Variety" and wild marigold 1 Kg	Mr. Amandeep Singh S/o Sh. Gurdip Singh Village Bhangwan, P.O Dalelpur, Tehsil and District Gurdaspur Punjab	04.02.2021
29	MTA for damask rose rooted plants " Jwala Variety" and wild marigold 1 Kg	Farmers School of Organic Farming, Village Janitpura, DeraBassi, District Mohali	04.02.2021
30	MTA for Damask rose variety "Jwala" plants (500 rooted plants)	Mr. Neeraj Kumar Pandey, House No 35, New Adarsh Colony, Mundian- Kalan, Ludhiana	11.02.2021
31	MTA for Damask rose variety "Jwala" plants (500 rooted plants)	The Eco Friendly Society of Farmers (Regd.), Vill. & P.O. RureKe Kalan, Tehsil, Tapa, District Barnala, Punjab	19.02.2021
32	MTA for 10 plants of stevia and tissue culture flask of Him Stevia	Mr. Anupam Sharma, House No. 192, NFL enclave, Sector 48 A, Chandigarh	01.03.2021

33	MTA for damask rose rooted plants "Jwala variety" plants (1000 Nos.) and Artemisia	Rami Bibi Dhou Dhou, Organic Centre, Village Bhagwan, Tehsil Kalanaur. District Gurdaspur (Punjab)	04.03.2021
34	MTA for damask rose rooted plants "Jwala variety" plants (1000 Nos.) and Artemisia	Farmers School of Organic Farming, Mohali., Punjab	04.03.2021
35	MTA for the 90 kg wild marigold seeds under CSIR Aroma mission phase 2	Association for peoples Advancement and Action Research (APAAR) C/o VSMD Enterprises, 1-97, Lajpat Nagar 1, New Delhi	09.03.2021
36	MTA for 2,000 rosemary rooted plants for cultivation	Himalayan Phytochemical & Growers Association, Baggi, Tehsil Sadar District Mandi (H.P)	10.03.2021
37	MTA for 12 kg seed of wild marigold (*Tagetes minuta*) variety Him Swarnima and 2 kg seed of Basil Tulsi (*Ocimum basalicum*) variety CSIR -IHBT selection	Samagra Adivasi Medicinal Plants Development Association, Kondagaon, Bastar, Chhattisgarh	31.03.2021
38	MTA for 25000 rooted plants of lavender for cultivation under CSIR Aroma Mission Phase II	Farmalogist Essence and Organic LLP at A-200, Lower Ground Floor, Lajpat Nagar, Part- 1 New Delhi	31.03.2021
	Biotechnology		
39	Tissue culture flasks of *Bambusa balcoa* (100 flasks), *Dendrocalamus asper* (100 flasks), *Bambusa nutans* (50 flasks) for propagation at their newly setup lab space	M/s Future Grapes Plantech Private Limited., Sr. No. 1102/8, Behind Police Head Quarter, At Post Adgaon, Nashik	26.11.2020

MISCELLANEOUS MoUs

	Agrotechnology		
1	MoU to join hands for project IRADA - Integration of Resources on Agro-forestry Development and Adaptation	Hrudaya Foundation, I-97, LGF Lajpat Nagar 1, New Delhi	7.12.2020
	Agrotechnology and Chemical Technology		
2	MoU for Installation of distillation unit (under CSIR-Aroma Mission) at the site of Progressive Farmers Association.	Progressive Farmers Association, Rattan Villa, IPH Colony, Ghumarwin, District Bilaspur (H.P.)	26.09.2020
3	MoU for Installation of distillation unit (under CSIR-Aroma Mission)	Kisaan Vikas Committee, Village Khal P.O. Bhanad Tehsil Salooni Distt. Chamba (H.P.) 176 325	09.03.2021
4	MoU for Installation of distillation unit (under CSIR-Aroma Mission)	EWOK Society, IIT Mandi, Kamand, Mandi (H.P.)	10.03.2021
5	MoU for Installation of distillation unit (under CSIR-Aroma Mission)	BB Bhumi Vikas Sabha, Teeka Garhi, VPO Thana Bargran, Tehsil Baroh, District Kangra (H.P.)	18.03.2021
6	MoU for Installation of distillation unit (under CSIR-Aroma Mission)	Choo Mata Uthaan Society, Village Bar, PO Tikri, Tehsil Sihunta, Chamba (H.P.)	19.03.2021
7	MoU for Installation of distillation unit (under CSIR-Aroma Mission)	Vikas Committee Suppa, Village Suppa P.O Ghared Tehsil Bharmour District Chamba(H.P.)	22.03.2021
8	MoU for Installation of distillation unit (under CSIR-Aroma Mission)	Panchayat Kolsar, Block Pouni, Tehsil & Distt. Reasi, Kolsar (J&K)	26.03.2021
9	MoU for Installation of distillation unit (under CSIR-Aroma Mission)	Human Advancement for Rural Masses (HRAM) VPO Kona Palampur, District Kangra (H.P.)	26.03.2021
10	MoU for Installation of distillation unit (under CSIR-Aroma Mission)	Jai Maa Kokila (SHG), Baram Post, District Pithoragarh, Uttarakhand	31.03.2021

Agrotechnology, Biotechnology and Food Technology			
11	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 Chamba District, Himachal Pradesh	Deputy Commissioner, Chamba, Himachal Pradesh, Deputy Commissioner Office Chamba at Chamba (H.P.)	17.02.2021
Academics			
12	Memorandum of Agreement (MoA) related to the Skill Vigyan Programme sanctioned by Department of Biotechnology, Govt. of India	Himachal Pradesh Council for Science, Technology & Environment "HIMCOSTE", Bemloe, Shimla, Government of Himachal Pradesh	09.09.2020
13	MoA for jointly sharing any IPR developed as consequence of joint scientific inputs by researchers of both institutes	Post Graduate Institution of Medical Education and Research (PGIMER), Sector 12, Chandigarh	21.09.2020
14	MoU for developing a module and study material (as per states of India) for awareness workshop and short-term training program	VSRF, No 67 MRS Compound Vakkil Street, Kovilpatti, Thoothukkudi District, Tamil Nadu	01.02.2021
15	MoU for close cooperation in research and academic activities	National Institute of Technology, Hamirpur (H.P.)	01.03.2021
16	MoU for close cooperation in research and academic activities	National Institute of Technology, Jalandhar (Punjab)	01.03.2021
Biotechnology			
17	Non-Disclosure Agreement for production of red pigment from cell and tissue culture of Arnebia euchroma for commercial application	Volt Research LLC, 1201Jacobson Ave, Ashland Ohio 44805	30.06.2020
18	MoU for Installation of Anaerobic Digester (capacity 250 kg/day) (under DST-WMT scheme) at the designated site 8th Mile, Gyalshing, West Sikkim.	Gyalshing Municipal Council, P.O. Gyalshing Bazar, West Sikkim	26.09.2020
19	MoU for Installation of Anaerobic Digester at Baijnath, Dist. Kangra H.P.	Nagar Panchayat Baijnath, Paprola, 4th Floor, Mini Secretariat, Ward No. 01, Baijnath (H.P.)	26.09.2020
20	MoU for collaboration to focus on the study of high altitude adaption using multi-omics approach and genetic biodiversity of high altitude community in the Himalaya	OMICS lab at Kent State University (OKSU), Ohio, USA	30.09.2020
21	Development of pro-biotics for plant tissue culture: Boosting the performance of micropropagated plant by supplementing plant associated useful endophytes	National Medicinal Plants Board, Ministry of AYUSH, Government of India, Indian Red Cross Society (IRCS), Annexe Building, 1st & 2nd floor,1 Red Cross Road, New Delhi	03.02.2021
Chemical Technology			
22	MoU for academic interaction for advancement of research in specified fields	Delhi Pharmaceutical Science and Research University (DPSRU), Mehrauli-Badarpur Road, Pushp Vihar, Sector 3, New Delhi	17.07.2020
23	MoU to undertake joint collaboration in the area of essential oils	M/s TojoVikas International Pvt. Ltd., 4 Adchini, Mehrauli Road, New Delhi	19.10.2020
24	MoU to take joint collaboration in the area of essential oils	M/s Jaishree Enterprises, Block No. D, Plot No. 18 Sector 4B, Adipur Gujarat	02.02.2021

Food Technology			
25	Agreement for Need based R&D project for co-development of herbal tea variants	M/s Komal Innovation and Wellness Initiatives (KIWI), Shed No. 4, Phase II, Industrial Area, Nagrota Bhagwan (H.P.)	30.12.2020
26	MoU for co-development of: i) different herbal beverage and premix (carbonated drink with a combination of medicinal herbs); ii) different variants of Herbal Beverage (with specific herbs effective on specific diseased condition and supplements for specific body type as mentioned in Ayurveda) and; iii) different variants of dry chutneys (with traditional Himalayan herbs)	M/s Komal Innovation and Wellness Initiatives (KIWI), Shed No. 4, Phase II, Industrial Area, Nagrota Bagwan– (H.P.)	01.03.2021
27	Co-development of the products related to metabolism enhancement	M/s Vigada Care Pvt. Ltd., Ground Floor, K-19A, Kalka Ji, New Delhi, South East Delhi	08.03.2021

AGREEMENTS WITH INCUBATEES / START-UPS

Agrotechnology			
1	Availing incubation facility under CM Startup scheme, H.P. for Geo-spatial solutions for resource mapping, assessment and monitoring - From Space to ground.	Mr. Sunil Kumar, Village Upli Majhetly P.O. Pathiar, Tehsil Nagrota Bagwan, District Kangra (H.P)	03.07.2020
2	Availing incubation facility under CM Startup scheme, H.P. of LIDAR system for remote sensing (UAV payload) facility	M/s Iotech World Avigation Pvt. Ltd.Plot # 1643, Sector-52, Gurgaon, 122001, Haryana	10.11.2020
3	Availing incubation facility under CM Startup scheme, H.P. for nursery raising of aromatic plants and processing of essential oil and perfumes	Ms. Reena Thakur, V.P.O Averi, Tehsil Baijnath, District Kangra (H.P.)	18.03.2021
Biotechnology			
4	Availing incubation facility under CM Startup scheme, H.P. to provide machine / device for waste to energy (biodegradable)	Mr. Rahul Sharma Village Chakrog P.O. Drubbal, Tehsil Joginder Nagar Distt. Mandi (H.P.)	09.06.2020
5	Availing incubation facility under CM Startup scheme, H.P. to produce cardamom and strawberry under hydroponics	Mr. Kanishak Kaushal House No. 11, Ward No. 2, V.P.O. Nagrota Bagwan, Teh. Nagrota Bagwan, Dist. Kangra (H.P.)	07.07.2020
6	Availing incubation facility under CM Startup scheme, H.P. for optimization of *In vitro cultivation process for orchid (Cymbidum aloifolium) and Aloe Vera (Aloe barbendensis) plantlets*	Mr. Roushan Kumar C/o Vinod Patial, Near Depot, above Monal Hostel, Village Bharmat, Palampur (H.P.)	09.07.2020
7	Availing incubation facility under CM Startup scheme, H.P. to make Organic Dustbins.	Mr. Jagdeep Singh, V.P.O Averi 78 Mile, Tehsil Baijnath, Distric Kangra (H.P.)	11.08.2020
8	Availing incubation facility under CM Startup scheme, H.P. for making/ producing Biofertilizer product	M/s Golden Rise, V.P.O. Patti, Tehsil Palampur District Kangra (H.P.)	17.02.2021
9	Availing incubation facility under CM Startup scheme, H.P. for cultivation of high value flower crops using hydroponic system	Mr. Sanjeev Thakur, Village Bisht Behar, P.O. Kais, Tehsil & District Kullu (H.P.)– 175 101	08.03.2021

Chemical Technology			
10	Availing incubation facility under CM Startup scheme, H.P. to make cedar hydrosol and its value added products	Mr. Bharat Mohan S/o Sh. Surender Mohan, 50 C, Post Office Baggi, Tehsil Sadar, Mandi (H.P.)	11.06.2020
11	Availing incubation facility under CM Startup scheme, H.P. for Aromatherapy candles and its testing	Mr. Rajan Minhas S/o Punjab Singh Minhas, 232, Near Dhauladhar Colony, V.P.O Maranda, Tehsil Palampur, District Kangra (H.P.)	15.06.2020
12	Availing incubation facility under CM Startup scheme, H.P. to make natural perfumes and air fresheners under CM Start-up scheme	Mr. Kushal Kumar S/o Satpal Soni, Ward No. 11, Rania, Tehsil Rania, District Sirsa, Haryana	03.09.2020
13	Availing incubation facility under CM Startup scheme, H.P. to make products from pine needles	Mr. Rajneesh Kanwar, Village Baroha, Post office Dugga, Tehsil and District Hamirpur (H.P.)	07.09.2020
14	Availing incubation facility under CM Startup scheme, H.P. to make products from natural clay, cow dung and aromatic plants under CM startup scheme	Mr. Anup Sood, M/s AB Scientific Solutions, Green Valley, Lohna, Palampur (H.P.)	10.09.2020
15	Incubation facility under CM Startup scheme of H.P for incubation for making herbal products	Mr. Surender Mohan S/o Late Sh. Sant Ram Gupta V.P.O Baggi, Teshil Sunder Nagar, District Mandi (H.P)	26.09.2020
16	Availing incubation facility under CM Startup scheme, H.P. for value addition in phenyl, Mosquito repellent, and natural aroma based candles.	Mr. Sanjeev Katoch, S/o Late Sh. Kaptan Chand Katoch Village Ram Chowk, Ghuggar (Behind IVRI Colony), PO and Tehsil Palampur, District Kangra (H.P.)	03.03.2021
17	Availing incubation facility under CM Startup scheme, H.P. to biomass utilization for 5- HMF and furfural conversion	Mr. Ajay Kumar, S/o Sh. Sardar Singh, Village & Post Office Trehal, Tehsil Baijnath, Kangra (H.P.) 176 063	09.03.2021
Food Technology			
18	Availing incubation facility under CM Startup scheme, H.P. to make skin products for pets and afterward nutritious products for pets under CM startup scheme	Dr. Ishan Kashyap, S/o Bhagat Raj Sharma, 35/9, Bhagwan Street, P.O. Mandi, Tehsil Sadar, District Mandi (H.P.)	15.09.2020
19	Availing incubation facility under CM Startup scheme, H.P. to make buckwheat based product development such as buckwheat leaves ready to eat curries and buckwheat flour based premixes.	Mr. Amarjeet S/o Late Sh. Bir Singh, V.P.O Keylong, District Lahaul & Spiti (H.P.)	11.12.2020
20	Availing incubation facility under CM Startup scheme, H.P. for enrichment of oyster mushroom with Vitamin D	Mr. Ashveen Khatri, S/o Sh. Oman Singh, CSIR-IHBT Apartments, Post Box No. 6, Palampur (H.P.)	03.03.2021

PRODUCTS DEVELOPED AND LAUNCHED UNDER CM START-UP SCHEME (2019-20 ONWARDS)

Name of the Start-up	Idea/Products Launched	
Mr. Sunil Kumar M/s. Rudra Shakti Herbs Pvt. Ltd. Village Bhadrin, P.O. Galore, Distt. Hamirpur H.P .	Aloe Vera Health & Fruit Juices	
Mrs. Sudershana Kumari M/s. HIMPINE Handicraft V.P.O Rait, Tehsil Shahpur, Distt. Kangra, H.P	Himpine-Naturaly Dyed Pine Needle Handicrafts	
Mr. Sahil Dutta M/s. Backyard Garden Pvt. Ltd Plot No.5, Waknaghat Industrial Area, Dist. Solan H.P.	Praanic' 100% Natural Fruit Juices	
Mrs. Swati Singhal M/S. Innovixa Health Products Pvt Ltd. Noida	Ojas – Drinks Of Himalyan Herbs	

Name of the Start-up	Idea/Products Launched	
Mr. Satish Kumar M/s. Himachal Honey V.P.O .Ghurkari, Kangra (H.P.)	Himachal Honey	
Mrs. Mona Singh M/s.Yuktiva Herbal Cookies, Bharmat, Palampur	Herbal Cookies	
Mr. Rakesh Kumar M/S K.P. Organics V.P.O. Kand Gwal Tikker Palampur	Herbal & Flavoured Green Tea	
Mr. Paritosh Bharadwaj M/s. Vidyani Herbs, Chauntra, Jogindernagar, Mandi	Herbal Green And Black Tea With Added AYUSH Recommended Ingredients	
Mrs. Reena Chandel M/S. Umang Natural Sweets Village – Gagal, Tehsil –Nadaun, Distt. Hamirpur	Papaya Based Sweets	

MISSION MODE PROJECTS

CSIR– AROMA MISSION (PHASE-II)

Nodal: Dr. Sanatsujat Singh

Co-Nodal: Dr. Rakesh Kumar

Principal Investigators: Dr. Ram Kumar Sharma, Dr. Probir Kumar Pal, Dr. Sushil Kumar Maurya, Er. Mohit Sharma, Dr. Ashok Kumar, Dr. SGE Reddy, Dr. Upendra Sharma, Dr. Dinesh Kumar, Dr. Satbeer Singh, Dr. Ramesh, Er. Amit Kumari, Dr. Robin Joshi, Dr. Kiran Singh Saini

CSIR-Aroma Mission was launched in 2017 with objectives to bring about 530 ha of area under captive cultivation of aromatic cash crops particularly targeting rain-fed/degraded land across the country; provide technical and infrastructural support for distillation and value-addition to farmers/growers all over the country; enabling effective buy-back mechanisms to assure remunerative prices to the farmers/ growers, and value-addition to essential oils and aroma ingredients for their integration in global trade and economy. CSIR-IHBT contributed by catalysing rural economy through cultivation of aromatic crops and made Himachal Pradesh the top state in the country in the production of wild marigold oil. 6.49 tonnes of high grade tagetes oil was produced during 2019-20 leading to revenue generation of Rs. 5.19 crores and benefitting 861 farmers. CSIR-IHBT endeavours led to area extension of aromatic crops over 538 ha in eleven states and two union territories. Forty-three field distillation units for extraction of essential oils were also set up in the farmers' fields leading to empowerment of farmers. Capacity building of 3110 farmers, unemployed youth, entrepreneurs was done through 137 training programs. During the program, five new varieties of aromatic crops of wild marigold, damask rose, Indian valerian, sea wormwood and white dragonhead were developed while thirteen agrotechnologies for cultivation of aromatic crops were also standardized.

The second phase of the CSIR-Aroma Mission was launched in January 2021 with following objectives:

- Bring about 30,000 ha of additional area under captive cultivation of aromatic cash crops particularly targeting rain-fed /degraded land across the country in the next three years
- Provide technical and infrastructural support for distillation and ~~values~~-addition to farmers/ growers and enterprenuers all over the country
- Exploring international markets for brand 'CSIR Aroma' – essential oils produced under the mission and enabling effective buy-back mechanisms to assure remunerative prices to the farmers/growers
- Value-addition of essential oils and aroma ingredients for their integration in global trade and economy

CSIR-IHBT is participating in following verticals under the Aroma Mission:

- Popularization of cultivation and processing of aroma crops suitable for underutilized lands and providing higher income to the farmers (CSIR-IHBT target is to cover 3000 ha area under aromatic crops during the mission program)
- Development of resource use efficient high-yielding varieties especially for degraded lands or stressed soils (nine varieties of aromatic crops)
- Development of need based (problem solving) region-specific agro and processing technologies and their deployment (13 agrotechnologies and 22 distillation units)
- Value-addition of aromatic crops/ essential oils (four technologies)
- Assessing safety/toxicity of essential oils
- Skill development activities (55 training/ awareness programs)

During the reporting period, the area under cultivation of aromatic crops was further extended by 587 ha in eleven states and two union territories. Of this, wild marigold (*Tagetes minuta*) covered ~270 ha area in Himachal Pradesh, Jammu & Kashmir and Uttarakhand. An area of about 19 ha was covered under damask rose in H.P., Punjab and Uttarakhand. Lemongrass was rejuvenated in 60 ha area in the warmer regions of H.P. and Punjab. In addition, aromatic crops like chamomile, Indian valerian and palmarosa (30 ha each) were cultivated by farmers in different parts of HP, Uttarakhand, Uttar Pradesh and Odisha.

To encourage and empower the farmers for growing aromatic crops, 8 distillation units for the extraction of essential oils were deployed in the farmers' fields by the Institute. This is in addition to the forty-three distillation units deployed during the first phase of the program. Owing to the mission and sustained efforts, Himachal Pradesh is now the top producer of wild marigold oil in the country. The annual production of 6.5 tonnes of *Tagetes* oil led to a revenue generation of Rs. 5.19 Cr. per annum.

Additionally, planting materials of targeted aromatic crops are being generated and supplied. The details of the same are presented in Table 1.

Table 1. Generation of quality planting material

S. No.	Crop	Planting material generated & supplied
1.	Wild marigold	1000 kg seeds
2.	Damask rose	1 lakh rooted plants
3.	Lemongrass	10 lakhs slips
4.	Spear and pepper mints	5 quintal stolons
5.	Mint	30 quintal stolons
6.	Rosemary	1.0 lakh rooted plants
7.	Ocimum	100 kg seeds
8.	Palmarosa	100 kg seeds
9.	Geranium	2.5 lakhs
10.	Indian valerian	5 lakh rooted plants
11.	Salvia	5 kg seeds
12.	Chamomile	100 kg seeds
13.	Lavender	2 lakh rooted plants
14.	Artemisia	40 kg seeds
15.	White dragonhead	3 kg seeds

New varieties/cultivars developed (2 nos.)

Two new varieties/cultivars namely CSIR-IHBT-TM-03 (*Tagetes minuta*) and CSIR-IHBT-VJ-08 (*Valeriana jatamansi*) have been developed under the breeding program of the mission.

CSIR-IHBT-TM-03 (*Tagetes minuta*)

Under the ongoing breeding program on the improvement of aromatic plants, a selection of wild marigold (TM-03) has been developed through the progeny selection approach. Both, the herb yield and essential oil content were significantly higher in the new variety than the check variety Him Gold (Table 2). The selection is rich in Z-B ocimene which is the major component imparting high quality to the wild marigold essential oil.

Table 2. Salient features of CSIR-IHBT-TM-03

Salient features	CSIR-IHBT-TM-03	Him Gold
Herb yield (g/plant)	436.9*	372.6
Oil content (%) (Clevenger)	0.375*	0.337
Estimated oil yield/ha	81.9	62.78
Ocimene (%)	49.86*	43.7
Dihydro-tagetone (%)	8.41	5.7

Molecular characterization of TM-03 along with eight other selections and check variety Him Gold was done using SSR markers. Based on cluster analysis of 30 polymorphic loci, TM-03 captured significant diversity and clustered away from the check variety Him Gold. Pair-wise genetic similarity of TM-03 varied from a minimum of 33% (Him Gold) to a maximum of 76% (TM-04). TM-03 captured a high level of genetic diversity and has potential use as a parental line in future improvement programs of wild marigold. Multi-location trials of TM-03 were undertaken at four different locations and the line performed consistently over all the locations with significantly higher essential oil content as compared to check variety Him Gold. TM-03 has also been registered by ICAR-PGRC with registration code INGR 20104 (Fig. 1). Variety 'CSIR-IHBT-TM-03' has an essential oil content of 0.37% and biomass yield of 21.8 tonnes/ha and was developed through half-sib progeny selection approach. It is two meters in height with multiple branches which are erect and upright. It has large leaves, green in colour with multiple clusters of flower heads. The variety recorded 11.27% improvement in essential oil yield over check variety 'Himgold'.

Certificate
Plant Germplasm Registration

It is certified that germplasm CSIR-IHBT-TM-03 of Marigold (INGR20104) developed by

Ashok Kumar, Sanatsujat Singh, Ram Kumar Sharma and Dinesh Kumar
CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh

has been registered by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research on December 21, 2020.

Member-Secretary
PGRC

Chairman, PGRC
DDG (CS) ICAR

Fig. 1 Field view of CSIR-IHBT-TM-03 and its registration certificate

CSIR-IHBT-VJ-08 (*Valeriana jatamansi*)

The variety was selected from breeding lines developed through progeny selection. Both the herb yield and essential oil content were significantly higher than the check variety Himbala (Table 3). The selection is rich in Patchouli alcohol which is the major component imparting high quality to the Indian valerian essential oil.

Table 3. Salient features of CSIR-IHBT-VJ-08

Salient features	CSIR-IHBT-VJ-08	Himbala
hizome yield (g/plant)	45.81*	41.84
Oil content (%) (Clevenger)	0.331*	0.297
Estimated oil yield/ha	12.74	10.46
Patchouli alcohol (%)	62.38*	33.35

*significant at p = 0.05

Molecular characterization of VJ-08 along with eight other selections and check variety Himbala was done using RAPD markers. Based on cluster analysis of 99 polymorphic loci, VJ-08 captured significant diversity and grouped in a different cluster from check variety Himbala. Pair-wise genetic similarity of VJ-08 varied from a minimum of 37% (VJ-01) to a maximum of 55% (VJ-03). Therefore, VJ-08 captures a high level of genetic diversity and has potential use as a parental line in future improvement programs of Indian valerian.

Multi-location trials of VJ-08 were undertaken at four different locations and the line performed consistently over all the locations with significantly higher essential oil content as compared to check variety Himbala. VJ-08 has also been registered by ICAR-PGRC with registration code INGR 20057 (Fig. 2). It is 40 cm in height with large leaves, green in colour with multiple clusters of flower heads. The variety has an essential oil content of 0.33% in comparison to essential oil content of 0.29% in the control variety 'Himbala'. The variety recorded 11.25% improvement in essential oil yield over check variety 'Himbala'. CSIR-IHBT-VJ-08 has a root biomass yield of 3.84 tonnes/ha.

Certificate
Plant Germplasm Registration

It is certified that germplasm CSIR-IHBT-VJ-08 of Tagar (Indian_Valeriana) (INGR20057) developed by

Ashok Kumar, Sanatsujat Singh, Ram Kumar Sharma and Dinesh Kumar
CSIR-Institute of Himalayan Bioresource Technology, Palampur, Himachal Pradesh

has been registered by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research on September 29, 2020.

Member-Secretary
PGRC

Chairman, PGRC
DDG (CS) ICAR

Fig. 2 Plants of CSIR-IHBT-VJ-08 variety and its registration

Further, multi-location trials of clary sage, chamomile, lavender, rosemary, geranium, palmarosa and ocimum have been laid out and are in progress at different locations. The best performing selections in different aromatic plants will be released as varieties.

Training and awareness programmes for skill development

Fourteen awareness cum training programmes on cultivation and processing technologies of aromatic crops were conducted from October 2020 to March 2021 and more than 536 rural farmers were trained (Table 4). Practical exposure on field preparation for nursery beds, plantation of crops, harvesting of crops at proper stage to obtain higher essential oil content, essential oil extraction in clevenger apparatus, mini distillation unit and the pilot plant was imparted. The training programme targeted aromatic crops namely damask rose, wild marigold, chamomile, lavender, scented geranium, lemongrass, and rosemary.

Table 4. Details of training programs organized in Himachal Pradesh

S. No.	District	Program Location	Program Date	Total Participants	Women Participants
1	Chamba	Village Parwai, Chowari block	10/28/2020	30	15
2	Chamba	Village Talla, Shiunta	11/7/2020	50	1
3	Kangra	Palampur	12/10/2020	7	0
4	Mandi	Dharampur and ladhbhadol, Mandi	12/22/2020	15	0
5	Chamba	Sihunta	1/15/2021	20	0
6	Mandi	Kotli	1/28/2021	20	0
7	Kangra	Palampur	1/19/2021	20	0
8	Chamba	Tallah, Sihunta	8/2/2021	17	5
9	Kangra	Palampur	2/22/2021	5	0
10	Chamba	Block Samiti Hall, Chamba,	2/23/2021	90	4
11	Kangra	Palampur	1/3/2021	126	18
12	Kangra	Palampur	3/9/2021	16	4
13	Bilaspur	Namhol	23/03/2021	30	0
14	Shimla	Rohru, Gumna, Chirgaon	24/03/2021	39	4
				485	**51**

Fig. 3 An awareness cum training program on aromatic plants cultivation to the farmers of Distt Reasi, J&K at CSIR-IHBT, Palampur

Fig. 5 Awareness cum training program on cultivation of aromatic crops at CSIR-IHBT, Palampur

Fig. 4 An awareness cum training program on aromatic plants cultivation at Namhol, Bilaspur, HP

Fig. 6 Distribution of quality planting material of wild marigold to farmers of Distt Mandi, H.P.

Fig. 7 Distribution of quality planting material of lemongrass to farmers of Tehsil Dehra, Distt Kangra, H.P.

Fig. 8 Awareness cum training program on cultivation of aromatic plants at Talla, Sihunta, Chamba, H.P.

Fig. 9 An awareness cum training program on aromatic plants cultivation at village Gumna, Tehsil Chirgaon, Distt Shimla, H.P.

Fig. 10 Director General CSIR & Director, CSIR-IHBT interacting with farmers at Talla, Chamba, H.P.

Fig. 11 Training program on extraction of wild marigold essential oil at aspirational district Chamba, H.P.

Fig. 12 Dr. Sanjay Kumar, Director, CSIR-IHBT, Palampur monitoring the cultivated aromatic crops at Bharmour & Chawari, Chamba, H.P., India

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 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.

Under the mission, four wild ornamental species i.e., *Paphiopedilum fairrieanum* (Lindl.) Stein, *Paphiopedilum insigne* (Wall. ex Lindl.) Pfitzer, *Incarvillea emodi* (Wallich ex Royle) Chatterjee and *Jasminum parkeri* Dunn were domesticated and multiplied. Further, a total of ~16 ha of land was brought under floriculture crops in Himachal Pradesh, Uttarakhand, Punjab, and Jammu & Kashmir. Of this, 2.50 ha is under Gladiolus, 9.50 under Marigold, and 3.00 ha under Tuberose. In addition, Lilium was introduced in seven villages of Ladakh UT (Villages Kargil, Sankoo, and Kurbathang in Kargil and four villages i.e., Ranbirpur, Stakna, Sankar, and Tukcha of Leh).

Generation of quality planting material

Bringing a large area under floriculture requires propagules, hence the Institute generated planting material for the same (Table 1).

Table 1. Planting material generated

Crops	Planting material generated
Gladiolus	3.50 lakh corms
Marigold	6.65 lakh seedlings
Tuberose	2.50 lakh bulbs
Lilium	45,000 bulbs
Chrysanthemum	20,000 cuttings
Alstroemeria	25,000 plants
Carnation	23,000 cuttings
Calla lily	50,000 plants
Bird of Paradise	3,500 plants
Rose (Loose)	10,000 cuttings
Rose (Cut)	25,000 cuttings

Training and awareness programmes for skill development

Four awareness cum training programmes on cultivation and value addition technologies of floricultural crops were conducted from February 2021 to March 2021 and more than 148 unemployed youth, rural women and farmers were trained (Table 2).

Table 2. Training programs conducted under the CSIR-Floriculture Mission

Program	Duration	Location	District	State	No. of participants
Training program on Crop Diversification in HP through cultivation of aromatic and floriculture crops	March 1 2021	CSIR-IHBT	Kangra	H.P.	43
Workshop on Suitable Agro-technologies in Chamba, HP	February 23 2021	The DC cum Chief Executive Officer, Distt. Rural Development Agency	Chamba	H.P.	75
Training program on Commercial Floriculture	March 9 2021	Department of Horticulture	Chamba	H.P.	30

Integration of Apiculture in Floriculture with the following objectives:

- Establishment of apiculture clusters targeting existing fruit orchards and new nectar-yielding floral crop fields.
- Development and deployment of technologies to improve quality and yield of honey.
- Collaboration with Khadi and Village Industries Commission (KVIC) and TRIFED.
- Marketing of honey and other related products.
- Awareness and training programme/skill development.

Under this vertical, floricultural crops viz., marigold, jasmine, roses, tuberose and existing orchards like litchi, citrus, kinoo, apple, guava etc., will be covered. About 500 bee hive boxes and bee colonies to be distributed to the farmers under cluster mode covering 600 ha.

Fig. 1 Distribution of Alstroemeria plants and Marigold seeds to the farmers of Kangra and Hamirpur, H.P. by the Hon'ble Minister of State for Finance and Corporate Affairs, Shri Anurag Thakur

Fig. 2 Release of technical brochure on Agrotechnology of Tulips by the Honb'ble minister

Fig. 3 Distribution of Gladiolus, Tuberose and Marigold planting material to the farmers of Roorkee, Uttarakhand

Fig. 4 Shri Anurag Thakur Ji visiting the floriculture stall

Fig. 5 Distribution of Gladiolus, Tuberose planting material to the farmers of Bilaspur, H.P.

Fig. 6 Distribution of Gladiolus, Tuberose planting material to the farmers of Dharamshala, H.P.

Fig. 7 Distribution of Rose planting material to the farmers of Dalhousie, Chamba, H.P.

Fig. 8 Distribution of Gladiolus, Tuberose, Marigold planting material to the farmers of Hamirpur, H.P.

Fig. 9 Distribution of Alstroemeria planting material to the farmers of Nagri, Dharamshala, H.P.

Fig. 10 Planting of Lilium crop in three villages i.e. Kargil, Sankoo, and Kurbathang of Kargil district and four villages i.e. Ranbirpur, Stakna, Sankar, and Tukcha of Leh district, Ladakh

Fig. 11 Distribution of Lilium planting material to the farmers of Khinning and Dalang, Lahaul, H.P.

Fig. 12 Planting of Tulip crop at Udaipur, Lahaul, H.P.

Fig. 13 Planting of Marigold, Gladiolus crop at farmers field in Panchrukhi, H.P.

Fig. 14 Planting of Tuberose and Gladiolus crop at farmers field in Roorkee, Uttarakhand

Fig. 15 Marigold plantation at farmers field at Chamunda, H.P.

Fig. 16 Awareness cum training program on commercial floriculture at village Sundla, Chamba, H.P.

Fig. 17 Farmers field survey for carnation plantation in Salooni, District Chamba, H.P.

Fig. 18 Marigold plantation at farmers field (Roorkee, Uttarakhand)

Fig. 19 Popularization and awareness creation on of floriculture crops, Baijnath, H.P.

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, under it's Mission on Nutraceuticals and Nutritionals (2018-2020), took a significant leap towards human health and wellbeing, and developed several health promoting products based on locally available bioresource. In this regard, significant achievements from CSIR-IHBT include the development of nutraceutical formulations for bone & cartilage health, cognition, immunity and sleep disorders. The technologies for some of the commercializable nutraceuticals have already been transferred to industries and products are in market while others are being taken forward. Recognizing the societal responsibility of CSIR, region specific and pan Indian Nutritious Breakfast/Tiffin/Snacks like products for school children that meet the Recommended Dietary Allowance (RDA) requirement of nutrients through food based approach are also being developed.

The unprecedented occurrence of the COVID19 pandemic highlighted a need for a fresh look into the concept of wellness and healthy living. There is an urgent requirement for the value addition of our naturally available resources from a scientific perspective and global positioning of our dietary supplements/nutraceuticals based on the traditional knowledge systems for the overall wellness of society.

Considering these, a new CSIR Mission entitled "Immunomodulatory Function of Nutritionals and Nutraceuticals for Health and Wellness" has been launched this year. Also, prioritized leads obtained during the first phase of the mission are being taken forward for clinical trials under Human Intervention Studies.

The objectives of the mission are:

- Explore, identify and develop nutraceuticals and nutritionals that boost immunity to fight microbial and viral infections.
- Development of region specific and pan Indian nutritious first meal of the day for children that meets the RDA requirement of basic nutrients.

Besides various dietary components, the mission will integrate traditionally known spices, a basic ingredient of food in every Indian household, for their immunity boosting properties. Evidence-based polyherbal formulations based on medicinal plants, especially in improving immunity will be developed under the mission.

Several immunomodulatory herbs and their combinations, including tea polyphenols are being explored to combat immune dysfunction. A comprehensive monograph with digital documentation and development of web portal on locally consumed fruits and vegetables, their phytoconstituents and immunity boosting properties is also envisaged under the mission. Furthermore, plant specific screening by computational approaches for immune boosting phytochemicals, including their interaction and pharmacological profile are also being targeted.

In this mission, ten CSIR labs across India are coming together in a network mode for the accomplishment of the above mentioned objectives.

The overall deliverable envisioned under this mission from different projects of CSIR-IHBT 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

AGRI NUTRI BIOTECH THEME

AGRI NUTRI BIOTECH THEME

Principal Investigators: Dr. R.K. Sud, Dr. Aparna Maitra Pati, Dr. Vipin Hallan, Dr. Ram Kumar Sharma, Dr. Amit Kumar, Dr. Sanatsujat Singh, Dr. Ravi Shankar, Dr. Probir Kumar Pal, Dr. Amit Chawla, Dr. SGE Reddy, Dr. Upendra Sharma, Dr. Pamita Bhandari, Dr. Ashok Singh, Dr. Kunal Singh, Dr. Shiv Shanker Pandey and Dr. Vidyashankar Srivatsan

With a mission to boost farmers' income, the Theme Agri Nutri Biotech caters to develop agrotechnologies of commercially important crops and value added products of industrial and societal relevance. Twenty CSIR labs are participating in the theme activities that cater to five sustainable development goals, i. e., No poverty, Zero hunger, Good health and well- being; Affordable and clean energy and Life on l a n d. CSIR-IHBT is participating in 3 Fast Track Translational (FTT), 1 Fast Track Commercialization (FTC) project, 3 Niche Creating Projects (NCP) and 11 Fundamental Basic Research (FBR) projects.

Approved FTT projects:

- Development of processes for edible and industrial dyes from plant sources for enhanced income
- Development of botanical formulation using Artemisia maritima extract for the control of aphids in cabbage/cowpea (DBAM)
- Development of microalgae based protein and micronutrient rich animal feed

Approved FTC projects

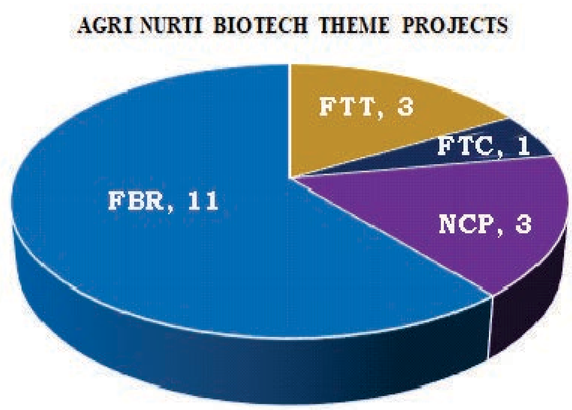
- Up-scaled production of disease free corms of saffron (*Crocus sativus*)

Approved NCP projects:

- Genetic improvement of high value medicinal plants
- Functional characterization of the host (plant) and vector (whitefly) proteins in systemic immunity and transmission of virus and virus-like pathogens
- High resolution NextGen remote sensing for medicinal, aromatic and commercially important crops

Approved FBR Projects

- iPRESS: Integrated Plant REgulomics Software & Server
- Exploration of Himalayan Plants for Novel Antimalarial Agents: Characterization of potential molecules (Phase II)
- AI based methodology for grading machine harvested tea leaves
- Genome-editing for crop improvement (GE-Crop)
- Deciphering the mechanism(s) of host-endophytes' coevaluation, enhanced secondary metabolite production and crop productivity
- Conservation of Threatened Plant Species of India
- Bio-stimulants for stress amelioration, enhanced plant productivity and soil health
- Next generation genomics for genetic improvement of *Stevia rebaudiana* Bert
- Development of bare-root seedling simulations system and automatic seedling transplanted for stevia.
- Introduction, characterization and cultivation of *Ferula assa-foetida* (*Heeng*) in cold desert regions of Indian Himalayas
- Biostimulants Network Project titled "Bio-stimulants for stress amelioration, enhanced plant productivity and soil health.



Outcomes expected from the above projects:

- Commercial cultivation of *Heeng* leading to income enhancement of farmers. Import substitution. Alternative system for production of oleo gum resin (*Heeng*).

- Image Products (Geo-tagged Aerial images, 3-D image, DEM) and other products to track the crop growth and health (Contours, Spectral libraries, Vegetation indices, Software tools & models, Comparative application potentials of various sensors, *etc.*).
- Basic information integratively revealing how post-transcriptional and transcriptional components interact to guide the regulatory pathways of the plant
- Efficacious anti-malarial molecules from Himalayan sources
- Study report on machine harvested tea leaf, its composition, characteristics and features useful for segregation. AI model for automatic segregation of premium quality tea leaves from machine plucked leaf. Technology for automatic tea-leaf segregation/ grading
- Development of resources and protocols for genome-editing of *C. sinensis* to develop superior tea varieties having enhanced yield, and improved nutritional quality with lesser regulatory concerns. In a long term the developed genome-edited varieties of tea have the potential to greatly increase the incomes of tea-growers.
- Potential endophytes improving acclimatization, growth promotion, secondary metabolite production from high-altitude medicinal plants at low-altitude. The products will strengthen India's positioning in the global market for natural/herbal medicine production.
- The conservation status of 100 threatened plants species from different bio-geographic regions of India will be available. Genetically diverse populations in case of Critically Endangered (CR) plants will be identified for in-situ conservation based on SSR markers. DNA barcoding of 200 threatened plant species will be available. Ecological Niche modelling will provide the accurate threat perception operating on the plant species and also identification of species-specific habitats. Meta-population modelling will provide the data on the current state of the species population in a given landscape by Population Viability Analysis (PVA)
- Protocols for mass multiplication of threatened plants species and its introduction in its natural habitats with the help of forest departments. Development of threatened plants conservatory and gene bank
- Rhizospheric microbiome information from native plant species of high altitude Indian semi cold desert of western Himalaya. High quality draft genome of few native microbial species from rhizosphere of Indian semi cold desert.
- Disease free planting material (corms) of saffron; cost reduction in tissue culture production protocol. Bioformulation of selected PGPMs. Enhancement of socio-economic status marginal farmers through supply of planting material of saffron)
- Extraction processes of specific colours/dyes i.e food, textiles etc. Stable herbal colorants for the food and textile industries. Safe and non-toxic herbal colours for the consumers.
- Genome-wide genomic resources (Key gene and pathways involved SGs accumulations and development phase transitions). High-throughput genotypic panel. Phenotypic and chemical variations. Plant genetic resources of superior cultivars, potential parental groups and trait specific mapping populations. Identifications of makers associated with SG accumulations and other desirables traits in stevia.
- Whitefly genes responsible for transmission of viroids and manipulation of Systemic acquired resistance pathways by plant viruses.
- Development of varieties with high yield and active metabolite content, commercial cultivation and value added products from *Picrorhiza kurrooa* and *Inula racemosa*.
- Botanical formulation for insect control.
- Development of microalgae based animal feed composites for poultry applications. Microalgae based protein concentrates for feed applications. Low cost cultivation strategy for mass multiplication of microalgae.

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

Heeng is another popular condiment used in most Indian cuisine, with a high demand of about 40% of the world's production. Ironically, *Heeng*, that grows naturally in countries like Afghanistan, Iran and Uzbekistan, is not cultivated in the country. India imports 1540 tonnes of raw asafoetida annually from Afghanistan, Iran and Uzbekistan and spends ₹ 942 crores per year on import of asafoetida (Personal communication with Directorate of Arecanut and Spices Development, 2020) for its domestic need. Therefore, CSIR-IHBT took the initiative of introducing *Heeng* in the country, and imported its 66 accessions through National Bureau of Plant Genetic Resources, New Delhi. The institute has standardized its production protocols under conditions of potential growing areas within the country.

The institute's efforts in promoting cultivation of Saffron and *Heeng* 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, Sh. Jai Ram Thakur, in his budget speech, on March 6, 2020, highlighted the efforts of CSIR-IHBT on introduction and cultivation of saffron and *Heeng* in the state. Consequently, two megaprojects have been funded in the form of "Technical and hand holding support by CSIR-IHBT Palampur for saffron Production" and "Production of *Heeng* in Himachal Pradesh - A new approach". 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.

***Heeng* plant**

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

Bamboo is the world's fastest growing plant which grows three times faster than most other species. India is the 2nd largest grower of bamboo in the world with about 45% of world's bamboo forests. As per the records of the National Mission for Bamboo Applications (NMBA), the growing bamboo stock in India is 169.32 million metric tonnes (MMT) spread in 13.96 million ha.; its collection is only 13.47 MMT (10.38% stock). The current estimated demand in India for bamboo is 26.69 MMT. It is one of the most important non-timber forest resources due to the high socio-economic benefits from bamboo-based products. The global bamboo's market size is projected to reach USD 98.3 billion by 2025 and is expected to grow at a cumulative average growth rate of 5.0% over the forecast period, according to a new report by Grand View Research, Inc.

CSIR-IHBT has expertise in mass propagation of different commercially important bamboos through tissue culture and nursery practices (seeds and nodal segments). The mass propagated plants of *Bambusa balcooa*, *B. bambos*, *B. multiplex*, *B. nutans*, *Dendrocalamus asper*, *D. giganteus*, *D. hamiltonii* and *Phyllostachys pubescens* have been catering to different government and private agencies throughout the country. In continuation of institute's efforts in promoting cultivation of bamboo to enhance the livelihood of farming communities have been widely acclaimed at the state level and we got support from National Bamboo Mission funding in the form of "Establishment of small and Hi-Tech nurseries of bamboos at CSIR-IHBT, Palampur under restructured National Bamboo Mission" for one year. In this project we have developed a small nursery and a Hi-Tech Nursery along with developed 2.0 ha land for bamboo cultivation. These nurseries are certified by Ministry of Agriculture and Farmers welfare, as "accredited nurseries" for National Bamboo Mission. In addition to this we will take this project forward in a self-sustainable manner till 2025 entitled as "Running and maintenance of the Institutes' bamboo nurseries for generation and supplying quality planting material".

Hi-Tech Poly house (215m^2)

Potting shed facility (140m^2)

Developed 2.0 ha nursery

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.) and *Heeng* (*Ferula assa-foetida* L.) are the two important spices commonly used in Indian cuisines. Of the 300 tonnes of saffron produced world over annually, the country has an annual domestic demand of 100 tonnes, but produce less than 6 tonnes per year, grown mainly in parts of Jammu and Kashmir. A major constraint in large scale cultivation of saffron is the scarcity of disease-free planting material, or healthy saffron corms. CSIR-IHBT has addressed this limitation and developed a tissue culture protocol for production of disease-free corms.

Technical and hand holding support by CSIR-IHBT Palampur for saffron production

Saffron (*Crocus sativus* L.), an important spice for Indian cuisines grown mainly in parts of Jammu and Kashmir; the country has an annual domestic demand of 100 tonnes but produces less than 6 tonnes per year. 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 the 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, Sh. 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.

After the signing of MoU with the state agriculture department, CSIR-IHBT initiated the project in the month by conducting a three days' capacity-building program for the agricultural officers on production technology of saffron from July 20-22, 2020. After the training of officers, quality planting material (corms) was supplied to the agriculture department for distribution among the farmers of 5 districts *viz*., Mandi, Chamba, Kullu, Kinnaur, and Kangra (Table 1 and Fig. 1 & 2). A total of 1 ha area have been covered to 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 the department of agriculture.

Fig. 1 Saffron (corms) planting material distribution of different districts of H.P.

Table 1. Detail of saffron corms (seed) distribution to Agriculture Department, Govt. of H.P. during 2020 under the saffron project

S. No.	Date	Seed material given to	Weight
1	15/09/2020	Deptt of Agri, Kinnaur	805 kg
2	26/09/2020	Deptt of Agri, Mandi	858 kg
3	26/09/2020	Deptt of Agri, Chamba	897 kg
4	26/09/2020	SMS Bhawarna, Kangra	78 kg
5	07/10/2020	SMS Nirmand, Kullu	580 kg
6	07/10/2020	SMS Panchrukhi, Kangra	60 kg
		Total	**3278 kg**

Fig. 2 Distribution of saffron corms to the state agriculture department

Training of Progressive Farmers on Saffron cultivation

On farm training programmes were also conducted for the progressive farmers of different villages of Chamba, Mandi and Kangra. In these training programmes progressive farmers and officers of Agriculture department participated (Table 2).

Table 2. On farm training programme organized in different District

Sr. No.	Date	Village	Distt.	No. of Farmers
1	17.10.2020	Supa, Bharmour	Chamba	10
2	08.10.2020	Janjheli	Mandi	15
			Total	**25**

Fig. 3 Training on production technology of saffron conducted at CSIR-IHBT

Fig. 4 Practical exposure of agriculture officers to saffron farming

Fig. 5 Interaction of CSIR-IHBT scientists and state agriculture officers with saffron farmers at Supa, Bharmour, district Chamba, H.P.

Fig. 6 Plantation of saffron at farmers field under supervision of agriculture department

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

The apple (*Malus domestica* Borkh.) is an important fruit (Rosaceae family) grown in areas where winter is cold, springs are frost free, summer is mild. Traditionally apple cultivation has been confined to temperate countries. Regions with long day-hours, bright sun-shine, cool nights and low humidity during the growing season associated with chilled winter season are preferred for apple cultivation. In India, it is predominantly grown in Jammu and Kashmir, Himachal Pradesh, and the hills of Uttarakhand.

During 2018, recognizing the success of apple in Mizoram, North East Council, Shillong, Meghalaya, Govt. of India sanctioned one project entitled "Capacity building programmes for NERCORMP Communities on cultivation and post-harvest management of low chilling varieties of apple". In this project, low chilling varieties of apple were introduced in Manipur and Meghalaya during 2019-2020 in association with the North Eastern Region Community Resource Management Project (NERCORMP). About 16 acres of area have been covered in different locations till now.

North East Council funded a project to CSIR-IHBT for bringing 56 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 Project (NERCORMP) communities was initiated during August 2020. Nine low chilling varieties *viz.*, Anna (400-600 h), Dorsett Golden (350 h), Red Fuji (500-600 h), Granny Smith (600 h), Pink Lady (500-600 h), Gale Gala (600 h), Sun Fuji (600 h), Early Fuji (500-600 h), Scarlet Gala (600 h) were supplied to Meghalaya as per the detail given in Table 1. The root stock of these varieties was raised through tissue culture technique and then grafted with the suitable variety. Root stock MM 793, MM111, and M7 have been used for raising the plant. Glimpses of project activities are shown in Fig. 1-3.

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

Sr. No.	Variety Name	Root Stock	Pack No.	No. of Plants/ Bundle	No. of Bundles	Total No. of Plants	Grand Total
1	Red Fuji	MM111	1 to 30	100	**30**	**3000**	4000
2	Red Fuji	M793	31 to 35	200	**5**	**1000**	
3	Granny Smith	MM111	36 to 41	200	**6**	**1200**	**2200**
4	Granny Smith	M793	42 to 46	200	**5**	**1000**	
5	Pink Lady	MM111	47 to 49	100	**3**	**300**	**900**
6	Pink Lady	M793	50 to 52	100	**3**	**300**	
7	Pink Lady	M7	53 to 55	100	**3**	**300**	
8	Gale Gala	M7	56 to 60	200	**5**	**1000**	**1700**
9	Gale Gala	MM111	61 to 67	100	**7**	**700**	
10	Sun Fuji	MM111	68 to 72	200	**5**	**1000**	**1700**
11	Sun Fuji	M793	73 to 75	200	**3**	**600**	
12	Sun Fuji	M793	76	100	**1**	**100**	
13	Early Fuji	MM111	77 to 89	100	**13**	**1300**	**6100**
14	Early Fuji	M7	90 to110	100	**21**	**2100**	
15	Early Fuji	M793	111 to 123	200	**13**	**2600**	
16	Early Fuji	M793	124	100	**1**	**100**	

Sr. No.	Variety Name	Root Stock	Pack No.	No. of Plants/ Bundle	No. of Bundles	Total No. of Plants	Grand Total
17	Scarlet Gala	M793	125	100	**1**	**100**	**1500**
18	Scarlet Gala	M7	126 to132	200	**7**	**1400**	
19	Dorsett Golden	M7	133 to 135	200	**3**	**600**	**3000**
20	Dorsett Golden	MM111	136 to145	100	**10**	**1000**	
21	Dorsett Golden	M793	146 to 159	100	**14**	**1400**	
22	Anna	M793	160 to 163	200	**4**	**800**	**3900**
23	Anna	MM111	164 to 183	100	**20**	**2000**	
24	Anna	M7	184 to 194	100	**11**	**1100**	
Total							25000

Glimpses of Project Activities

Fig. 1 Packaging of planting material

Fig. 2 Packaging and supply of low chilling varieties of apple to North East

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

Fig. 3 Glimpses of apple bearing fruits in low chilling varieties planted at Champhai, Mizoram by CSIR-IHBT Palampur

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

For the dissemination of the technologies developed at laboratory scale and with a vision to create rural livelihood and double the farmer's income a unique initiative was taken by CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT), Palampur in collaboration with Ministry of Micro, Small & Medium Enterprises (MoMSME), New Delhi under Scheme of Fund for Regeneration of Traditional Industries (SFURTI). A meeting was held between Director, CSIR-IHBT, Palampur and Secretary (MoMSME) in the month of June 2019 where it was decided to establish SFURTI clusters using the technologies developed by CSIR-IHBT. Later, after the detailed discussion within the ministry between Joint Secretary (ARI), MoMSME and other officials of the Ministry and, with the Director CSIR-IHBT, it was decided that CSIR-IHBT will be appointed as Technical Agency (TA) and Khadi and Village Industries Commission (KVIC), Mumbai and Foundation of MSME Clusters (FMC), New Delhi as Nodal Agency (NA) for development of clusters under the SFURTI Scheme. Subsequently, CSIR-IHBT has been empanelled as Technical Agency (TA) under SFURTI cluster by both KVIC and FMC. Currently, scientifically validated technologies like "Vitamin D_2 enriched *shiitake* mushroom production and processing", "Efficient bacterial formulations for enriched compost in cold hilly region" and "Technology of dried cut flower and vegetable processing" have been considered by the MoMSME for the sanction of seven SFURTI clusters in the rural areas of Sikkim and Himachal Pradesh (Fig 1).

For the effective dissemination of Vitamin D_2 enriched *Shiitake* mushroom technology, CSIR-IHBT has got approval of three SFURTI clusters with a total project cost of Rs 7.35 crore expecting to impact 750 beneficiaries. In the three sanctioned clusters there is provision of establishment of one mother common facility centre (CFC) and four extension CFCs in each cluster. Each organized *shiitake* cluster will consist of required infrastructure (spawn production, incubation rooms, fruiting rooms, value addition, packaging

भारत सरकार
सूक्ष्म , लघु और मध्यम उद्यम मंत्रालय
Ministry of Micro, Small & Medium Enterprises
(AN ISO 9001:2008 CERTIFIED ORGANISATION)

Scheme of Fund for Regeneration of Traditional Industries(SFURTI)

Sikkim

SN	Name of Cluster	Product Category	Sub Category	Nodal Agency	State / UT	District	No. Of Artisans	Total Project Cost (Rs. in Lakh)	Total GOI Assistance (Rs. in Lakh)	Financial Year	Basic Proposal Detail	Soft Intervention Details	Hard Intervention Details
1	Moonew Tareybhir Enriched Composting / Vermicomposting Cluste	Enrich & Vermicompost	Vermiwash	Foundation for MSME Cluster(FMC)	SIKKIM	WEST DISTRICT	200	205.08	196.89	2019-2020			
2	Norbuchoeling Shitake Mushroom & Other Food Processing Cluster			KVIC	SIKKIM	SOUTH DISTRICT	250	244.90	234.71	2019-2020			
3	Sumbuk Shitake Mushroom & Other Food Processing Cluster			KVIC	SIKKIM	SOUTH DISTRICT	250	244.90	234.71	2019-2020			
4	West Sikkim Shiitake Mushroom & Other Food Processing Cluster			KVIC	SIKKIM	WEST DISTRICT	250	244.90	234.71	2019-2020			
	Himachal Pradesh												
1	Gondla Cut Flower Cluster	Cut flowers	Exotic vegetables	Foundation for MSME Cluster(FMC)	HIMACHAL PRADESH	LAHUL AND SPITI	126	156.45	150.24	2019-2020			
2	Shansha Cut Flower Cluster			Foundation for MSME Cluster(FMC)	HIMACHAL PRADESH	LAHUL AND SPITI	225	174.15	167.24	2019-2020			
3	Triloki Enriched Composting/ Vermicomposting Cluster	Enrich Vermicompost, Vermiwash, Vermi compost	compost	Foundation for MSME Cluster(FMC)	HIMACHAL PRADESH	SIRMAUR	200	205.08	196.89	2019-2020			

Fig 1. List of approved SFURTI clusters based on scientifically validated technologies with technical guidance of CSIR-IHBT (URL: https://sfurti.msme.gov.in/SFURTI/Reports/DPR.aspx)

of *shiitake* and other food processing products) for the production of *shiitake* mushroom and value-added processing of *shiitake* and other regional agro-products. Each cluster is targeted to benefit 250 farmers (total 3X250= 750 farmers) and it is expected that apart from their earning from conventional farming, through cluster each associated beneficiary will be earning Rs 50,000-60,000/- per year. Under the 'SFURTI' programme, three organised clusters are 80 % ready at rural areas of South and West district of Sikkim with a total project cost of Rs 7.35 crore expecting to impact 750 beneficiaries. Due to the pandemic situation the implementation process got delayed, but it is expected to get functional by September 2021.To disseminate the technology on efficient bacterial formulations for enriched compost in cold hilly region, "Enriched Composting/ Vermicomposting Cluster" the project of Rs 4 crore 10 lakhs has been granted 'SFURTI' at Sirmaur, Himachal Pradesh and West Sikkim in collaboration with Foundation of MSME clusters (FMC) as NA. Under the project, the financial assistance is helping in the establishment of a CFC building comprising of a microbial culture room, bioreactor room, compost quality test room, training hall and model 20 concrete compost pits (Fig. 2).

The CFC will be equipped with all the advanced instruments including bioreactor (50 l), autoclave, laminar air flow, distilled water unit, BOD incubator, automatic kjeldahl apparatus, flame photometer, UV spectrophotometer, pH and conductivity meter, moisture analyzer, hot air oven, etc. The construction of the CFCs is under progress and machineries are ordered. The first trial is expected to resume by September 2021. The scheme will benefit 400 cattle rearers and each of them will get toolkit worth Rs 28,600/- With the implementation of this cluster apart from controlling the organic waste, the farmers are expected to earn additional Rs 30,000/- per year by selling enriched compost. Further, to empower the tribal population of Lahaul valley technology of dried cut flower and vegetable processing is getting implemented with support of FMC as NA. Clusters at Gondla and Shansha in Lahaul are under implementation. The project of Rs 3.31 crore is expected to benefit 351 farmers belonging to SC/ST communities. This project will also increase the market window from 35 days to 90 days thereby increasing the margin of the farmers by 35%. The direct impact of this intervention will be an additional increase of Rs 36,000/- per year by selling lilium flowers and bulbs. CFC construction work is under progress and it is expected that the cluster will be operational by October 2021. An overview of the current status of CFCs at different locations is presented in Fig 2. With SFURTI organized cluster models, CSIR-IHBT targets to generate sustained employment and regular income for the rural population by providing capacity building and enhanced product marketability in all the sanctioned clusters at different rural areas of Himalayan states with scientifically validated advanced technologies.

Fig. 2 Progress of SFURTI clusters at different rural locations of Sikkim and Himachal Pradesh

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

It is now very pertinent that bioresources are fast declining and their population needs to be revived. Majority of the multipurpose tree species occurring in HP not only provide basic amenities to the inhabitants but also sustain the fauna, and perform ecological functions that results in a cohesive ecosystem. However, population of many of these species is now reported to be plummeting.

Therefore, under the National Mission on Himalayan Studies, the institute is coordinating a project titled "Promoting Conservation of Declining Life Support Forest Tree Species in Himachal Pradesh".

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.

Through this coordinated project, efforts are on the revival of prioritized multipurpose tree species viz., *Corylus jacquemontii, Juglans regia, Taxus wallichiana* and *Ulmus wallichina*.

Specifically, the project targets

- 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, and Shimla districts. Also, plant nurseries have been established in Mandi and Solan districts. It is proposed to prepare an updated account of the species vis-à-vis their conservation status.

Himachal Pradesh Forest Department

Himalayan Forest Research Institute

Dr. Yashwant Singh Parmar University of Horticulture & Forestry
Nauni, Solan - 173 230 (Himachal Pradesh) India

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

The CSIR-IHBT is a member of the “Indian Himalayan Central Universities Consortium” (IHCUC) as approved by the NITI Aayog.

The IHCUC comprises of the following:

1. Assam University, Silchar
2. Central University of Himachal Pradesh
3. Central University of Jammu
4. Central University of Kashmir
5. CSIR-Institute of Himalayan Bioresource Technology, Palampur (HP)
6. HNB Garhwal University
7. Manipur University
8. Mizoram University
9. Nagaland University
10. North Eastern Hill University
11. Rajiv Gandhi University, Itanagar
12. Sikkim University, Gangtok
13. Tezpur University
14. Tripura University

Presently the IHCUC is focusing on the following five thematic areas:

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

Herein, the CSIR-IHBT is coordinating the thematic area “Agro-ecology in Himalayan states with special emphasis on marketing” where its prime role is to provide technological interventions for societal development in the Himalaya. For this, CSIR-IHBT has shared the technologies developed by it with the thirteen central universities of the Himalayan region and also the NITI Aayog. CSIR-IHBT also made detailed presentations on the available technologies and its relevance to the IHCUC. Through this, niche Himalayan products, their markets, and value chains are being prioritized.

Members of the IHCUC

EFFORTS TOWARDS MANAGEMENT OF COVID-19

COVID-19 TESTING FACILITY

Principal Investigator: Dr. Yogendra Padwad

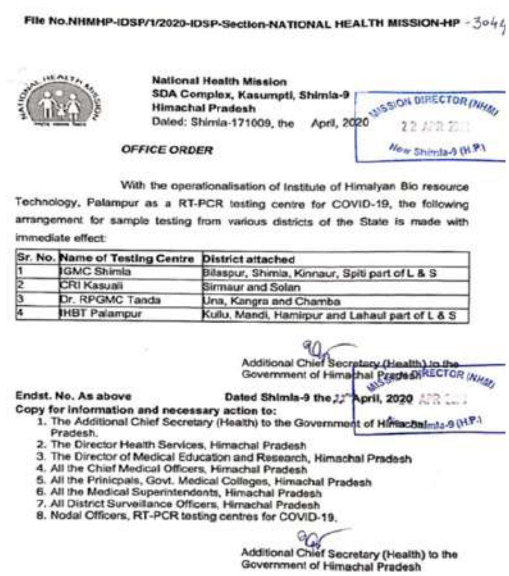
Co-Principal Investigators: Dr. Vipin Hallan and Dr. Narendra Vijay Tirpude

Research group: Dr. 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

The Background

As per the World Health Organization, *"COVID-19 is the infectious disease caused by the most recently discovered coronavirus. This new virus and disease were unknown before the outbreak began in Wuhan, China, in December 2019. COVID-19 is now a pandemic affecting many countries globally"*. It has affected 216 countries, and as of now 4,628,903 confirmed cases and 3,12,009 confirmed deaths have been reported from across the globe. These estimates are changing with a blink.

India is no exception to this onslaught by COVID-19 and is staring a humongous challenge. However, unlike many other nations, the strategies adopted by India and the innovations at every possible levels have helped to check the trajectory of COVID-19 to some extent. Considering the huge population of India, the number of confirmed cases and death due to COVID-19 in the country reveal a strong will and determination of its inhabitants that is now being acknowledged worldwide. Each individual and every single organization has come forward to play a very positive role in combating COVID-19. The CSIR-Institute of Himalayan Bioresource Technology, Palampur is also contributing towards the same in its own humble way. Recognizing the far reaching implications of the current pandemic, the CSIR-IHBT is doing its bit to serve the nation and society by utilizing the expertise it has and the state-of-the-art laboratories that it harbours.



File No.NHMHP-IDSP/1/2020-IDSP-Section-NATIONAL HEALTH MISSION-HP -3044

National Health Mission
SDA Complex, Kasumpti, Shimla-9
Himachal Pradesh
Dated: Shimla-171009, the April, 2020

MISSION DIRECTOR (NHM)
22 APR 2020
New Shimla-9 (H.P.)

OFFICE ORDER

With the operationalisation of Institute of Himalyan Bio resource Technology, Palampur as a RT-PCR testing centre for COVID-19, the following arrangement for sample testing from various districts of the State is made with immediate effect:

Sr. No.	Name of Testing Centre	District attached
1	IGMC Shimla	Bilaspur, Shimla, Kinnaur, Spiti part of L & S
2	CRI Kasuali	Sirmaur and Solan
3	Dr. RPGMC Tanda	Una, Kangra and Chamba
4	IHBT Palampur	Kullu, Mandi, Hamirpur and Lahaul part of L & S

Additional Chief Secretary (Health) to the
Government of Himachal Pradesh

Endst. No. As above Dated Shimla-9 the 22 April, 2020

Copy for information and necessary action to:

1. The Additional Chief Secretary (Health) to the Government of Himachal Pradesh.
2. The Director Health Services, Himachal Pradesh
3. The Director of Medical Education and Research, Himachal Pradesh
4. All the Chief Medical Officers, Himachal Pradesh
5. All the Prinicpals, Govt. Medical Colleges, Himachal Pradesh
6. All the Medical Superintendents, Himachal Pradesh
7. All District Surveillance Officers, Himachal Pradesh
8. Nodal Officers, RT-PCR testing centres for COVID-19.

Additional Chief Secretary (Health) to the
Government of Himachal Pradesh

The Contributions

Hand sanitizers: The Institute was amongst the first to recognize the importance of hand sanitizing. It prioritized work on the same and developed a formulation of hand sanitizer that has alcohol content as per WHO guidelines.

The formulation contains active tea constituents and natural aroma, and is free from parabens, triclosan, phthalates & synthetic fragrance. Till date it has distributed ~5000 litres of hand sanitizer to the front line staff at Police Stations, Medical Colleges and Hospitals; Banks; State Disaster Management Cell; Educational Institutes; Administrative Offices and Village Panchayats. The Himachal Pradesh Chief Ministers Office also received the sanitizer and expressed its gratitude towards the Institute. In addition to the above, industry partners of the CSIR-IHBT also supplied 4500 litres of it to the State and Central Government Offices in different parts of the country.

Soaps: Washing hands is the most recommended strategy against COVID-19, and therefore, the demand for soaps is rising. The CSIR-IHBT developed herbal soaps with natural saponins. These soaps are free of mineral oil, Sodium Lauryl Sulphate and Sodium Dodecyl Sulphate. They are proven to be antifungal and antibacterial with cleansing and moisturising benefits. The soaps have been distributed 2000 soap bars to the masses and the State administration.

Ready to eat nutritious food: Rising to the occasion, the CSIR-IHBT extended a helping hand towards feeding the migrant workers who had been stuck in various parts of the country. The Institute up-scaled its food processing unit to meet the staggering demands and provided ~5,28,000 packs of tinned food to the needy. This includes supply to Orissa, Himachal Pradesh, New Delhi, and other States through CSIR headquarters at New Delhi. It is pertinent to mention that the packed food is rich in nutrients and at the same time it is chemical and preservative free. The Institute also providing the following food items:

Food Distribution

Iron and zinc enriched spirulina bars:

(a) 1,00,000 Nos. (4 tons) during Cyclone Amphan (May, 2020) in Orissa/ Kolkata under NDRF supply.

Multigrain protein powder:

(a) 1,00,000 Nos. during Cyclone Amphan (May, 2020) in Orissa/ Kolkata under NDRF supply

COVID-19 testing facility: To fill in the void that exists because of the lack of COVID-19 Testing centres, the Institute upgraded and repurposed its regulatory laboratory as a COVID-19 testing facility. The facility is recognized by the Indian Council of Medical Research and since April 22, 2020 it is helping the Himachal Pradesh Government by conducting RT-PCR tests. Tasted 1.20 lakhs samples from Kullu, Mandi, Hamirpur, and Lahaul part of Lahaul & Spiti are being tested in the this newly created facility. Additionally, CSIR-IHBT rendered its help in setting up a testing facility at Dr. Rajendra Prasad Government Medical College at Kangra (HP) by providing and installing a RT-PCR machine in the medical college.

Exploring herbals to fight the pandemic: The Institute is exploring herbals to fight COVID-19. In a path breaking research, the CSIR-IHBT identified tea polyphenols to be having a good potential in combating the pandemic. Screening of other Himalayan plants is being actively pursued and the isolated molecules are being sent to CSIR-IICT for validation and value addition.

Awareness: Regarding awareness and information dissemination, the CSIR-IHBT designed posters for display at prominent places.


nature india https://www.natureasia.com/en/nindia/article/10.1038/nindia.2020.86

Tea plant chemicals block coronavirus activity better than anti-HIV drugs

Researchers from the CSIR-Institute of Himalayan Bioresource Technology in Palampur have identified organic chemicals in tea plants that could be potentially used to stop the proliferation of the novel coronavirus[1].

They have found that the chemicals, known as polyphenols, bind to a specific viral protein more efficiently than three commercially available anti-HIV drugs approved for treating COVID-19 patients.

These chemicals, they say, might block the activity of the viral protein that helps the virus to thrive inside human cells.

Tea polyphenols have been shown to inhibit the growth of the human immunodeficiency virus (HIV). These chemicals also possess anticancer and antidiabetic properties. However, their roles against the coronaviruses, particularly the novel coronavirus, were largely unexplored.

Promoting entrepreneurship for economic revival: It is now evident that the economic repercussions of COVID-19 would be grave. Thus, in order to plan and revive the economy, the Institute is proactively incubating firms for manufacturing hand sanitizers and ready to eat food. In the larger interest, the CSIR-IHBT has transferred the technologies of hand sanitizers to five firms that includes one from Jharkhand-

- M/s. A B Scientific Solutions, Palampur (H.P.)
- M/s Sandeep Kumar & Company, Nadaun, Hamirpur (H.P.)
- M/s Baijnath Pharmaceuticals Pvt. Ltd., Paprola, Dist Kangra (H.P.)
- M/s VLCARE HEALTH, Bistupur, Jamshedpur, Jharkhand.
- M/s Nature Green Chamba Herbs, Village: Sutrar, Tehsil Nurpur, Dist Kangra (H.P.)

Similarly, with a backdrop of ensuring food availability, the ready to eat food technology has been transferred to three firms-

- Lennix Inc., New Delhi
- A Qube Inc., Ludhiana
- M/s Sai Foods, Baijnath (H.P.)

Additionally, various agreements are being signed under the aegis of MSME SFURTI with an aim to provide livelihood options to the communities in the emerging scenario. These agreements relate to Shiitake cultivation, vermicomposting, and cut flowers; and span from Himachal Pradesh to the North Eastern states of the country. In principle the MSME has approved a financial support of Rs. 15 crores for this initiative.

Social responsibility

- Ladies and staff of CSIR-IHBT family contributed Rs 2.61lakhs to the Prime Minister's Citizen Assistance and Relief in Emergency Situations (PM-CARES) and Chief Minister Relief Funds.
- The Institute employees donated their one-day's salary to the PM-CARES Fund, amounting to a total contribution of Rs 6.136 lakh.
- To minimize disease spread, donated foot-operated-hand wash spout (taps) for functional demonstration at key offices in the district.

Foot operated hand wash system

The Epilogue

The CSIR-IHBT is committed towards the nation and society. In these tough times, it stands hand-in-hand with all stakeholders to combat COVID-19 through Science & Technology. These are unprecedented times that call for unprecedented efforts, which the Institute will continue to pursue with vigour, compassion and safety.

APPRECIATIONS BY THE STATE GOVERNMENT

Mohit Chawla, IPS
ADC to Governor
Himachal Pradesh

सत्यमेव जयते
RAJ BHAVAN

मोहित चावला, भा.पु.से.
परिसहाय राज्यपाल
हिमाचल प्रदेश

Dear Dr. Sanjay ji

No. ADC/(G)/HP-/20
23rd June 2020

Jai hind

I would like to express my profound gratification and put the same on record for your professionalism and devotion towards duties. During the COVID-19 pandemic, your invaluable contribution is highly appreciable, as you and your team have extended support by giving personal care and attention.

It is indeed, a matter of pride for the state to have professionals like you who are earnestly serving the society. Your positive approach, warm behaviour and committed attitude towards duty is highly appreciable and felicitously acknowledgeable. I wish you all the best for future endeavours and hope that you will continue to contribute in the collective fight against the pandemic.

May god be with us all.

Warm regards
Yours faithfully,

(Mohit Chawla, IPS)

Dr. Sanjay Kumar,
Director,
CSIR-IHBT Palampur,
Holta, Palampur,
District Kangra, HP.

राज भवन, शिमला-171 002
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0177-2624152
governorsecy-hp@nic.in

COVID-19 WARRIORS

COVID-19 WARRIORS

जिला प्रशासन कांगड़ा, हिमाचल प्रदेश

हिमाचल प्रदेश सरकार

प्रशस्ति पत्र

डॉ. नरेन्द्र त्रिप्युडे, कोविड लैब, आई.एच.बी.टी. (सी.एस.आई.आर.) पालमपुर

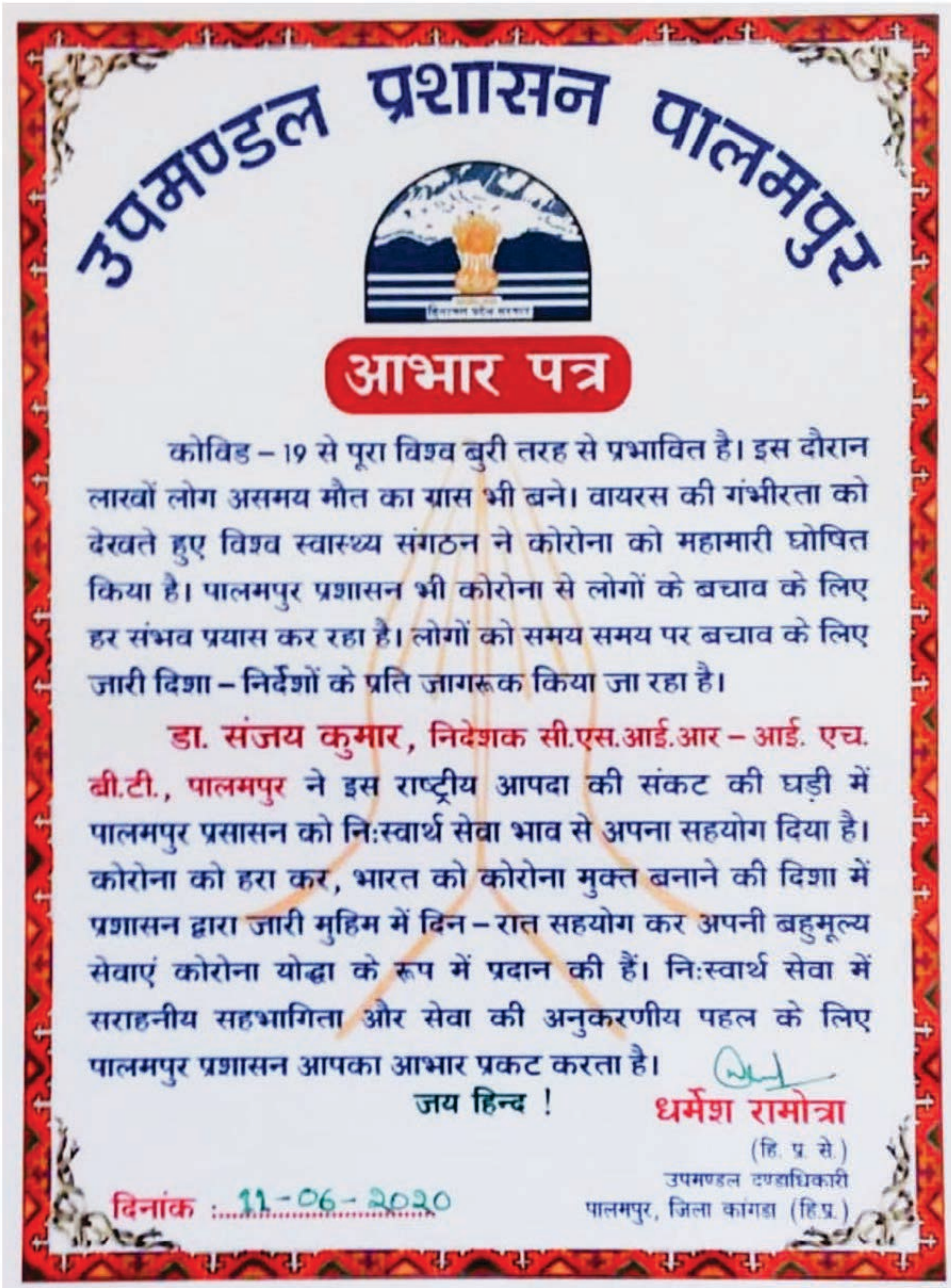
हर्ष का विषय है कि COVID-19 वैश्विक महामारी के समय आपने निःस्वार्थ भाव से प्रत्यक्ष एवं परोक्ष रूप से मानवता की जो सेवा की है, उसके लिए आप प्रशंसा के पात्र हैं। इस कठिन समय में अपने आपको स्वैच्छिक सेवा के लिए प्रस्तुत करना, जरूरतमंद लोगों को विभिन्न सेवाएं तथा वस्तुओं की निःस्वार्थ आपूर्ति करवाना, मानवता का उत्कृष्ट उदाहरण प्रस्तुत करता है। मानव इतिहास में बहुत सारे ऐसे संकट आए, आज हम उन विपत्ति की घड़ियों को याद नहीं करते बल्कि संकट के समय राष्ट्र व मानवता की सेवा करने वालों का नाम सदैव गर्व के साथ स्मरण करते है। आपके सहयोग को शब्दों में व्यक्त करना संभव नहीं है। "सेवा परमो धर्मः" के मूल मंत्र को आपने सजीव कर दिखाया है। आपकी सेवाओं को सदैव हर्षित मन से याद किया जाएगा ।

आने वाले समय में भी आप मानवता व राष्ट्रहित के कार्यों से जुड़े रहेंगे, इस आशा के साथ आपके सुखद भविष्य की मंगल कामना करता हूं ।

आभार ।

Deputy Commissioner District Kangra

राकेश कुमार प्रजापति (भा.प्र.से)
उपायुक्त, जिला कांगड़ा स्थित धर्मशाला
हिमाचल प्रदेश



उपमण्डल प्रशासन पालमपुर

आभार पत्र

कोविड – 19 से पूरा विश्व बुरी तरह से प्रभावित है। इस दौरान लाखों लोग असमय मौत का ग्रास भी बने। वायरस की गंभीरता को देखते हुए विश्व स्वास्थ्य संगठन ने कोरोना को महामारी घोषित किया है। पालमपुर प्रशासन भी कोरोना से लोगों के बचाव के लिए हर संभव प्रयास कर रहा है। लोगों को समय समय पर बचाव के लिए जारी दिशा – निर्देशों के प्रति जागरूक किया जा रहा है।

डा. संजय कुमार, निदेशक सी.एस.आई.आर – आई. एच. बी.टी., पालमपुर ने इस राष्ट्रीय आपदा की संकट की घड़ी में पालमपुर प्रसासन को निःस्वार्थ सेवा भाव से अपना सहयोग दिया है। कोरोना को हरा कर, भारत को कोरोना मुक्त बनाने की दिशा में प्रशासन द्वारा जारी मुहिम में दिन – रात सहयोग कर अपनी बहुमूल्य सेवाएं कोरोना योद्धा के रूप में प्रदान की हैं। निःस्वार्थ सेवा में सराहनीय सहभागिता और सेवा की अनुकरणीय पहल के लिए पालमपुर प्रशासन आपका आभार प्रकट करता है।

जय हिन्द !

धर्मेश रामोत्रा
(हि. प्र. से.)
उपमण्डल दण्डाधिकारी
पालमपुर, जिला कांगड़ा (हि.प्र.)

दिनांक : 11-06-2020

AGROTECHNOLOGY DIVISION

Rakesh Kumar Sud

Chief Scientist
rksud@ihbt.res.in
Agrotechnology, Advisory and Extension,
Planning, Project Monitoring and Evaluation

Tea Science

In tea plantations, farm mechanization has become inevitable to cope the rising costs of manual plucking and other farm operations, non-availability of the skilled farm workers and squeezing profit. Plucking in tea is the costliest-most field operation which accounts for 60-70% of its cultivation cost. Therefore, advantage of mechanical plucking using various available tea machines was demonstrated in comparison with manual plucking during the year for its wider adoption. Being non-selective to pick the desired quality shoot of standard size, research work on artificial intelligence based methodology for automatic grading of machine harvested tea leaves has been started during the year in collaboration with CSIR-CMERI. In addition, extensive extension activities were continued during this year also on dissemination of improved agro-technology package from planting of improved clones to pruning, skiffing, plucking, spraying etc both mechanical and manual means for achieving better productivity, quality and returns for upliftment of small tea growers in Himachal Pradesh. The detailed description of the activities and outputs has been given hereunder.

Artificial intelligence based methodology for automatic grading of machine harvested tea leaves

The project was sanctioned by CSIR under FBR category where CSIR-CMERI is the nodal lab and our institute is a participating lab (PI: Dr RK Sud & Co-PI: Dr Amit Kumar). The aim of the project is to study composition of machine harvested fresh tea leaves in terms of different grades and develop AI model for segregation of tea leaves in terms of harvested tea grades.

Plucked leaves of tea (*Camellia sinensis*) representing various grades such as one leaf with terminal bud (1L+B), two leaves with terminal bud (2L+B), three leaves with terminal bud (3L+B), four leaves with terminal bud (4L+B) and five leaves with terminal bud (5L+B) were collected from the tea gardens of Palampur region in Himachal Pradesh (Table 1).

Photographs of such 2930 tea leaf samples were captured in the laboratory using Nikon 7500 DSLR camera with uniform camera, height, light and background settings (Fig. 1).

Table 1. Details of photographs recorded for different tea grades

Shoot types	1L+B*	2L+B*	3L+B*	4L+B*	5L+B*
Date of observation	Number of photographs				
30.09.2020	60	50	81	55	52
02.10.2020	276	391	296	262	39
07.10.2020	201	201	201	200	200
03.11.2020	95	63	116	91	0
Total	**632**	**705**	**694**	**608**	**291**

*Harvestable shoot comprising of given no. of leaves (L; 1 to 5) with active terminal bud (B)

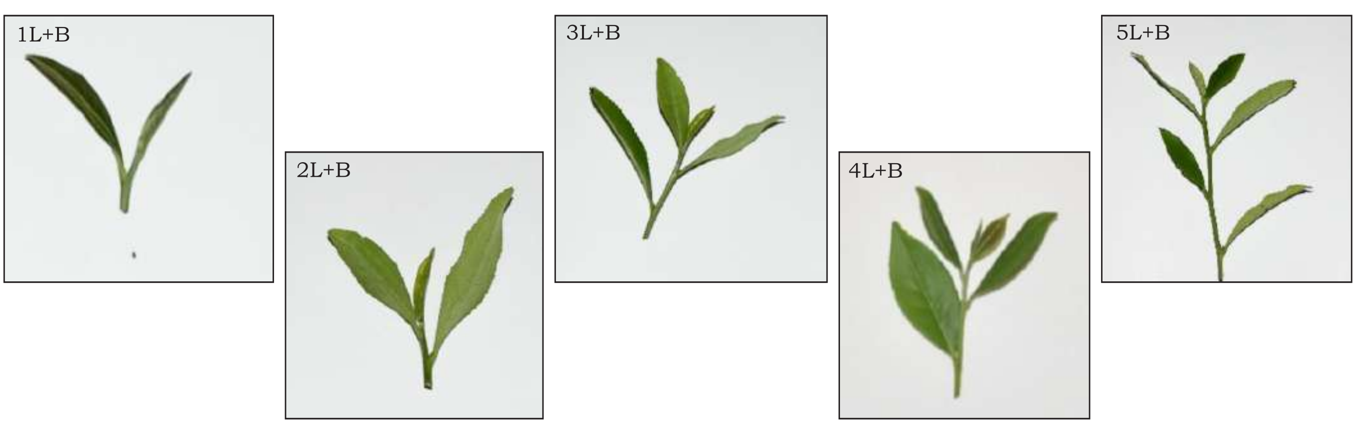


Fig. 1 Recording of photographs of tea leave

More number leaf samples will be collected and photographed in the coming tea season for the training of the AI model for segregation of tea leaves.

Application of improved tea agro-technologies for higher productivity, quality and returns for upliftment of small tea growers in Himachal Pradesh

Tea advisory & extension services

The focus of the activity was (i) to educate and train the small tea growers on the fundamentals of quality tea production, marketing and generating point of sale, (ii) to promote mechanization of tea farm operations for coping up labour shortage and boosting economic viability, and (iii) promote planting of improved clones amenable for mechanical harvesting. Efficient garden management practices, production of quality planting material for new plantations, integrated pest and nutrient management, appropriate plucking, skiffing and pruning operations, handling machines and their maintenance, setting up new plantations, quality tea manufacture and value addition was facilitated during the year. Details of advisory visits/training programmes/demonstrations conducted physically as well as virtual means during the year have been shown in Table 2.

Table 2. Advisory visits, field demonstrations & training on improved tea agro-technologies

Date	Tea Garden/Location	Details of the activity
17/04/2020	Kangra Valley tea estate (TE), Kangra Distt.	Mechanized plucking advisory & demonstration
18/04/2020	Thondole TE, Kangra Distt.	--do--
20/04/2020	Band Bihar area, Kangra Distt.	--do--
01/05/2020	Chauntra area, Mandi Distt.	Management of scale insect
05&06 /05/2020	Chambi TE, Darang TE, Ballah TE, Raipur TE and Dharmshala TE	--do--
11/05/2020	Saloh TE & Thondole TE, Kangra Distt.	--do--
03/06/2020	Khilpat TE, Mansimbal TE, Kangra Distt.	IPM particularly Red spider control
05/06/2020	Kangra valley TE, Sidhbari TE, Kangra Distt.	--do-
17/06/2020	Chakwan TE, Dharmshala area	--do--
26/06/2020	Band Bihar area, Kangra Distt.	IPM & INM – Advisory visits during plucking season
06/07/2020	Band Bihar area, Palampur area	Mechanized plucking demonstration
07/07/2020	Chauntra, Mandi Distt.	--do--
07/07/2020	Dehluhar, Mandi Distt.	--do--
18/08/2020	Rajehar area, Kangra Distt.	Soil sampling for selection of new tea planting site for demo plot
29/09/2020	Rajehar area, Palampur, Kangra Distt.	Land preparation and transportation of nursery tea plants for demo plot
01/10/2020	--do--	Demonstration of tea plantation of 800 tea plant by manual pit making method
06/10/2020	Sullah area, Kangra Distt.	Plucking demonstration
20/10/2020	Chauntra, Mandi Distt.	Training on management of new plantation in the demo plot cum technical advisory
20/10/2020	Darang TE, Sidhbari TE, Kangra valley TE, Kangra Distt.	Pruning cycle planning
22/10/2020	Paprola- Baijnath area, Kangra Distt.	--do--

Date	Tea Garden/Location	Details of the activity
24/10/2020	Thandole, Palampur, Kangra Distt.	--do--
28/10/2020	Mansimbal TE, Palampur	--do-
30/10/2020	Rajehar area, Palampur	--do--
03/11/2020	Mansimbal TE, Palampur	Establishment of demo plot with mechanized planting
11/11/2020	Band Bihar area, Palampur	Demonstration of mechanized skiffing operations
03 & 04/11/2020	Thandole TE, Darang TE, Towa TE and Chambi TE, Kangra Distt.	Pruning cycle planning
13/11/2020	Paprola, Langhu-Sakri, Chauntra, Mandi Distt.	To review status of newly planted demo plots; technical advisory onmanagement of tea garden including
30/10/2020 to 4/12/2020	Palampur area	Raising of improved tea cultivar plants in the nursery sites
02/12/2020	Messairna TE, Bhadal Devi, Sullah area, Kangra Distt.	Pruning cycle & winter operation
09/12/2020	Bhadal area, Mansimbal TE and Thandole TE, Kangra Distt	Training cum advisory on winter operations in tea gardens and technical advisory
17/12/2020	Banuri Tea Experimental Farm, CSIR-IHBT, Palampur	Demonstration of vacancy infilling using one man earth auger machine
05/01/2021	Raipur TE, Mansimbal TE, Kangra Distt.	New planting demonstration
20/01/2021	Khalet TE, Messairna TE, Kangra Distt.	Mechanization pruning demonstration
09/02/2021	Chauntra area, Mandi Distt.	Vacancy in filling in new and old section
19/02/2021	Darang TE, Kangra Distt.	Lane making for mechanized plucking
25/02/2021	Sidhbari TE, Kangra Distt.	Development of unproductive area
02/03/2021	Chambi, Kangra valley TE, Dharmshala TE, Chakwan TE, Thandole TE, Bundla TE, Messairna TE, Sungal TE, Darang TE and Ballah TE, Raipur TE, Kangra Distt.	Fertilizer recommendation, calculation of fertilizer dosages and application methods

Demonstration on mechanization of tea plucking

Plucking in tea husbandry is the most costly most field operation which accounts for 60-70% of total cost of cultivation. With an aim to cope up labour shortage and boosting economic viability, mechanization of tea leaf plucking using various available tea machines viz., manual shear, one man battery operated machine, one man petrol operated machine, and two men petrol operated machine were demonstrated and compared with manual plucking during the year at the institute's experimental farm. Plucking efficiency with different machines has been summarized in Table 3.

Table 3. Comparison of plucking efficiency by different machines

S. No.	Mechanical Method of Plucking	Plucking Efficiency (Folds)	Leaf Plucked Per Day
1	Manual Shear (Simplest method)	2	60-70 Kg
2	One Man Battery Operated Machine	4-5	120-150 Kg
3	One Man Petrol Operated Machine	8-10	250-350 Kg
4	Two Men Petrol Operated Machine	15-20	600-1000 Kg

One man petrol operated machine

Hand shear plucking

One man battery operated machine

Manual plucking

Two men petrol operated machine

Machine plucked leaf

Demonstration of tea plucking machine was held at village Band Bihar in the tea garden of Mr Prem Vyas on June 26, 2020. Similar demonstrations on plucking and other aspects of mechanizations were held at other locations viz., Chauntra, Paprola, Baijnath, Thandole, Palampur, Mansimbal, Langhu-Sakri, Chambi etc. in the growers' field during the year.

Planting of improved tea clones with better quality and return

During the year demonstration plots on planting of improved tea clones were set up at two sites after testing the soil for its suitability. First plot was set up at village Rajehar in Palampur area where aim was diversification from traditional crops to tea.

New tea plantation at village Rajehar in Palampur area

The second plot was set up at Mansimbal Tea Estate in Palampur area. The growth of the plants has been satisfactory.

New planting at Mansimbal Tea Estate

Demonstration of infilling vacant site by using one-man earth auger machine

Vacancy infilling demonstration was conducted at the institute's experimental area in the main lab campus on during winter season. In this demonstration, 380 vacancies were in-filled with young tea plants by using one-man earth auger machine. The cost of unit pit making was found to be Re 0.57 with the auger, which has reduced to one tenth than that of manual pit making (Rs. 5.60).

Pit making by one-man earth auger machine and tea plantation

Demonstration of mechanized tea skiffing and foliar spray

Tea skiffing demonstration was held at village Band Bihar in the garden of Mr Prem Vyas in November, 2020, where 3000 tea bushes were covered. The relative cost of light skiffing was recorded to be Rs. 1 which was one third of that of manual method. Similarly, demonstration of high volume power sprayer was undertaken at the institute's experimental farm. High volume power spray covered 6 ha area against 1.88 ha area with battery operated and 1.0 ha area with manual backpack sprayer. The relative economics spraying was Rs. 311.06, Rs. 222.57 and Rs. 350.00 with high volume power sprayer, battery operated sprayer and manual pump, respectively, exhibiting that battery operated pump are more economical for small size of holdings.

Demonstration of mechanized skiffing and high volume powers sprayer

Demonstration cum training on machine repairing

Machines repairing training was provided to the tea growers to handle them successfully in the garden in order to achieve maximum efficiency. Proper oiling, greasing, filter cleaning, silencer cleaning and nut & bolt tightening and other similar mechanical actions are needed to be done for enhancing the working efficiency of the machines and prolonging their functionality and life.

Interactive meet on strengthening the Kangra tea industry at CSIR-IHBT

Organized an interactive meet on strengthening the Kangra tea industry through video conferencing (MS Teams) on 29th August 2020 under the chairmanship of Director, CSIR-IHBT Palampur, Dr Sanjay Kumar. All stakeholders of the tea industry viz., Chairman Palampur Tea Cooperative Factory, Director of Agriculture, Member of Tea Board India Kolkata, Deputy Director Tea Board of India Palampur, President of Kangra Tea Planter Association, senior planters from Sungal Tea Estate, Wah Tea Estate, Dharmshala Tea Co., Himalayan Brew and small tea planters and manufactures of the region, as well as scientists of CSIR-IHBT participated.

The main issues discussed include hindrances/ limitations in the Kangra tea industry, improving productivity and quality of Kangra tea from the existing plantations, scope of expansion of the tea plantations in traditional and non-traditional locations in the state, integration of mechanization with production of diversified value added products and marketing of Kangra tea. The meeting was summed up as below:

- There was a need to develop short term and long term plans for converting abandoned tea to abundance stage – it includes running of existing plantations to its full capacities with appropriate agro-technologies, development of dilapidated tea plantations and introduction of improved blend tea cultivars and varieties in new areas to boost the state tea production to the critical level with best quality tea, may it be green, black, white or purple teas.
- Secondary grade teas, whether made tea or green leaf, need to be converted to value added tea products and their marketing can be done through HPMC or similar marketing agency network.
- For promoting Kangra tea brand in domestic and international market, celebrations like Tea Day and frequent exhibitions of unique teas and value added products are needed.

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Farm Mechanization

BAMBOO CHARCOAL AND ITS DIVERSIFIED PRODUCTS

This year the protocol and technique were developed for conversion of different bamboo species into charcoal. The bamboo charcoal powder was used as a carrier material for the production of "Compost Booster- a microbial formulation for rapid degradation of night soil to manage human waste in cold desert areas". The bamboo charcoal helped in reduction of the foul odur and also acted as soil conditioner. The carrier material was required in large quantity, hence the pulverization technique, size of bamboo charcoal powder and mixing of base material with bacterial consortium was optimized which is congenial to human health. The Institute has so far supplied approximately 2600 kg of the Compost Booster to the beneficiaries at Lahaul Spiti district of Himachal Pradesh and Army Head Quarter of Leh district of Union Territory of Ladakh. In addition to that a lab scale technique for conversion of fully utilized spent of Shiitake Mushrooms into charcoal under zero loss (negligible loss) was standardized for the value addition of the waste remaining after Shiitake mushroom production.

Mixing of base material with microbes

Mixing of Compost Booster after Maceration

Stacking Compost Booster

Transportation of Compost Booster different beneficiaries

Development of incense sticks making facility at CSIR-IHBT

Incense stick, also called Agarbatti in India, vary in length from 20-25 cm and have a huge economic potential. The incense market is worth Rs 7,500-8,000 crore with an annual growth rate of around 3.6 percent. Indian incense sticks are exported to more than 150 countries with US, UK, Malaysia, and Nigeria being the top markets.

Bamboo is the primary material for making incense sticks. Recognizing this, the institute has developed a technology for making incense sticks from bamboo. This is being supported by the Department of Agriculture, HP that has sanctioned Rs. 20 lakhs under the National Bamboo Mission for "Establishment of bamboo treatment and seasoning plant" and Rs. 15 lakhs for "Incense sticks making". Owing to this, a one of its kind facility has been established in the institute.

Bamboo Incense (Agarbatti) Sticks

Multipurpose Bamboo Stick Making Machine

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Plant Breeding

The focus of my research work is on breeding of floriculture, aromatic and medicinal plants for developing varieties for superior yield, quality and field performance.

Gerbera jamesonii

Four hybrid F_1 selections of gerbera developed through a controlled crossing program and multiplied through *in vitro* micro-propagation were morphologically characterized under protected cultivation with respect to floral traits (Table 1 & Fig. 1) and evaluated for field performance over a period of two years at four locations. Plantation was done in Randomized Block Design with fifteen plants per genotype replicated three times. Data recording was done on five plants per replication for flower diameter (cm), stalk length (cm) and number of flowers per plant at four locations in 2020-21. Data obtained from four locations were used to work out the analysis of variance for the field performance of selected genotypes. CSIR-IHBT-Gr-WSD-13 (white; semi-double), CSIR-IHBT-Gr-RSD-08 (red; semi-double), CSIR-IHBT-YS-20 (yellow; single) and CSIR-IHBT-MS-12 (maroon, single) exhibited variations for stalk length (cm) with maximum length in YS-20 followed by RSD-08. The flower size of RSD-8 was mini, while other lines had standard flower size (> 10 cm flower diameter). YS-20 was superior for the number of flowers per plant in a year in comparison to parental lines (Table 2).

Fig. 1 Potential gerbera genotypes with high *in vitro* proliferation (left to right: CSIR-IHBT-Gr-WSD-13, CSIR-IHBT-Gr-RSD-8, CSIR-IHBT-YS-20 and CSIR-IHBT-MS-12)

Table 1. Details of floral features of new gerbera F_1 selections

S. No.	Plant No.	Flower colour	Flower shape	Disc colour	Flower type
1.	CSIR-IHBT-Gr-WSD-13	White	Semi-double	Green	Standard
2.	CSIR-IHBT-Gr-RSD-08	Red	Semi-double	Green	Mini
3.	CSIR-IHBT-YS-20	Yellow	Single	Green	Standard
4.	CSIR-IHBT-MS-12	Maroon	Semi-double	Green	Standard

Table 2. Mean performance of gerbera F_1 selections at different locations for flower diameter, stalk length and number of flowers per plant

Selections	Flower diameter (cm)			
	Palampur	Bajaura	Jaisinghpur	Jwalamukhi
CSIR-IHBT-Gr-WSD-13	10.24	10.09	10.26	10.21
CSIR-IHBT-Gr-RSD-08	8.91	8.90	8.75	8.91
CSIR-IHBT-YS-20	10.51	10.61	10.46	10.54
CSIR-IHBT-MS-12	10.64*	10.65*	10.57*	10.61*
S. E. (d)	0.260	0.296	0.322	0.131
C. D.	0.610	0.696	0.756	0.308

Stalk length (cm)				
CSIR-IHBT-Gr-WSD-13	43.54	42.21	42.87	44.07
CSIR-IHBT-Gr-RSD-08	51.83	51.00	50.21	51.97
CSIR-IHBT-YS-20	54.54*	52.36*	53.51*	53.32*
CSIR-IHBT-MS-12	45.62	45.55	45.59	46.56
S. E. (d)	1.471	0.986	2.130	1.827
C. D.	3.456	2.317	5.006	4.293
Flower number/plant				
CSIR-IHBT-Gr-WSD-13	23.33*	23.00*	23.33*	23.25*
CSIR-IHBT-Gr-RSD-08	21.00	21.67	22.00	21.25
CSIR-IHBT-YS-20	22.00	24.67	21.00	22.50
CSIR-IHBT-MS-12	17.00	17.00	17.33	17.00
S. E. (d)	1.065	1.220	1.106	1.000
C. D.	2.502	2.867	2.598	2.350

*Significant at P = 0.05

Analysis of variance for the field performance parameters indicates significant variations for flower size (diameter in cm), stalk length (cm), and flower number per plant among the four selected hybrids (Table 3).

Table 3. ANOVA test for the differences in flower number per plant, stalk length (cm) and flower size (diameter in cm) among ten genotypes of gerbera

Source of variaiton	Variance	F- value
Flower size (diameter in cm)	2.637	384.303*
Stalk length (cm)	89.840	195.848*
Flower number per plant	30.517	27.975*

*Significant at P = 0.05

Rosa bourboniana

One of the objectives of rose breeding is on development of compact roses (Patio roses) which are one to three feet in height and spread and are suitable for smaller gardens, terraces and containers. These combine characteristics of larger miniature roses and smaller floribundas. At CSIR-IHBT, a selection (CSIR-IHBT-RB-13-6) made in progenies of *Rosa bourboniana* falls in this category with pleasant odour of flowers and is suitable for pot culture (Fig. 2a). The clonal propagation of CSIR-IHBT-RB-13-6 is 80% and contributes to fast multiplication of the plants (Fig. 1(a) and (b). The selection CSIR-IHBT-RB-13-6 has been morphologically characterized and evaluated for field performance at four locations. 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 flower diameter (cm), length of flowering shoot (cm) and number of flowers per flowering shoot at four locations in 2020-21.

Fig. 1 (a) Flower of CSIR-IHBT-RB-13-6 (b) flower buds in a shoot

Analysis of variance for the field performance parameters indicate significant variations for flower size (diameter in cm), plant height (cm) and flower buds per shoot among the selection and *Rosa bourboniana* lines (Table 4).

Table 4. Mean performance of CSIR-IHBT-RB-13-6 at different locations for flower diameter, stalk length and number of flowers per plant

Selections	Flower diameter (cm)			
	Palampur	Bajaura	Jaisinghpur	Jwalamukhi
CSIR-IHBT-RB-01	6.87*	6.47*	6.50*	6.66*
CSIR-IHBT-RB-13-6	5.10	5.00	5.10	5.12
CSIR-IHBT-RB-02	5.80	5.87	5.87	5.86
S. E. (d)	0.140	0.132	0.098	0.132
C. D.	0.603	0.568	0.422	0.568
Plant height (cm)				
CSIR-IHBT-RB-01	206.00*	205.33*	203.00*	204.50*
CSIR-IHBT-RB-13-6	82.33	80.00	78.67	79.17
CSIR-IHBT-RB-02	168.67	168.00	165.00	167.42
S. E. (d)	1.795	4.405	2.419	3.328
C. D.	7.724	18.956	10.409	14.319
Flower buds/shoot				
CSIR-IHBT-RB-01	3.00	3.67	2.33	2.92
CSIR-IHBT-RB-13-6	13.33*	11.67*	12.33*	12.33*
CSIR-IHBT-RB-02	2.67	2.33	2.33	2.50
S. E. (d)	0.596	0.770	0.843	0.243
C. D.	2.566	3.312	3.629	1.047

*Significant at P = 0.05

Salvia sclarea

Germplasm collections were made in the form of seeds from healthy plants identified in the wild representing 14 locations of Himalayan regions of Mandi, Chamba and Kullu districts in Himachal Pradesh. These germplasm liness were grown at CSIR-IHBT, Palampur and were characterized for morphological and essential oil parameters. Out of these 10 selections were made for morphological parameters i.e. high biomass yield (range of variations for yield are 120 g to 230 g/plant), early maturity, suitability for stressed degraded land, low irrigation requirement (drought tolerant) and essential oil parameters (with upto 0.13% essential oil content). Seeds were collected from the selected plants. These ten potential selections are being evaluated in the multi-location trials (Fig. 2).

Fig 2. Selected lines of *Salvia sclarea*

Pelargonium graveolens

Eight mutant lines developed through chemical mutagenesis (0.1% EMS treatment for 3 hours to vegetative cuttings of scented geranium) were established at CSIR-IHBT, Palampur. The mutant lines were characterized on morphological basis for morphological attributes like leaf size, leaf number, plant height and fresh biomass (490 g to 700 g/plant) and essential oil yield (0.31% to 0.43%). These eight mutant lines are being evaluated in the multi-location trials (Fig. 3).

Fig. 3 Mutant lines of *Pelargonium graveolens*

Rosmarinus officinalis

Hybridization was done among two potential germplasm accessions (CSIR-IHBT-RO-01 & CSIR-IHBT-RO-02) at CSIR-IHBT, Palampur. Fifty-five F_1 hybrids generated through manual crossing were established at CSIR-IHBT, Palampur. The F_1 hybrids obtained were characterized on morphological basis. Large variations were observed for morphological attributes like plant height, leaf length, leaf number and fresh aerial biomass. Out of these, 9 selections were made on the basis of aerial biomass (range of variations 180 g to 295 g/plant). The selected F_1s were clonally multiplied for generation of planting material by raising cuttings. The essential oil content was up to 1%. These nine potential selections are being evaluated in the multi-location trials (Fig. 4).

Fig. 4 F_1 selections of *Rosmarinus officinalis*

Inula racemosa

Thirty-nine germplasm accessions of *Inula racemosa* collected from diverse locations which are being maintained at Ribling farm (Fig. 5) of Centre for High Altitude Biology (CeHAB), a research centre of CSIR-IHBT, Palampur, were screened for morphological variations and ten lines were selected on the basis of high root biomass obtained (range of variations from 0.5 kg to 1.1 kg per plant fresh root biomass). These ten potential selections are being evaluated in the multi-location trials.

Fig. 5 Selections of *Inula racemose*

Picrorhiza kurrooa

Three hundred seventy-six germplasm accessions of *Picrorhiza kurrooa* were collected from diverse high altitude locations and are being maintained at Ribling farm of Centre for High Altitude Biology (CeHAB), a research centre of CSIR-IHBT, Palampur. The accessions were screened for morphological variations and ten potential clonal lines were selected on the basis of high root biomass obtained (range of variations from 4.66 g to 10.7 g per plant fresh root biomass). These ten potential clonal selections are being evaluated in the multi-location trials (Fig. 6).

Fig. 6 Selections of *Picrorhiza kurrooa*

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Development of Agrotechnologies

Our group is developing agro technologies for *Rosa damascena, Tagetes minuta, Crocus sativus, Matricaria chamomilla, Ocimum basilicum,* and *Hypericum perforatum*. We are also involved in providing technical and hand holding support to farmers for saffron production and promotion of low chilling apple plantation in the North Eastern Region of India.

DEVELOPMENT OF AGROTECHNO-LOGIES

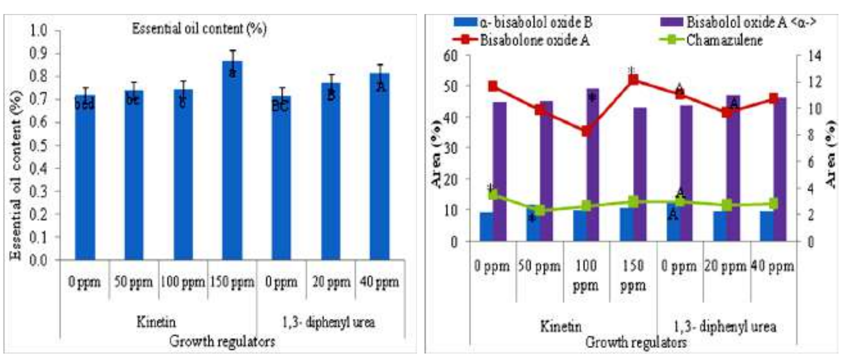
German chamomile (*Matricaria chamomilla* L.) Effect of growth regulators on German chamomile

German chamomile (*Matricaria chamomilla L.*) is a flowering herb commonly grown commercially for blue colour essential oil obtained from its flower heads. The essential oil yield and composition of chamomile were greatly affected by various factors. A field experiment was conducted to study the effect of two growth regulators *viz.*, kinetin (0, 50 100, and 150 ppm) and 1,3- diphenyl urea (DU) (0, 20, and 40 ppm) on yield and essential oil composition of German chamomile during 2019-2020. The essential oil content was 22.2% and 12.5% higher in 150 ppm kinetin and 40 ppm DU, respectively. The results revealed that chamazulene was significantly higher in control. α-Bisabolol oxide A was 8.76 % and 6.58 % higher in 100 ppm kinetin and 20 ppm DU application compared to control, respectively (Fig. 1).

Sweet basil (*Ocimum basilicum* L.)

Effect of biostimulants on yield, and secondary metabolite of sweet basil

Sweet basil (*Ocimum basilicum: Lamiaceae*) is a medicinal aromatic herb, commercially grown for its methyl chavicol-rich essential oil obtained from its leaves and flowers. A field experiment was conducted to elicit the growth, yield, and secondary metabolite of sweet basil by using biostimulants *viz.*, vermicompost, plant growth promoting rhizobacteria (PGPR), and seaweed extract (SWE) during 2020-2021. The analyzed results revealed that the application of vermicompost (8 t/ha) recorded 70.9%, and 67.3% higher fresh biomass and essential oil yield, respectively, compared to control. Similarly, the PGPR inoculation showed 59.7% and 73.3% increased biomass and essential oil yield compared to control. In addition, the foliar application of SWE @ 7mL/L significantly ameliorated the fresh biomass and essential oil yield by 55.7% and 69.6% respectively compared to control. In terms of essential oil constituents, the application of organic manure, PGPR, and seaweed extract significantly increased the amount of key constituents i.e. methyl chavicol by 2.2%, 2.9%, and 2.3% whilst an increase of 3.9%, 6.0%, and 3.6% were recorded in linalool, respectively (Fig. 2).



(a) (b)

Fig. 1 Effect of growth regulators on essential oil content and composition of German chamomile

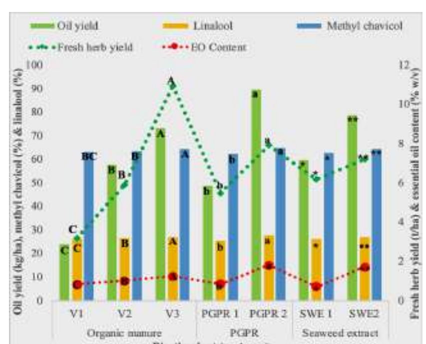


Fig. 2. Effect of biostimulants on yield, and secondary metabolite of sweet basil

Research group: Kiran Singh Saini, Arvind K. Verma, Kuldip Singh, Swati Walia, Shalika Rathore, Yog Raj and Deepak Kothari

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Agronomy

The domestic, as well as global market size of medicinal and aromatic plants (MAPs) is increasing day by day. However, the main bottlenecks in the MAPs sector are underdeveloped agronomic practices, scarcity of characterized plant materials, and sustainable supply of authentic quality raw materials. Therefore, our research group is essentially focusing on the development of region-specific agrotechnology of medicinal, aromatic, and commercially important plants for increasing productivity and quality under the western Himalayan conditions as well as for plain regions in India. Emphases are also placed to generation quality planting materials on large scale, and consequently to increase the area under MAPs.

Nitrogen (N) and water are essential components for plant growth and development, and ultimately for agricultural productivity. However, the excess application of these resources in agriculture maximizes the risks of N losses to the environment due to poor synchronization between the soil N supply and the plant demand. The worldwide demand for stevia (*Stevia rebaudiana*), a low caloric natural sweetener, is steadily increasing.

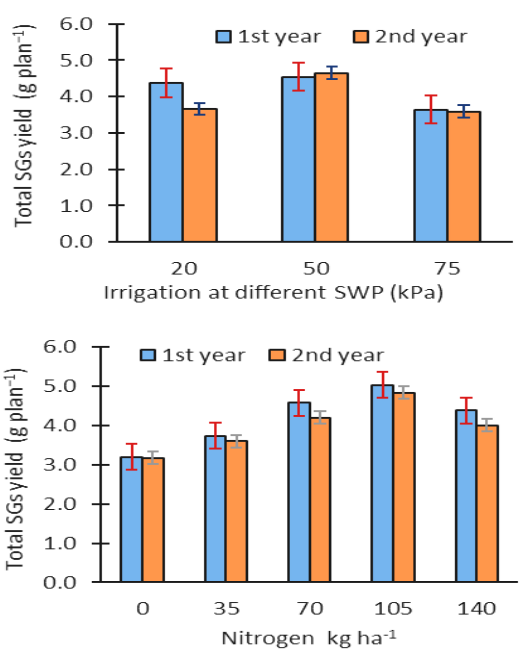

Fig. 1 Effect of irrigation schedule and nitrogen level on total steviol glycosides (SGs) yield of stevia

However, the yield and quality of stevia are largely governed by the availability of soil water and nitrogen. Thus, one field experiment was conducted to understand how the individual and interaction effects of N soil-moisture influence the soil physico-chemical properties, total SGs yield, and nitrogen use efficiency (NUE) of stevia. Analyzed data revealed that the total steviol glycosides (SGs) yield of stevia was found maximum with the irrigation at 50 kPa (Fig 1). On the other hand, the higher dose of N (140 kg ha^{-1}) did not enhance the total SGs yield compared with N at 105 kg ha^{-1}. The apparent Low N-recovery and agronomic N-efficiency at higher doses of N indicate higher accumulations of N into the environment. The soil N-balance sheet shows that the maximum N has been harvested with the higher dose of N under water stress conditions.

In another experiment, the study was conducted to evaluate the chemical profiling of Valeriana jatamansi essential oil of four wild populations (Rupena, Kugti, Garola, Khani) and two cultivated sources (CSIR-IHBT and Saloonie), and to understand the effects of repetitive distillation on recovery and quality of essential. The oil concentration in root/rhizome was found significant ($P \leq 0.05$), and the maximum value (0.35%) was observed with the population collected from Kugti and Khani. (Fig. 2). In essential oil, irrespective of population and distillation day, patchouli alcohol was the major compound, which ranged from 19 -63.1%.

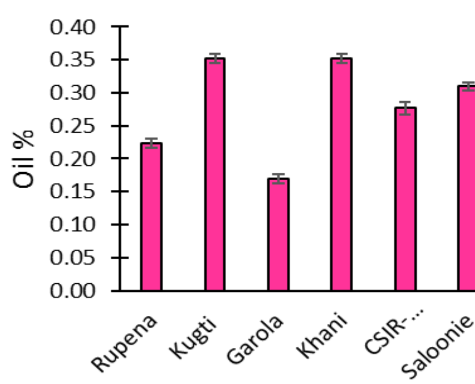

Fig. 2 Concentration of essential in root/rhizome from different population of *Valeriana jatamansi*

The dynamic of patchouli alcohol and seychellene in the essential oil of *V. jatamansi* populations has been influenced by the distillation days. The results showed that the maximum percentages of patchouli alcohol, irrespective of the source of materials, were registered with the oils obtained during the first day of distillation. In contrast, the percentage of seychellene was abruptly increased with subsequent days of extraction in all the populations.

The experiment on *Rosa damascena* has been conducted to understand the effect of different pruning systems and months of pruning on the growth, yield, and composition of essential oil. Results of this study revealed that ground-level pruned plants, irrespective of the month, produced significantly ($P \leq 0.05$) higher flower yield (618.62 and 473.29 g bush−1) compared with ground pruning followed by top pruned plants in both seasons. Average across pruning system, deep-pruning in October registered significantly ($P \leq 0.05$) higher flower yield (709.10 and 605.13 g bush−1) compared with the deep-pruning during June- August (Fig. 3). Citronellol + nerol content was higher (37.45%) in ground-pruning followed by the top-pruning system. On the other hand, geraniol content was higher (22.02%) in ground-pruned plants during June.

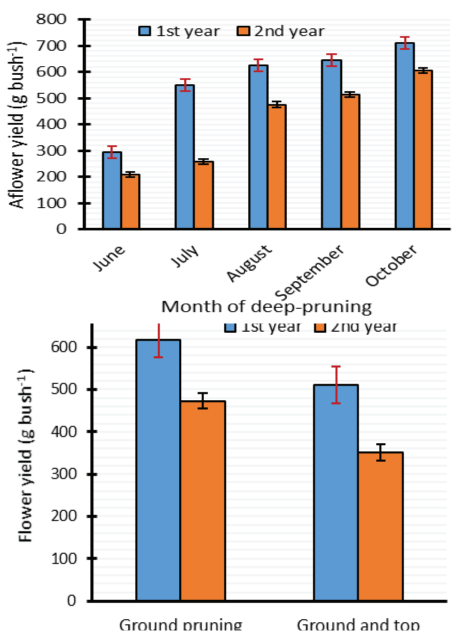

Fig. 3 Effect of month of deep-pruning on flower yield of *Rosa damascena*

Our research emphasis is also placed on a new crop like monk fruit (*Siraitia grosvenorii*), which is used as a non-caloric natural sweetener in some countries.

Understanding the basic physiology, life cycle, and growth behaviors are important for any species to introduce in the new ecosystem. Thus, we have studied the complete life-cycle of monk fruit (Fig. 4). Seed germination study, morphology, anatomy, chemical characterization, and dynamic of mogroside-V accumulation have also been studied to understand whether it behaves like native places.

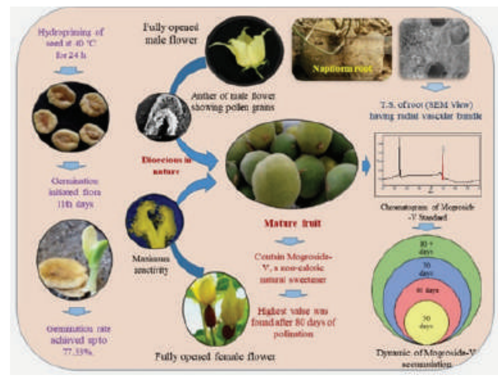

Fig. 4 Seed germination, flowering behaviors, and dynamic of mogroside-V

Extension Activities/ Rural development:

About 100 acres of land has been brought under stevia, medicinal, aromatic crops cultivation in Punjab, Himachal Pradesh, Chhattisgarh, and Uttar Pradesh, Assam, and Maharashtra in the traditional crop growing areas. Besides, large numbers of quality planting materials of stevia, *Valeriana jatamansi,* and other MAPs have been generated to support the farmers under CSIR – Aroma Mission and other projects. The planting materials have been supplied to the industry and farmers to promote the cultivation of MAPs in different parts of the country (Fig. 5).

Fig. 5. Plantation of *Valeriana jatamansi* to utilize the forest land at Champawat Uttarakhand

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Bioprospecting fungi for biopesticides and nutraceutical potential

In the direction of developing biopesticides, some entomopathogenic fungi (*Beauveria*, *Tolypocladium*, *Simplicillium*) isolated from lepidopteron larval cadavers showed insecticidal activities against different insect and mite pests under laboratory conditions. Submitted three gene sequences of entomopathogenic fungi to NCBI.

Standardized methods for estimation of free amino acids, total flavonoids, total polyphenols, protein, fatty acids and polysaccharides from *Ophiocordyceps* samples collected from Uttarakhand, India. Further, these *Ophiocordyceps* samples showed promising antioxidant activity, suggesting their huge nutraceutical potential.

JIGYASA Program

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, different online activities were conducted under the Jigyasa programme to motivate students towards science. Worked as Coordinator of IISF 2020 and JIGYASA Program for HP, we successfully organized "Student Science Village" (Khurana House) for school students. Invited and motivated students and teachers from all JNVs, KVs, Government and Public schools of HP to participate actively in IISF-2020.

This year, a total of 9238 participants participated in JIGYASA programme in different activities:

- Webinar on "Bioprospecting biodiversity of Himalayas"
- 6th India International Science Festival (IISF 2020)
    - Curtain Raiser Ceremony
    - Vigyan Yatra
- National Science Day Celebrations
- Details of these activities are uploaded on JIGYASA website: http://csirjigyasa.niscair.res.in/

Jigyasa-Virtual Laboratory

In a new initiative, this year attempts were made to disseminate R&D activities of CSIR-IHBT to school students and their teachers through online mode. Coordinated this programme for the preparation of five short films (2.0-3.5 minutes) with the concerned scientists at CSIR-IHBT and outsourced party in script writing and production of following short films:

- Conservation and mass propagation of rare endangered and threatened (RETs), and other economically important plants
- Enzymes from microbial world
- Mapping and exploring rich Himalayan biodiversity using remote sensing and other techniques
- Soil-less cultivation to boost farmer's income
- All about natural products: Isolation, identification, characterizations and bio prospection

Skill development programmes

Coordinated CSIR-Integrated Skill Initiative and Skill Vigyan programme of DBT-HIMCOSTE. Keeping in view the Covid-19 pandemic situation, the first batch of Quality Control Biologist (15 No.) and Lab Technician/ Assistant (10 No.). was selected for three months' online courses under Skill Vigyan programme sponsored by DBT-HIMCOSTE. Some training activities were conducted under the CSIR-Integrated Skill Initiative programme.

Training/ Internship of students

Institute is providing trainings/ internship to Graduate/ Post Graduate/ Ph.D. students from different Institutes, Universities and affiliated colleges. this year 38 students were selected for training at CSIR-IHBT. Out of these, 19 students have completed the training and 19 are ongoing.

Restructured National Bamboo Mission (R-NBM)

Coordinated this programme at CSIR-IHBT in which we have established a Hi-Tech and a small bamboo nursery for generating and providing quality bamboo planting material to the Department of Agriculture, H.P. and other stakeholders. Under this program, CSIR-IHBT has supplied 12000 bamboo plants, and about 25000 plants have been generated.

Adoption of Atal Tinkering Lab (ATL) to by CSIR-IHBT, Palampur

In another new initiative, 10 different KVs and Govt. schools of HP having ATLs were shortlisted and selected for their adoption by CSIR-IHBT. In this programme, Institute has finalized scientists and research scholars to mentor each ATL. Based on the inputs received from all CSIR-Labs, on April 9, 2021, CSIR has adopted 295 ATLs across India with the aim of inculcating scientific research and innovation culture among students. A series of webinars for students on scientific and technological concepts, ideas and societal issues are also proposed under this programme.

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Plant Breeding

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

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

F. assa-foetida is one of the top condiments and medicinal plant traded in India. Recognizing its importance, six accessions of *Heeng* were introduced through ICAR-National Bureau of Plant Genetic Resources (ICAR-NBPGR), New Delhi, with Import Permit No. 318/2018 and 409/2018. Seed germination was standardized by overcoming seed dormancy. The seedlings were raised in the controlled conditions at CSIR-IHBT, Palampur, and conducted trials at Centre for High Altitude Biology (CeHAB), Ribling, (Lahaul and Spiti), and CSIR-IHBT, Palampur (Fig.1) under the vigil of ICAR-NBPGR. MoU between CSIR-IHBT and the State Department of Agriculture, Himachal Pradesh was signed on June 6, 2020 for a joint collaboration for the cultivation of asafoetida in the State. The target under this collaborative project is to set up seed production centres and bring about 300 ha of land under *Heeng* cultivation in the next five years. A capacity-building program was organized for officers of the State Department of Agriculture from July 20 to 22, 2020.

Fig.1 *Heeng* plant in field

The first seedling of asafoetida was planted by Dr. Sanjay Kumar, Director, CSIR-IHBT on 15th October, 2020 at farmer's field in village Kwaring of Lahaul valley to mark the initiation of cultivation of asafoetida in India (Fig. 2). Further, training programs were organized on asafoetida cultivation and demonstration plots were laid out at villages Kwaring, Madgran, Beeling and Keylong in Lahaul & Spiti; Janhehali, Majakhal, Kataru and Ghayan in Mandi; Mebar, Kothi, Dunni, Reckong Peo and Powari, Rali, Graming and Kafnoo in Kinnour districts of Himachal Pradesh in collaboration with officers of State Agriculture Department for establishment of seed production chain and cultivation of asafoetida at commercial scale.

Director General, CSIR, Dr. Shekhar C. Mande planted the first plant of *Heeng* in Janjehali on 8th Nov 2020 to mark the cultivation of *Heeng* for the first time in Distt Mandi.

Fig. 2 Plantation of *F. assa-foetida* in village Kwaring of Lahaul valley on 15th October 2020

Palmarosa [*Cymbopogon martini (Roxb.)* W. Watson] Breeding :

Two hundred sixty diverse germplasm lines selected from the open-pollinated palmarosa plant population were screened for morphological traits and essential oil content. These lines were grown and evaluated at Experimental Farm of Agrotechnology Division, CSIR-IHBT, Palampur.

Seedling populations obtained from these germplasm lines were further characterized on morphological and essential oil content basis. Large variations were recorded for morphological attributes i.e. plant height (140-230 cm), tiller number (4-50), leaf length (17.41-32.61 cm), internode length (11-43.33 cm), and fresh biomass.

Pollination behavior and inflorescence development studies of palmarosa are also carried out. We investigated the inflorescence development of palmarosa into 7 distinct stages (IDS 1-IDS 7) and also worked on its floral biology for further improvement in quality of essential oil. The essential oil composition of different plant parts of palmarosa (whole plant, leaves, and inflorescence) analyzed by GC and GC-MS with respect to inflorescence developmental stages. Considerable variations of essential oil yield (%) in different plant parts of palmarosa were obtained at various essential oil extraction stages. The essential oil extraction observed in whole plant 0.3-0.5%, in leaves 0.6-1.7% and in inflorescence 0.8-1.2% (Fig. 3).

Fig. 3 Palmarosa plants in field.

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Biopesticides and Pest Management

Insect pests play a major role in reducing the economic yield if control measures are not initiated timely. Indiscriminate and non-judicious application of chemical pesticides for pest control led to insecticide resistance, harmful to beneficial insects (predators and parasitoids), human beings, environment etc. Use of bio-insecticides for the control of pests increased globally. Therefore, my research group carried out the screening of plant-based extracts, fractions, essential oils, and pure compounds for insecticidal properties against crop and stored grain pests for the development of botanical formulation. My group also developed an improved bee hive in collaboration with CSIR-CSIO, Chandigarh for quality and hygienic extraction of honey.

Insecticidal activities of plant extracts, fractions, and pure molecules *Trillium govanianum*against diamondback moth (*Plutellaxylostella*) and aphid (*Aphis craccivora*)

Insecticidal activity of plant extract, fractions, and pure steroidal saponins from *T. govanianum* was evaluated for their bio-efficacy against *P. xylostella*and *A. craccivora*. Results showed that parent extract was found more effective (LC_{50}=1541.2 mg/L) against larvae of *P. xylostella* after 96 h than n-butanol, n-hexane, and ethyl acetate fractions (LC_{50}=3030, 3578, and 3878.1 mg/L, respectively). For *A. craccivora*, ethyl acetate fraction (LC_{50}=2186.3 mg/L) was most effective after 96 h than n-hexane fraction (LC_{50}=2234.6 mg/L), n-butanol fraction (LC_{50}=2696.3 mg/L) and parent extract (LC_{50} =3709.1 mg/L). Among pure molecules, govanoside B was found more effective (LC_{50}=3279.5 mg/L) followed by borassoside E (LC_{50}=3467.1 mg/L) against *A. craccivora* after 96 h.

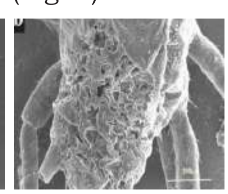
Utilization of apple pomace as a substrate for growth and spore production of entomopathogenic fungi (EPF)

Apple pomace (AP), the leftover waste after extraction of juice is often dumped in the open field and that adds to environmental pollution. In this context and a rich source of carbohydrates, we tried to standardize the AP as a substrate for growth and spore production of EPF viz., *Lecanicillium lecanii*, *Beauveria bassiana,* and *Paecilomyces fumosoroseus* by adding water, ammonium nitrate, as well as using different temperatures and pH. Results have shown that the addition of 40 mL of water, 4 g of ammonium nitrate, and maintaining the temperature at 30°C and pH alkaline (pH 8 & 10) in AP recorded significantly higher spore production of *L. lecanii* (50.53, 52.81, 151.2 and 50.26 to 52.2 lakh spores/mL, respectively), *B. bassiana* (50.44, 51.87, 152.2 and 50.14 to 51.66 spores/mL, respectively) and *P. fumosoroseus* (50.56, 52.18, 149.3 and 50.14 to 52.31 lakh spores/mL, respectively) as compared to positive control, potato dextrose agar (41.76 to 43.8 lakh spores/mL).

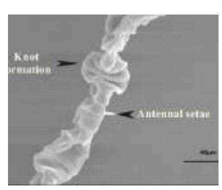
Effect of *Tagetes minuta* oil on the morphology of *Aphis craccivora* by Scanning Electron Microscopy (SEM)

The effect of *T.minuta* oil on the morphology of *A.craccivora* is reported in the scanning electron microscopy (SEM). Results showed that, flagellar segments of antenna treated with *T. minuta* showed filamentous and knotted without losing the setae after 96 h of treatment. The sensilla (Type I and II) showed remarkable deformation, reduction in the length and width. Morphometric measurements also helped to identify the deformed sensilla on cuticle andantenna. Type I and antennal sensilla reduced its length by 30% and type II sensilla by 42%. The breadth of type I and II sensilla was also reduced by 35% (Fig. 1).

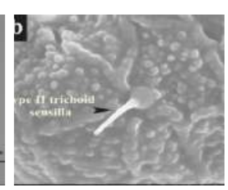

Untreated aphid


Treated aphid (Crumbling of body)

Well-developed antenna (Untreated aphid)



Knot formation in the antenna (Treated aphid)


Sensilla (Untreated)

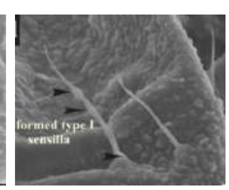

Deformed sensilla (Treated)

Fig. 1 Effect of *Tagetes minuta* oil on the morphology of *Aphis craccivora* by SEM

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Floriculture

Area of work: Protected cultivation of flower crops, indoor pollution abatement plants, hydroponics, soilless cultivation, vertical gardening, urban floriculture.

Propagation of *Jasminum parkeri*: A critically endangered wild ornamental woody shrub from Western Himalaya

Jasminum parkeri Dunn is a narrowly endemic, critically endangered woody ornamental shrub confined to sub-temperate zone of the Western Himalayas. In the present study, a propagation technique of *J. parkeri*, using stem cuttings, was established for the first time through the application of auxins, namely, indole-3-acetic acid (IAA), 1-naphthaleneacetic acid (NAA), and indole-3-butyric acid (IBA), at varying concentrations ranging from 1000 to 4000 ppm. The highest rooting percentage (98.33% (85.68% ± 4.32)), number of primary roots (36), root length (29.68 cm) and survival percentage (96.67% (83.85% ± 6.16)) were recorded for cuttings treated with 3000 ppm NAA (Fig. 1).

The phenological comparison between pot plants propagated through seeds and stem cuttings in a naturally ventilated polyhouse revealed a reduction in vegetative and flowering phases in cutting raised plants. Additionally, a noteworthy adaptive behaviour of two weeks of early flowering and four weeks of extended flowering (February to October) was observed in plants raised under polyhouse conditions (Fig. 2). This method will help in protecting the species from population decline, thereby significantly increasing its potential to be harnessed as an ornamental plant in India. Furthermore, plants grown *ex-situ* will be reintroduced in natural populations.

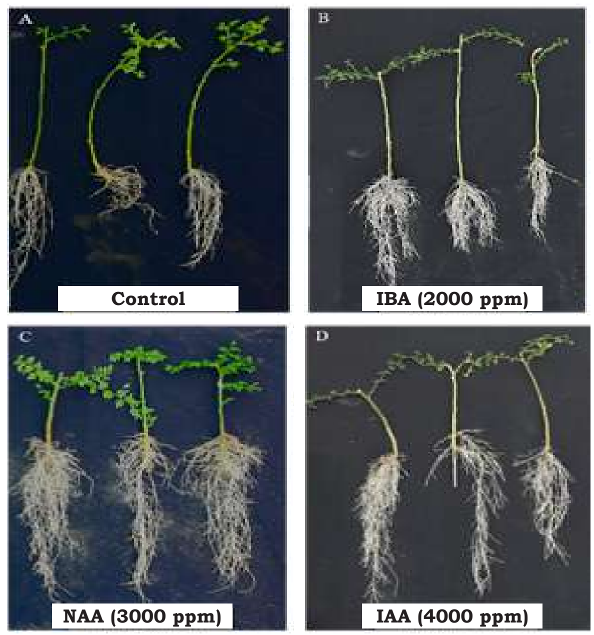

Fig. 1 Root formation in *Jasminum parkeri* cuttings as affected by different auxin treatments

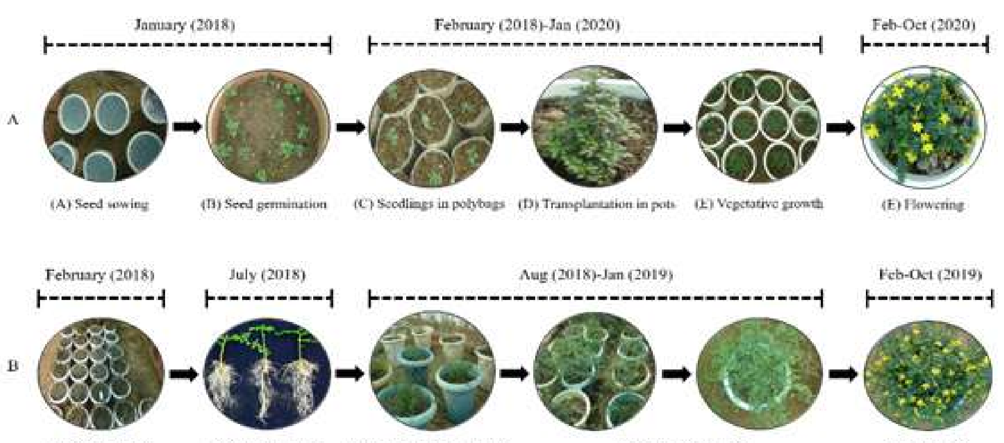

Fig. 2 Vegetative and flowering stages during propagation of *Jasminum parkeri*: (A)-through seed; (B)-through stem cuttings

Growth and flowering response of African marigold (*Tagetes erecta* L.) Sel-1 to different planting times

Marigold (*Tagetes erecta* L.) is an important commercial loose flower crop in the Indian floriculture industry owing to its versatility in terms of ornamental and pharmaceutical purposes. The demand of marigold flowers raises during the festival season during October and November. It is principally grown as a loose flower, which is used for decoration purposes in weddings and festivals. During the months Planting date manipulation is an important factor that ensures the augmented yields and continuous supply of quality flowers. Thus, this study aimed to determine the shifts in growth and flowering parameters crediting to different transplanting dates. Transplanting was done at a one-week interval commencing from August 14, 2020, and extending up to October 2, 2020. As reported by the findings of the experiment, maximum plant height (63.89±0.45 cm) was observed in the plants transplanted on August 28, 2020. Whereas, concerning flowering parameters, maximum number of flowers per plant (42.67±2.12), yield per plant (1.06±0.01), and minimum duration of flowering (49.53±0.73 days) were observed in plants transplanted on August 21, 2020. Fresh weight (29.19±4.86 g) and dry weight (3.45±0.29g) of the flower were recorded highest in the plants transplanted on October 02, 2020. On this account, this study put forward that transplanting of marigold in August is beneficial considering its desirable outcomes on growth and flowering.

Table 1. Effect of different planting dates on growth and flowering of *Tagetes erecta* L. Sel. 1.

Planting Dates	Days taken to flowering	Plant Height (cm)	Fresh weight (g)	Dry weight (g)	Number of flowers per plant	Yield per plant (kg)
T1 (14-8-2020)	52.60±0.41	58.78±1.43	17.86±0.59	2.43±0.13	37.33±3.50	0.67±0.00
T2 (21-8-2020)	49.53±0.73	55.74±0.33	24.75±2.54	2.44±0.13	42.67±2.12	1.06±0.01
T3 (28-8-2020)	55.27±0.80	63.89±0.45	21.58±0.65	2.98±0.10	37.20±2.14	0.83±0.00
T4 (04-9-2020)	51.27±1.47	60.67±2.37	20.40±1.19	2.92±0.10	34.13±0.98	0.80±0.01
T5 (11-9-2020)	51.47±1.28	63.83±1.01	23.34±2.36	3.13±0.06	36.53±5.09	0.70±0.00
T6 (18-9-2020)	52.60±0.41	62.73±2.49	29.18±3.94	3.30±0.15	29.47±0.24	0.85±0.01
T7 (25-9-2020)	61.53±0.48	56.74±3.33	24.74±0.49	3.35±0.15	28.53±1.99	0.77±0.01
T8 (2-10-2020)	63.40±0.62	57.85±0.34	29.19±4.86	3.45±0.29	26.40±1.79	0.73±0.00
CD (P = 0.05)	2.614	NS	NS	0.58	9.50	0.02

* Values are mean±S.E.

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Agrotechnology and Biotechnology of Himalayan Plants

Research in my lab currently focuses on four aspects. The first one involves the Himalayan medicinal plants *Nardostachys jatamansi* and *Valeriana jatamansi* (Fig. 1). The therapeutic properties of *N. jatamansi* and *V. jatamansi* are attributed to the secondary or specialized metabolites present in the rhizomes and roots, many of which belong to a diverse group of natural compounds called sesquiterpenoids. Sesquiterpenoids are produced through chemical reactions catalyzed by one or several sesquiterpene synthases (STS). Our goal is to identify STS in *N. jatamansi* and *V. jatamansi* using RNA-seq. These can then be heterologously expressed in *E. coli* or yeast.

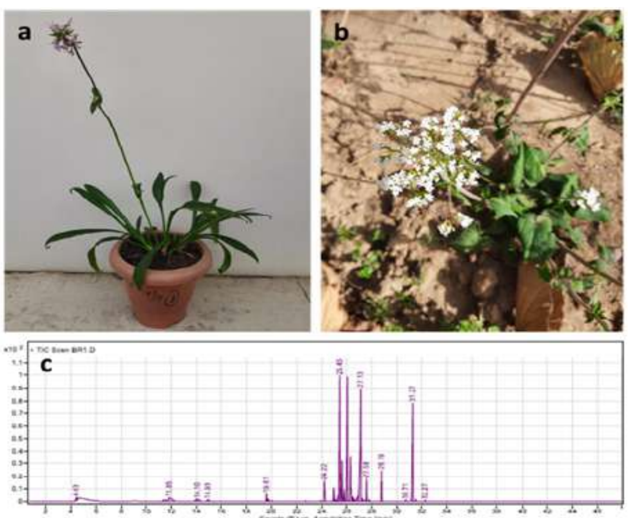

Fig. 1 a, *Nardostachys jatamansi*; b, *Valeriana jatamansi*. c, sesquiterpenoids of *V. jatamansi* from the roots

At the same time, callus induction from the leaves of the critically endangered medicinal plant *Nardostachys jatamansi* has been achieved (Fig. 2).

The second aspect revolves around the pitcher plant *Nepenthes khasiana* (Fig. 3). SERB has awarded a project under the SRG scheme entitled 'Does it take two key regulatory genes *ASYMMETRIC LEAVES1* and *REVOLUTA* to make a pitcher in *Nepenthes khasiana*?' As the title suggest, the two genes from *N. khasiana* will be cloned in Arabidopsis *as1* and *rev* loss-of-function mutants, to specify their role in pitcher development.

Fig. 2 Callus induction in the critically endangered medicinal plant *Nardostachys jatamansi*

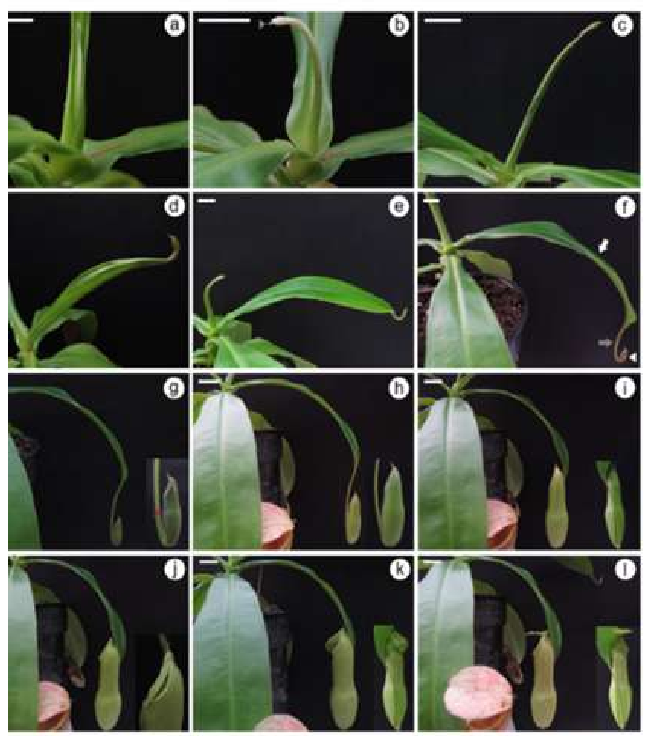

Fig. 3 Leaf development in *Nepenthes khasiana*

The third aspect deals with the development of agrotechnology for *Sapium sebiferum*, a fast-growing oil-producing deciduous tree found in diverse habitats of varied soil types at 500 - 1600 masl elevation across the Indian Himalayas. Seeds are covered by a white waxy layer called tallow (Fig. 4), from which 12-35% oil is extracted (tallow oil). Around 13-32% oil can also be extracted from the seed kernel (stillingia oil). The tree produces 4,700 l of oil ha^{-1} year^{-1}. Huge potential in biofuel production (biodiesel).

Lastly, in collaboration with other scientists, two nurseries, small and hi-tech, were established at CSIR-IHBT under the Restructured National Bamboo Mission of the Government of Himachal Pradesh. The goal here is to supply quality bamboo planting materials through cuttings and tissue culture techniques, which can help meet the demand for raw material by the Indian bamboo industry. As part of this programme, *in vitro* seed germination of *Dendrocalamus strictus* has been initiated. The germinated seedlings will then be utilized as explants for mass propagation (Fig. 5).

Fig. 4 a, Preparation of nursery beds for plantation of *Sapium sebiferum*. b, seeds of *S.* sebiferum

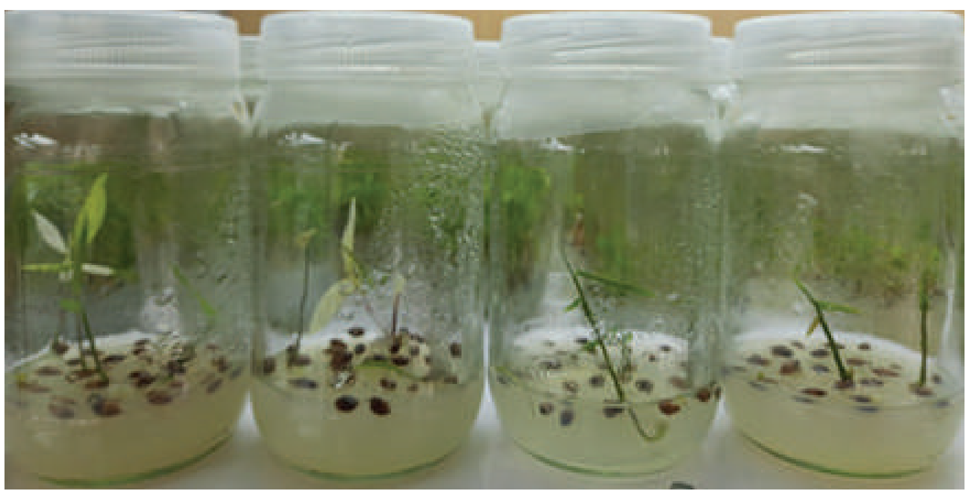

Fig. 5 *In vitro* seed germination of *Dendrocalamus strictus*

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Plant Breeding

Work is being done on genetic improvement and varietal development of aromatic crops like German chamomile (*Matricaria recutita* L.) and Lavender (*Lavandula angustifolia*). Work is also commenced on germplasm collection and genetic improvement of Quinoa (*Chenopodium quinoa*). We are also involved in the varietal development of *Heeng*, genetic improvement of *Kala zeera,* and breeding of high altitude medicinal plants.

Studies on reproductive biology of German chamomile

Several experiments of controlled pollination included self-pollination, emasculation via disc floret removal, manual cross pollination, and open pollination were conducted to study reproductive biology in German chamomile. Controlled pollination experiments showed the highest (91%) viable seed setting in open pollination conditions. However, seed setting was successfully achieved in selfed conditions (73%) as well as on manually hand-pollinated experiments (78%). While seed was not developed in covered emasculated flower head,which showed absence of apomixes. It is hence proved that ray florets are fertile pistilate florets. The experiments showed that the practice of removal of disc florets could be successfully used as the emasculation principle in German chamomile.

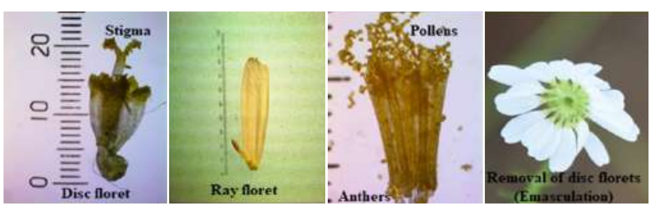

Fig. 1 Reproductive biology of German chamomile

Generation advancement in German chamomile

About 58 diverse German chamomile plant progenies from the previously selfed 70 plants were advanced to the next generation through controlled pollination under progeny selection based on appearance and desired trait behavior.

Fig. 2 Generation advancement in German Chamomile

Also, 14 superior selections are being evaluated at multi-locations for varietal development.

Hybridization in lavender

Genetic variation is the key requirement for improvement and varietal development in any breeding program. Lavender is asexually propagated through cuttings, and hence lacking in genetic variability. Hence, a total of 28 crosses were made between eight selected plants from two populations Akashi and Sher-e-Kashmir. Also, the reproductive biology and breeding behavior are being studied to decide the appropriate breeding strategy in lavender.

Fig. 3 Hybridization to generation new variation in Lavender

Germplasm collection and breeding in Quinoa

Quinoa (*Chenopodium quinoa*) is a pseudo cereal annual crop, rich in nutritional values. This plant has wide adaptabilities over the environments and soil type, and it could be an alternate future food grain crop. A systematic breeding program is needed to improve its nutritional qualities as lower saponins and higher grain yield. Hence, a total of 15 germplasm accessions were collected and being evaluated for their yield and nutritional qualities for further development of diverse breeding lines in quinoa. Breeding behavior is also being studied to decide future breeding programs in this crop.

Fig. 4 Development of diverse breeding lines in quinoa

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Floriculture

My group is focused on the breeding and agrotechnology of floricultural crops. We are also exploring the nutraceutical potential of edible flowers.

Edible flowers: A new direction towards healthy lifestyle

The increasing interest in functional foods and nutraceuticals has exaggerated exploration into new foods that have positive effects on human wellbeing. Even more, we see edible flowers as a new way of nutritional health. Various phytochemicals such as flavonoids, anthocyanins, carotenoids, and phenolics are responsible for the health-promoting effects of edible flowers. Keeping these in mind, the present investigation was conducted to study the nutritional profiling of some edible flowers (Rose, Marigold and Elderberry). Fresh flowers of these selected plants were harvested in full bloom stage and subsequently freeze-dried. In the edible flowers studied, the total protein content ranged from 1.22 to 18.03 percent. The highest total protein content was found in Elderberry flowers. Marigold line MD2 was found superior for crude lipids (174.8 mg/g) followed by *Rosa hybrida* cv. First Red (125.6 mg/g). *Rosa hybrida* cv. Himalayan Wonder recorded maximum total carbohydrates (207.34 mg/g) followed by marigold line MD1 (183.33 mg/g). Total carotenoid content ranged from 0.19 to 2.05 mg/g. The highest carotenoid content was recorded in marigold line MD1 (2.05 mg/g), whereas the lowest carotenoid content was recorded in elderberry flowers (0.19 mg/g). Total phenolic content ranged from 74.47 to 282.88 µg/g. Flowers of *Rosa hybrida* cv. First Red were rated as best for total phenolic content (282.88 µg/g). The obtained results will contribute to the popularization of edible flowers as a new and prospective source for the food industry, gastronomy as well as a promising object of human nutrition. Seeing the potential of these flowers in terms of nutritional and phytochemical profiles, functional food products can be developed utilizing edible flowers (Fig. 1 & 2).

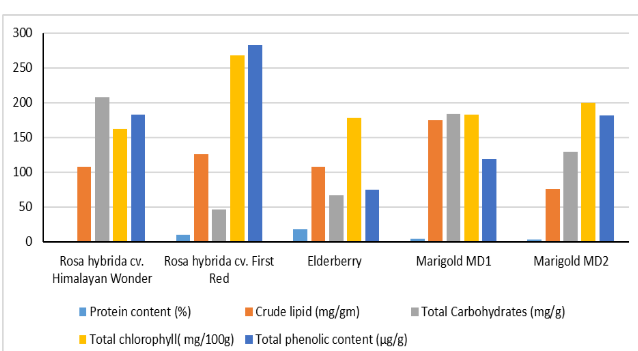

Fig. 1 Nutritional and phytochemical composition of edible flowers

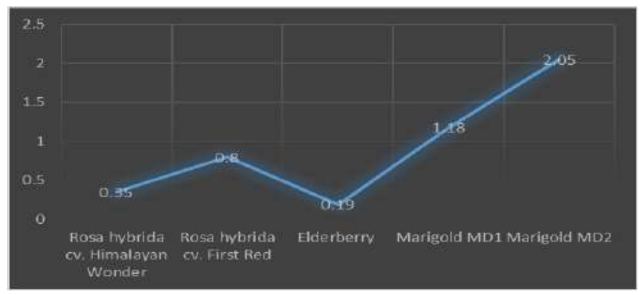

Fig. 2 Total caotenoid content of edible flowers

Seed setting behaviour among lilium genotypes

A total of eight intervarietal cross combinations of lilium genotypes were made and tested at CSIR-IHBT with an objective to find out the potentiality of seed setting in different cross combinations. Among all the crosses made only four cross combinations recorded seed set, whereas in the remaining four cross combinations no seed set was recorded. The cross combination 'Party Diamond × Treasure' recorded maximum number of seeds per cross (427) followed by cross 'Party Diamond x Prato' (404), Nashville x Prato (395) and Nashville x Amiga (354) (Fig. 3 & 4).

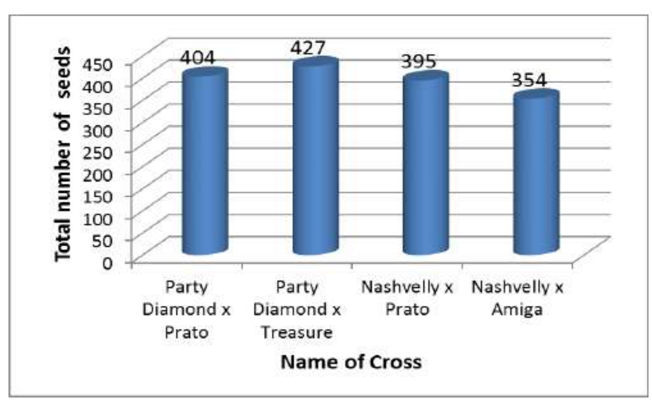

Fig. 3 Seed setting among different cross combinations of lilium

Fig. 4 Pod formation and seed germination in different cross combinations of lilium

Morphological characterization of rose germplasm

Rose is one of the most important commercial flower crops cultivated worldwide for its beauty, fragrance and nutraceutical values. At CSIR IHBT, Palampur we have a unique collection of roses comprising of Hybrid Teas, Floribunda, miniature and climbers. Characterization of rose germplasm provides precise information about the extent of diversity present among the cultivars. It also helps in cultivar identification, intellectual property rights protection, variety improvement, and genetic diversity conservation. Therefore, morphological description of rose varieties is being done and described below Table 1.

Table 1. Morphological characteristics of rose genotypes

Characteristics	Genotypes						
	Schloss Eutin	Samrourai	Vasavi	Sweet Surrender	Magestic Burgundi	White Queen Elizabeth	Bellerina
Plant growth habit	Upright	Upright	Upright	Upright	Upright	Upright	Semi-upright
Plant height (cm)	55	52	43	35	75	100	71
Young shoot anthocyanin coloration	Present	Present	Absent	Absent	Present	Present	Absent
Number of prickles	Many	Few	Few	Few	Medium	Medium	Many
Prickle predominant colour	Reddish purple	Green purple	Red purple	Brown	Red green	Reddish	Reddish
Prickle shape	Concave	Concave	Concave	Concave	Concave	Concave	Concave
Leaf size	Medium	Medium	Small	Small	Medium	Large	Medium
Intensity of green colour of leaf	Dark	Dark green	Dark	Dark	Medium	Light green	Medium
Leaf anthocyanin colouration	Absent	Absent	Absent	Absent	Present	Present	Absent
Leaf glossiness of upper side	Medium	Medium	Absent	Medium	Medium	Medium	Weak
Leaflet : undulation of margin	Absent	Absent	Absent	Absent	Medium	Medium	Weak
Leaflet serration of the margin	Medium	Medium	Medium	Fine	Fine	Fine	Fine
Shape of flower bud	Acuminate	Urn	Urn	Urn	Ovate		
Flower type	Double	Double	Double	Semi double	Semi double	Double	Semi double
Number of petals	Many (>30)	Medium (20-30)	Medium	Medium	Medium	Many	Few
Flower colour group	65 C	58 D	155 D	58 B	46 B	4 D	57 C
Flower diameter (cm)	8	9	9	7	5	10	5
Petal density	Dense	Medium	Medium	Medium	Dense	Dense	Loose
Flower shape from above	Round	Round	Round	Star	Round	Round	Irregular round
Fragrance	Medium	Medium	Medium	Strong	Weak	Absent	Absent

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Agronomy

Involved in developing agrotechnology of *Ferula assa-foetida, Bunium persicum, Inula racemose, Saussurea costus,* and *Sinopodophyllum hexandrum.* We are also involved in extension of *Heeng* (*Ferula assa-foetida*) in the cold desert region of Himachal Pradesh.

Influence of phytohormones on adaptation of *Bunium persicum* under mid hill conditions of Himachal Pradesh

Kala zeera [*Bunium persicum* (Boiss.) Fedtsch.] is a high-value herbaceous spice, growing wild in forests and grasslands of high hills dry temperate region ranging from 1800 to 3500 m.a.s.l. The Phytochemical profile of essential oil and extracts of this plant showed flavonoids, phenolic acids, aldehydes, mono-terpenes, and sesquiterpenes. Commercial cultivation of this plant in the cold desert region is very limited because the seed exhibits poor germination as a result of very deep dormancy. An attempt has been made to grow this crop using bulbs/tubers under mid hill conditions of Himachal Pradesh by substituting chilling requirements through application of phytohormones. The results revealed that the application of GA_3 (100 ppm) + TDZ (20 ppm) on bulbs/tubers of *B. persicum* (avg. wt. 8-10 g) for 24 hours recorded the least mean germination time and maximum sprouting percentage over other treatments (Fig. 1).

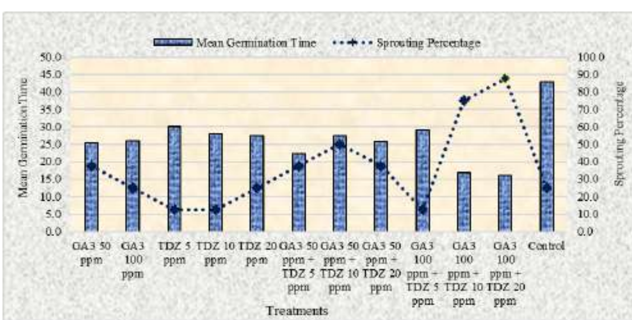


Fig. 1 Effect of phytohormones on mean germination time and sprouting percentage in *B. persicum*

Fig. 1 Effect of phytohormones on mean germination time and sprouting percentage in *B. persicum*

Extension of *Heeng* in Himachal Pradesh

Heeng (*Ferula assa-foetida* L.) is a perennial herb indigenous to Iran, Afghanistan and Uzbekistan. To promote its cultivation in India, our group generated quality planting material of the same for extension in the suitable areas. Consequently, *Heeng* cultivation has been initiated in Distt. Mandi, Kinnaur, and Lahaul & Spiti of Himachal Pradesh. Training on *Heeng* cultivation to the Officers of State Agriculture Department and farmers have been conducted in different places of targeted Districts in which 236 farmers including Agriculture Officers has been trained. Further, about 3300 seedlings of *Heeng* were also distributed to the farmers which covered an area of 0.50 ha.

Germinated Bulbs/tubers

Sprouting

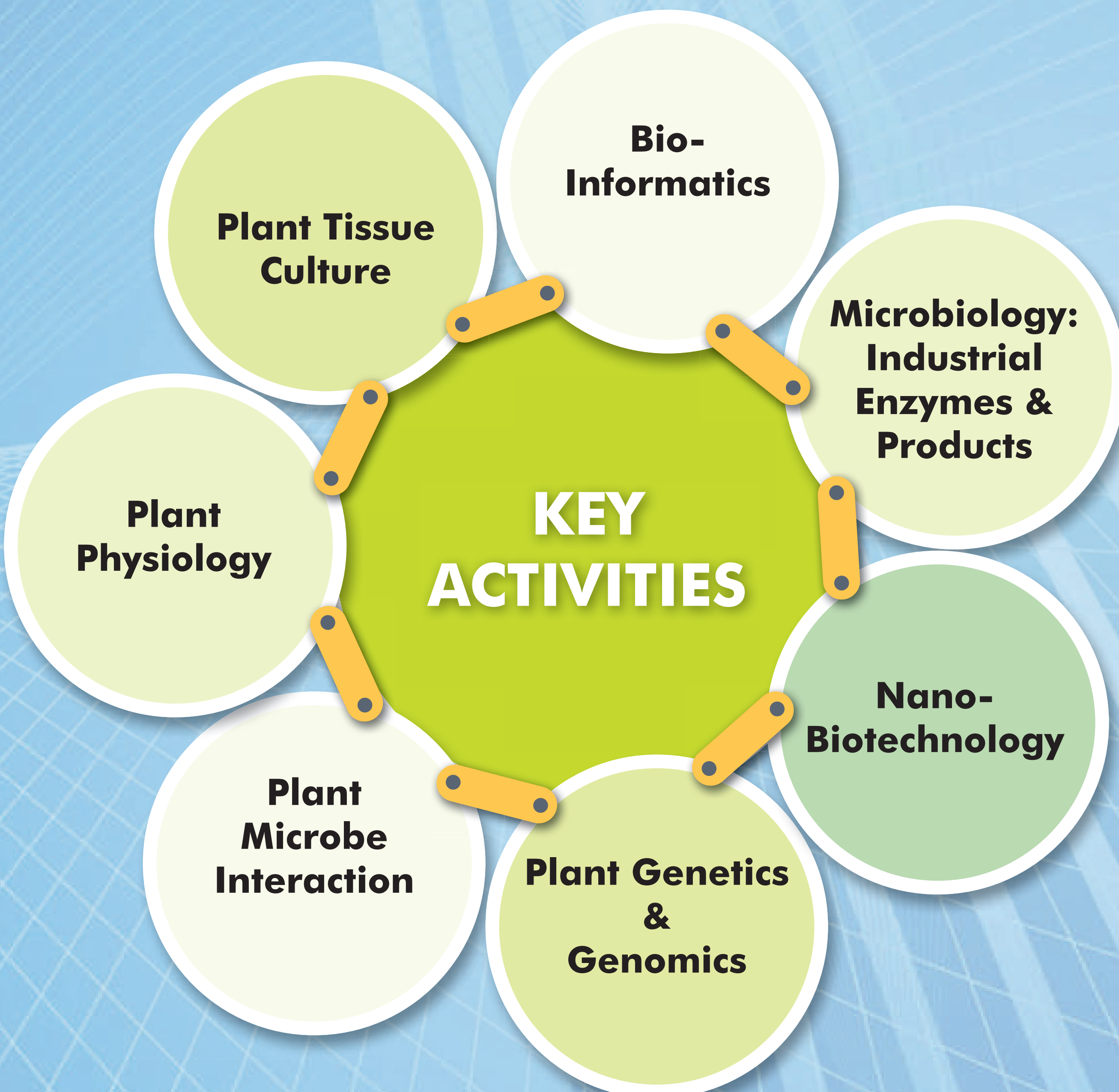
Vegetative Growth

Formation of Umbels

Flowering

Fig. 2 Different growth stages in *B. persicum*

BIOTECHNOLOGY DIVISION



Sanjay Kumar
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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 Himalayas, and gene prospection for societal and industrial uses.

Thermostable Fe/Mn superoxide dismutase (GsSOD) of *Geobacillus* isolated from glacial soils of Himalaya

We have been working on superoxide dismutase (SOD) since long. Moving ahead, a gene encoding Fe/Mn SOD was cloned from *Geobacillus* sp. strain PCH100 isolated from Pangi region of Himachal Pradesh. Upon heterologous expression in *E. coli*, GsSOD was purified and its kinetic parameters were studied. Maximum enzyme velocity (V_{max}) and Michaelis constant (K_m) of the GsSOD were 1098.90 units/mg and 0.62 µM, respectively. GsSOD was found to be a dimeric protein, exhibiting activity across wide range of temperature and pH (Fig. 1). The enzyme retains 52.80% residual activity after heating at 80 °C for 180 min. Interestingly, GsSOD tolerated a temperature of 100 °C and 130 °C up to 15 min and 5 min, respectively. Higher thermostability of GsSOD was further established using circular dichroism and differential scanning calorimetry. In the presence of Fe^{2+} and Mn^{2+}, apoenzyme of GsSOD regained its activity confirming GsSOD to be a Fe/Mn superoxide dismutase. Further, GsSOD showed stability in the presence of wide range of denaturants, inhibitors, and metal ions (***Int. J. Biol. Macromol***., 179: 576-585, 2021). Higher thermostability and resistance to wide range of chemical inhibitors makes GsSOD a potential enzyme for various industrial applications.

Expression of a gene encoding thaumatin like protein from tea (*CsTLP*) enhanced drought tolerance in transgenic *Arabidopsis*

In our previous work, we reported upregulation of thaumatin-like protein (TLP) of *Camellia sinensis* (*CsTLP*) in a drought-tolerant cultivar (UPASI-9) of tea as compared to a drought-susceptible cultivar (TV2) in response to drought. Also, the gene was induced by other stresses that interacted with drought stress namely heat, salinity and osmotic stresses (***Funct. Integr. Genomics***, 12(3): 565-571, 2012). TLPs are pathogenesis-related (PR5) proteins, which are induced in response to various biotic and abiotic stresses. We cloned *CsTLP* and evaluated the response of transgenic lines of Arabidopsis constitutively expressing *CsTLP* under drought conditions. Expression of *CsTLP* resulted in higher drought tolerance as revealed by lower relative electrolyte leakage and higher water retention capacity in transgenic lines as compared to the wild-type (WT) plants under drought stress. Confocal microscopy showed

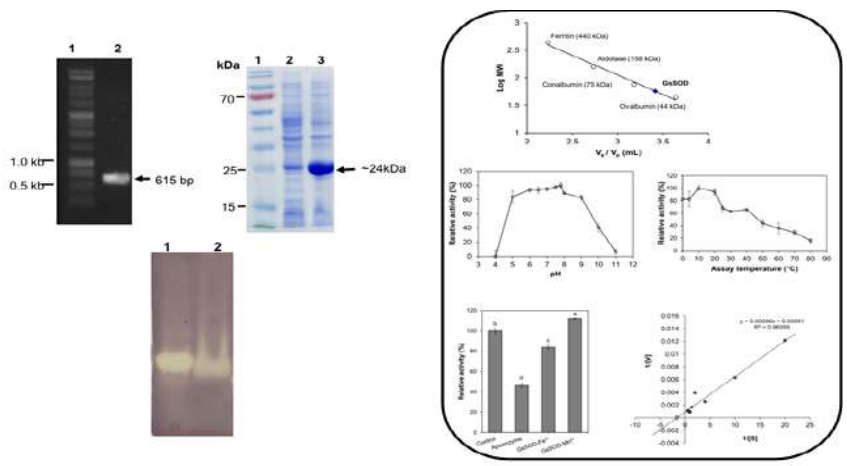

Fig. 1 Cloning, heterologous expression, and characterization of thermostable Fe/Mn SOD of *Geobacillus* sp. PCH100 (GsSOD) isolated from glacial soil of western Himalayas

TLP to be localized in the cell membrane which moved to the intercellular spaces under prolonged drought stress. Also, after re-irrigation transgenic lines showed higher recovery (57% to 81%) as compared to the wild-type (WT) where only 34% of plants resumed growth (Fig. 2). Total seed yield was found to be 35% to 62% higher in transgenic lines as compared to the WT upon recovery from drought (***Plant Physiol. Biochem***., 163: 36-44, 2021). These findings, therefore, provide new insight in to the physiological role of TLP in plants under the condition of drought stress.

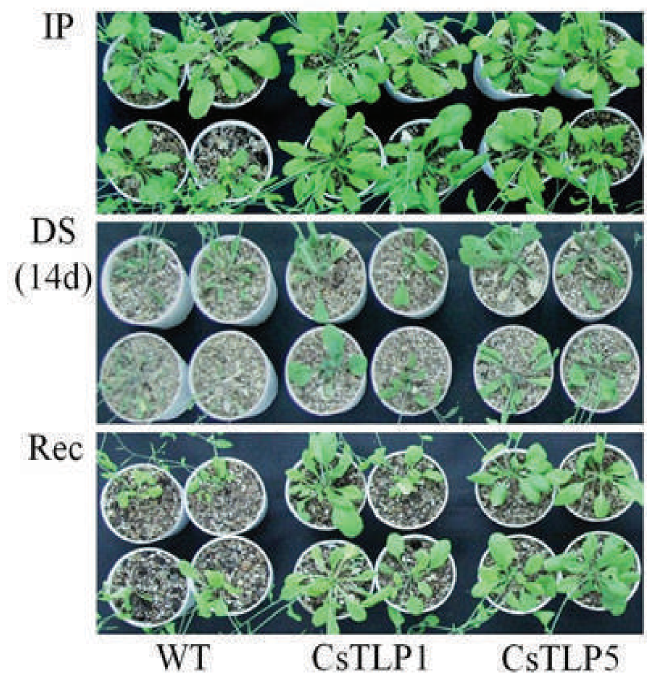

Fig. 2 Wild-type (WT) and transgenic lines (*CsTLP1* and *CsTLP2*) of *Arabidopsis* subjected to drought stress by withholding irrigation. IP, irrigated plants; DS, drought-stressed plants; Rec, plants recovered from drought

Identification of key molecular mechanisms helping *Rheum australe* to adapt in the high altitude environment

In our continuing efforts to understand molecular basis of adaption of plants at high altitude, *Rheum australe*, an endangered medicinal herb characterized by unusual broad leaves was selected. The species thrives well under the environmental extremes in its niche habitat. Since, temperature is one of the major environmental variables in the niche of *R. australe*, we compared transcriptome of the species growing in natural habitat and those grown in growth chambers maintained at 4 °C and 25 °C. A total of 39,136 primarily assembled transcripts were obtained from 10,17,74,336 clean read, and 21,303 unigenes could match to public databases. An analysis of transcriptome by fragments per kilobase of transcript per million, followed by validation through qRT-PCR showed 22.4% up- and 22.5% down-regulated common differentially expressed genes in the species growing under natural habitat and at 4 °C as compared to those at 25 °C. These genes largely belonged to signaling pathway, transporters, secondary metabolites, phytohormones, and those associated with cellular protection, suggesting their importance in imparting adaptive advantage to *R. australe* in its niche (Fig. 3; ***Sci. Rep***., 11(1): 1-16, 2021). The work suggested the importance of plant signaling and protective mechanism helping *R. australe* to adapt in the alpine environment of high altitude.

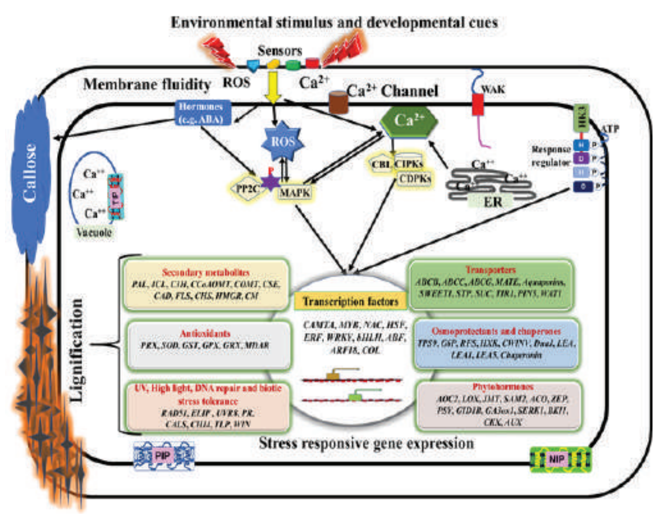

Fig. 3 Proposed model depicting response of *Rheum australe* to environmental stresses

Presently, we are also working on other important research issues including (i) deciphering the genome sequence of *Picrorhiza kurrooa*; (ii) studying cultivable endophytes of *Arnebia euchroma* that offer adaptive advantage to the species, and (iii) deciphering the molecular mechanisms of prickle morphogenesis in rose.

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Plant Growth Promoting Rhizobacteria

The rhizobacteria earlier isolated from the saffron rhizosphere was found to be highly tolerant to stress. It could grow in temperature spanning across 4°C-52°C, pH ranging from 4-8, could grow under high salinity and osmotic conditions. Experiments were laid to assess various plant growth promoting attributes like phosphate solubilization, siderophore production, ACC-deaminase production and IAA production under varied temperature regime. Interestingly, it was observed that though temperature impacted the growth promoting potential to a varying extent but the bacteria retained its plant growth promoting property under low and high temperature regime making it a good candidate for biofertilizer.

The identification was carried out by extracting DNA from the pure colonies raised on TSA adopting standard 16s rRNA sequencing technique, using 27F and 1492R primers. The sequence thus obtained was analyzed through BLAST (NCBI website) and was found to exhibit 99.8% similarity with Bacillus altitudinis. The bacteria was deposited to MTCC, IMTECH Chandigarh and ID MTCC 25416 has been assigned to it.

The impact of *Bacillus altitudinis* in ameliorating salinity stress in *Valeriana jatamansi* was studied in pots under the controlled condition at CSIR-IHBT. The salinity of soil was increased gradually by adding 500mM NaCl solution in targeted pots (T3 and T4) till Electrical conductivity(EC) reached 8ds/m. Thereafter, the salinity level was maintained throughout the experiment. The following experiment was set up in triplicate (Table 1). About 30 days old uniform plants of *V. jatamansi* procured from CSIR-IHBT Chandpur farm were used for the investigation.

Table 1. Treatments of *Valeriana jatamansi*

T1	Plants without salinity stress and without PGPR
T2	Plants without salinity stress with PGPR
T3	Plants with salinity stress without PGPR
T4	Plants with salinity stress with PGPR

Various growth parameters were recorded and biochemical analyses conducted 45 days after planting in pots. Maximum root length, shoot length, aerial biomass and root biomass was recorded in T2 treatment (Plants without salinity stress with PGPR) clearly indicating that PGPR promotes the overall growth of plants. When the plants were subjected to salinity stress, it was observed that PGPR treated plants (T4) were more green and healthy than the non-treated plants (T3). The shoot length was 1.45 times and the aerial biomass was 5.33 times more than T3 plants. However, there was no significant difference between T3 and T4 root length and root biomass. The biochemical analysis of the plants revealed that biofertilizer treated non stressed plants (T2) had maximum total chlorophyll (a and b) and carotenoids followed by biofertilizer treated stressed plants (T3). Lipid peroxidation associated with salt stress was found to be highest in T3 plants while it was 2.18 times less in PGPR treated counterpart (T4), indicating that PGPR imparts salt tolerance to plants. This was further strengthened by the trends of antioxidants produced in PGPR treated plants. Further studies are being carried out in this area to understand the salt tolerance mechanism.

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

Experiments were initiated to cut down the cost of tissue culture protocol already developed by the Institute (M1). The challenge was to use low-cost media components without compromising the rate of propagation. In this regard following four media alternatives were tried by substituting carbon source and gelling agent (Table 2).

Saffron corms (upto 3 cm) were placed in an Induction medium after thorough cleaning and surface sterilization and by 22 days sprouting of several shoot buds were observed. After 22 days the shoot buds were carefully split and transferred to proliferation medium and kept for another 21 days at 15°C under 38μmolm^{-2}S^{-1}. No significant difference was noticed with respect to plant response in different medium (Table 3 and Fig. 1) though there was 6.23 times cost reduction compared to standard M1 medium.

Table 2. Cost comparison of medium

Cost per flask in Rs	M1(standard Medium)	M2	M3	M4	M5
Induction Media (For 22 days)	10.30	1.61	6.18	8.08	8.40
Proliferation Media (For 22 days)	10.40	1.71	6.28	8.18	8.50
Total cost	**20.70**	**3.32**	**12.37**	**16.26**	16.90

Table 3. Plant response in different medium

Media type:	Day 0-7	day 8-14	day 15-22
M1	Sprouting initiated	Sprouted shoot were about 7-8 cms	shoots were 8-about 11cm and ready for subculturing
M2	Sprouting initiated	Sprouted shoot were about 5-7cms and were ready for subculture.	shoots were 8-about 11 cm and ready for subculturing
M3	Sprouting initiated	Sprouted Shoot were about 5-10cms	Shoots were about 8-11cms and were ready for sub culturing.
M4	Sprouting initiated	Sprouted shoots were about 5-8cms; slight release of phenolics was noticed	Shoots were 8- 11 cms and were ready for sub culturing.
M5	Sprouting initiated	Sprouted Shoots were about 6-8cms	Shoots were 9-11cms and were ready for sub culturing.

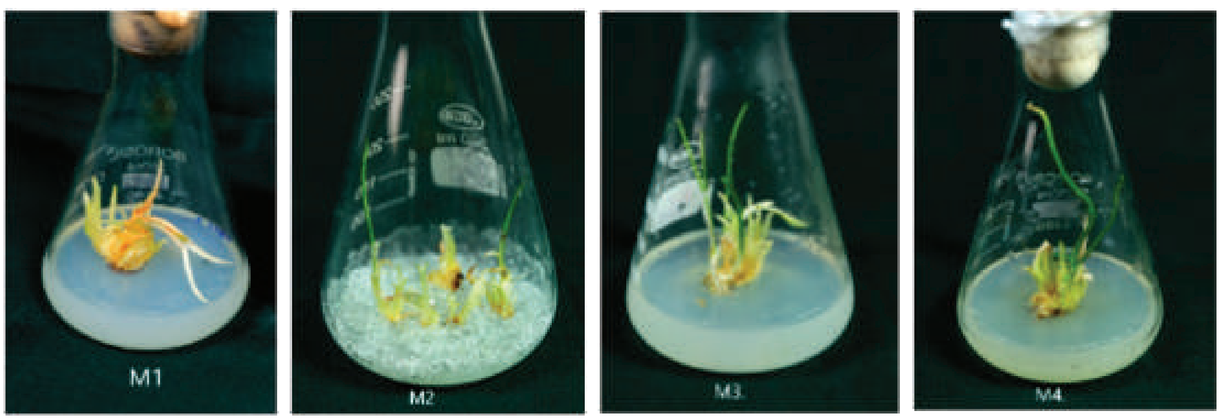


Fig. 1 Response in proliferation media

The other aspect of this project is to increase the size of tissue cultured raised corms through the application of Plant Growth Promoting Rhizobacteria in field. In this regard saffron corms of different sizes were sorted and categorized according to their weight and treated with PGPR based biofertilizer. They were characterized in six categories: 9 -10 gm of corms procured from Kashmir; 4-6 gm of corms procured from Kashmir; 6-7 gm of corms raised at CSIR-IHBT field; 3-4 gm of corms raised at CSIR-IHBT field; 1-2 gm of tissue culture corms of CSIR-IHBT; and 0.5-1 gm of corms of tissue culture corms of CSIR-IHBT. The results will be analyzed once the harvesting is done in the month of June.

The analysis of field trials laid earlier as a look “see experiment” revealed that corms of different sizes respond differently to PGPR treatment. The small corms raised through tissue culture (0.5 -1gm) treated with PGPR increased 2.0 times in size compared to untreated counterparts, while for medium sized tissue cultured corms (1-2 gm) PGPR treatment favoured production of daughter corms which was about 4 times more than the non-treated controls, but average weight of daughter corms of treated and non- treated were similar. In commercial sized field grown corms (9-10 gm) PGPR slightly favoured (non significant) higher daughter corms production but significantly improved the weight of daughter corms by 1.5 times over non treated controls. Further experiments are underway to understand the impact and growth promoting trend of PGPRs.

Transfer of technology is an important component of this project. In this regard an entrepreneur, Mr. Rajveer was incubated under Chief Minister's Startup scheme for the production of biofertilizer (Fig. 2). Growth curve of *B. altitudinis* was critically studied and several cost effective media mainly by substituting cheap carbon and nitrogen source were tried. Thereafter, processing parameters were standardized in a cost effective media for the production of *B. altitudinis in* 25 L bioreactor. The production can be further upscaled whenever required. An eco-friendly low cost material was selected as a carrier matrix and the biofertilizer thus produced was found to have shelf- life of over 9 months and BCR > 2.5. To strengthen the product further, samples of biofertilizer were provided to farmers to get their feedback. To assess the growth promoting potential of the biofertilizer experiments were laid in tomato plants in pots under controlled condition, in marigold under open field and in pots under greenhouse condition and in tulsi under field condition at CSIR-IHBT. The initial results appeared promising and detailed analyses are underway.

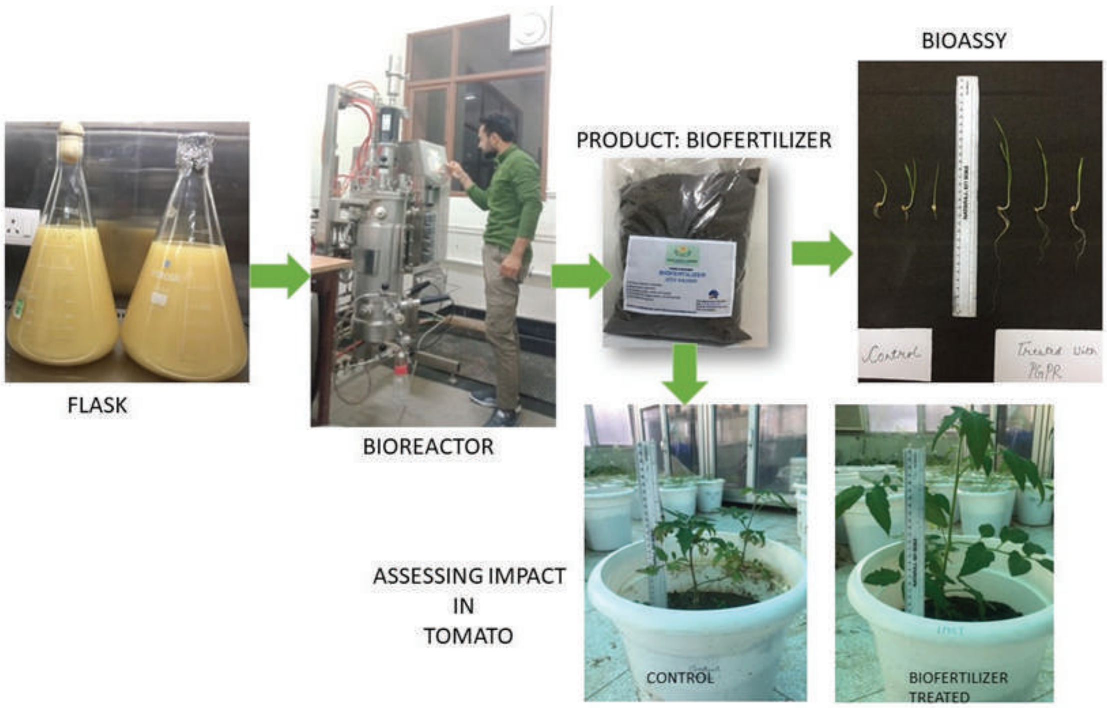
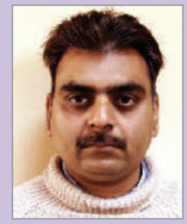


Fig. 2 Biofertilizer production and assessing its potential

Research Group: Nilofer Ali, Sukrit Saklani and Rajveer



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Plant Microbe Interaction of Plant Viral Pathogens

The lab works in the area of plant microbe interaction involving viral and viroid pathogens, molecular characterization, epidemiology and farmer friendly diagnostics for commercially important crop viruses. Current projects 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)" and "Studies to identify host factors that are manipulated by Cucumber mosaic virus for disease development and spread (DST SERB)" deal 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.

PkGPPS.SSU interacts with two PkGGPPS to form heteromeric GPPS in *Picrorhiza kurrooa*: Molecular insights into the picroside biosynthetic pathway

Geranyl geranyl pyrophosphate synthase (GGPPS) is known to form an integral subunit of the heteromeric GPPS (geranyl pyrophosphate synthase) complex and catalyzes the biosynthesis of monoterpene in plants. *Picrorhiza kurrooa* Royle ex Benth., a medicinally important high altitude plant is known for picroside biomolecules, the monoterpenoids. However, the significance of heteromeric GPPS in *P. kurrooa* still remains obscure. Here, transient silencing of *PkGGPPS* was observed to reduce picroside-I (P-I) content by more than 60% as well as picroside-II (P-II) by more than 75%. Thus, *PkGGPPS* was found to be involved in the biosynthesis of P-I and P-II besides other terpenoids. To unravel the mechanism, small subunit of GPPS (PkGPPS.SSU) was identified from *P. kurrooa*. Protein-protein interaction studies in yeast as well as bimolecular fluorescence complementation (BiFC) in planta have indicated that large subunit of GPPS PkGPPS. LSUs (PkGGPPS1 and PkGGPPS2) and PkGPPS. SSU form a heteromeric GPPS (Fig. 1). Presence of similar conserved domains such as light responsive motifs, low temperature responsive elements (LTRE), dehydration responsive elements (DREs), W Box and MeJA responsive elements in the promoters of PkGPPS.LSU and PkGPPS. SSU documented their involvement in picroside biosynthesis.

Further, the tissue specific transcript expression analysis vis-à-vis epigenetic regulation (DNA methylation) of promoters as well as coding regions of PkGPPS.LSU and PkGPPS.SSU strongly suggest their role in picroside biosynthesis. To conclude, the newly identified PkGPPS.SSU formed the heteromeric GPPS by interacting with PkGPPS. LSUs to synthesize P-I and P-II in *P. kurrooa*.

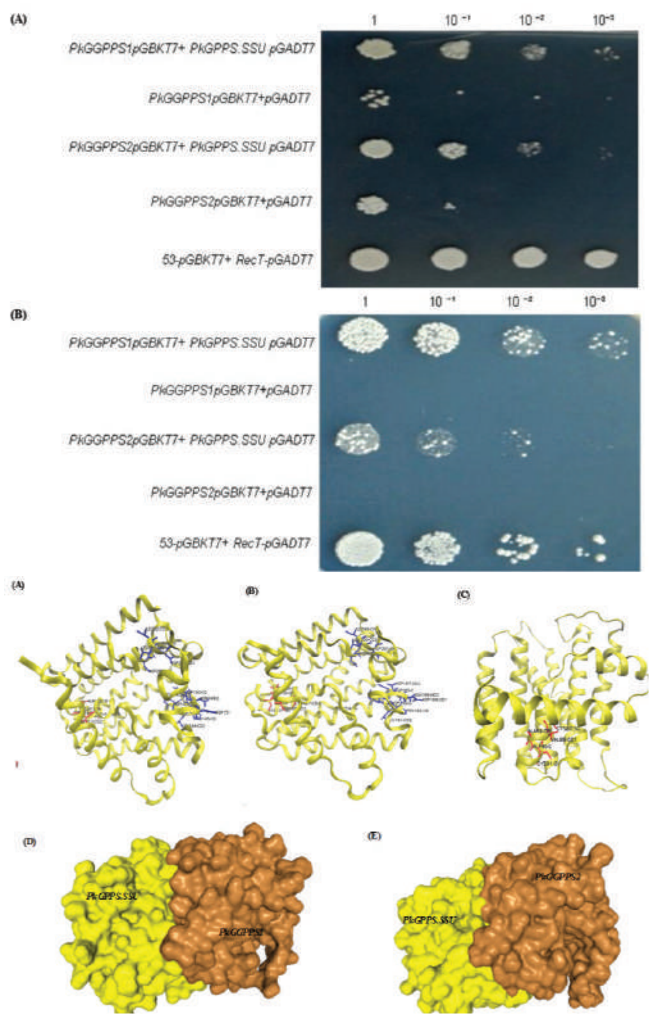

Fig. 1 (a) Yeast two-hybrid analysis and (b) their bioinformatics based structural analysis to understand protein-protein interaction of the subunits

Mapping the gene expression spectrum of mediator subunits in response to viroid infection in plants (in collaboration with Czech group)

The mediator (MED) represents a large, conserved, multi-subunit protein complex that regulates gene expression through interactions with RNA polymerase II and enhancer-bound transcription factors. Expanding research accomplishments suggest the predominant role of plant MED subunits in the regulation of various physiological and developmental processes, including the biotic stress response against bacterial and fungal pathogens. However, the involvement of MED subunits in virus/viroid pathogenesis remains elusive. In this study, we investigated for the first time the gene expression modulation of selected MED subunits in response to five viroid species (*Apple fruit crinkle viroid, Citrus bark cracking viroid, Hop latent viroid, Hop stunt viroid , and Potato spindle tuber viroid*) in two model plant species (*Nicotiana tabacum and N. benthamiana*) and a commercially important hop (*Humulus lupulus*) cultivar. Our results showed a differential expression pattern of *MED* subunits in response to a viroid infection (Fig. 2).

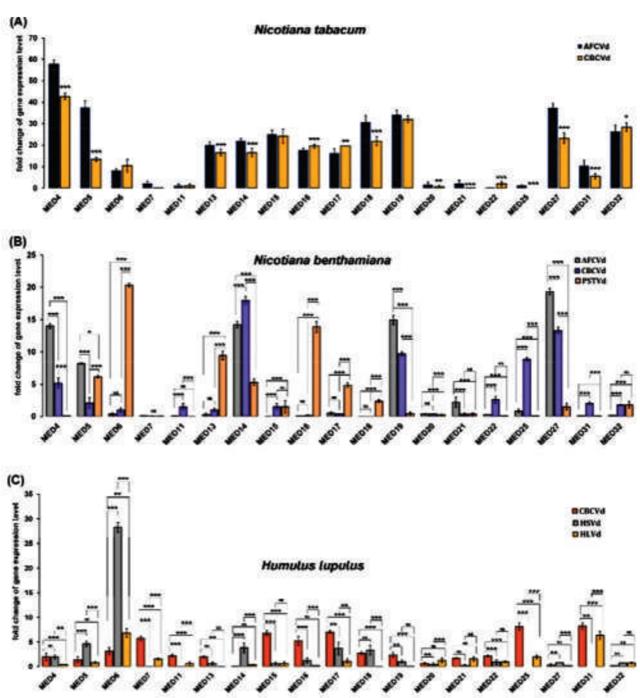

Fig. 2 Reverse transcriptase quantitative real-time PCR (RT-qPCR)-based expression profiling of selected mediator subunits in response to the viroid infection in *N. tabacum* (A), *N. benthamiana* (B) and hop (C) plants

The individual plant *MED* subunits displayed a differential and tailored expression pattern in response to different viroid species, suggesting that the *MED* expression is viroid- and plant species-dependent. The explicit evidence obtained from our results warrants further investigation into the association of the *MED* subunit with symptom development. Together, we provide a comprehensive portrait of *MED* subunit expression in response to viroid infection and a plausible involvement of *MED* subunits in fine-tuning transcriptional reprogramming in response to viroid infection, suggesting them as a potential candidate for rewiring the defense response network in plants against pathogens.

Development of immunodiagnostics for *Apple stem pitting virus* and *Apple mosaic virus infecting apple* in India

Apple stem pitting virus (ASPV) and *Apple mosaic virus* (ApMV) are considered to be among the major viral pathogens infecting apple. These viruses have high disease incidence in the apple orchards of Jammu & Kashmir (J&K) and Himachal Pradesh (HP), so a method was required for easy virus detection. Here, we have attempted to develop a polyclonal antiserum against the coat proteins of both these viruses expressed in bacterial systems for serological based diagnostics. The purified proteins were used for rabbit immunizations and subsequently for raising antibodies. These antibodies were conjugated with alkaline phosphatase and an ELISA based protocol was standardized for detection of both the viruses. We evaluated seventy-five field samples both for ASPV and ApMV of which 25 samples for ASPV and 21 samples for ApMV were tested positive by DAS-ELISA, corroborated by RT-PCR analyses. An immunocapture was standardized for ASPV detection using the developed antibody for validation purpose.

New record of a monopartite begomovirus and papaya leaf curl betasatellite infecting *Mirabilis jalapa* in Himachal Pradesh, India

Mirabilis jalapa is an important plant species for its ornamental and medicinal values. Leaf samples showing vein yellowing symptoms were collected from kangra district of Himachal Pradesh and examined for begomovirus infection (Fig. 3). PCR analysis using DNA-A and betasatellite specific primers gave desired amplification in all infected samples. However, no PCR amplification was obtained for DNA-B that suggested monopartite nature of the infecting virus.

Sequence analysis showed that the partial begomovirus sequence was most similar (92%) to *Mirabilis leaf curl virus* (MLCV). The full-length betasatellite (1374 bp) showed highest identity (99%) to *Papaya leaf curl betasatellite* (PaLCuB), reported from *Valeriana jatamansi*. Phylogenetic analysis clustered begomovirus sequence with MLCV whereas the betasatellite sequence clustered with various isolates of PaLCuB reported from India and Pakistan. This is the first report of a monopartite begomovirus and papaya leaf curl betasatellite on a new host, *M. jalapa*.

Fig. 3 (a) *Mirabilis jalapa* plant showing typical vein yellowing phenotype, and close-up view of a leaf showing yellow network of veins

Molecular and biological characterization of an Indian variant of *Chrysanthemum stunt viroid*

Chrysanthemum stunt viroid (CSVd), is known to cause severe stunting symptoms in chrysanthemum (Fig. 4). A strain that infects chrysanthemum in India has been identified and biologically characterised 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. Sequence changes in the Terminal Conserved region (TCR) corroborated with change in RNA secondary structure which might have implications associated with the viroid pathogenicity.

Fig. 4 Image showing CSVd transcripts inoculated on chrysanthemum plant displayed stunting symptoms (right) compared to healthy plants (left) and inset shows mottling symptoms observed on same CSVd infected plant

Research group: Surender Kumar, Aditya Kulshrestha, Bharati Barsain, Ranjana Gautam, Usha Kumari Rattan, Bipasha Bhattacharjee, Kamini Kapoor, Savita Chaudhary, Anish Tamang, Preshika Awasthi, Yashika and Ishwer Jadhav

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Our current efforts to utilize next-generation molecular genetics and genomics approaches for harnessing natural diversity for genetic improvement of Himalayan plant genetic resources and commercial important plant species. I am the key investigator of aroma and Fundamental Basic Research (FBR), and various projects sponsored by DST, DBT and NTRF, including international Indo-Sri Lanka joint research project on tea. In continuation of the previous reports, during the period under report following achievements were made by the group.

Transcriptional dynamics of quality characteristics in tea (*Camellia sinensis* (L.) O. Kuntze)

Tea quality is a polygenic trait that exhibits tremendous genetic variability due to accumulation of array of secondary metabolites. To elucidate global molecular insights controlling quality attributes, metabolite profiling and transcriptome sequencing of twelve diverse tea cultivars was performed in tea shoots harvested during quality season. RP-HPLC-DAD analysis of quality parameters revealed significant difference in catechins, theanine and caffeine contents.

Transcriptome sequencing resulted into 50,107 non-redundant transcripts with functional annotations of 81.6% (40,847) of the transcripts (Fig. 1). Interestingly, 2872 differentially expressed transcripts exhibited significant enrichment in 38 pathways (FDR ≤ 0.05) including secondary metabolism, amino acid and carbon metabolism. Thirty-eight key candidates reportedly involved in biosynthesis of fatty acid derived volatiles, volatile terpenes, glycoside hydrolysis and key quality related pathways (flavonoid, caffeine and theanine-biosynthesis) were highly expressed in catechins-rich tea cultivars (Fig .1)

Flavonoids, synthesized through a well characterized flavonoid pathway, constitute the most abundant metabolite present in plants including tea. In our study, PAL, 4CL, CHS, CHI/CFI, F3′ H, F3′5′ H, ANS and LAR genes involved in flavonoid pathway were highly expressed in catechins-rich cultivars as compared to moderate and low-catechin cultivars (Fig. 2).

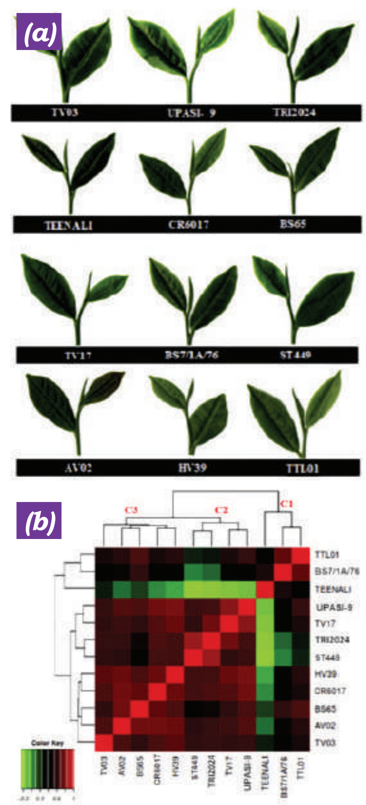

Fig. 1 (A) Shoots (two leaves and bud) of cultivars used in the present study. (B) Correlation matrix of differentially expressed transcripts depicting clustering of the 12 tea cultivars

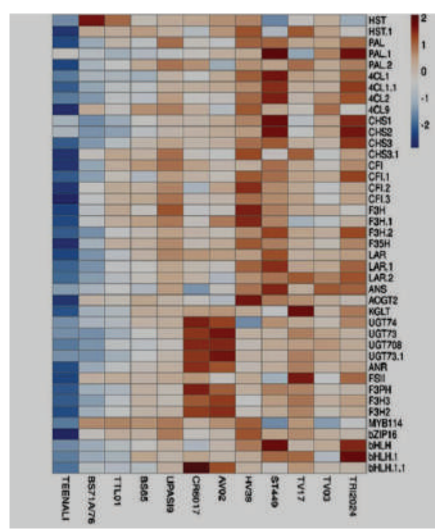

Fig. 2 Heat map of differentially expressed transcripts associated with genes involved in Flavanoid biosynthesis in 12 diverse tea cultivars

Furthermore, enrichment of candidates involved in flavonoid biosynthesis, transcriptional regulation, volatile terpene and biosynthesis of fatty acid derived volatile in protein-protein interactome network revealed well-coordinated regulation of quality characteristics in tea (Fig. 3).

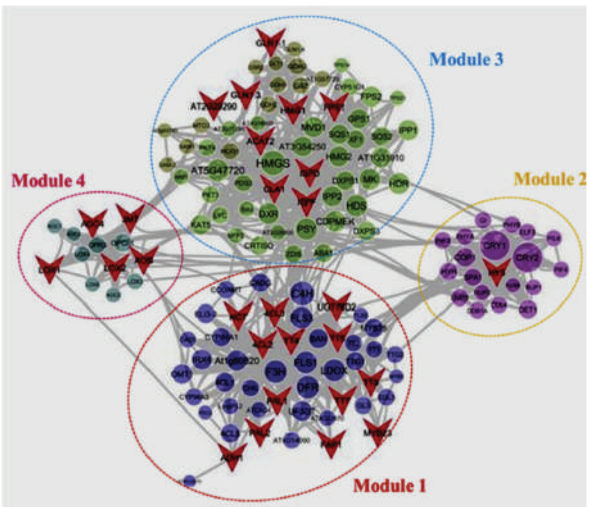

Fig. 3 Protein-protein interaction (PPI) network of the differentially expressed transcripts. Inverted red nodes are the mapped DEGs

Additionally, ascertainment of 23,649 non-synonymous SNPs and validation of candidate SNPs present in quality related genes suggests their potential utility in genome-wide mapping and marker development for expediting breeding of elite compound-rich tea cultivars (Fig. 4).

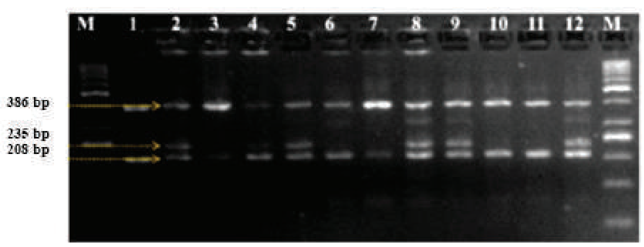

Fig. 4 Representative gel showing allele-specific amplification of SNPs in diverse tea cultivars. Numbers 1–12 represent cultivars; TV17, TRI2024, TV03, CR6017, BS65, AV02, ST449, HV39, TEENALI, UPASI-9, BS7/1A/76 and TTL01 respectively

Transcriptome sequencing of multiple diverse tea cultivars enriches the functionally relevant genomic resources in tea. Furthermore, ascertainment and validation of high-quality trait specific non-synonymous SNPs can be utilized for development of high-density genotyping platform for expediting molecular breeding in tea. ***(Genomics 113 (2021) 305–316)***

Molecular dissection of seasonal induced anthocyanin degradation and leaf color transition in purple tea (*Camellia sinensis* (L.) O. Kuntze)

Purple-tea, an anthocyanin rich cultivar has recently gained popularity due to its health benefits and captivating leaf appearance. However, the sustainability of purple pigmentation and anthocyanin content during production period is hampered by seasonal variation. To understand seasonal dependent anthocyanin pigmentation in purple tea, global transcriptional and anthocyanin profiling was carried out in tea shoots with two leaves and a bud harvested during in early (reddish purple: S1_RP), main (dark gray purple: S2_GP) and backend flush (moderately olive green: S3_G) seasons. Of the three seasons, maximum accumulation of total anthocyanin content was recorded in S2_GP, while least amount was recorded during S3_G (Fig. 5).

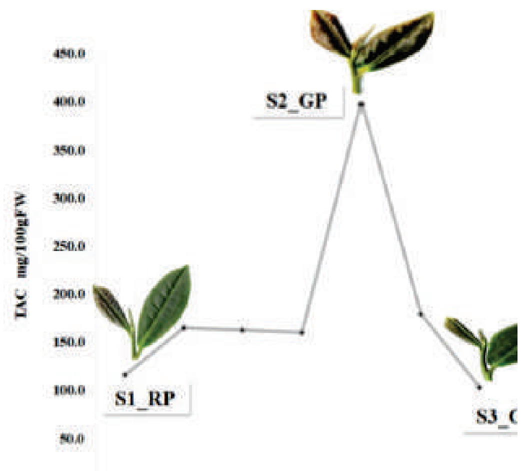

Fig. 5 Leaf color transition and variation in total anthocyanin content

Reference based transcriptome assembly of 412 million quality reads resulted into 71,349 non-redundant transcripts with 6081 significant differentially expressed genes.

Interestingly, key DEGs involved in anthocyanin biosynthesis [PAL, 4CL, F3H, DFR and UGT/UFGT], vacuolar trafficking [ABC, MATE and GST] transcriptional regulation [MYB, NAC, bHLH, WRKY and HMG] and Abscisic acid signaling pathway [PYL and PP2C] were significantly upregulated in S2_GP. Conversely, DEGs associated with anthocyanin degradation [Prx and lac], repressor TFs and key components of auxin and ethylene signaling pathways [ARF, AUX/IAA/

SAUR, ETR, ERF, EBF1/2] exhibited significant upregulation in S3_G, correlating positively with reduced anthocyanin content and purple coloration (Fig. 6).

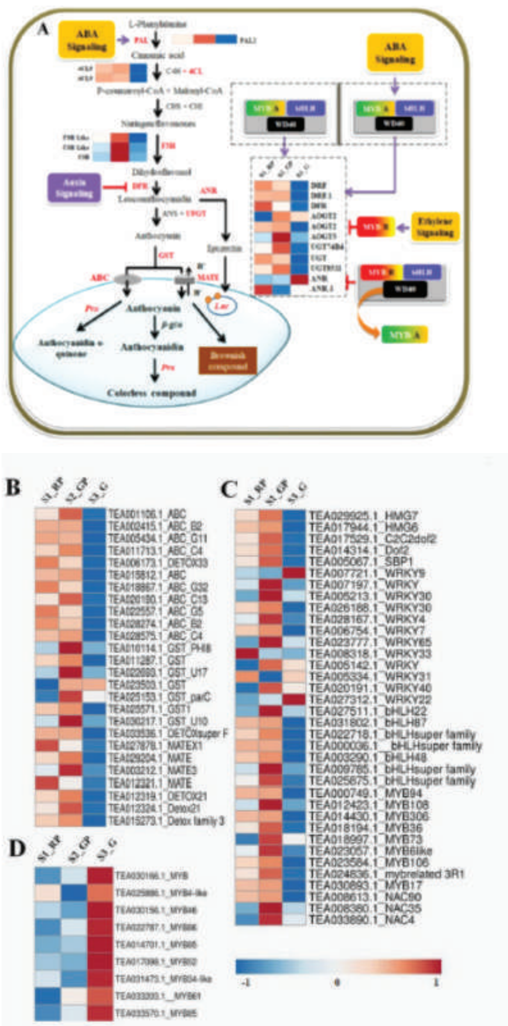

Fig. 6 (A) Anthocyanin biosynthesis pathway. (B) Heatmap of differentially expressed transporters. (C) Transcription factors associated with anthocyanin biosynthesis in tea. (D) Putative repressor MYBs

Interestingly, upregulated expression of anthocyanin reductase (ANR) reportedly involved in epicatechin biosynthesis was negatively correlated with TAC during S3_G indicating their important role in regulating metabolic flux towards anthocyanin biosynthesis in tea. Moreover, distribution of anthocyanin biosynthesis genes in 11 of 15 chromosomes including Chr1, Chr2, Chr3 and Chr10 successfully mapped with quality related QTLs, suggests close linkage between anthocyanin and other quality related parameters in tea (Fig. 7).

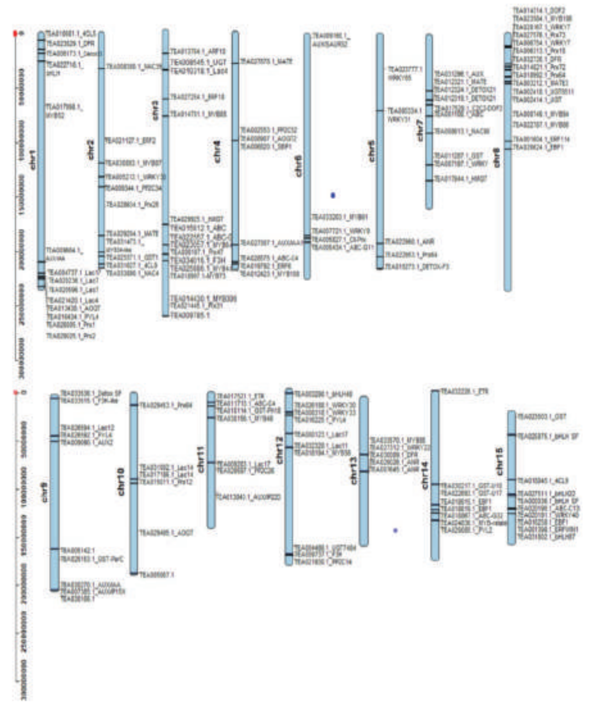

Fig. 7 Chromosomal distribution of DEGs involved in anthocyanin biosynthesis and degradation in tea

The present study for the first-time elucidated genome-wide transcriptional insights and hypothesized the involvement of anthocyanin biosynthesis activators/repressor and anthocyanin degrading genes via peroxidases and laccases during seasonal induced leaf color transition in purple tea. Futuristically, key candidate gene(s) identified here can be used for genetic engineering and molecular breeding of seasonal independent anthocyanin-rich tea cultivars. (Scientific Reports (2021) 11:1244).

Elucidation of key regulators of PTOX biosynthesis in geographically separated *Podophyllum hexandrum*

Podophyllum hexandrum is the major source of podophyllotoxin (PTOX), a highly bioactive lignan of great pharmacological importance with anti-cancerous activities. The industrial demand of PTOX relies on the highly endangered natural resources only. It is therefore, desirable to elucidate global molecular processes and identify key genes for enhancing PTOX biosynthesis by overexpressing the targeted candidates. Transcriptome of leaf, rhizome, and stalk was generated to analyze the spatial regulation of PTOX biosynthesis in genetically diverse genotypes. Overall, 198 million high-quality paired-end reads were assembled into 85,531 transcripts. In addition, 32,341 transcripts were assigned gene ontologies with 6570 hits in distinct pathways and 15,886 transcription factors representing 70 families (Fig. 8).

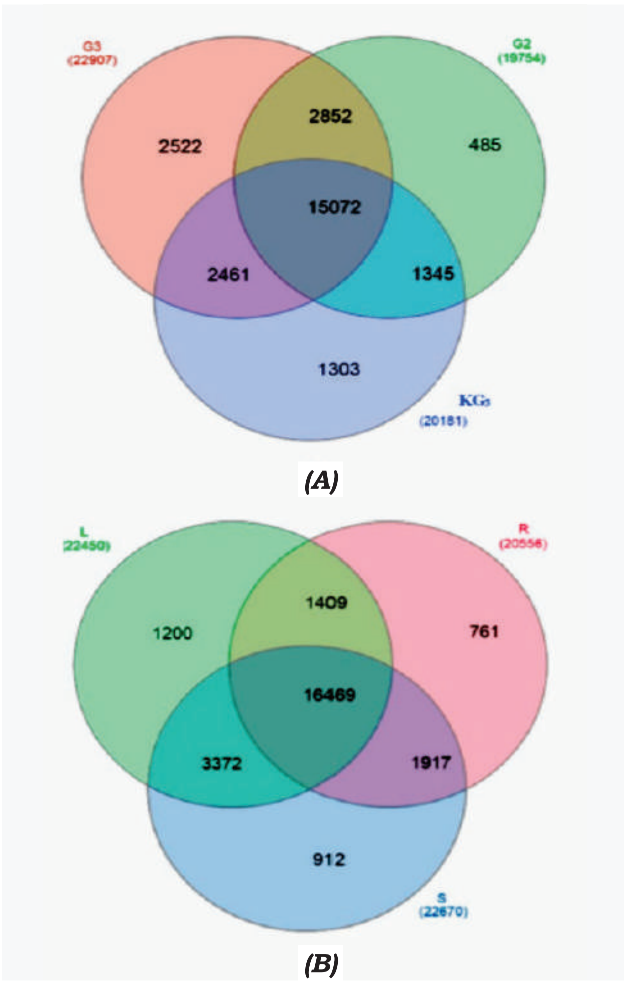

Fig. 8 Summary of significant and differentially expressed genes (FDR>0.05) in *P. hexandrum* (A) for three genotypes-GG1, GG2, and KG3; (B) for tissues-leaf (L), stalk (S), and rhizome (R)

Interestingly, comparative expression analyses revealed that 12 of 31 genes of PTOX biosynthesis were upregulated in rhizome. However, shikimate and phenylalanine pathways that generate PTOX precursors were abundantly upregulated in leaves. Thus, a further insight on the inducers of these genes can be extended to enrich the aerial tissues for downstream pathway through genetic manipulations. Additionally, higher expression of transcription factors WRKY, MYB, bZIP, bHLH, and AP2, transporters ABCB and ABCC, UGTs, CYP450s, and jasmonate pathway in rhizome supported the secondary metabolism (Fig. 9).

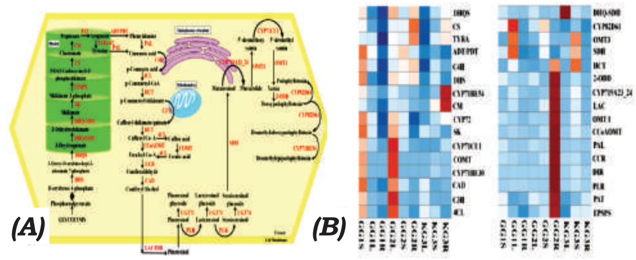

Fig. 9 (A) Diagrammatic representation of PTOX biosynthesis pathway genes and (B) Heat map representing the differential expression of these genes in geographically separated genotypes

The comprehensive genomic resource created during this study will provide deeper understanding of lignan biosynthesis and its regulation. This will further enable selection of the elite genotypes and potential genes that can be directed to enhance PTOX production and yield at an industrial scale. (***Industrial Crops and Products*** (2020) 147: 11224)

Genome-wide microsatellite markers resource and population genetic diversity inferences of *Trillium govanianum*

Trillium govanianum ethnobotanical perspectives include the treatment of cancer, hypertension, neurasthenia, giddiness, arthritis, dysentery, and inflammation. As its industrial demand for steroidal content is increasing, the endemic species have been subjected to severe habitat degradation and fragmentation by the illicit trade in Indian Himalayan Region (IHR). Additionally, molecular genetics efforts in *T. govanianum* has also lagged, mainly because of the non-availability of genome-wide molecular marker resources. Apropos, using tissue specific transcriptomic data derived from the rhizome, stem, leaf, and fruit, the present study identified 5337 novel functionally relevant genome-wide SSR markers. The tri repeats were most abundant (41%) with a higher occurrence of CCG/CGG repeat motif, mostly located in the CDS region (Fig. 10). Based on functional annotations of SSR transcripts with multifarious public databases (NR, TAIR, KEGG, KOG, SwissProt & PTFdb), a set of 288 SSR markers encompassing important roles in steroidal saponins pathway, cellular and metabolic processes such as response to stress, binding, and catalytic activity were validated, successfully. Genetic diversity and population structure analysis of 290 genotypes of 14 geographically distinct populations representing eight different valleys (2086–3500 m amsl) of the IHR amplified an average of 4.33 alleles per locus. Overall, a low genetic diversity (He: 0.25), high genetic divergence (GST: 0.23), high within populations molecular variance (72 %), limited gene flow (0.792), and slight positive isolation by distance (Rxy = 0.260; p = 0.030) is recorded in *T. govanianum* populations. Further, neighbor-joining (NJ) based hierarchical clustering, PCoA, and Bayesian structure clustering identified two major groups in the tested populations (Fig. 11). Novel microsatellite marker resources and population diversity inferences studied for the first time revealed that there is a need to recuperate diversity *in situ* and maintain effective population size, a much-required step to mitigate high anthropogenic pressure on *T. govanianum* in Indian Himalayan region. (***Industrial Crops and Products*** (2020) 154: 112698)

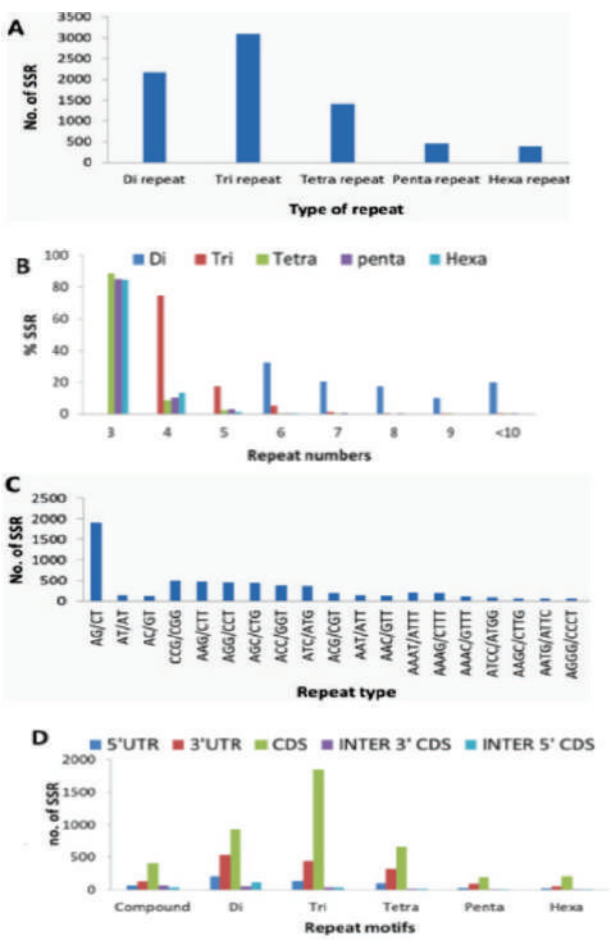

Fig. 10 Characteristics and distribution of microsatellites in *Trillium govanianum.* (A) Percentage distribution of different repeat type classes; (B) Relative frequency (%) of SSR types by the number of repeat units; (C) Relative percentage frequency of classified repeat types; (D) Localization of SSRs in different genic regions

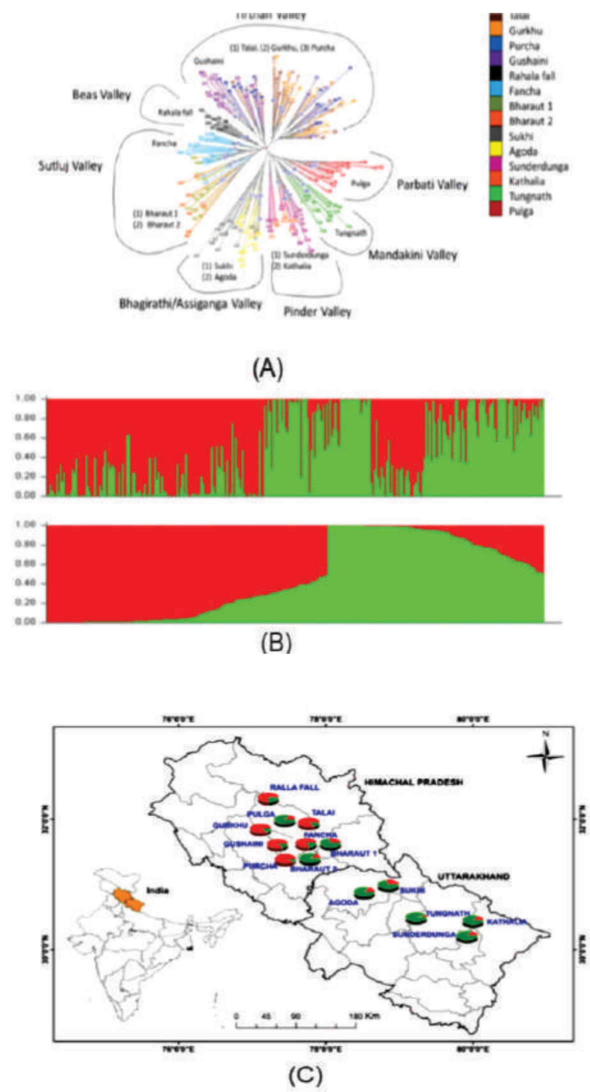

Fig. 11 (A) Neighbour-joining tree based on genetic distances of 290 individuals of *Trillium govanianum* from 14 populations of the Indian Himalayan Region. (B) Bayesian analysis of population structure (Structure software) using the admixture model. (C) Bayesian analysis of population structure (Structure software) using the admixture model

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Any living system is an outcome of the interactions between its various regulatory components and their networks. These components may be classified into two major levels: transcriptional regulators and post-transcriptional regulators.

Transcriptional regulators like transcription factors and enhancers have been studies a lot. Lately, attention has been paid to post-transcriptional regulators like miRNAs. However, there exist another post-transcriptional regulator, the RNA Binding Proteins, which are supposed to be the biggest regulators. For any given condition, a cell expressed only 2-3% of transcription factors, but almost 10 times more RNA binding proteins, suggesting clearly that how bigger stake these regulators have in the genome.

Machine learning on predicting RBP-miRNA interactions

Interestingly, another post-transcriptional regulator, miRNAs which controls regulation of majority of the genes of any system, is itself enormously dependent upon post-transcriptional regulation by RNA binding proteins (RBPs). miRNA turnover is highly spatio-temporal in nature and for that these RBPs are responsible.

For past couple of years we dedicated our efforts to unravel the communication system of these post-transcriptional regulators and how RBPs affect and control miRNAs formation. In doing so, we analyzed more than 25 TB of HTS data from different platforms and derived the Bayesian causal nets for 1,204 human miRNAs which could explain their biogenesis levels for any given conditions with >90% accuracy when modelled through a machine learning approach. These models have been tested across wide range of experimental conditions, profiles, and cell lines and stood firmly robust and accurate in predicting the miRNAs profile. The developed algorithm has been translated into a freely available software system, miRbiom, availability at our lab website. A user just needs to provide the RNA-seq data for any experimental condition, and in turn the software gives miRNA profile for that given condition without need of doing miRNA-seq experiments or any sort of dedicated miRNA profiling experiment.

Besides predicting the miRNAs profile, the software also provides provisions for in depth target and system analysis supported by highly visually rich and interactive user interface, going as deep as targets discovery, enrichment analysis and pathways mapping.

The software is available at: https://scbb.ihbt.res.in/miRbiom-webserver/

Other notable research contributions

Further to this front, transcriptome analysis of *Rheum australe* was also done to study them for the difference between the naturally grown plants and those grown in a controlled manner.

On nSARS-CoV2 research front, screening and molecular structural analysis of natural componds against the virus done.

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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. The main protease (Mpro) is a well characterized and attractive drug target because of its crucial role in processing of the polyproteins which are required for viral replication. In order to provide potential lead molecules against the Mpro for clinical use, we docked a set of 65 bioactive molecules of Tea plant followed by exploration of the vast conformational space of protein-ligand complexes by molecular dynamics (MD) simulations (1.50 µs). Top three bioactive molecules (Oolonghomobisflavan-A, Theasinensin-D, and Theaflavin-3-O-gallate) were selected by comparing their docking scores with repurposed drugs (Atazanavir, Darunavir, and Lopinavir) against SARS-CoV-2. Oolonghomobisflavan-A molecule showed a good number of hydrogen bonds with Mpro and higher MM-PBSA binding energy when compared to all three repurposed drug molecules during the time of simulation. The overall work flow of the study is depicted in Fig. 1. The findings of this work were published in a repute journal [***J. Biomol. Struct. Dyn.***, 39(10): 1-10, 2020].

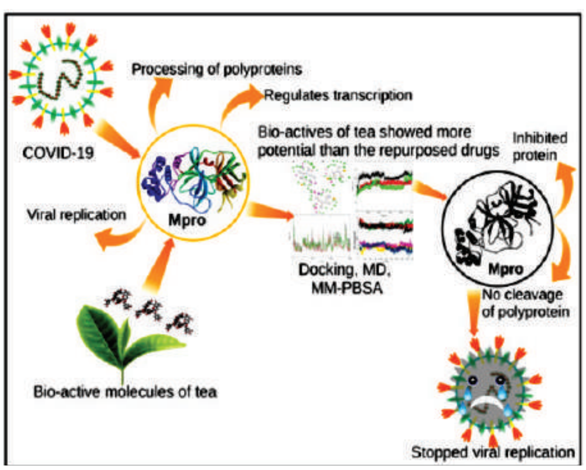

Fig. 1 The overall work flow of study to identify potential inhibitors of Mpro of SARS-CoV-2

In another study, we screened a set of novel classes of in-house developed acridinediones molecules to efficiently bind and inhibit the activity of the SARS-CoV-2 by targeting the Mpro. The repurposed FDA-approved antivirals were taken as standard molecules for this study. Long term MD simulations were performed to analyze the conformational space of the binding pocket of Mpro bound to the selected molecules. The molecules DSPD-2 and DSPD-6 showed more favorable MM-PBSA interaction energies and were seated more deeply inside the binding pocket of Mpro than the topmost antiviral drug (Saquinavir). Moreover, DSPD-5 also exhibited comparable binding energy to Saquinavir. The analysis of per residue contribution energy and SASA studies indicated that the molecules showed efficient binding by targeting the S1 subsite of the Mpro binding pocket. The DSPD-2, DSPD-6, and DSPD-5 could be developed as potential inhibitors of SARS-CoV-2. Moreover, we suggest that targeting molecules to bind effectively to the S1 subsite could potentially increase the binding of molecules to the SARS-CoV-2 Mpro. A pictorial representation summarizing the outcomes of study is shown in Figure 2. The findings of this work were published in a well reputed journal [***Comput. Biol. Med.***, 128: 104117, 2021].

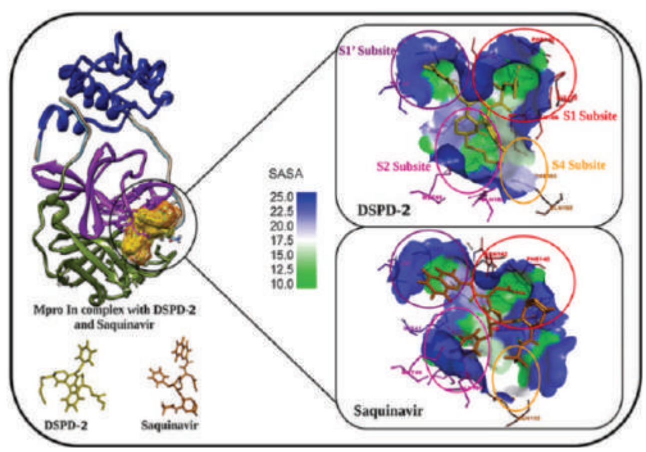

Fig. 2 A pictorial representation summarizing the inhibition of Mpro protein of SARC-CoV-2

Non-structural protein 15 (Nsp15) has emerged as a promising target for such inhibitor molecules. Nsp15, a member of the EndoU family of enzymes, is nidoviral RNA uridylate-specific endoribonuclease

(NendoU) with a catalytic domain at the C-terminal and has been observed to be conserved in various virus families. Targeting the conserved Nsp15 active site via potent inhibitor molecules will not only hinder its involvement in virus replication activity but also prohibit the protein from interfering with the host's innate immune response, enabling it to fight the viral invasion. We carried out this study with an aim of finding potent inhibitor molecules that could strongly bind to the active site of Nsp15. In this regard, we docked bioactive molecules of tea onto the active site of Nsp15. Based on their docking scores, top three molecules (Barrigenol, Kaempferol, and Myricetin) were selected and their conformational behavior was analyzed via molecular dynamics simulations and MMPBSA calculations. The results indicated that the protein had well adapted ligands in the binding pocket thereby forming stable complexes. These molecules displayed low binding energy during MMPBSA calculations, substantiating their strong association with Nsp15. The inhibitory potential of these molecules could further be examined by *in-vivo* and *in-vitro* investigations to validate their use as inhibitors against Nsp15 of SARS-CoV2. The major findings of the analysis are depicted in Fig. 3. The findings of this work were published in a well reputed international journal [***Food chem.***, 346: 128933, 2021].

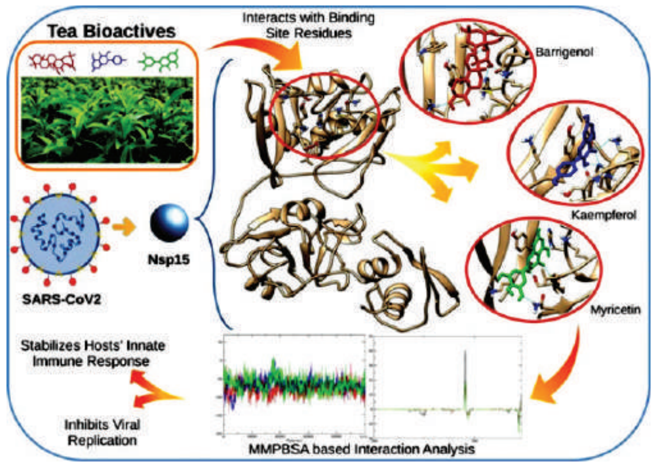

Fig. 3 The findings of the analysis to identify potential inhibitors of Nsp15 of SARS-CoV-2

Research group: Sachin Kumar, Ankita Dhiman, Vijay Kumar Bhardwaj and Rahul Singh

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The major focus of my lab is to bioprospect microbes of high altitude Himalayan niches for industrial applications. Also, we are trying to understand the adaptation of microbes to extreme niches in the Himalayas. In the past, we have found novel and unique bacteria with distinct features from extreme niches of high altitude (***FEMS Microbiol. Lett.*** *365*(14), fny144, 2018; ***Can. J. Microbiol.***, *64*(11): 798-808, 2018; ***3 Biotech,*** 9(7):275, 2019; ***Bioresour. Technol.*,** 319:124235, 2021). Further, we performed whole genome sequencing of novel bacterial isolates and dissected their survival and adaptation in the glacial and high altitude environment. Microbes from extreme niches have the capability to produce unique biomolecules and can accomplish the desired goal of the co-production of biomolecules to make commercially viable bioprocess.

Biodegradable bioplastic and violacein pigment from Himalayan bacterial source: Through isolation, screening, and characterization of bacterial isolates from high altitude niches, we reported for the first time few genera which are good producers of Polyhydroxyalkanoates (PHA). Furthermore, towards the co-synthesis of biomolecules, a unique bacterium, *Iodobacter* sp. PCH194 with innate ability to synthesize PHB and violacein pigment was isolated from the sediments of a kettle lake at high altitude in western Indian Himalaya. A *patent* on the developed bioprocess entitled "*Bioprocess for simultaneous production and extraction of polyhydroxybutyrate and violacein pigment from Himalayan bacterium Iodobacter sp. PCH 194*" has been filed and received patent application No. 202011039834, dated 12 Sept 2020.

A research finding from the patent work and additional work done on bioplastic and violacein pigment using *Iodobacter* has been published in a prestigious journal *Bioresource Technology*. In this paper, we discussed about a developed bioprocess for the co-production of biodegradable-bioplastic polyhydroxyalkanoates (PHA) and violacein pigment from Himalayan bacteria (Fig. 1). PHA has been evaluated for bioplastic and violacein for anticancerous and antimicrobial activities.

Key points:

- More than 400 Himalayan bacterial culture were isolated and screened for PHA synthesis.
- 181 bacterial isolates were found positive for PHA.
- Developed bioprocess co-produces PHB (11.0 ± 1.0 g/L) and violacein pigment (1.5 ± 0.08 g/L).

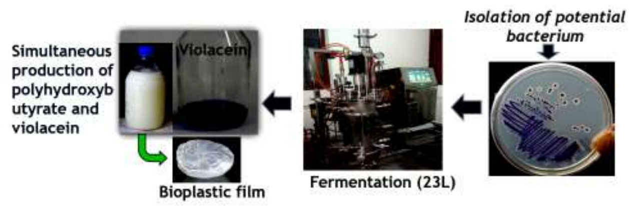

Fig. 1 Simultaneous production of polyhydroxy-butyrate and violacein pigment using *Iodobacter* sp.

Discovery of a bacterial Laccase enzyme with a role in lignin depolymerization: In this research finding, we developed a bioprocess for valorization of lignin by using bacterial enzyme identified from high altitude niches of western Himalaya. The extracellular enzyme is produced by bacterial fermentation using lignocellulose as a carbon source. Bacterial Laccase capable of lignin depolymerization is characterized and optimized for *in vitro* expression in the host bacterium *E. coli*. The process comprises of optimized conditions for Laccase production using wild and recombinant strain, and thereupon lignin depolymerization using wild type strain and purified recombinant enzyme (Fig. 2). The developed process has been filed as a *patent* with Ref. No. 0214NF2020, dated 01 Dec, 2020.

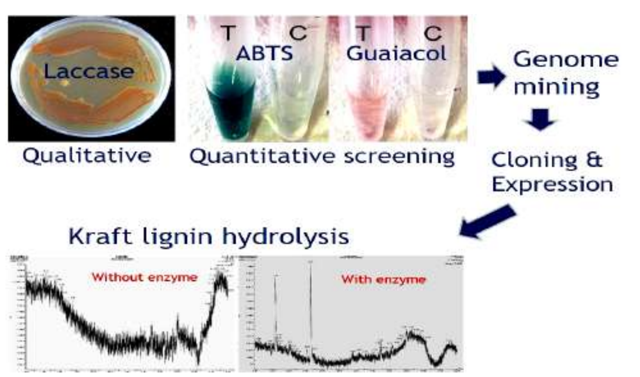

Fig. 2 Identification of bacterial Laccase enzyme and its process development for lignin depolymerrization

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The Chemical Nanotechnology and Nanobiology group at CSIR-IHBT takes bioresources as inspiration to design and synthesize different functional nanomaterials. The group with interdisciplinary people are focussed towards; (a) the development of anti-amyloidogenic and fibril destabilization nanomaterials and their mechanism studies to combat neurodegeneration, (b) anti-bacterial/anti-biofilm nanomaterials and their mechanism studies to combat antibiotic resistance, (c) exploring nanozymes as Point of Care (PoC) diagnostics responsive biomedical applications, biosensing and immunoassay, (d) nanomaterial-protein/cell interactions and their implications in determining the efficacy of nanomedicine, and (e) nanotechnological interventions to enhance the bioavailability of bioactive.

Carbon nanozyme with dual catalytic activity to counter cellular oxidative stress

Engineered carbon nanozyme (LC-CNS@NTA) was prepared from the nitrogen rich weed *Lantana camara* (LC). TEM studies revealed size of ~160 ± 20 nm for LC-CNS@NTA whereas, the same showed fluorescence emission at ~520 nm with ~63% quantum yield. The developed nanozyme showed bifunctional catalase and peroxidase activity to defy intracellular H_2O_2 stress.

Plant based hydrophilic cellulose nanoonions as cleanser for amyloidal protein to combat neurodegeneration

Chemical template mediated gold nanoparticle conjugated hydrophilic cellulose nanoonions were synthesized from cellulose nanocrystals. These photothermally active cellulose nanoonions showed inhibition against both Hen Egg White Lysozyme (HEWL) and amyloid β (Aβ42) fibrillation. The developed cellulose nanoonions reduced protein aggregation induced cytotoxicity via regulation of oxidative stress and ion homeostatis.

Nanoemulsion of citral to enhance its anti-bacterial activity

Process for the synthesis of citral nanoemulsion (NE) was developed. The developed NEs showed minimal decrease in oil content with retention of antioxidant activity. Further, these also showed enhanced anti-bacterial activity towards *Pseudomonas aeruginosa* compared to pure citral.

Green synthesized gold nanoparticle as novel anti-bacterial agent

Green synthesis of gold nanoparticles was achieved using plant extract. The role of plant polyphenols as stabilizers and as reducing agents were established through different spectroscopic techniques. Developed nanoparticles showed strong anti-bacterial activity against *P. aeruginosa*.

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Our research includes developing software as well as applying integration of system biology with machine learning to analyze and mine all kind of biological data available from Himalayan bio resources. Details of the research can be found at the link: fgcsl.ihbt.res.in.

Our latest work deal with the pipeline available for the interested researchers for calculation of molecular adaptation analysis of Himalayan microbes associated with cold conditions with the link:https://github.com/fgcsl/Molecular-daptational- analysis-cold.

Molecular adaptation analysis of *Arthrobacter* revealed insights into its survivability under multiple high-altitude stress in Himalayan region

We have carried out comparative genomic studies of two strains of *Arthrobacter*, ERGS1:01 and ERGS4:06, and their mesophilic counterparts with efficient survivability under high altitude stress conditions. Physiological analysis and genome insights supported the survival of these strains under multiple high-altitude stress conditions. Molecular cold-adaptation and substitution analysis of the studied strains supported the incidence of more cold-adapted proteins for functionality at low temperatures. Studied strains preferred amino acids like serine, asparagine, lysine, tryptophan for favoring increased flexibility supporting their broad temperature survival. By means of the cold-adaptor indicators [acidic residues, proline residues, aromaticity, aliphacity, hydrophobicity, and the ratio of arginine (R) and lysine (K)], we observed more of significantly 'cold adapted' proteins than 'hot adapted' proteins in the two *Arthrobacter* species. As expected, four indicators *viz*., lower amount of acidic, aromatic, and proline residues and lower ratio of R/K supported the presence of more cold-adapted proteins as compared to mesophilic relatives (Bonferroni corrected $P < 0.001$) in ERGS1:01. In ERGS4:06, three indicators *viz.* lower amount of acidic and proline residues; and lower R/K ratio supported the presence of more cold adapted proteins as compared to their mesophilic relatives. Our findings supported the incidence of more cold-adapted proteins promoting increased flexibility and functionality at low temperatures. To the best of our knowledge, this is the first molecular cold adaptation analysis performed for the genus *Arthrobacter* and has revealed that 'aromaticity', one of the cold-adaptor indicators, should be carefully considered while evaluating cold adaptation strategies in psychrotrophic/ psychrophilic bacteria. One major finding in the current study was the preference of tryptophan over tyrosine residues to maintain the thermal stability in cold-adaptive enzymes of both the strains with growth range 4–28°C (Table 1). A significant molecular strategy acquired by bacteria to adapt to the extreme, cold environment is the genetic redundancy, whereby two or more copies of the gene encode proteins that perform the same function, enhancing their survival. The CDSs in multiple copies were examined for their cold adaptation scores in both the *Arthrobacter* strains. Numerous CDSs in a predicted were observed to be cold adapted, hot adapted as well as in the neutral category. It was found that the majority of the CDSs in both the *Arthrobacter* strains were neither cold nor hot adapted, supporting their growth over a broad temperature range of 4–28°C. The current study provides the first kind of an in-depth report on the molecular adaptation of psychrotrophic *Arthrobacter* sp. at the amino acid level. Such a study can potentially augment the knowledge on the prevalence and survival strategies of this species at high altitude stressful environments. Furthermore, the study opens up opportunities for an intensive investigation into the cold-adapted proteins that enable their survival in extreme niches. For interested researchers, in-house script is available at https://github.com/fgcsl/Molecular-adaptational-analysis-cold, the molecular adaptation analyses of any other cold-adapted microbes can be carried out.

Table 1. List of cold/hot adaptation ratio and chi-square test calculation of six amino acid indices for both the *Arthrobacter* genomes considered in this study

Amino Acid indices	*Arthrobacter sp.* ERGS1:01		*Arthrobacter alpinus* ERGS4:06	
	Cold/HotRatio	chi-square test	Cold/HotRatio	chi-square test
Acidic	529/142	3.229157640121758e-50*	488/197	1.562946654143564e-28*
Proline	377/254	1 933212344843127e-06*	451/200	1 452748410779698e-22*
Aliphatic	163/526	2.8832302948757724e-43**	227/462	4.891827873041328e-19**
R/K ratio	435/153	4.727208847107056e-31*	572/91	1.4760194444688568e-77*
GRAVY	105/659	4.801579063869927e-89**	116/674	2 16801146916493e-87**
Aromatic#	349/293	0.029955607997992992	365/310	0.03766692222862869
Tyrosine	364/278	0.0007945614815359356*	373/276	0.00016434359610611326*
Tryptophan	260/283	0.3451132527383721	275/291	0.5283694469388824

*Significantly 'cold-adapted' with a Bonferroni corrected P-value < 0.001
**Significantly 'hot-adapted' with a Bonferroni corrected P-value < 0.001
#Under Aromatic indices, tyrosine and trytophan were also checked separately where only tyrosine was found significantly 'cold-adapted' with a Bonferroni corrected P-value < 0.001

Integration of RNA-seq and network analysis revealed key regulators involved in epilepsy-induced cardiac damage

Sudden unexpected death in epilepsy (SUDEP) is a significant outcome of cardiac dysfunction in epileptic patients. An integrated approach of RNA-Seq, proteomics, and system biology analysis was used to identify key regulators involved in epilepsy-induced cardiac changes. Bioinformatics RNA-Seq analysis was carried out in the cardiac tissue of normal *naiveG* and epileptic *epiG* groups. The expression analysis identified 1157 differentially expressed genes (DEGs) in epileptic animal's hearts. Our developed network analysis revealed seven critical genes *Stat3, Myc, Fos, Erbb2, Erbb3, Notch1,* and *Mapk8* (Fig. 1) could play a potential role in epilepsy-induced cardiac changes. Our multi-omics approaches including RNA-seq and large scale system biology analysis for sudden unexpected death in epilepsy (SUDEP) have identified that *Stat3, Mapk8,* and *Erbb3* are the key regulators of seizures-associated cardiac damage. The hubs play a key role in providing fundamental structure and support to the network. Hence, its removal can cause the network to collapse and likely disruption of the protein functions. The LC-MS/MS analysis of the heart's ventricular part showed the expression of 1264 proteins of various pathways in the *epiG* group. The results also showed the involvement of proteins associated with oxidative stress–mediated inflammation, fibrosis, and hypertension to be linked with cardiac changes in epileptic animals. The conjoint transcriptomic and proteomic datasets revealed an overlap of 19 genes common to the significant pathways, including MAPK, inflammatory, and mTOR. These pathways were found to be regulated at both transcriptomic and proteomic levels and thus could be involved in seizures-linked cardiac damage. The lower percentage of overlapped genes between proteomics and transcriptomics datasets is in line with the literature that supports very little congruence among these observations. The study has also provided a deeper understanding of molecular, cellular, and network-level operations of the identified regulators that leads to cardiac changes in epilepsy. The identified regulators can be used as potential candidates for clinical therapeutics and management of SUDEP.

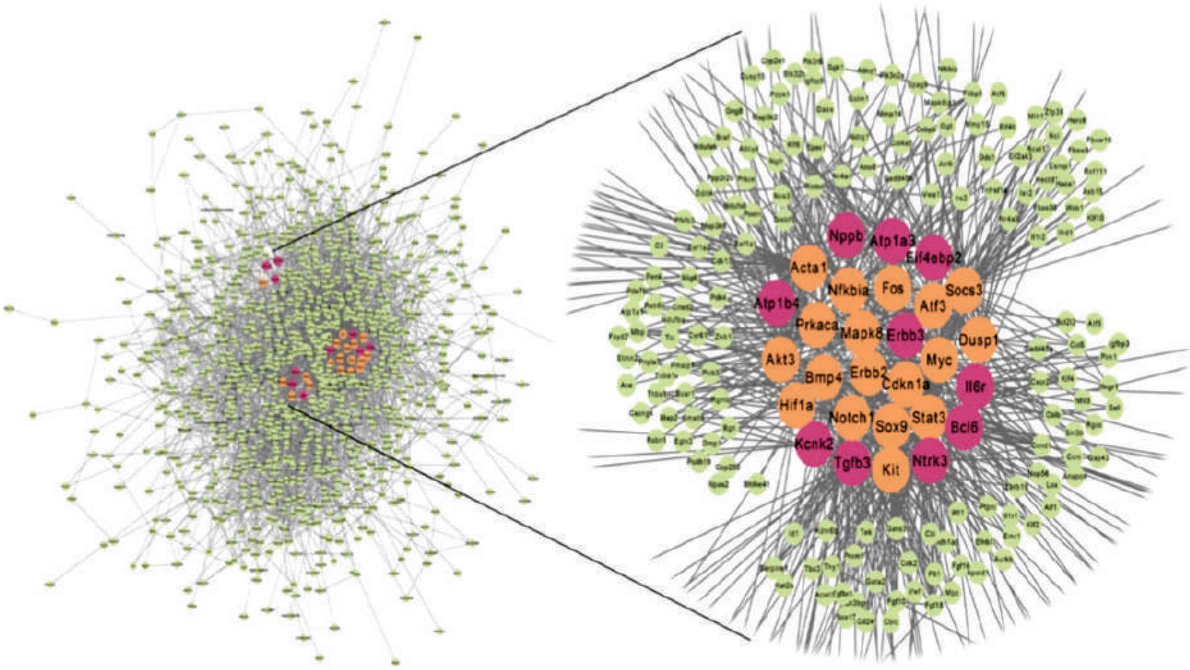

Fig. 1 Network showing intramodular (orange) and intermodular (pink) hubs in the heart tissue of epileptic *epiG* group. The intramodular hub is defined as a node with a high degree or maximum edges linked to it. The degree of a node is defined as the number of interaction partners connected with it. The intermodular hub is the node that connects two or more intramodular hubs and has a high score of betweenness centrality. Betweenness centrality of nodes is defined as the shortest path between nodes i and j that pass-through node s, divided by the shortest path between nodes i and j. Removal of the *Erbb3* intermodular hub can lead to network destruction in less time and effort

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Plant-Microbe Interaction

Our lab has focussed on two themes in the outgoing year. First, a few beneficial plant growth promoting rhizobacteria (PGPR) has been assessed for their efficacy and then novel fungal endophytes has been isolated from *Crocus sativus* corm. In future, their characterisation may help understanding the saffron biology.

Efficacy of two efficient PGPR on garlic plants at farmers field

PGPR are a group of bacteria that increase plant growth and yield via various plant growth-promoting activities. Two efficient rhizobacteria *Arthrobacter psychrochitiniphilus* IHBB 13602 and *Pseudomonas trivalis* IHBB 745 were previously isolated from Lahaul region based on the beneficial plant growth-promoting attributes like phosphate (P) solubilization, indole acetic acid (IAA) production and ACC deaminase activity. These beneficial plant growth promoting attributes are involved in the stress response of plants during water scarcity. A field experiment was conducted to study the effect of these two rhizobacteria on garlic growth and yield. Garlic bulb yield increased significantly with the inoculation of microbial inoculants which was comparable to the NPK treated plant in the experimental field trial. Among the two, *Pseudomonas trivalis* IHBB 745 showed the maximum leaves number, plant height (cm), garlic yield (qu/ha), and garlic diameter, closely following that of the NPK 100% treated leaves number, and FYM treated plant height (cm) and garlic yield. In contrast to previous results, 2nd year data showed no difference in the yield outcome in Garlic crop after treatment with bacterial inoculum relative to control as both showed yield of nearly 16-18 quintal/hectare. The efficacy is low in comparison of previous year results may be due to differential environmental factor (Fig. 1&2).

Isolation of endophytic fungi from saffron corms for beneficial attributes

Saffron corms were procured and given harsh surface sterilisation with Tween-20 followed by 0.1% bavistin solution for 15 minutes along with 70% ethanol for 30 seconds. After ethanolic treatment, 0.1% mercuric chloride treatment was given for 10-12 minutes followed by rinsing with autoclaved distilled water 5-6 times and kept under standard tissue culture condition at 22°C with murashige skoog medium or water agar. After 20-40 days they were checked for any microbial growth arising out of corms. Fungal growth were observed in tissue culture flasks after a minimum of 20 days of initial planting of corm in flask under asceptic conditions. Different fungal morphotypes were identified and further sub-cultured on Potao Dextrose Agar plates. Different morphotypes were characterized at molecular level based on their ITS region sequence analysis using ITS1 (TCCGTAGGTGAACCTGCGG) and ITS4 (TCCTCCGCTTATTGATATGC) primer set. Identified sequences were searched against nR database at NCBI.

Our sequencing analysis confirmed the presence of four different genera with a total of six species of fungal endophytes in *Crocus sativus* bulb from 15 different morphotypes. The major fungal endophytes identified are *Rhexocercosporidium* sp., *Phialophora mustea*, *Cadophora* sp., from our present study (Fig. 3). They are at present being assessed for any perceived beneficial attributes such as phosphate solubilization, IAA production, siderophore production etc. The different plant growth promoting activities will be assessed both qualitatively and quantitatively under *in-vitro* conditions such as plate growth assay for phosphate solubilisation activity under pikovskaya agar medium.

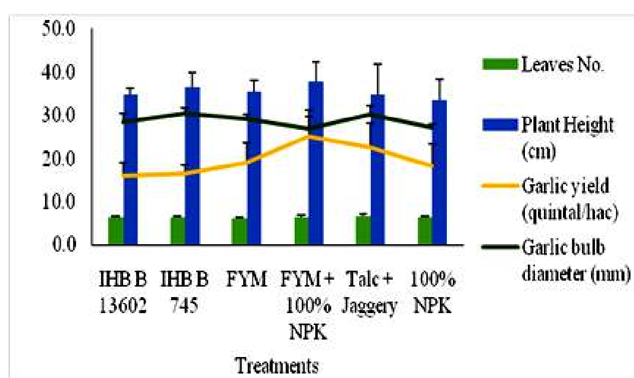

Fig. 1 Effect of PGPR on garlic growth and yield

Fig. 2 PGPR treated Garlic experimental field trial at Sulah, Kangra, H.P.

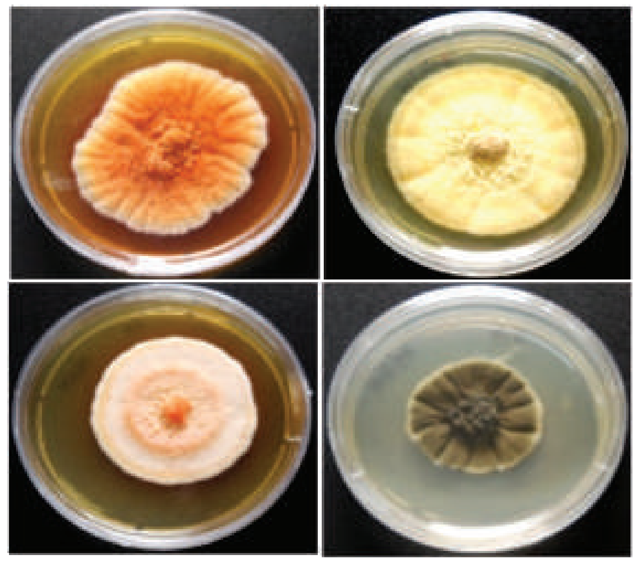

Fig. 3 Endophytic fungi isolated from saffron corms after harsh surface sterilisation as described in text. The fungus in above images are *Phiaophora* sp., *Cladosporidium*, *Rhexocercosporidium* sp. and *Phialophora mustea* in clockwise direction from right

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Plant Tissue Culture

Commercial scale propagation of economically and medicinally important plants

Our group mainly focuses on the development of high efficiency *in vitro* protocols for mass propagation of economically and medicinally important plants. India imports 111.13 million USD per annum of Asafoetida (commonly known as *Heeng* and a popular kitchen spice) from middle-east countries. We have standardized the mass scale callus proliferation of *Ferula assa-foetida* using different combinations of plant growth regulators (PGRs). Further, there is a gap of ~93.5 tonnes between the demand and supply of *Crocus sativus* in India. We are trying to fill this gap by commercially producing disease-free corms through *in vitro* propagation using previously developed protocol from our lab (Fig. 1). An MoU has already been signed between CSIR-IHBT and Agriculture Department, Himachal Pradesh for the propagation and cultivation of *Heeng* and saffron.

The fruits of *Siraitia grosvenorii* (monk fruit) are commercially exploited for mogrosides that are 250-300 times sweeter than sucrose. Micro-propagation of this plant was done by inoculating the nodal segments on Murashige and Skoog (1962) medium without any PGR with 0.8% agar and 3% sucrose at 23°±2°C under 16/8h photo-period (Fig. 2). For multiple shoot induction, the axillary buds were cultured in a medium supplemented with different concentrations of 6-Benzylaminopurine (BAP) and Kinetin (1.0 to 7.5 µM). Further, rooting was observed in 1.0 µM of BAP (Annual Meeting of Plant Tissue Culture Association, 2021). Using this protocol, we were able to mass propagate monk fruit at commercial scale.

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". We are commercially propagating different bamboo species i.e., *Dendrocalamus hamiltonii, Dendrocalamus asper* and *Bambusa balcooa* under National Bamboo Mission. In addition, we are standardizing protocols for commercial propagation of *Bambusa tulda, Dendrocalamus giganteus* and *Phyllostachys edulis*. For commercial scale micro-propagation, nodal segments were inoculated in MSO medium to produce 2-3 shoots per bud. These shoots were then transferred to the shoot multiplication medium supplemented with different combinations of BAP, 1-Naphthaleneacetic acid (NAA) and Adenine sulphate with 15 days subculturing for 3-4 months. After multiple shoot development they were transferred to the rooting media supplemented with NAA, sucrose and phytagel. Rooted plantlets were then hardened in the mixture consisting of sand: soil: FYM:: 1:1:1 for 2 months under greenhouse conditions. More than 85% survival rate was observed under field conditions. We also hypothesized that the differential response during *in vitro* micropropagation among these genotypes may be due to their differential physio-chemical, histological and transcriptional regulations (PTCAI, 2021). In addition, we also commercially propagate bamboo plants through cuttings, layering and seeds (Fig. 3).

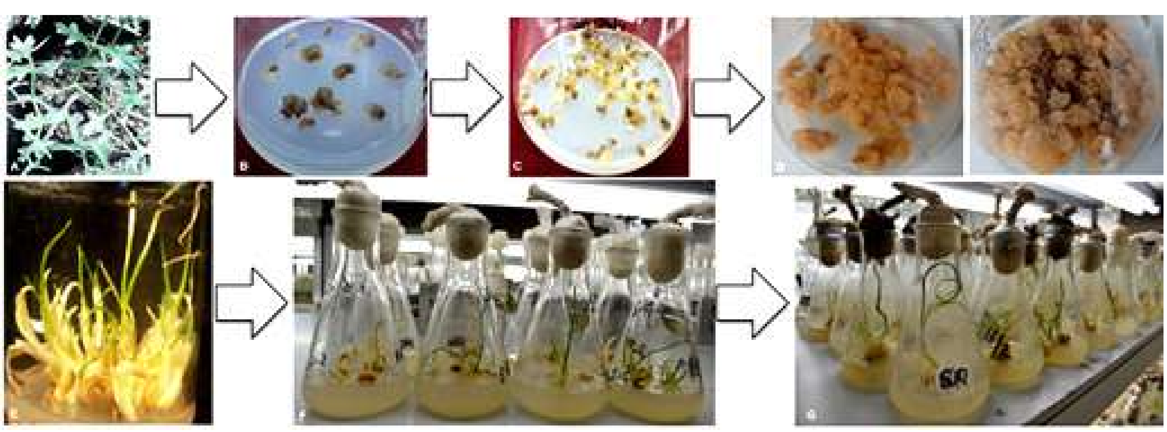

Fig. 1 Commercial scale propagation of *Ferula assa-foetida* (A-D) and *Crocus sativus* (E-G) through tissue culture

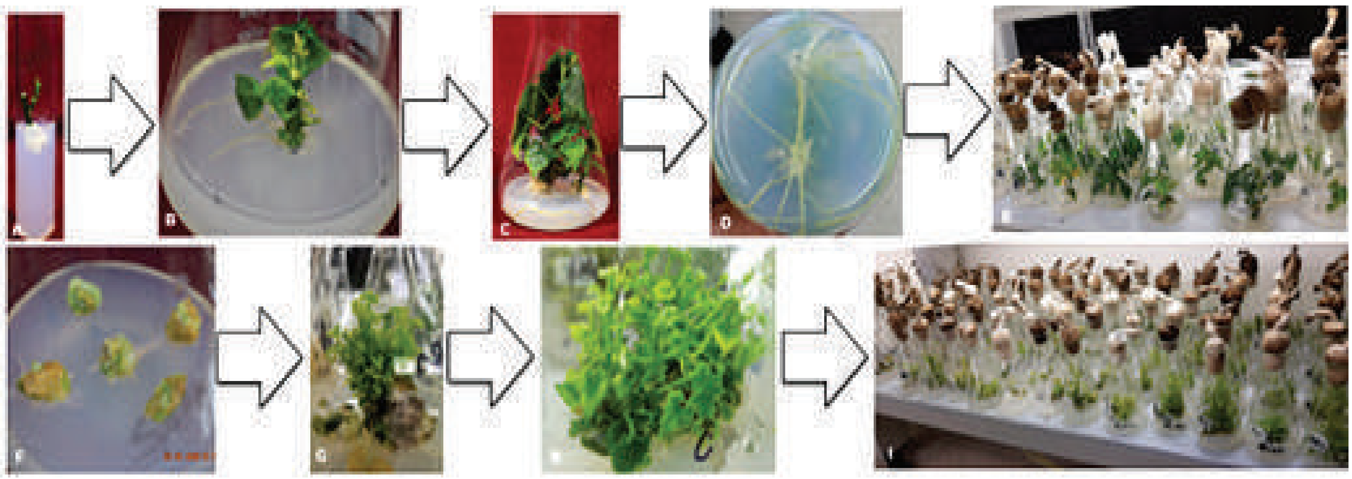

Fig. 2 Commercial scale propagation of *Siraitia grosvenorii* through tissue culture. (A-E) through nodal cuttings and (F-I) through callus culture

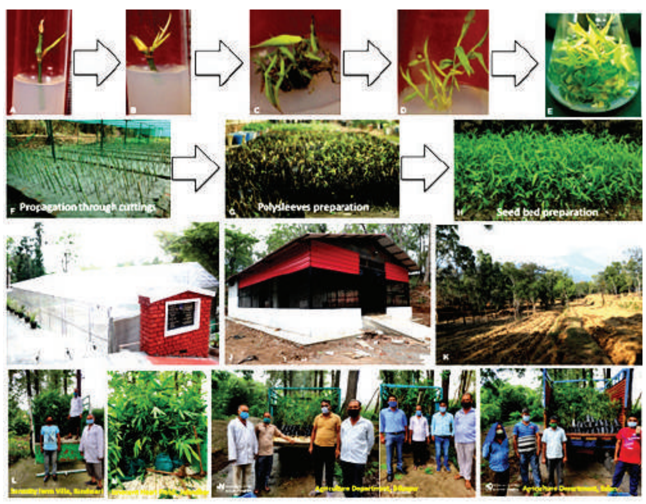

Fig. 3 Commercial scale propagation of bamboos through tissue culture (A-E), Cuttings (F), Seedlings (G) and Seeds (H). Development of Hi-Tech Green House, Potting shed and 2.0 ha land preparation under National Bamboo Mission. Supply of bamboo plants to government agencies and other planters (L-O)

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Plant-Microbe Interaction, Plant Adaptation, and Plant Physiology

My research group explores endophytes of Himalayan medicinal plants for improvement of plant productivity, production of therapeutically important secondary metabolites, and studying adaptation mechanisms of plants under environmental stress.

Endophytes of *Valeriana jatamansi* and *Podophyllum hexandrum*

V. jatamansi and *P. hexandrum* are important Himalayan medicinal plants that are extensively used for therapeutic purposes. Due to overexploitation, these plants are on the verge of extinction. Therefore efforts need to be made for their conservation and the development of new approaches for their cultivation. We are identifying potential endophytes enhancing plant productivity and production of therapeutic compounds. We have a collection of >250 endophytes isolated from different parts of plants collected from different natural habitats (multiple locations) (Fig.1). These isolated microbes are being tested to enhance plant productivity and the biosynthesis of therapeutic metabolites.

Fig. 1 Collection of samples of selected Himalayan medicinal plants from their natural habitats (a). *Podophyllum hexandrum* (b,c), *Valeriana jatamansi* (d,e) and *Picrorhiza kurrooa* (f) at natural locations. Representative picture showing the endophytes isolated from selected Himalayan medicinal plants (g)

Development of probiotics for plant tissue culture

The use of plant cell and tissue culture technology has increased extensively over the past decade. Successful propagation of tissue culture-generated plants depends upon their field survival. Therefore, the hardening of tissue culture generated plants in the greenhouse and their acclimatization to the field conditions limit their use and acceptability. It also restricts the successful micropropagation of most of the plants, especially rare, endangered, and threatened (RET) plant species. In addition to this, after repetitive subculturing, the tissue culture plants (tissues) continuously reduce their potential to synthesize secondary metabolites. We believe that the plant materials generated through *in-vitro* systems lack the plant-associated microbes (especially endophytes) due to their continuous cultivation in aseptic conditions, causing reduced hardening efficiency and secondary metabolite content. We are making our efforts to supplement endophytes to the tissue culture generated *Fritillaria roylii*, *Rhodiola*, *Picrorhiza kurrooa,* and *Trillium govanianum* plants at the time of hardening to improve hardening efficiency and performance in the field.

Evaluation of the role of endophytes in mogroside production

Cultivation of the monk fruit, *Siraitia grosvenorii* is very limited (predominantly produced in Guangdong, Guangxi, and Hunan provinces of China only) and specific to environmental conditions; this exclusively limits its use at a large scale and makes its use expensive. Therefore, we are exploring endophyte technology for its sustainable cultivation. We have found the associated endophytes with *S. grosvenorii* (Fig. 2).

Genome-editing of *Camellia sinensis*

Tea [*Camellia sinensis* (L.) O. Kuntze] is used as the most popular beverage worldwide second only to water. Its demand is tremendously rising due to increased awareness of its medicinal importance. Several efforts have been made to improve the quality of tea. In general, the conventional breeding approach is used for tea improvement, but this

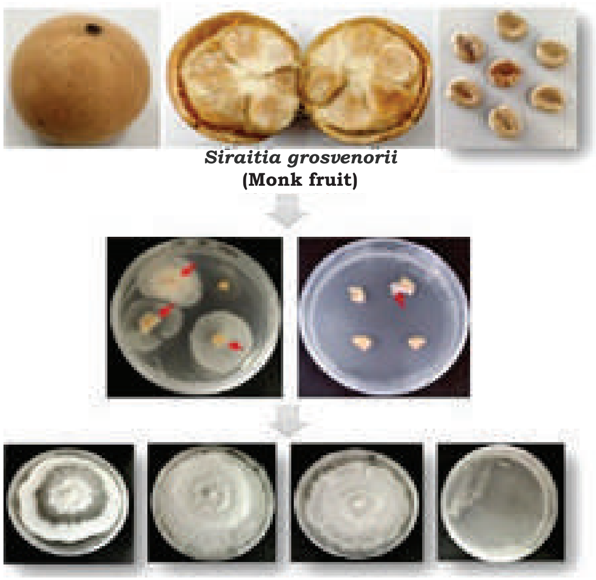

Fig. 2 Endophytes associated with *Siraitia grosvenorii* (Monk fruit).

is a time- and labor-intensive processes, and is limited by a long period of juvenility (6-10 years), high inbreeding depression, self-incompatibility, differences in time of flowering and fruit-bearing capability, scarcity of land and labor, and the low success rate of hand pollination. Therefore, we are exploring biotechnological approaches such as genome editing using CRISPR/Cas9 to improve *C. sinensis*. A similar approach can also be applied to other medicinal plants.

Additionally, we are also involved in exploring the combination of phytohormones for breaking the seed dormancy of *Bunium persicum* and developing an efficient method for its sustainable cultivation. Similar strategies are also being used to attain 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, and Molecular biology Lab is working on alternative approaches for metabolite production from high-altitude Himalayan medicinal plants using callus culture techniques. Also, involved in hydroponic and aeroponic cultivation for quality biomass production of medicinal plants and spice crops. The lab is also engaged in micropropagation of Himalayan RET species under grant-aided projects.

Friable callus culture of *Rhodiola imbricata* for metabolite production

The plant cell culture provides an efficient technique for growth and production kinetics studies of bioactive compounds present in plants. Therefore, the present study investigated the specific culture days required for higher metabolite yield in *Rhodiola imbricata*. The leaf callus cell line showed an optimum growth rate (FW: 20 g/100 mL, DW: 1.21 g/100 mL), growth index (19.00), salidroside (3.68 mg/g DW, rosavin (0.21 mg/g DW and rosarin (0.08 mg/g DW) on 24th day of the incubation period (Fig. 1). Moreover, the antioxidant study displayed maximum phenolic content (8.07 mg/g DW) on day 18, flavonoid content (9.73 mg/g DW) on day 3, and DPPH activity (IC_{50}; 0.79 mg/mL) on day 24 in leaf callus cell line. The RT-qPCR analysis showed upregulation of *PAL*, *4-HPAAS, 4-HPAAR*, and *UDPGT* genes associated with metabolite accumulation. Furthermore, the optimized parameter could be exploited for a higher yield of specific metabolite and sequential scale-up studies.

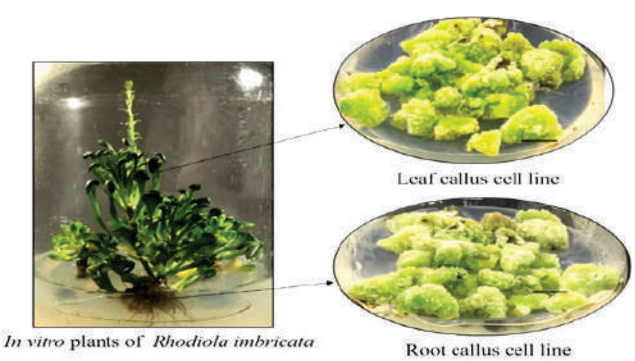

Fig. 1 Development of friable callus culture of *Rhodiola imbricate*

Friable callus culture of *Picrorhiza kurrooa* for picrosides production

Picrosides are the specialized metabolite of *Picrorhiza kurrooa* and mainly accumulate in the rhizome and leaves. Therefore, friable callus culture was developed from leaf explant for picrosides content accumulation under different culture regimes (i.e. 25°C dark/light & 15°C dark/light) (Fig. 2). The results revealed that under light 15 °C culture condition, highest accumulation of picroside II (0.58 µg/mg) were detected. Major reported biomolecule in callus was picroside I (1.63 µg/mg) under dark 15°C culture condition. For the first time, picroside III content (range 0.26-0.56 µg/mg) was also detected and quantified in the leaf derived callus. Study revealed that callus culture of *P. kurrooa* may offer a cost effective and environmentally friendly platform for sustainable production of picrosides.

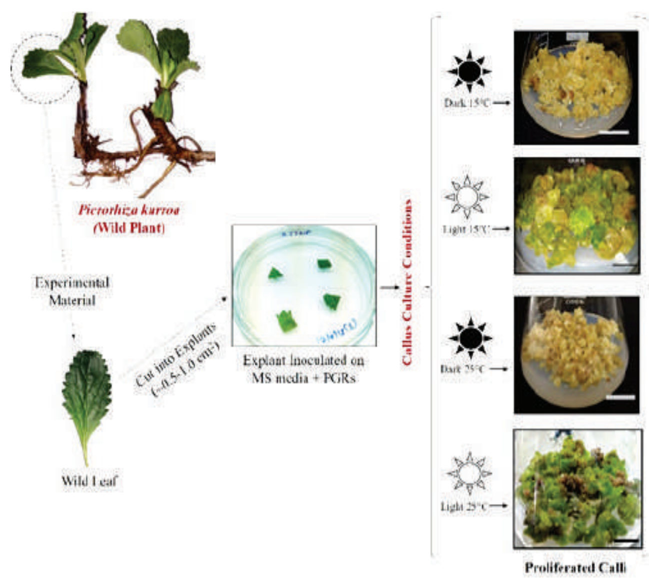

Fig. 2 Development of friable callus culture of *Picrorhiza kurrooa*

Enhancement of steviol glycosides content in *in vitro* cultures of *Stevia rebaudiana*

Different elicitors, such as polyethylene glycol (PEG), alginate (ALG), chitosan (CHI), salicylic acid (SA), and yeast extract (YE), were used in *in vitro* shoot cultures of *Stevia rebaudiana* for biomass yield and steviol glycosides content.

In media supplemented with 0.5 mg/L YE, the highest leaf number (16.33), root number (4.67), and shoot length (3.80 cm) were observed, while maximum shoot number (2.44) and root length (1.89 cm) were observed in 1.5 mg/L CHI and 1.0 mg/L PEG, respectively. Elicitation with 1.0 mg/L YE enhanced biomass production by 114.01 mg/plantlet for leaves, 90.27 mg/plantlet for stems, and 204.28 mg/plantlet for shoots. In 2.0 mg/L ALG, stevioside (ST) content increased by 5-fold (0.77 mg/g leaf DW), though rebaudioside A (RA) content increased by 7-fold (1.9 mg/g leaf DW) in 0.5 mg/L ALG. The research identified ALG as a promising elicitor in *S. rebaudiana* for producing high-quality biomass with improved metabolite profiling (Fig. 3).

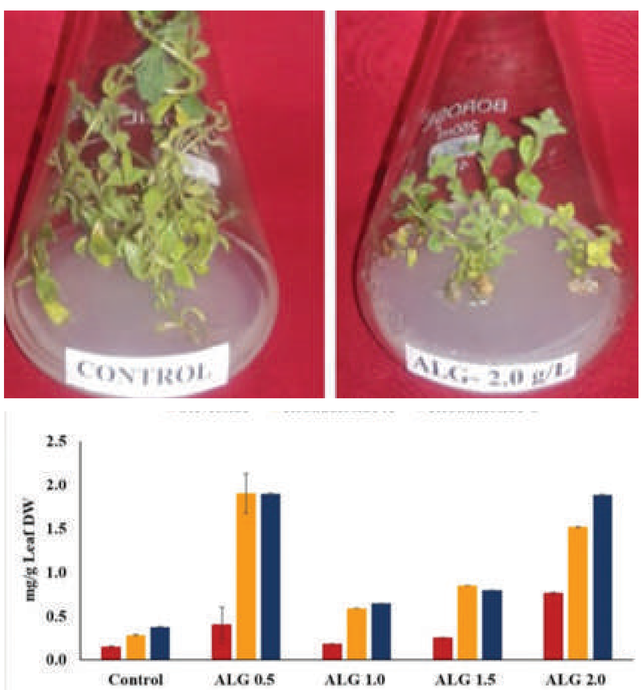

Fig. 3 Metabolite content detection in *in vitro* shoot cultures of *Stevia rebaudiana*

Hydroponic cultivation of *Petroselinum crispum* for quality biomass production

Hydroponic is considered as an eco-friendly and sustainable agro-practice for commercial-scale production of culinary herbs. For the first time, the present investigation corroborates the effect of nutrient recipes (T1; Hoagland and T2; Thakur nutrient solution) on plant vegetative growth biomass and essential oil yield in *Petroselinum crispum* (Parsley) cultivated under a hydroponic system (Fig. 4). Results revealed that hydroponic cultivation with a nutrient recipe (T1) significantly improved the morphological attributes and physiological performance (photosynthetic rate - 15.52 µmol $m^{-2}s^{-1}$) of *P. crispum*. Similarly, the highest growth (fresh weight and dry weight; g / per plant) of leaf, stem, and root were also observed in plants treated with a nutrient recipe (T1) cultivated under hydroponic condition. GC-MS study revealed myristicin (39.84 - 51.40%), apiol (8.28 - 15.94%), *β*-phellandrene (2.54 - 9.13%), and elemicin (2.88 - 6.36%) were identified as major volatile compounds in the essential oil of *P. crispum*. Overall, the present study provides a simple yet robust hydroponic cultivation protocol for quality biomass production. The investigation will significantly contribute to environmental sustainability and encourage soilless agriculture.

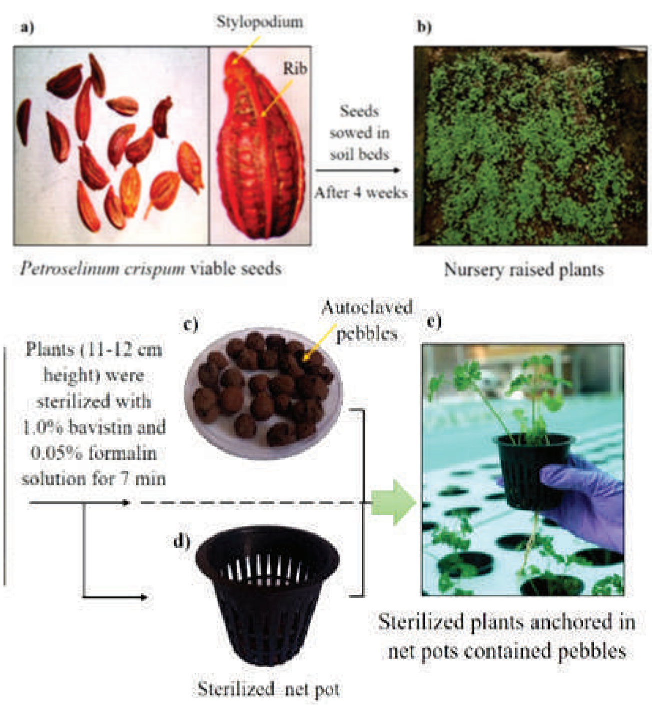

Fig. 4 Hydroponicallly cultivated *Petroselinum crispum* plants, a) *Petroselinum crispum* viable seeds, b) Nursery raised plants, c) Autoclaved pebbles, d) Sterilized net pot and e) Sterilized plants

Hydroponic cultivation of *Ocimum basilicum* for quality biomass production

Ocimum basilicum L. (sweet basil) was cultivated to evaluate media effects on plant growth biomass, physiological performance, antioxidant activity, and chemical composition under hydroponic conditions. In the present study, the vegetative growth biomass (stem length; 25.68 cm, number of leaves; 39.10), photosynthesis (10.19 µmol m^{-2} s^{-1}), and antioxidant activity (IC_{50}; 1.14 mg/mL) were estimated maximum in nutrient medium compared to Hoagland medium. Total phenolic (17.12 mg/g; DW) and total flavonoids (54.65 mg/g; DW) content were found maximum in the nutrient medium compared to Hoagland medium and tap water. Gas chromatography-mass spectrometry analysis identified twenty-three volatile compounds and neophytadiene (29.82%), eugenol (28.83%), and methyl eugenol (22.00%) were found as a major component in basil leaf extract cultivated under hydroponic and pot condition. Overall, the present study emphasized the nutrient media management for efficient, sustainable, persistent, and rapid quality biomass production under hydroponic cultivation.

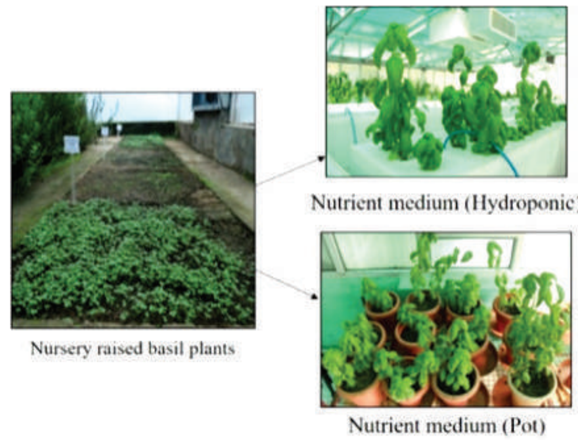

Fig. 5 Hydroponicallly cultivated *Ocimum basilicum* plants

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Plant Proteomics

Research in our lab focus on comprehensive mapping of transcriptome, proteome, metabolome and epigenome of medicinal plants that will be helpful for understanding the multilayered control of adaptation process.

Mass spectrometry based reference map of *Picrorhiza kurrooa*: A high altitude medicinal plant

The Himalaya is an important repository of medicinal and aromatic plants that are a rich source of novel compounds for pharmaceutical industry. Most of them are confined to high altitude regions that are characterized by extremes temperatures, radiations, high snowfall and partial pressure of gases. These plant species synthesize extensive arrays of secondary metabolites having medicinal importance. Owing to the successful acclimatization to extreme environmental conditions, high-altitude plants can serve as a model for explication of various abiotic 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 medicine systems as hepatoprotective, antiperiodic, cholagouge, stomachic, antiamoebic, antioxidant, antihelmintic, antiinflammatory, cardiotonic, laxative, carminative and expectorant. The therapeutic value of *P. kurrooa* is mostly ascribed to picrosides, which are iridoid glycosides. Morphologically, plants are herbaceous with an elongated rhizome (rootstock) and aerial portion with basal leaves and terminal inflorescence (flowering spike). *P. kurrooa* propagates vegetatively as young buds on rhizomes, which subsequently develops as a new rhizome with autonomous root and shoot sections. In addition, rhizome survives underground during extreme environment such as snow cover whereas, shoot emerges rapidly during onset of suitable growth conditions. The underlying molecular response of these organs to chronic environment fluctuations at high altitude is largely unknown. In order to determine protein atlas of *P. kurrooa*, morphologically differentiated four major organs at two developmental stages were chosen for 1D-GE that have the advantage of protein solubilization during fractionation prior to nanoLC coupled with mass spectrometry for deeper proteome coverage. An illustration of the entire workflow was shown in Fig. 1.

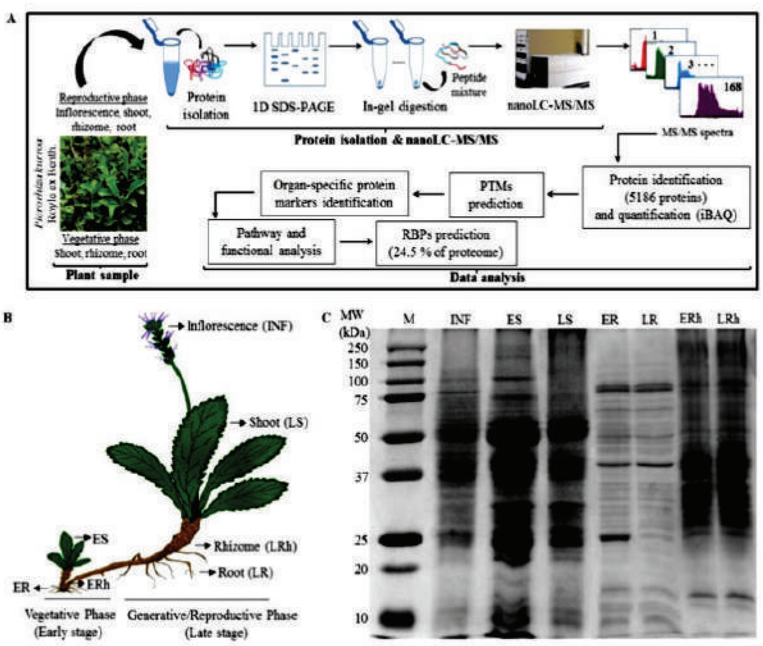

Fig. 1 Flow chart depicts proteomic study among organ and developmental stage specific in *P. kurrooa* (A), and representative 12.5% SDS-PAGE electropherom

Root, shoot and rhizome were harvested from both early (vegetative/before flowering) and late (reproductive/after flowering) stage, whereas inflorescence was collected from various plants at late stage, which represent seven samples. To reduce the impact of biological variation, each of these samples were pool of at least eight different plants. To ensure efficient protein extraction, we used phenol-based protocol that has potential to generate highly pure samples as other plant compounds partition into discrete aqueous phase from protein-enriched phenol phase. Protein from each organ and developmental stages was fractionated using 1D-SDS-PAGE and stained with CBB. Each sample lane was split into 8 fractions, which were digested with trypsin and subsequently analyzed using nanoLC coupled with Agilent 6560 Q-TOF mass spectrometer that lead to 168 nanoLC-MS/MS runs. The resulted tandem mass spectra were searched against NCBI protein database containing predicted proteins of all green plants and generated a total of 5186 non-redundant proteins (FDR $< 1\%$, peptide score ≥ 3 and SPI (%) ≥ 60). The proteins having at least one distinct peptide and clustering of similar protein based on sequence homology into same group were considered as positive identification.

Most of the identified proteins are associated with cellular processes, response to abiotic stimuli and metabolic processes. Organ specific sub-proteomes and protein markers were identified along with hierarchical assessment across inflorescence, shoot, root and rhizome highlighting organ specialized functions. We observe the abundance of proteins linked to growth, development and stress in belowground organs, supporting evidence for the role in vegetative propagation and stress tolerance. As a manifestation of comprehensiveness, we were able to compare pathway centric functional differences between vegetative and reproductive phases of *P. kurrooa* development. Furthermore, proteome-wide identification of predicted RBPs (24.5 % of total proteome) and PTMs might expand the biological information in response to developmental and environmental cues. A comprehensive list of proteins expressed in different organs would offer insights to explore tissue profile for specific protein classes. This report represents first extensive proteomic description of organ and developmental dissected *P. kurrooa*, providing a platform for future studies of this medicinal herb.

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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 (Fig. 1). The genes have been cloned in pET-28a vector for expression in *E. coli* and pPICZalpha A for expression in yeast.

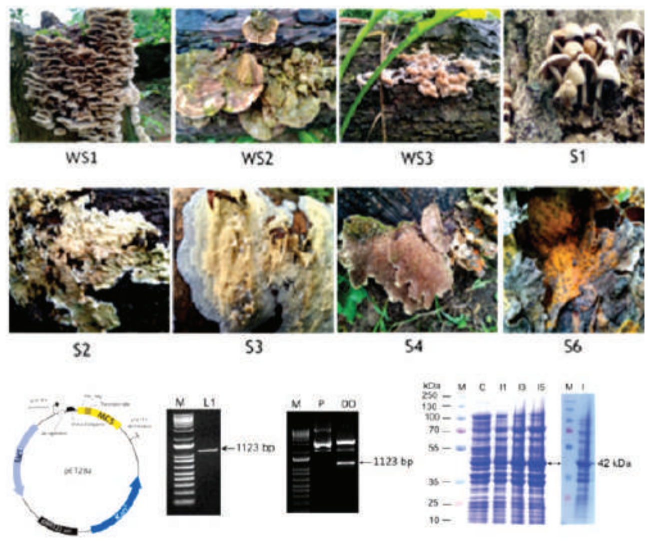

Fig. 1 Identification of potential sources of LPMOs from various ecological niches of Himalayas (a) for cloning and heterologous expression in *E. coli* (b)

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

The on-going COVID-19 pandemic due to SARS-CoV-2 has paralyzed the whole world, which motivated the scientific community around the world to find possible remedies. The genome of SARS-CoV-2 is composed of about 30,000 nucleotides: its replicase gene encodes for two overlapping polyproteins namely, pp1a and pp2ab, required for the replication and transcription of virus. The polyproteins are proteolytically processed, mainly by the 33.8-kDa main protease (M^{pro}) also known as 3C-like protease. Such functional importance of M^{pro} in the life cycle of the virus along with the absence of its closely related homologs in human beings, recognize M^{pro} as an attractive target for the anti-viral drug designs. Another major target for drug design is a transmembrane protein called Spike Glycoprotein (S). It contains two functional subunits namely, Spike S1 and S2. The Spike S1 subunit contains the receptor-binding domain(s) that recognizes and attaches to the Angiotensin Converting Enzyme 2 (ACE2) receptors. The S2 subunit is responsible for the fusion of host cellular and viral membranes. Considering the importance of these proteins in the viral life cycle, these are considered as potential drug targets.

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} and Spike proteins. 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 (Fig. 2). 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. Detailed studies are being conducted to understand the mechanism of action of these molecules. Leads from our studies will help to develop plant-based products that can be commercialized to combat the COVID-19 pandemic and the knowledge generated can be extrapolated to control other viral diseases as well.

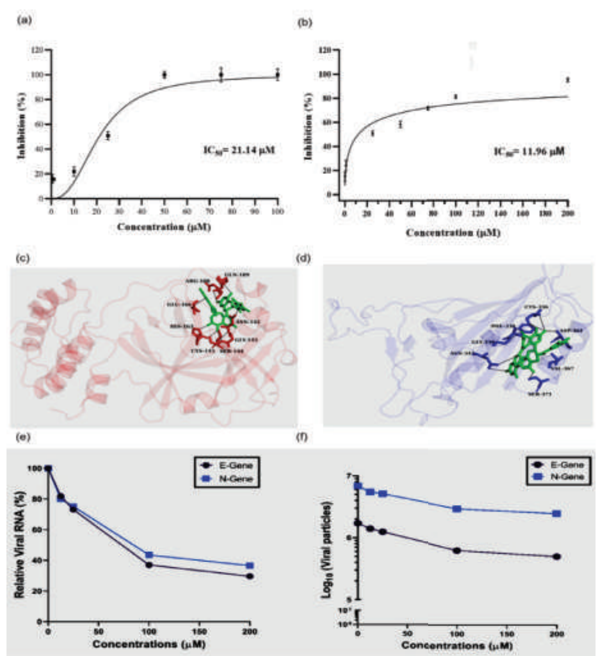

Fig. 2 Inhibition of SARS-CoV-2 by tea molecule. The tea molecule (IHBT-BT-AK-10) inhibited the M^{pro} (a) spike S1 (b) proteins of SARS-CoV-2 by interacting with their active site residues (c,d). The IC_{50} values for the molecule against Mpro and spike S1 protein were 21.14 µM and 11.96 µM, respectively. The molecule also inhibited of viral replication under *in vitro* conditions (this work was done in collaboration with CSIR-CCMB, Hyderabad). Relative viral RNA % (e) and Log reduction in viral particles (f) in response to tea molecule in Vero cells at 50, 100, 150, and 200 µM was calculated using quantitative PCR of N and E viral genes. The molecule reduced the viral count by 63% (the viral particles were reduced from $10^{6.8}$ to $10^{6.3}$) at 200 µM concentration

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 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 (Fig. 3) and a system-wide approach was undertaken to dissect the resistance/susceptibility mechanisms in rice against *R. solani* at genetic and epigenetic level.

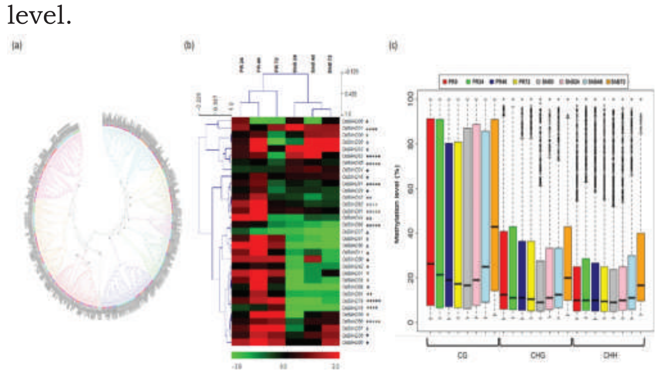

Fig. 3 Identification, expresion and DNA-methylation analyses of *BAHD* gene family in rice in response to *R. solani* AG1-IA. Phylogenetic relationship (a) of OsBAHD-ATs with that of *Arabidopsis*, *G. max*, *Z. mays*, *S. bicolor*, and *B. distachyon*; (b) the heat map representation for the transcript abundance level of *OsBAHD-AT* genes in *R. solani* AG1-IA challenged rice genotypes *viz.* PR and ShB at different time intervals; (c) 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

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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) 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 and made initial progress during last year.

Understanding the excess energy dissipation and ROS scavenging mechanisms in high-altitude plants for sustaining adverse conditions

The plants growing in environmental extremes have the ability to sustain adverse conditions via their evolved excess energy dissipation and ROS scavenging systems (Fig. 1). To understand adaptive mechanisms in Himalayan plants, we are focusing on Himalayan plants, including *Picrorhiza kurrooa* and *Rhododendron anthopogon*, to decipher their excess energy dissipation and ROS scavenging mechanisms activated by retrograde signaling in these plants. Extremophytes of various environmental extremes undergo morphological, physiological, and physiological modifications, complemented with their genetic make-up to avoid and endure adverse conditions.

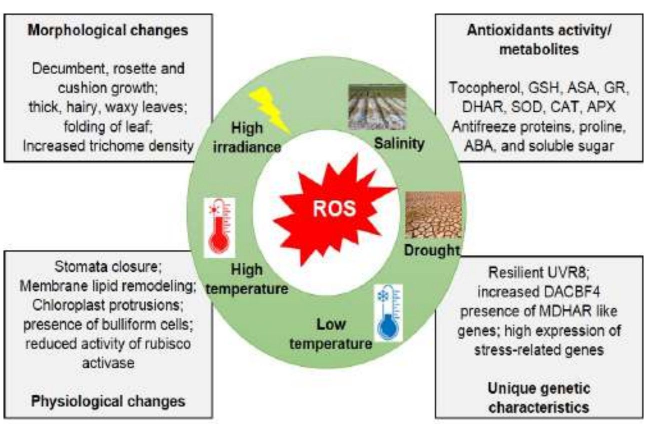


Fig. 1 Strategies implemented by extremophytes to manage excess ROS generation

Deciphering chloroplast oxi-proteome and engineering ROS-resilient photosynthetic machinery

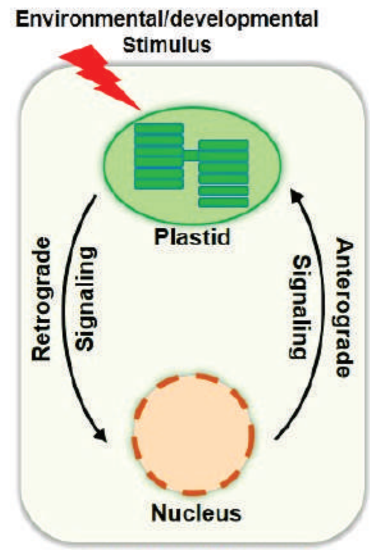
Using model plant *Arabidopsis thaliana*, we are also studying photosynthetic processes emphasizing light-dependent reactions. We are focusing on stress-induced ROS-triggered perturbations in chloroplast homeostasis and cognate retrograde signaling cascades activating stress responses. The fundamental information gained can be used to engineer stress/ROS-resilient photosynthetic apparatus. In a collaborative work between Prof. Chanhong Kim, PSC Shanghai, and Prof. Wataru Sakamoto, Okayama University, Japan; ROS-resilient D1 protein in photosystem II was engineered in unicellular alga *C. reinhardtii* (mainly done at Okayama Univ). Accordingly, at CSIR-IHBT, we are working on engineering ROS-insensitivity in photosynthetic proteins, including D1 and CP43 (light-dependent), and RCA and RbCL (light-independent) in *Arabidopsis* and trying to identify natural ROS-insensitive variants of these proteins in the Himalayan plants. Various site-directed mutagenesis-based synthetic constructs are prepared and being transformed in wild type and cognate mutants in *Arabidopsis thaliana*.

Decoding the link between stress-induced chloroplast division defects leading to cell cycle arrest and programmed cell death

Besides, we are trying to unveil the role of chloroplasts as stress sensors. Recently we have carried out a chemical-based mutagenesis screening of an *Arabidopsis* mutant having dysfunctional chloroplasts and exhibiting ROS-induced cell cycle arrest and programmed cell death. We have identified specific second site mutants showing attenuation of chloroplast-triggered cell death and growth defects. These suppressor mutants are now being characterized to delineate chloroplast-triggered stress responses.

Deciphering the 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. Using this transcriptional module, we are now trying to engineer prickle-less roses where overexpression, VIGS, and CRISPR constructs are prepared for the transformation in Rose calli. In addition, we are also initiating a project on increasing the accumulation of secondary metabolites in mentha using gene-editing tools and germplasm screenings.



Molecular Plant Biology & Cell Signaling (MPBCS) Lab

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Plants are rooted to a fixed spot; hence they cannot escape episodes of environmental stress. Our lab is broadly interested in exploring the intricacies of plant-environment interactions at various scales spanning from genes-to-plants-to-ecosystems (PlantAdaptOme). Specific research interests lie to advance the mechanistic understanding of plant responses to global climate change factors such as rising atmospheric CO_2, temperature and drought. The ultimate goal of our research is to develop climate-resilient and resource-efficient plants by utilizing ecological, chemical, genetic engineering, and/or genome editing technologies.

Unravelling the mechanisms underlying transgenerational heat stress adaptation

Among the predicted features of the future climate – an increase in the frequency and intensity of extreme heat events is predominant. Short-term heat 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. Multi-generational experiments can be crucial to dissect stress-induced transgenerational effects, which originate either from genetic (mutations) or epigenetic changes. Mutation frequency is relatively low, thus the enhanced tolerance observed in the progeny of stressed parents over a few generations is not likely explained by genetic changes alone. Environmental stress can also lead to epigenetic modifications (e.g. DNA methylation, histone modification and small non-coding RNAs), which are rapid and inherited to the next generations.

Thus, to investigate multi-generational effects of heat stress, we are using *Arabidopsis thaliana* – and exposing it to repeated heat stress for multiple generations (Fig. 1). The model plant *Arabidopsis thaliana* is an excellent choice here because of its short generation time, availability of high-quality genome data and genetic resources. The multi-generational experiments have been undertaken with various Arabidopsis ecotypes originated from different geographic regions of the world. Also, various epigenetic mutants related to DNA methylation and histone modifications are being used. These evolved plants will be analysed at the genetic, epigenetic, transcriptomic, metabolic, physiological, and morphological levels. This comprehensive analysis will allow us to obtain a detailed understanding of the mechanisms underlying transgenerational heat stress adaptation, which is crucial to capture evolution in action under hot climate.

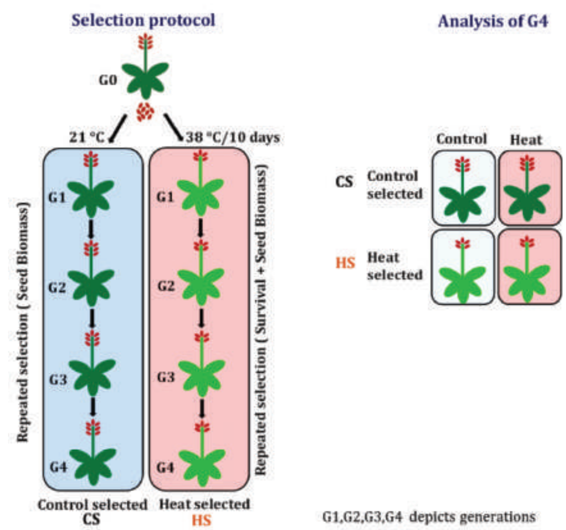

Fig. 1 Schematics for transgenerational heat stress experiment with Arabidopsis

Identification of temperature sensing components to engineer thermotolerant in plants

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. However, while studying the impact of high temperature on plants – the distinction between ambient high temperature (warming) and extreme heat (heat waves) need to be made as both trigger very different responses. For instance, ambient high temperature induces various phenological/ developmental changes in plants including early flowering and elongation of vegetative organs. While extreme heat stress inhibits growth and photosynthesis, and causes floral abortion. The signaling networks involved in the perception of ambient high temperature and heat shock are distinct, and well dissected in the model plant *Arabidopsis thaliana*. PHYB is a central hub to perceive ambient high temperature, followed by the downstream signaling cascade of *PIF4*, *ARP6* and *H2A.Z* etc., which trigger the expression of auxin (*AUX/IAA*) and flowering (*FT*) genes. On the other hand, extreme heat induces the expression of heat shock transcription factors (HSFs) such as *HSFA* and heat shock proteins (HSPs), which play crucial role in heat shock signaling and defense.

In our lab, we are exploring the role of these two independent high temperature signaling pathways in model plant Arabidopsis and crop systems such as Potato and Chenopodium to engineer climate-proof crops. Also, we are investigating the role of secondary metabolism pathway to enhance heat tolerance in plants. Several genes including *FT*, *HSFA*, and *BAS* have been cloned and are ready to be transferred into plants (Fig. 2). Overexpression and CRISPR/Cas9 gene knock out lines will be also generated.

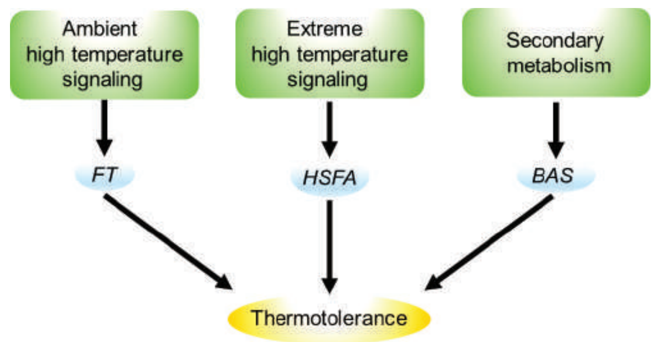

Fig. 2 Strategy opted to engineer thermotolerance in plants

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Our lab research focus lies in plant developmental biology and metabolic engineering. Several important plants undergo activity-dormancy cycles in the Himalayan region, which is required to survive under unfavourable conditions. Also, critical developmental processes such as flowering, metabolite synthesis, tuber/corm/bulb formation etc., are regulated by photoperiod and temperature. Thus, we aim to decipher the molecular regulation of seasonal growth, development and dormancy in economically important underground vegetative tissues.

Secondly, secondary metabolites produced in plants have therapeutic and culinary uses. These specialized metabolites are synthesized via different pathways *in planta*. We aim to elucidate these pathways and engineer them for enhanced metabolite production. Below are a few projects going presently in the lab.

Saffron Developmental Biology

Saffron (*Crocus sativus*), the world's most valued spice, is mainly propagated vegetatively by corms. Flower formation, ultimately saffron production, is directly proportional to the development of quality corm, and corm number is paramount in determining the saffron crop yield. Not much is studied when it comes to saffron flowering transition and corm development. Thus, we have started to work on 'Deciphering molecular mechanism regulating corm development and flowering transition in Saffron corms (*Crocus sativus*) and understanding its developmental biology'.

Corm development

In saffron, once flowers, leaves, and roots are developed from a mother corm, the development of daughter/replacement corms starts. A mother corm leads to the development of 2-3 daughter corms during the growing season, and the size of the daughter corm is also influenced by mother corm size. This low multiplication rate for the development of daughter corm is rate-limiting for seed production. Various internal and external factors such as photoperiod, temperature, nutrients, and source to sink strength are suggested in regulating corm size. The circadian clock helps plants to anticipate and synchronize their growth and development with the daily and seasonal cycles of the environment. Changes in light, day length and temperature are perceived via dedicated receptors and cause resetting of the circadian clock to local time and regulate plant growth and developmental processes. Thus, clock genes and downstream pathways are important regulators of plant growth, and we aim to study these components in saffron plant with respect to annual growth and corm development.

In order to identify signals and signalling factors regulating corm development, we have performed experiments to de-couple the role of photoperiod and temperature in corm development. Corms of similar size 8-10gms were grown at 22^0C under 24/0 hour and 16/8-hour light-dark cycle and monitored for growth and corm development (Fig. 1).

Fig. 1 Effect of photoperiod on plant growth and corm development

Plants grown at 24h/0h light/dark cycle produced bigger corms but fewer daughter corms than plants grown at 16h/8h light/dark cycle and showed early leaf senescence and smaller root size and biomass.

We have also isolated and cloned a few circadian clock genes such as Flowering Locus T (FT), Constans (CO), GIGANTEA (GI), Early Flowering 3 (ELF3), Late Elongated Hypocotyl (LHY), etc. and are in the process of their characterization during annual growth and corm development.

Thermoresponsive pathway underlying the regulation of flowering

Like corm development, little is known and studied about flowering transitions and differentiation in saffron corms. Saffron corms remain dormant during warmer climatic conditions, and when there is a decrease in temperature, it starts sprouting, followed by the production of flowers and leaves. Flowering in saffron can be majorly divided into two phases 1. Flower differentiation, and 2. Flowering transition. The temperature has been shown to have an important role in regulating both phases (Fig. 2).

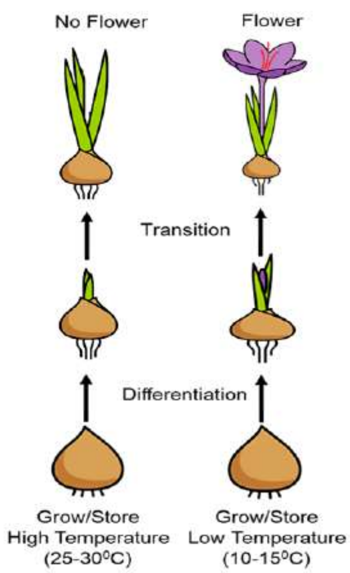

Fig. 2 Schematic representation of temperature regulated flowering in saffron

Flower initiation or differentiation takes during the dormancy/storage stage in summer when the average temperature is around 25-30^{0}C, while the flowering transition takes place around at an average temperature of 15-20^{0}C. Inappropriate temperatures at any time point, i.e. at storage or flowering, resulted in flower atrophy and reduced or no flowering. We hypothesize that a thermosensory pathway is involved in regulating flowering (differentiation and transition) in saffron and trying to elucidate it using the transcriptomics approach, coupled with morphological and anatomical studies. For this, we are using meristem-enriched tissue collected from corms stored and grown at two different temperatures (low and high) and performing the studies. We have successfully cloned a few genes which are believed to have a conserved role in other plant species and characterizing their role in temperature-regulated control of flowering in saffron.

Synthetic biology approach to engineer Asafoetida's specialized terpenoid production

The primary aroma, flavour and bioactive compounds of asafoetida constitute terpenoids and their derivatives. The production of these compounds in the desired amount takes years *in planta*. Therefore, efficient methods for producing terpenoid compounds are an unmet need, considering the demand and supply. Plant cell cultures such as hairy root, callus cultures, adventitious roots etc., are a faster and more controlled way of producing plant metabolites. Combining these methods with biotechnological approaches such as gene editing and metabolic engineering, the production of terpenoids can be significantly improved. Thus, we aim to decipher and engineer the terpenoid pathway in *Ferula assa-foetida* using synthetic biology approach.

Understanding the role of terpene synthases in specialized terpenoid biosynthesis of *Ferula assa-foetida*

Terpene synthases (TPS) are very substrate-specific enzymes and catalyze the final step involved in synthesizing specialized terpenoids. They are also responsible for generating the vast structural diversity found in terpenoid natural products' superfamily. Thus, identifying Terpene synthases involved in the process and characterize their role in Asafoetida terpenoid metabolism will break ground and pave the way for the efficient engineering of terpenoids.

In the above context, we have identified and cloned 6 Terpene synthase genes (TPS1-6), highly expressing in the roots/rhizome of *Ferula assa-foetida* (Fig. 3). We will generate knockout, knockdown and overexpression transgenic lines in hairy root cultures developed from *F. assa-foetida* for functional evaluations of terpene synthases *in planta*, which can be further utilized for metabolic engineering.

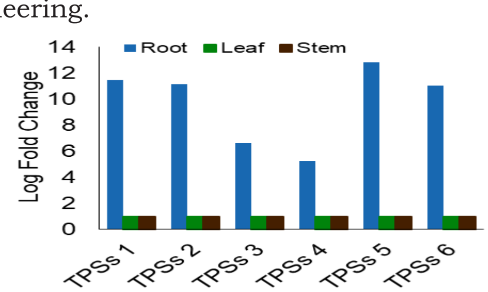

Fig. 3 Relative expression value for Terpene synthase genes (*TPSs*) named 1-6, from *F. asafetida*

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Our research group focuses on exploring the microbial community from extreme environments of the Himalaya for its application in society and industry. Our major research achievement targeted solid waste management in high Himalayan regions by scientifically intervening and facilitating faster degradation of the night soil and other agro-kitchen waste. This year we have distributed two tonnes of "Compost Booster- a microbial formulation for rapid degradation of night soil to manage human waste in cold desert areas" in Lahaul region and 1 tonne to the Army for its use in Ladakh. Our publications have provided the scientific basis on the exploration of bacteria for plant growth promotion and bioprospection for industrial applications. Our research efforts on *Shiitake* mushroom processing and enriched composting have led to the establishment of five Scheme of Fund for Regeneration of Traditional Industries (SFURTI) clusters under the Ministry of Micro, Small & Medium Enterprises (MoMSME) providing livelihood opportunities to 1150 people. The research work of our lab can be discussed under following categories.

Bacterial bioprospection of alpine region for industrial enzymes

Unexplored cold and extreme niches provide bioprospection opportunities for potential microorganisms with the ability to produce cold-active enzymes with wide temperature activity. Enzyme functioning under variable processing conditions is particularly useful in food industry. Hence, such a cold-active enzyme with activity spanning over a broad temperature range may act as an attractive and efficient biotechnological tool for the development of functional food ingredients, impacting human health. In this regard, protease is an important biocatalyst for releasing antioxidant peptides with health benefits from protein sources. A cold-adapted bacterium *Chryseobacterium polytrichastri* ERMR1:04 produced an extracellular protease enzyme optimally at 20°C, pH 8 with 1.25 g/100 mL skim milk inducer. The purified 22.24 kDa protease was active over a broad temperature 5-65° optimum at 37° and pH 6-10 (optimum at pH8) range, inhibited by EDTA and 1, 10-phenanthroline, enhanced by Ca^{2+} Mn^{2+} and hexane, and retained its activity with surfactants and detergents. ERMR1:04 protease-mediated hydrolysis of soy protein generated antioxidant peptides of <6 kDa, showing radical scavenging activities of 77% for DPPH (2, 2-diphenyl-1-picryl-hydrazyl-hydrate), 96% for ABTS (2,2'-azino-bis(3-ethylben zothiazoline-6-sulfonic acid), 93% for ferrous ion chelation and Abs_{700} 0.159 for reducing power assay. Such promising properties qualify the ERMR1:04 proteases as a potent catalyst for high-value functional food production (Fig. 1).

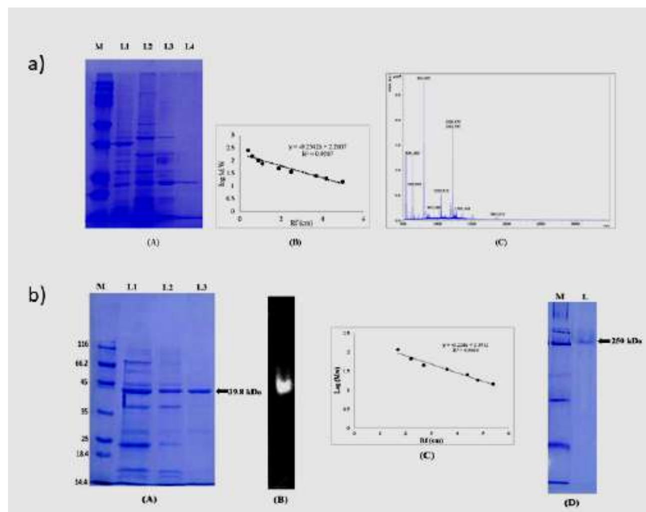

Fig. 1 SDS-PAGE analysis of purified (a) protease and (b) lipase, from *Chryseobacterium polytrichastri* ERMR1:04 and its molecular weight determination

The same bacterium, C. *polytrichastri* ERMR1:04, was explored for the bioprospection of cold active lipase. Optimum lipase production was carried out by the bacterium in 1% (v/v) rice bran oil, pH 7 at 20°C. Extracellularly produced enzyme was purified by size exclusion and hydrophobic interaction chromatography by up to 21.3-fold. The purified enzyme was predicted to be a hexameric protein of 250 kDa, with ~39.8 kDa monomeric unit (Fig. 1b) MALDI-TOF-MS analysis of the purified lipase showed maximum similarity with alpha/beta hydrolase (lipase superfamily). Biochemical characterization of the purified enzyme revealed optimum pH (8.0), temperature (37° C) and activity over a temperature range of 5.65° C. The enzyme showed remarkable compatibility with the commercial detergents and could be explored further for its application in detergent formulations to enhance the detergent performance at varied temperatures.

Effort to save winter dry toilets in Lahaul and Spiti districts of Himachal Pradesh

Efficient cold-tolerant bacterial consortia extracted from the cured night soil compost has been scaled up and mixed with suitable carrier materials for the production of "Compost Booster-a microbial formulation for rapid degradation of night soil to manage human waste in cold desert areas". The product is very user friendly as the dry-toilet users have to use a handful of the material after defecating. The samples of compost boosters were distributed among a few households in Lahaul for trial in 2018. After receiving very positive feedbacks and with increased demand and product popularity, awareness drives, interaction sessions and training programmes were conducted across five gram-panchayats in Lahaul, and Compost booster was distributed to approximately 160 households in December 2020 and January 2021. Scientific validation of one of the bio-inoculant among the psychrotrophic bacterial consortia was established using physiological and genomic evidences and comparative genomics. In the study, the bacterium was analyzed for its safety, cold-adaptation, efficient degradation, and plant growth-promoting (PGP) attributes. *Glutamicibacter arilaitensis* LJH19, a psychrotrophic bacterium, was isolated from the NSC of Lahaul valley in northwestern Himalaya. The strain exhibited amylase (186.76±19.28 U/mg), cellulase (21.85±0.51 U/mg), and xylanase (11.31±0.51 U/mg), activities at 10 °C. Possessing efficient hydrolytic activities at low-temperature garners the capability of efficient composting to LJH19. Additionally, the strain possessed multiple PGP traits such as indole acetic acid production (166.11±5.7 μg/ml), siderophore production (85.72±1.06 pus), and phosphate solubilization (44.76±1.5 μg/ml). Enhanced germination index and germination rate of pea seeds under the LJH19 inoculation further supported the bacterium's PGP potential. Whole-genome sequencing (3,602,821 bps) and genome mining endorsed the cold adaptation, degradation of polysaccharides, and PGP traits of LJH19. Biosynthetic gene clusters for type III polyketide synthase (PKS), terpene, and siderophore supplemented the endorsement of LJH19 as a potential PGP bacterium. Chromosomal map showing the unique genomic regions across the strain LJH19 depicts the uniqueness of the strain LJH19 (Fig. 2). Comparative genomics within the genus revealed 217 unique genes specific to hydrolytic and PGP activity. The physiological and genomic evidence confirmed LJH19 as a potentially safe bio-inoculant to formulate psychrotrophic bacterial consortia for accelerated degradation and improved night-soil compost.

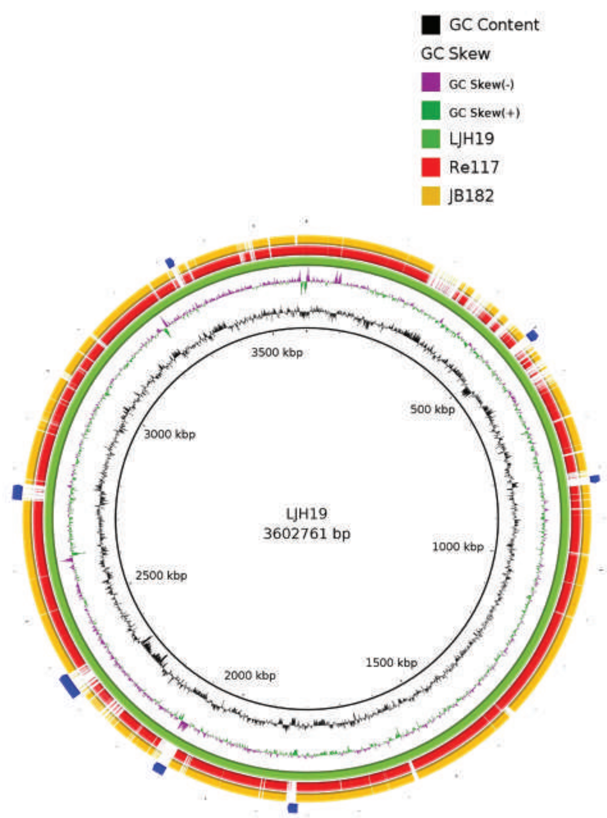

Fig. 2 Circular genome representation and clusters of orthologous groups (COG) classes of *G. arrilaitensis* LJH19 across the three closely related strains, including type strain *G. arrilaitensis* Re117T, *G. arrilaitensis* JB182, and *G. arilaitensis* LJH19, which resulted in identification of the unique genomic region across the isolate LJH19

Exploration of indigenous alpine bacteria to serve as a biopriming agent for the biohardening of micropropagated *Picrorhiza kurrooa* plantlets in cold regions

Picrorhiza kurrooa Royle ex Benth is a highly valued perennial medicinal herb, endemic to alpine areas of Himalayas. The below ground parts of the plant possess hepato-protective, antioxidative, anti-cancer and immuno-modulatory properties. Hence, *P. kurrooa* is extensively used in the Ayurveda system of medicine for treating ailments of liver, spleen and upper respiratory tract, gastric troubles fever, asthma, jaundice, dyspepsia, anaemia, cancer etc. Although, the plant is self-regenerating, indiscriminate harvesting of the plant from the wild and lack of organized cultivation has led to considerable depletion of its natural population. As a result, the plant is now enlisted as an 'endangered' species, as per IUCN criteria. Although several micropropagation protocols have been developed and reported for the plant's sustainable production, survival of *in vitro* plantlets under green house/open field poses a major challenge. Biopriming of micropropagated plantlets with plant growth-promoting rhizobacteria (PGPR) are among the successful methods to combat this problem. *Serratia quinivorans* PKL:12 was the best-characterized PGPR from rhizospheric soil of *P. kurrooa* as it increased the vegetative growth (shoot height 2.64 fold higher, root length 2.39 fold higher and lateral root numbers 1.73 fold higher) most efficiently (Fig. 3).

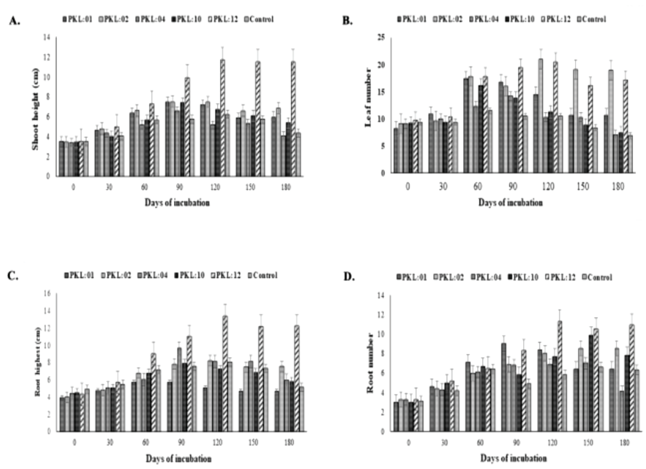

Fig. 3 Response of PGPR treated *in vitro* plantlets of *P. kurrooa* under greenhouse condition. A) Shoot height; B) Leaf number; C) Root height; D) Root number as compared to untreated control for 180 days

The survivability of the PKL:12 treated biohardened *in vitro* plantlets increased from <50% to 86.7%. This signifies the importance of using an indigenous bacteria obtained from the rhizosphere of the plants growing in natural condition for its biohardening process. Lots have been talked about the plant growth promoting potential of the species *Serratia quinivorans*, but there have been no reports on its genetic evidence. The reported high quality gapless single contig complete genome is the first to relate the physiological and genetic evidence of *S. quinvoans* for plant growth promotion. Detailed study on genetic evidence on plant growth promotion and biocontrol potential of the bacterium, and comparative genome study to reveal closest associated strains through phylo-taxono-genomics and screening of the unique genes important for biocontrol activity, makes the study more interesting. The concept of biopriming has been primarily used for plant growth promotion and biohardening, but the current study is the first of a kind to utilize this technique to sustain the micropropogation methods of a very important endemic Himalayan plant *Picrorhiza kurrooa*.

Exploration of traditional fermented beverage "*lugri*" from Lahaul valley for probiotics and value added products

Cereal-based traditional fermented beverages (TFBs) are prevalent among India's ethnic community, and *lugri* is one such TFB popular among the tribal people of the Lahaul valley in North-Western Himalaya. Previous studies have reported that lugri harbors probiotics and contains amino acids and vitamins but comprehensive substrate-specific exploration of *lugri* for probiotic attributes was unexplored. The present study selected three substrate-based *lugri* (wheat, rice, and barley) to study their biochemical properties and explore potential probiotics. This study screened the best probiotic strains for antioxidant studies and the fermentative process. Biochemical analysis determined that rice-based *lugri* had a higher alcohol content, electric conductivity, crude protein, and lower pH than barley and wheat-based *lugri*. A total of 134 distinct morphotypes were screened, and 43 strains were selected based on their qualitatively superior acid and bile tolerance. Rice-based undistilled lugri harbored the most probiotics, with 22 out of 43 strains isolated. All 43 bacterial isolates exhibited properties like cell surface hydrophobicity, cell-auto aggregation, β-galactosidase, and exopolysaccharide production, supporting them as possible probiotics. Based on antibiotic susceptibility, hemolytic activity, and biofilm formation, all the bacterial strains were found to be non-pathogenic. Taxonomically, they ranged among eight distinct genera and 10 different species. Statistically, 12 isolates were found to be the most promising probiotic, and eight strains were isolated from rice-based undistilled *lugri*. Furthermore, the antioxidant activity of the promising isolates was tested, based on free-radical scavenging ability toward 2,2-diphenyl-1-picrylhydrazyl (4.39-16.41%) and 2,2´-azino-bis (3-ethylbenzothiazoline-6sulfonic acid) (15.29-57.74%). The strain *Lacticaseibacillus paracasei* LUL:01 showed the best antioxidant activity and probiotic attributes, and hence was used for the production of fermented milk. The strain LUL:01 fermented the sterile milk within 18 h, and the viable count remained above the legal requirement of 6 $\log^{10}$ CFU/ml during 28 days' storage at 4°C. The obtained probiotic strains represent a suitable candidate for the production of functional food formulation with health benefits.

Molecular adaptational approach to understand the survivability of *Arthrobacter* under multiple high-altitude stress

Arthrobacter is a dominant aerobic bacterium under the class *Actinobacteria*, known for its nutritionally versatile nature and wide prevalence in stressful environments. Representative two *Arthrobacter* strains, ERGS1:01 and ERGS4:06, with efficient survivability under high altitude stress conditions were selected for comparative genomic studies with their mesophilic counterparts. Physiological analysis and genome insights supported the survival of these strains under multiple high-altitude stress conditions. Molecular cold-adaptation and substitution analysis of the studied strains supported the incidence of more cold-adapted proteins for functionality at low temperatures (Fig. 4). Studied strains preferred amino acids like serine, asparagine, lysine, tryptophan for favoring increased protein flexibility supporting their broad temperature survivability. The molecular cold adaptation analysis of the genus *Arthrobacter* has revealed that 'aromaticity' one of the cold-adaptor indicators, should be carefully considered while evaluating cold adaptation strategies in psychrotrophic/ psychrophilic bacteria.

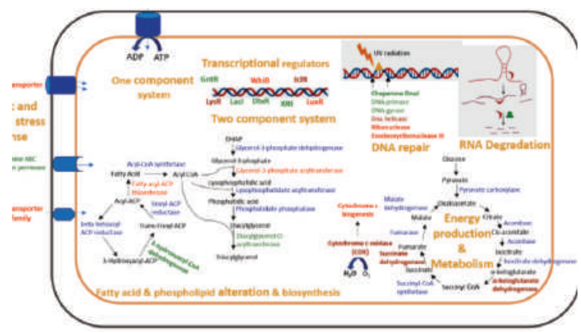

Fig. 4 Schematic representation of the molecular adaptation analysis of selected known cold genes in *Arthrobacter* sp. ERGS1:01 and ERGS4:06

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Iron enrichment in microalgae biomass for combating anaemia

A process for enrichment of iron content in the microalgae biomass was developed. *Spirulina platensis* and *Chlorella pyrenoidosa* were selected as model microalgae for enrichment studies. Incremental addition of iron salt to cultivation medium resulted in multi-fold increase in iron content in the microalgae biomass. For example, *Spirulina platensis* biomass cultivated under control medium containing 4 PPM iron (Fe), the total iron content was 202.63 ± 10.13 mg kg^{-1} (202 PPM) while the biomass obtained under incrementally dosed iron (Fe) medium containing 16 PPM iron (Fe), the total accumulated iron content in biomass was 1697.45 ± 84.87 mg kg^{-1} (1697 PPM). Additionally supplementation of zinc sulphate ($ZnSO_4$) in the medium enhanced the zinc by 1.2 fold (Fig. 1).

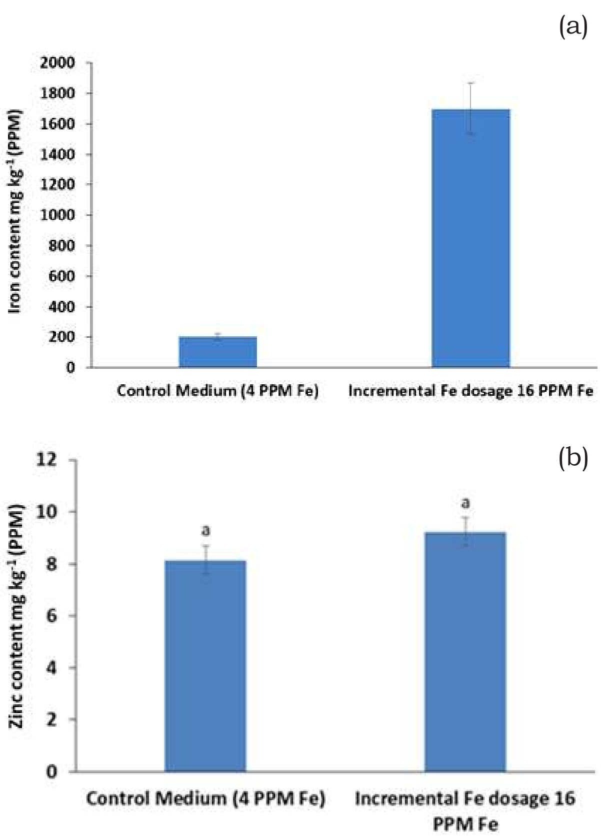

Fig. 1 a) Iron content of Spirulina biomass and b) Zinc content of Spirulina biomass

The bio-efficacy of iron enriched Spirulina biomass in reversing the anaemia symptoms was studied using *in vivo* iron repletion experiments in animal models (Sprague-Dawley rats). Ferrous ascorbate was considered as reference iron source. Supplementation of Spirulina biomass in iron deficient rats resulted in 1 to 1.5-fold increase in haemoglobin levels,serum total protein and albumin levels. Further supplementation of Spirulina biomass resulted in 2- fold increase in total serum iron content. Spirulina supplementation ameliorated oxidative stress in liver, spleen and kidney by reducing the lipid peroxidation induced due to anaemia. The tissues showed enhanced super oxide dismutase levels compared to reference material. Histopathological analysis revealed that sutpplementation of Spirulina biomass reversed the fatty accumulation in liver, thinning of myocardial fibres and degeneration of intestinal villi induced due to iron deficiency (Fig. 2).

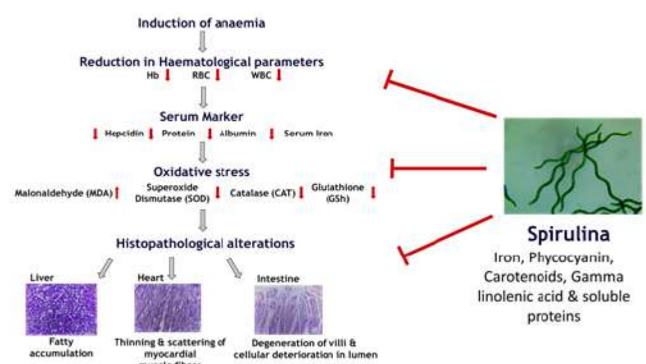

Fig. 2 Bio-efficacy of iron enriched Spirulina biomass in amelioration of iron deficiency induced anaemia

Development of microalgae based protein and micronutrient rich animal feed

Indian livestock sector faces huge deficit in feed supply accounting to about 39% in dry fodder, 36% in green fodder and a 57% in feed concentrate and proteins. India ranks 5th in global production and consumption of animal feed at 29.4 million MT utilizing mainly cereals, pulses and oilseeds (India Feed Industry, 2018-19). This huge demand for animal feed exerts tremendous pressure to divert the food crops towards animal feed, a scenario which is not sustainable for a country like India facing huge challenge of feeding its population.

Microalgae could offer an excellent source of feed ingredients such as protein and amino acids, vitamins - carotenoids, essential polyunsaturated fatty acids, and minerals such as iron, zinc, phosphorus, magnesium and potassium. In addition to its benefit as concentrated source of nutrients, microalgae do not have anti-nutrition factors such as phytic acid or oxalates thereby having higher bioavailability.

In this context, we propose utilization of fast growing microalgae strains viz., *Spirulina platensis*, *Chlorella* sp. and *Scenedesmus* sp. as source feed ingredient. The protein content ranged between 25% and 50% dry weight with protein digestibility corrected amino acid score (PDCAAS) ranging between 0.80 to 0.90, similar to other plant based protein sources such as soybean. The nutritional quality of these microalgae revealed presence of essential fatty acids such as gamma linolenic acid, alpha linolenic acid and an average total carotenoid content of 100 μg 100 mg^{-1} (Table 1). The beta carotene and total polyphenol content of the microalgae biomass was 10 folds higher when compared to maize. For cost effective cultivation, fertilizers such as urea, N:P:K, super phosphate, baking soda were evaluated and found to support luxuriant growth of microalgae. Further, food processing waste water was evaluated as source of nutrients during cultivation of microalgae. In addition, downstream processing strategies such as flocculation was optimized for efficient harvesting of microalgae. Chitosan, polyamines and cationic starch were found to induce agglomeration of microalgae cells at low concentrations such as 20 mg L^{-1} to 30 mg L^{-1} dosage reducing the energy required in dewatering microalgae biomass.

Table 1. Nutritional value of microalgae

Microalgae	Protein Content (% dry basis)	In-vitro digestible protein (% total protein)	Major Fatty acid (% total fatty acids)
Spirulina platensis	53.54±0.54	88.49%	C-16:0 = 47%, C-18:3 (n-6) = 13%
Chlorella pyrenoidosa	25.27±0.47	62.05%	C16:0 = 29.5% , C18:1 = 35.6%
Chlorella sorokiniana	47.16±0.55	83.55%	C16:0 = 25.6%, C18:2 = 18.6%, C-18:3 (n-3)= 11.9%
Scenedesmus obliquus	30.45±1.79	79.05%	C16:0 = 37.1%, C18:1 = 21.4%, C-20:4 (n-6) = 1.8%
Scenedesmus acutus	41.39±0.80	81.25%	C16:0 = 28.7%, C18:1 = 24.2%, C-20:4 (n-6) = 2.1%
Scenedesus abundans	35.92±2.75	83.40%	C16:0 = 30.8%, C18:1 = 24.6%, C-20:4 (n-6) = 1.2%

*The research outcomes of this work was commercialized in the form of transfer of technologies for commercial production of iron and zinc enriched microalgae based food products to various industry partners.

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Our major research focus is on the development of molecular markers, genetic dissection, and molecular breeding for important traits in high-altitude plants.

Development of Hypo-methylated Saffron Population (HySP) to Explore Saffron Epigenomics

Saffron (*Crocus sativus* L.), belonging to the family Iridaceae, is the highest value spice globally and also known as "red gold". It is majorly grown in the Mediterranean basin, North Africa, Iran, and Kashmir. India is the second-largest producer of saffron after Iran. Saffron is a triploid crop having three sets of eight chromosomes (2n=3x=24) with a large genome (>10 GB; 1C = 3.45 Gbp). Due to the triploid nature, it became sterile (no seed setting reported), and thus exclusively propagated through corms. To explore the involvement of epigenetics in the growth and development of saffron, we developed a hypomethylated saffron population (HySP) using 5-azacytidine (hypomethylation agent). Two doses i.e., 250 µM and 500 µM of 5-azacytidine were given to uniform size (6-8g) corms, and corms were dipped in the solution for 18h. Total 250 plants in M_0 generation were raised during crop season 2020-21. 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 for days to germination, number of sprouts, leaf length, flowering in chemically treated plants than control plants. For instance, untreated corms germinated minimum after 8 days of sowing, however, some treated corms germinated within three days only. Similarly, the maximum length of leaf in control plants was 25.5 cm, whereas, it was increased up to 31.4 cm in the HySP.

Hypomethylation led to a reduction in flowering (50%) as compared to control plants. The difference in above mentioned morphological traits in HySP than control plants suggested the vital role of DNA methylation in saffron growth and development. Further, significant differences were also observed for above mentioned morphological traits in the open field and controlled environmental conditions. To determine the change in methylation pattern at the DNA level, the hypomethylated population was also genotyped using methylation-sensitive amplification polymorphism (MSAP) markers (Fig. 1).

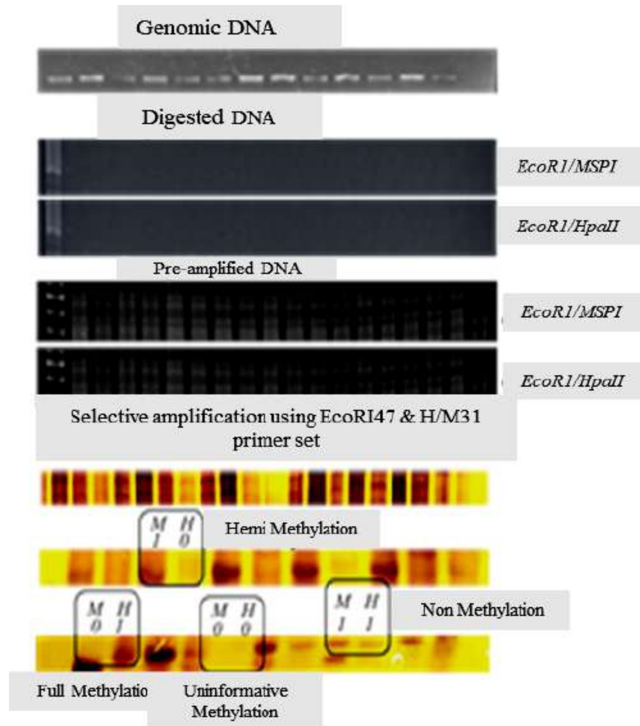

Fig. 1 Methylation status of each individual in the HySP population was detected using MSAP analysis with the primer combinations EcoRI47 and H/M31

MSAP profiling revealed that the population varies for methylation patterns. HySP developed during the present study may prove an important asset to explore and understand the role of epigenetics in essential traits of saffron. Important epigenetic marks associated with these key traits may be identified using developed HySP through the epi-GWAS approach, and further, be utilized in saffron improvement programs through epi-breeding.

GRAS Gene Family in *Rosa chinensis* and Their Potential Role in Growth and Development

GRAS is a family of plant-specific transcription factors (TFs) that play a pivotal role in regulating several biological processes of plant growth and development. Despite its great importance, it is unexplored in rose. Rose, belonging to the *Rosaceae* family, is one of the most important ornamental crops, that has huge demand in different industries like perfumery, cosmetics, and pharma, etc. The present study identified 59 GRAS genes distributed on seven chromosomes of rose and were grouped into 17 subfamilies including one *Rosaceae*-specific subfamily (Fig. 2). Maximum 21 GRAS genes were grouped in LISCL subfamily. The majority (48) of GRAS genes were intronless, however, 11 GRAS genes had 1-2 introns. The protein length and molecular mass of the RcGRAS TFs showed enormous variations, with lengths ranging from 160 to 832 amino acids, molecular weights ranged from 19.08 to 93.79 kDa and isoelectric points ranged from 4.63 to 9.62. Further, $K_a/K_s < 1$, indicated purifying selection of these genes during the evolution.

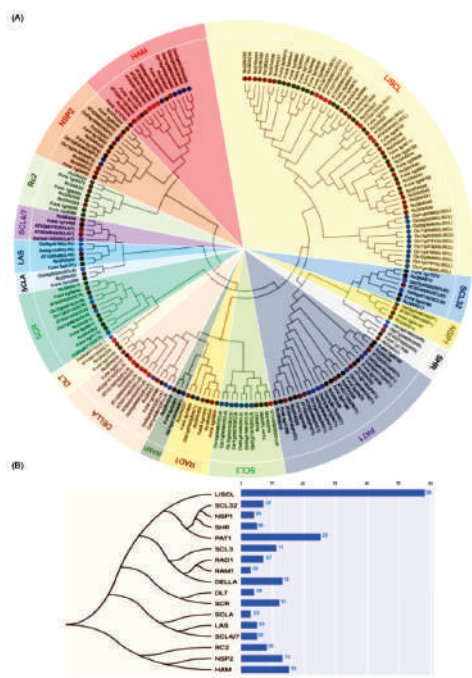

Fig. 2 Phylogenetic relationships of GRAS proteins (A) Phylogenetic tree based on GRAS sequences from Rosa chinensis, Arabidopsis thaliana, and Oryza sativa. The GRAS proteins are clustered into 17subfamilies are indicated by different colors. (B) Phylogenetic tree showing the relatedness among the 17 different subfamilies of GRAS members and bar-plots showing the number of GRAS members in each subfamily

The NLS prediction in the GRAS TFs revealed that out of 59 rose GRAS TFs, 31 members have either bipartite or monopartite or both types of NLS. Forty-four *RcGRAS* genes were located in the nuclei and the remaining 15 were located in the cytoplasm. Expression profiling of a total of 22 GRAS genes was conducted on three different tissues including leaf, stem, and flower bud (Fig. 3). Three genes (*RcGRAS57*, *RcGRAs9*, *RcGRAS4*) of subfamily HAM showed a different pattern of expression in three tissues. No significant differences were observed in the expression of *RcGRAS57* in leaf, stem, and flower bud, however, *RcGRAS9* was significantly upregulated in the stem than the leaf and bud, and in the case of *RcGRAS4* significant downregulation was observed in flower bud as a comparison to leaf. Similarly, in the case of DELLA, three genes (*RcGRAS7*, *RcGRAS23*, *RcGRAS25*) showed different expression patterns in three tissues. No expression difference was observed for *RcGRAS23*; however, *RcGRAS7* and *RcGRAS25* significantly down- and up-regulated in stem tissues respectively. Altogether, four GRAS genes [*RcGRAS9* (HAM), *RcGRAS22* (LISCL), *RcGRAS19* (SCR), and *RcGRAS8* (SCL4/7)] exhibited unique expression in the stem; and a total of five GRAS genes [*RcGRAS7* (DELLA), *RcGRAS30*/*RcGRAS1* (SCL3), *RcGRAS50* (LAS), *RcGRAs53* (Rc2)] showed leaf specific expression. The present study may assist the future function validation of *GRAS* genes and to be utilized in rose improvement programs.

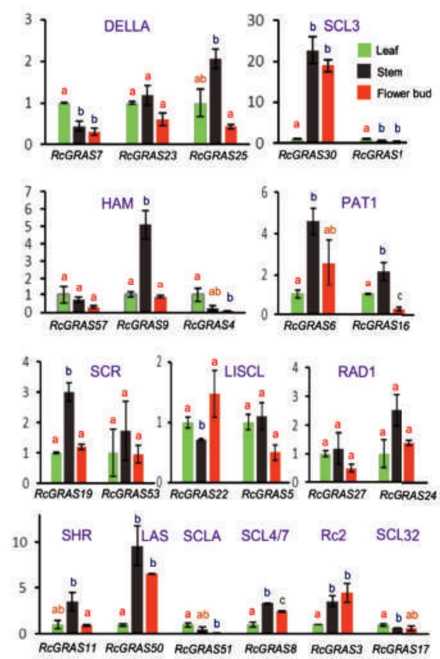

Fig. 3 Tissue-specific expression profiles of 22 selected *RcGRAS* genes in leaf, stem, and flower bud tissues. Y-axis represents the relative expression value. Bars represent the mean values of two biological and technical replicates ± SE. Lowercase alphabets represent the significant difference (p <0.05, Student's t-test)

Research group: Priya Kumari, Vishek Choudhary and Deepika Shekhawat

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My group's main focus is on the exploration of probiotic microorganisms obtained from Himalayan (Western) indigenous cow, yak, and goat milk and microbial enzymes, aiming to produce essential metabolites and their industrial applications.

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

The samples of various milk and milk-based fermented products were selectively obtained from indigenous cows, yaks, and goats and some from traditional non-dairy fermented products collected from different high-altitude regions of Western Himalaya (Lahaul and Spiti of Himachal Pradesh and Ladakh) (Fig. 1&2). The samples were evaluated for their nutritional and micronutrient profiling i.e. carbohydrates, minerals, vitamins, proteins, and fat contents (AOAC international methods for proximate analysis and FSSAI, 2015. Manual of Methods of Analysis of Foods: Oils and Fats) (Table 1.) and compared with the milk and milk-based products obtained from non-indigenous cow's milk. Potential probiotics from these foods were screened using standard protocols (Fig. 3). Further, we will also explore different transitional probiotic resources of foods from Lahaul Spiti and Kinnaur (Himachal Pradesh) and Ladakh of Western Himalaya for the potential probiotic cultures with various health benefits for commercial production of fermented functional foods (Fig. 4).

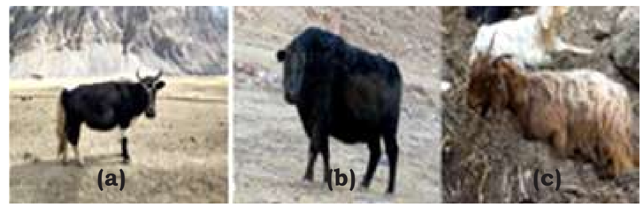

Fig. 1 Indigenous (a) cow, (b) yak and (c) goat from different high altitude of Western Himalaya

Fig. 2 Milk and milk based products from indigenous cow, yak and goat respectively from different high altitude of Western Himalaya

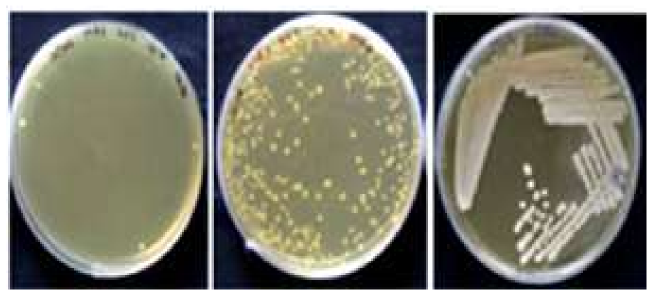

Fig. 3 Plates showing the microbial growth after enrichment of the collected milk samples on the MRS media

Table 1. Nutritional profiling of various milk samples obtained from indigenous cow, yak and goat from different high altitude of Western Himalaya

S.No.	Sample of Milk	Location	moisture (%)	Ash (%)	Protein (%)	Carbohydrate (mg/ml)
1.	Yak	Zanskar (Ladakh)	84	6.13	20.393	0.168
2.	Yak	Losar (Lahaul Spiti, H.P.)	72	4.78	34.324	0.01
3.	Cow	Losar (Lahaul Spiti, H.P.)	84	5.55	29.735	0.137
4.	Cow	Kaza (Lahaul Spiti, H.P.)	84.6	4.66	18.446	0.082
5.	Goat	Chamba (H.P.)	76	2.92	18.531	0.082

Fig. 4 Soil samples collected from different lignocellulosic degradation sites of Himachal Pradesh

Medium engineering for the production of thermo-active/stable cellulase free xylanase and pectinase from Himalayan microbial sources

Various kinds of samples including forest soil, dung, decaying wood, and other lignocellulosic materials were collected from different areas of Western Himalayan regions of India for the screening of potential microorganisms for the production of xylanase and pectinase enzymes.

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Research methodology: Our research group has been dedicated to developing different new and challenging synthetic methodologies through reagent and catalyst chemistry. Among these, the development of nano-particles as a heterogeneous catalyst and their applications in carbon monoxide fixation reaction for arylquinazolinones, aminocarbonylation and methylthioesters synthesis have been achieved in this year.

Lignocellulosic bio-waste utilization

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

Lignocellulosic biomass and carbohydrates as feed-stock for scalable production of 5-hydroxymethylfurfural (HMF)

A one-pot process to convert lingo-cellulosic bio-mass and carbohydrates to 5-hydroxymethyl furfural (HMF), following a highly specific approach. First, raw sugarcane bagasse and corn-cob biomasses were mechanically grinded to fine powder and further applied as feedstock for HMF and furfural production in a one-pot and scalable synthesis. A synergistic role of mixed acids such as oxalic acid, $AlCl_3$ and HCl, charcoal, and solvent system was critically investigated for HMF production.

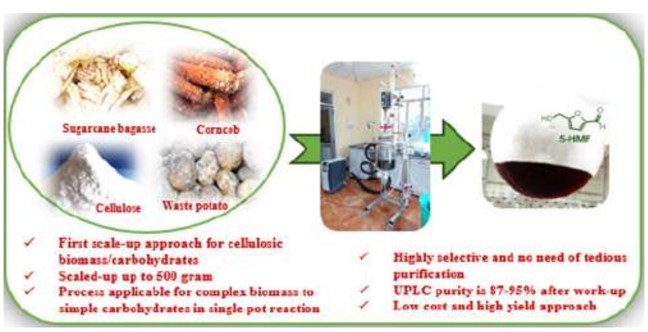

Fig. 1 Ligno-cellulosic biomass conversion to HMF

The optimized process further tested up to 0.5 kg scale biomass conversion to HMF production successfully. The scope of the process further extended for conversion of waste raw potato, corn powder, starch, glucose and fructose to HMF production with high specificity and conversion. After solvent extraction, avoiding tedious column chromatography, the UPLC purity of HMF was 87–95% (Fig. 1).

Metal-catalyst and hydrogen gas-free reduction of biomass-derived furfuraldehydes to alkyl furans as a biofuel additive

A metal catalyst and a hydrogen gas-free approach has been developed to reduce aldehyde to an alkyl group of different substituted furan compounds. In this process, hydrazine hydrate under basic conditions at reflux temperature selectively participated in reducing the aldehyde moiety to the corresponding alkyl group of highly reactive furan compounds in a selective manner. The developed protocol was applied for selective and scalable reduction of 5-hydroxymethylfurfural (5-HMF) up to 250 g to 5-methylfurfuryl alcohol (MFA) in a 70% yield. Under the same process, furfuraldehyde was also tested in a 250 g reaction for 2-methylfuran (MF) synthesis in a highly selective manner and the product was distilled out from a single-pot reaction with gas chromatography (GC) purity ≥90%. The scope of the process was further extended for different substituted furfuraldehydes successfully. In addition, the protocol is found to be efficient for scalable production and easy separation of the product (Fig. 2).

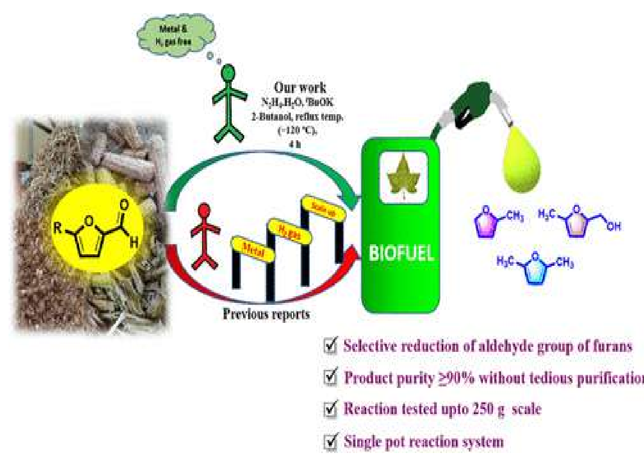

Fig. 2 Alkyl furans synthesis as a biofuel additive

Benzosuberene-sulfone analogues synthesis from *Cedrus deodara* oil and their therapeutic evaluation by computational analysis to treat type 2 diabetes

Benzosuberene-sulfone (BSS) analogues have been semi-synthesized following green approaches from himachalenes, extracted from the essential oil of *Cedrus deodara*. In this process, benzosuberene in the presence of different aryl or alkyl sodium sulfinates, I_2 and potassium persulfate ($K_2S_2O_8$) in acetonitrile–water solvent conditions gave BSS-analogues at room temperature. The BSS-compounds were obtained with moderate to excellent yields under mild conditions. All the compounds were computationally subjected to drug likeliness and toxicity prediction studies. Further, evaluated the synthesized molecules under *in-silico* studies for their binding affinity towards the native Peroxisome Proliferator-Activated Receptor Gamma (PPARG) and two PPARG mutants (R357A and V290M). Both the mutant forms of PPARG are deficient in eliciting treatment with full and partial agonists. Our computational studies suggested that the molecule 3q performed better than the standard drug (Rosiglitazone) in all three protein structures (Fig. 3).

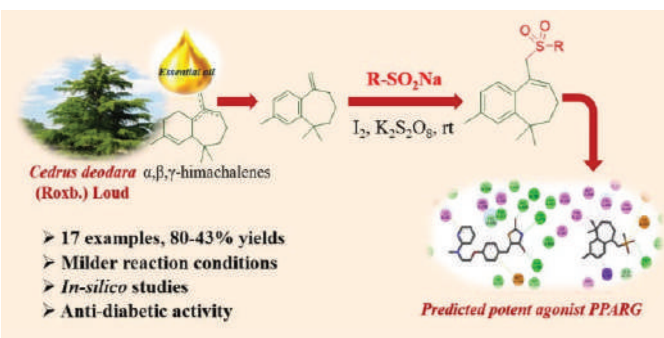

Fig. 3 Computational analysis of benzosuberene-sulfone analogues for type 2 diabetes

Palladium-catalyzed *ortho*-halogen-induced deoxygenative approach of alkyl aryl ketones to 2-vinylbenzoic acids

The 2-vinylbenzoic acids have wide applications in polymer chemistry and key precursor in the synthesis of important bioactive molecules. Herein, the ortho-halogen-induced deoxygenative approach of alkyl aryl ketones for the generation of 2-vinylbenzoic acids by palladium catalysis has been discovered and explored. This approach requires no base or stoichiometric additives and can be carried out through a simple one-step process. Furthermore, the present reaction is scalable up to a one-gram scale. The commercially available palladium on carbon (5 wt %) was used as a heterogeneous catalyst and showed excellent recyclability (<5 times) without significant loss in catalytic activity (Fig. 4).

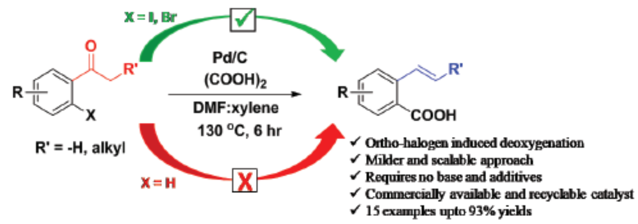

Fig. 4 Synthesis of 2-vinylbenzoic acids

Pd/C catalyzed cascade synthesis of 2-arylquinazolinones from 2-iodoacetanilides employing ammonia and CO precursors

An efficient and straightforward approach has been demonstrated for 2-aryl quinazolinones synthesis from 2-iodoacetanilides using ammonium carbamate/ammonium carbonate and oxalic acid under heterogeneous Pd/C catalyzed conditions. Herein, we have carried out the reactions employing oxalic acid and ammonium carbamate or ammonium carbonate as two gaseous precursors, i.e. CO and NH_3 respectively for the synthesis of desired quinazolinones in appreciable yields. The protocol followed cascade aminocarbonylation and cyclization under optimized reaction conditions. The heterogeneous Pd/C catalyst was found to be recyclable up to four consecutive runs without a significant decrease in catalytic activity (Fig. 5).

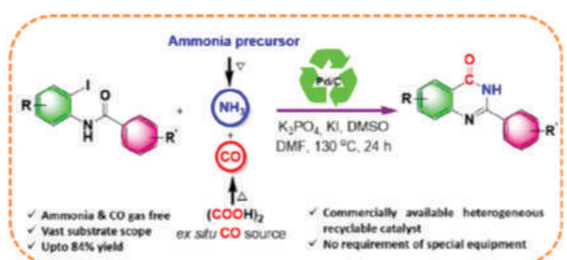

Fig. 5 Synthesis of arylquinazolinones

Supported palladium-catalyzed aminocarbonylation of aryl iodides employing bench-stable CO and NH_3 surrogates

A simple, efficient and phosphine-free protocol for the carbonylative synthesis of primary aromatic amides under polystyrene supported palladium (Pd@PS) nanoparticle (NP) catalyzed conditions was demonstrated. Herein, instead of using two toxic and difficult to handle gases simultaneously, we have employed the solid, economical, bench stable oxalic acid as the CO source and ammonium carbamate as the NH_3 source in a single pot reaction. For the first time, we have applied two non-gaseous surrogates simultaneously under heterogeneous catalyst (Pd@PS) conditions to synthesize primary amides using an easy to handle double-vial (DV) system. The Pd@PS catalyst was easy to separate and can be recycled up to four consecutive runs with a small loss in catalytic activity (Fig. 6).

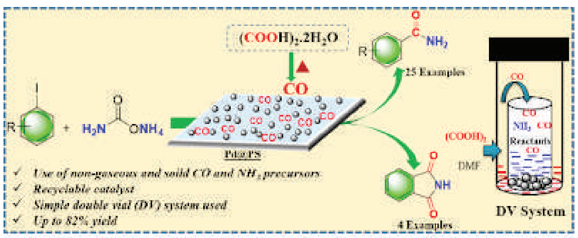

Fig. 6 Aminocarbonylation reaction of aryl iodides

Supported palladium-gold catalyzed carbonylative methylthioesterification of aryl iodides using oxalic acid and DMSO as CO and CH_3SH surrogates

The polystyrene-supported palladium-gold (Pd–Au@PS) catalyst was prepared and well-characterized by HR-TEM, EDX, Elemental Mapping, XPS and P-XRD analysis. The Pd–Au@PS NPs displayed superior catalytic activity than their monometallic forms. The first time, the catalyst was applied for methylthioesterification reaction of aryl iodides with oxalic acid and DMSO as *in situ* carbon monoxide (CO) and methyl mercaptan (CH_3SH) precursor. Yet, there is no report available where DMSO has been applied as a CH_3SH source for methylthioester synthesis. The CH_3SH and CO are likely to poison the metal catalyst, whereas in Pd–Au@PS catalyst, the beneficial inter-electronic interactions between Pd and Au metals make the catalyst highly reactive, poisoning resistant and recyclable during the transformation (Fig. 7).

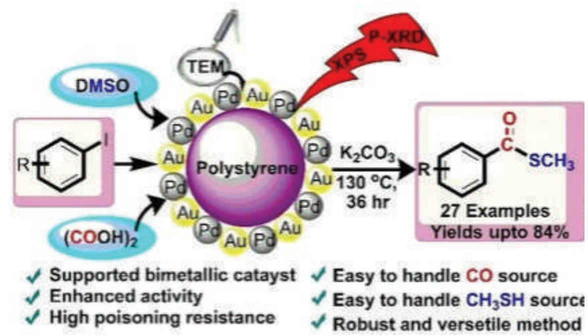

Fig. 7 Methylthioesterification of aryl iodides

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

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Natural Products and Essential Oils
Bio-prospection

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

NMR Based Metabolic Profiling of *Saussurea lappa* Roots and Aerial Parts from Western Himalaya

In the present study, polar and nonpolar fractions of ethanolic extracts of *Saussurea lappa* (aerial parts and roots) were taken for detailed profiling using NMR. Fifty-six compounds of different classes were unambiguously identified using 1D and 2D NMR and quantified by a relative quantification method. Metabolites belonging to diverse classes, including sesquiterpene lactones, steroids, triterpenoids, phenolics, carbohydrates, organic and amino acids, were identified. Roots were enriched with sesquiterpene lactones and phenolics. Triterpenoids and steroids were dominating in the aerial parts (Fig. 1).

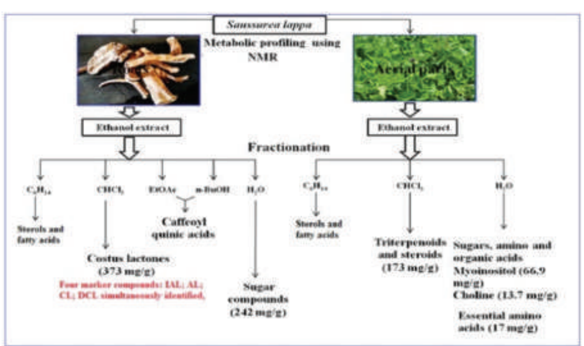

Fig. 1 NMR Based Metabolic Profiling of *Saussurea lappa* Roots and Aerial Parts

Biologically active sesquiterpene lactones including alantolactone, isoalantolactone, dehydrocostus lactone, and costunolide were observed as 121.7±1.5, 111.7±0.6, 82.5±2.0 and 42.6±1.4 mg/g dried wt. respectively in *S. lappa* roots. The simultaneous presence of these four important marker compounds in the chloroform fractions of roots were the major finding of this study. Health care metabolites, myoinositol (66.97±3.0 mg/g), and choline (13.74±0.08 mg/g) were also detected in the aqueous fraction of *S. lappa* aerial parts.

Volatile composition, antibacterial and antioxidant activities of *Artemisia tournefortiana* Reichb. from Kashmir, India

Artemisia tournefortiana essential oil (EO) was representing 93.4% of the total oil composition. Oxygenated monoterpenes (54.46%) were found to be dominant over other classes of compounds. *cis*-spiroether (47.66%), Z-β-farnesene (22.83%), *trans*-nerolidol (3.89%) and camphor (3.80%) were found to be the major constituents. *cis*-spiroether is first time identified in this region. Antibacterial effects were observed against both gram-positive and gram-negative bacteria with maximum zone of inhibition (32 mm) against *Staphylococcus aureus*. The minimum inhibitory concentration (MIC) of all tested strains was found in the range of 1.6–3.4 mg/ mL. The EO showed moderate antioxidant effect through DPPH assay with IC_{50} value of 56.2 mg/mL (Fig. 2).

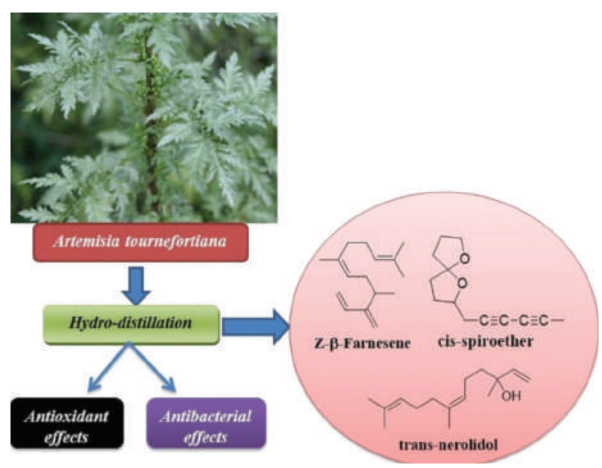

Fig. 2 Essential oil from *A. tournefortiana*

Chemical composition, antioxidant and cytotoxic activity of *Artemisia gmelinii* essential oil growing wild in Kashmir valley

The present study was carried to observe the phytochemical profile of aromatic constituents of *Artemisia gmelinni* essential oil (EO) using GC-FID, GC-MS and ^{13}C NMR and to evaluate anticancer and antioxidant activities. Twenty chemical constituents were detected from EO, accounting for 92.05% of the total oil composition. Oxygenated monoterpenes (73.64%) were the dominant class of compounds. The major constituents are isoascaridol (29.70%), α-terpinolene (25.37%), phellandrene (9.26%) and ascaridole (4.17%). Ascaridole and isoascaridole are first time identified to be the constituents of this EO. The essential oil effectively inhibits the growth of cancer cells and showed maximum anti-proliferative activity at 125 mg/mL concentration. Still, highest inhibition in cell growth was found in the A-549 (lung cancer) cell line. Our study revealed that EO effectively restricted the migration of A-549 cells up to 15% than control at 125 mg/mL concentration. The essential oil also showed moderate antioxidant activity (Fig. 3).

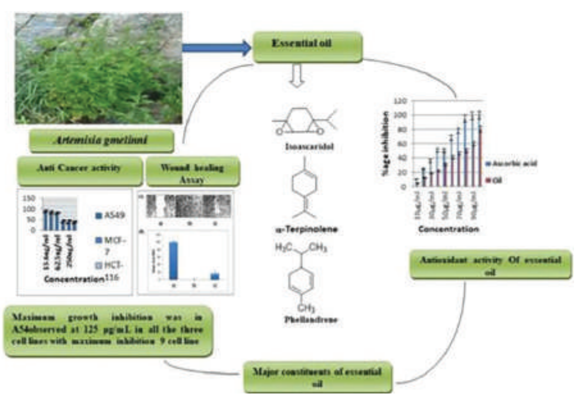

Fig. 3 Extraction of essential oil from *A. gmelinii*

Chemical composition and insecticidal properties of essential oils against diamondback moth (*Plutella xylostella* L.)

Seven essential oils such as *Curcuma aromatica*, *Hedychium spicatum*, *Mentha piperita*, *Mentha spicata*, *Mentha longifolia*, *Cinnamomum camphora*, and *Cymbopogon flexuosus* were representing 85.2–95.8% of the composition of the total oil. Extracted essential oils were evaluated for their insecticidal activities against the larvae of the diamondback moth, *Plutella xylostella* (L.). Results showed that *M. longifolia* was most toxic (LC_{50} 1.06 mg mL^{-1}) to second instar larvae of *P. xylostella via* residual toxicity bioassay followed by *C. aromatica* (LC_{50} 1.35 mg mL^{-1}) and *M. piperita* (LC_{50} 1.37 mg mL^{-1}). *M. piperita* and *M. spicata* showed promising repellent (RC_{50} 1.33 mg mL^{-1}) and feeding deterrence activity (66.07%) to third instar larvae, respectively (Fig. 4).

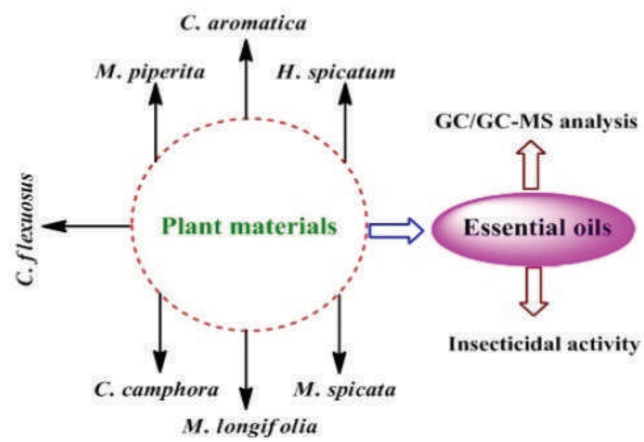

Fig. 4 Chemical composition and insecticidal properties of essential oils

Research group: Ram Chander and Antim Kumar Maurya

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Synthetic Organic & Medicinal Chemistry,
Chemical Biology

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 for synthesis of bioactive molecules.

Synthesis and antibacterial activity evaluation of bioactive complex small molecules-ciprofloxacin conjugates

Conjugates between pharmaceuticals and small molecules enable access to a vast chemical space required to discover new lead molecules with modified therapeutic potential. However, the dearth of specific chemical reactions capable of functionalizing drugs and bioactive natural products presents a formidable challenge for preparing their conjugates.

Ciprofloxacin is a broad-spectrum bactericidal antibiotic available in more than 100 countries to treat about 14 types of infections, especially UTIs such as uncomplicated cystitis, chronic bacterial prostatitis, and lower respiratory infections. The solubility of ciprofloxacin hydrochloride is very high at acidic pH, whereas solubility remains a challenge for it and its free base at intestinal pH like 6.8 and 7.0. The absorption, permeability, and solubility issue put ciprofloxacin to be a Biopharmaceutics classification system (BCS) class IV compound. These compounds exhibit the least oral bioavailability, low solubility, and intestinal permeability among all pharmaceutical classes of drugs. Because of these issues, ciprofloxacin needs more favorable pharmacophore modifications to retains therapeutic activity along with enhanced oral bioavailability, solubility, and permeability.

Amides are among the most frequently used pharmacophore modifications, and 1,2,3-Triazoles is among the most commonly used isosteres for amide bond due to their structural features that permit a good overlap with amide, better H-bond donor and accepter capacities, and favorable physicochemical properties. 1,2,3-Triazoles group serves as rigid linking units, possesses strong dipole moment. 1,2,3-Triazoles is a prominent class of heterocycles due to associated biological properties such as antibacterial, anticancer, antimalarial, and anti-HIV. These compounds find versatile application in research a building block for more complex chemical compounds, including *β*-lactamase inhibitors such as tazobactam. We have developed a support-free CuI NPs catalyzed strategy for conjugating electron-deficient and electron-rich terminal alkynes with a ciprofloxacin methyl ester. Our conjugation technique exploits late-stage functionalization of bioactive natural products such as tocopherol, vasicinone, amino acids, and pharmaceuticals such as aspirin and paracetamol to provide conjugates in excellent yields under mild and green conditions.

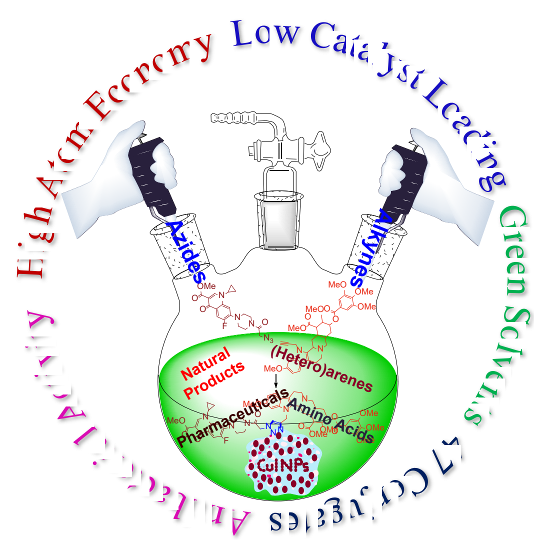

Fig. 1 **A overview of the developed protocol**

The developed method also enabled the synthesis of (hetero)arene-ciprofloxacin 1,4-disubstituted 1,2,3-triazoles in good yield and high regioselectivity

These synthesized conjugates were evaluated for their antibacterial activity against a panel of relevant bacteria. The result suggests that a significant number of conjugates showed comparable activity against Gram-positive and Gram-negative bacteria. Interestingly, some conjugates exhibited less toxicity than ciprofloxacin against two mammalian cell lines suggesting the future investigation of these compounds for *in vivo* efficacy and pharmacokinetic studies.

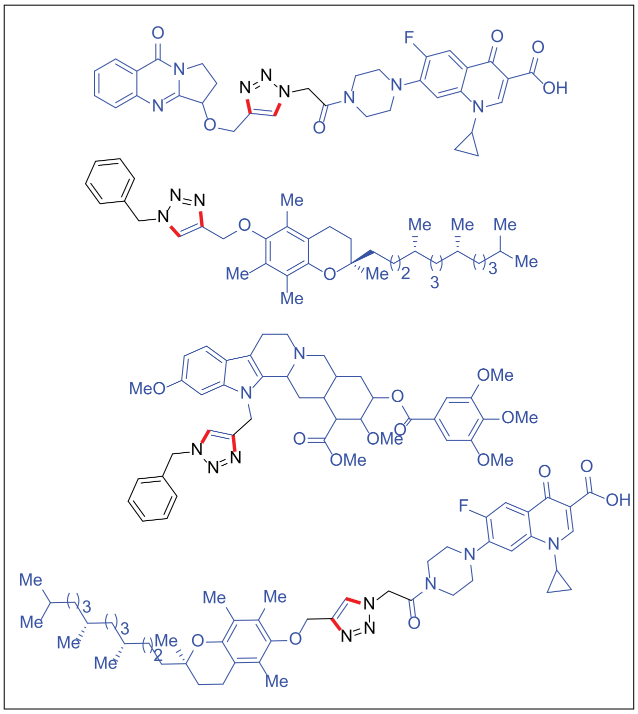

Fig. 2 Structure of selected conjugates synthesized using the developed protocol

We have developed a novel protocol that enables the conjugation of ciprofloxacin methyl ester and various complex small molecules to their respective 1, 4-disubstituted 1,2,3-triazole derivatives *via* click chemistry. The developed protocol efficiently utilized CuI NPs greener solvent composition of 3:7 of ACN:H_2O under base free and air endurance conditions at mild temperature. Various biologically active molecules such as tocopherol, vasicinone, aspirin, and paracetamol were functionalized under the developed protocol. The strategy was demonstrated with (hetero)arenes, bioactive complex natural products, amino acid and pharmaceuticals. Various heterocyclic alkynes such as pyridine, quinoline, indole, pyran, and complex molecules were derived from developed protocols to respective triazoles in good to excellent yield and high regioselectivity. Ciprofloxacin-amino acid conjugates showed comparable antibacterial activities compared to that of ciprofloxacin. Several conjugates demonstrated less toxicity than ciprofloxacin which was observed based on the hemolysis and *in vitro* mammalian toxicity studies. These synthesized conjugates could be potential candidates for *in vivo* efficacy and PK/PD studies in the future.

Value-added products from Non-edible vegetable oil

Natural feedstocks are the important raw material for industries to develop environmentally friendly and sustainable processes. Vegetable oils are such significant feedstocks that predominantly contain fatty acids. Vegetable oils like soybean, canola, peanut, olive, rapeseed, sunflower and coriander oils are the potential sources of fatty acids. However, these edible vegetable oils are not considering sustainable due to obvious food *vs.* rest competition. Therefore, non-edible vegetable oils are important raw materials for sustainable chemistry. Sapium oil, obtained from the *Sapium sebiferum* seeds, contains high unsaturated fatty acids, could be a valuable feedstock for such value-added products. Products and molecules developed from sapium oil will support productive activities and enhance the farmer's income. We are working to utilize *Sapium sebiferum* seed oil to develop value-added products.

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Chemical Technology

Area of expertise: Development, design and up-scaling of improved technologies for processing of bioactive materials from medicinal and aromatic plants, Studies on supercritical fluid extraction, Cellulose value addition. Preparation of Techno-economic feasibility and project reports for prospective entrepreneurs.

Development of eco-friendly process for extraction of fibre from plants

Natural cellulose fibres have successfully proven their qualities when considering an ecological view of fibre materials for textile and technical applications, e.g., bast or stem fibres. Retting which separates fibres from non-fibre tissues in plants, involves bacteria and fungi treatments and mechanical and chemical processes for fibres extraction. Dew/ water retting takes long processing time, weather dependent, creates foul smell, huge water consumption, and leads to environmental pollution. Therefore, a process has been developed to find alternative fiber sources based on inexpensive, underutilized, abundantly available and renewable lignocellulosic biomass which is less time consuming, efficient and environment friendly than conventional methods.

A low cost and eco-friendly process has been developed to extract and prepare phloem fibres of high quality and high counts. The process is suitable for plants having a stalk diameter of range 8-13mm. In this process, industrial waste is utilized for the separation of fibers during downstream processing.

Fig. 1 Process flow for fiber extraction

In addition to this, green protocols for bleaching of fibers are also optimized. The extracted fibers have been further used for making pure yarns and blended yarns. The physical properties of the extracted fibers are also analyzed by standard methods for physico chemical properties (Fig.1).

Design, fabrication and setting up of distillation units and catalyzing setting up of farmer's cooperatives for marketing of the produce: Mission Aroma

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

Fig. 2 Installation and commissioning of different capacities distillation units at farmers' sites under CSIR Aroma Mission

Processing of Damask rose flowers on the pilot plant

Fresh Damask rose flowers were processed on the pilot plant during April-May 2020 and produced 1800 liters of rose water during the season for sale and complimentary samples.

Commercial scale production of tea catechin from green tea leaves, development of formulations as nutraceuticals and their human intervention studies DBT- BIRAC

Tea leaves contain 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.

Under the second phase of the project, the process equipment was designed and technical consultancy was given to M/s Baijnath Pharmaceutical P Ltd. Paprola. The process was further up scaled up to 500 kg per batch. In addition to this, the seasonal variation in quality and yield was also collected at this scale and data was collected. The tea catechins obtained at this scale were analysed for quality and further used for making formulation and safety studies. Development of an efficient improved process for value-added products from green tea shoots. Optimization and validation of 500 kg per batch green tea leaf processing capacity plant at M/s Baijnath Pharmaceutical Pvt. Ltd., Paprola. This technology is beneficial for the upliftment of the tea industry through the value addition of tea leaves.

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

Optimization of process parameters for better yield and quality of anthocyanins on pilot scale were done. In addition to this, the complete process covering step by step for production of natural color from red cabbage was demonstrated to a representative of industry M/s Nanotech chemical, Ludhiana, Punjab under technology transfer MoU. All the process steps like crushing, squeezing of juice, extraction of de-juiced cabbage, filtration, column chromatography, drying etc. had been demonstrated for the same. A batch of 35 kg fresh red cabbage had been processed for the same (Fig. 3).

Fig. 3 Process upscaling for extraction coloring compound at pilot scale

Formulation of stevia liquid drops

A green process developed for direct processing of dry stevia leaves into formulated liquid drops was further improved and produced following parties for production of the Stevia liquid against processing charges as per MoU terms & conditions.

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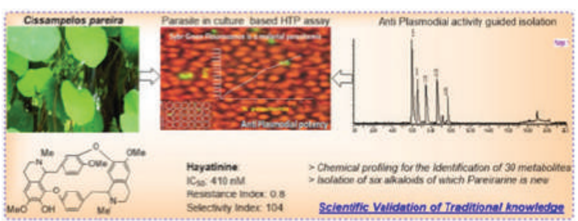
Catalysis for C-H Activation, Natural Product Chemistry, Medicinal Chemistry

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

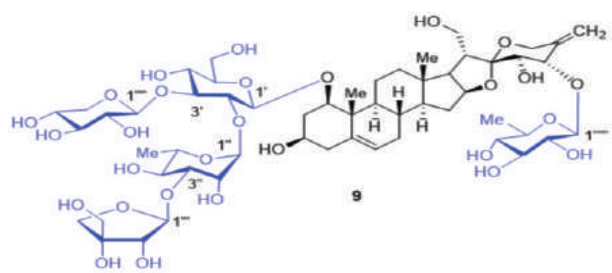
In natural product chemistry, our group is involved in the phytochemical investigation of medicinal plants. This year phytochemical investigation of *Cissampelos pareira* and *Trillium govanianum* led to the isolation of seventeen molecules, including a new alkaloid and a steroidal saponin. Further ultra-performance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

Phytochemical investigation of *Cissampelos pareira*



Cissampelos pareira is used traditionally in India as a remedy for the treatment of various diseases including malaria but the active ingredients responsible for antiplasmodial activity have not yet been investigated. The identification and quantification of compounds responsible for antiplasmodial activity in different parts (leaf, stem and root) of *C. pareira* was studied. A rapid and simple UPLC-DAD method was developed to identify and quantify of pharmaceutically important metabolites of *C. pareira*. Among different extracts, the hydroethanolic extract of the root part of *C. pareira* was found most active with IC_{50} values (μg/ml) of 1.42 and 1.15 against *Pf* 3D7 and *Pf* INDO, respectively. Further, phytochemical investigation of active fractions of root part led to the isolation and characterization of a new isoquinoline alkaloid, namely pareirarine, along with five known compounds Hayatinine, a bisbenzylisoquinoline alkaloid, isolated from root ethyl acetate fraction was the most promising compound with IC_{50} of 0.41 μM (*Pf* INDO) and 0.509 μM (*Pf* 3D7). Thirty compounds were detected in studied extracts and fractions; structures were assigned to 15 of these, and five of these biologically important compounds were quantified. Isolation of saluteridine from *C. pareira* and evaluating antiplasmodial activity of pure compound from *C. pariera* is disclosed for the first time. This study concludes that the antimalarial potential of *C. pareira* may be attributed to isoquinoline type alkaloids present in this plant and provides scientific evidence for the traditional use of this plant in the treatment of malaria.

Phytochemical investigation of *Trillium govanianum*



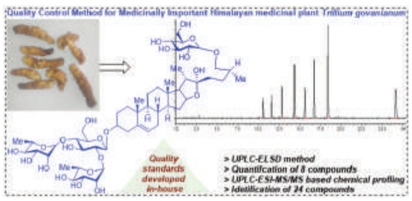
Structure of new compound 9

Trillium govanianum, commonly known as Nag Chhatri and Teen Patra, is a popular herbal supplement traditionally used for curing different inflammatory and sexual disorders, infection, and wound healing. Steroidal saponins are considered as active components of this species. The present study demonstrated the isolation of nine steroidal saponins, including one new compound named govanoside B (9) and eight known, pregna-chacotrioside (1), pennogenin-triglycoside (2), borassoside E (3), pennogenin-tetraglycoside (4), protodioscin (5), clintonioside B (6), pennogenin-diglycoside (7), and borassoside D (8). This is the first report on the isolation of 1, 2, 4, 5, 6, 7 and 8 from rhizomes of *T. govanianum*. The extract, fractions and isolated compounds were further evaluated for their DPPH and ABTS radical scavenging activity.

Qualitative and quantitative determination of steroidal saponins in *Trillium govanianum* by UHPLC-QTOF-MS/MS and UHPLC-ELSD

An ultra-high-performance liquid chromatography-quadrupole time of flight tandem mass spectrometry (UHPLC-QTOF-

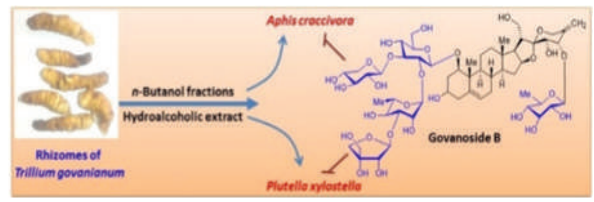
MS/MS) and ultra high performance liquid chromatography-evaporative light scattering detector (UHPLC-ELSD) methods was developed for the quali-quantitative determination of steroidal saponins in *T. govanianum*. The dried rhizomes of *T. govanianum* (100 mg) were extracted with ethanol: water (80:20, 10 mL) by ultrasonic treatment for 30 min at 40 °C.



The prepared sample was analyzed by UHPLC-QTOF-MS/MS and UHPLC-ELSD for the qualitative and quantitative determination of steroidal saponins. Total twenty-four saponins were identified using UHPLC-QTOF-MS/MS; seven were characterized by comparing them with standards. Furthermore, five saponins [govanoside B, protodioscin, pennogenin tetraglycosides, borassoside E, and borassoside D] were quantified using the UHPLC-ELSD method in different extracts and fractions of *T. govanianum*. The method showed good linearity (R^2 ≥ 0.993), limit of detection (0.92-4.09 µg/mL), limit of quantification (3.1-13.5 µg/mL), precision (intra-day RSDs < 4.3% and inter-day RSDs < 5.5%), and accuracy (86.1-110.3%). This is the first report on the quantification of steroidal saponins in *T. govanianum*. The present study provides an efficient analytical method for identifying and quantifying of steroidal saponins and will be helpful for the quality evaluation of *T. govanianum*.

Insecticidal activity of the extract, fractions, and pure steroidal saponins of *Trillium govanianum* Wall. ex D. Don for the control of diamondback moth (*Plutella xylostella* L.) and aphid (*Aphis craccivora* Koch)

In this study, the insecticidal activity of plant extract, fractions, and pure steroidal saponins from *T. govanianum* was evaluated for their bio-efficacy against targeted pests. Parent extract was found more effective (LC_{50} = 1541.2 mg L^{-1}) against larvae of *P. xylostella* after 96 h than *n*-butanol, *n*-hexane, and ethyl acetate fractions (LC_{50} = 3030, 3578 and 3878.1 mg L^{-1}, respectively). For *A. craccivora*, *n*-butanol fraction (LC_{50} = 1541.2 mg L-1) was most effective after 96 h than ethyl acetate fraction (LC_{50} = 2186.3 mg L-1), *n*-hexane fraction (LC_{50} = 2234.6 mg L^{-1}) and parent extract (LC_{50} = 3709.1 mg L^{-1}). Among pure molecules, govanoside B was found more effective (76% mortality, LC_{50} = 3279.5 mg L^{-1}) followed by borassoside E (74%, LC_{50} = 3467.1 mg L^{-1}) against *A. craccivora* after 96 h. Parent extract/fractions of *T. govanianum* showed promising efficacy against larvae of *P. xylostella* and *A. craccivora*.

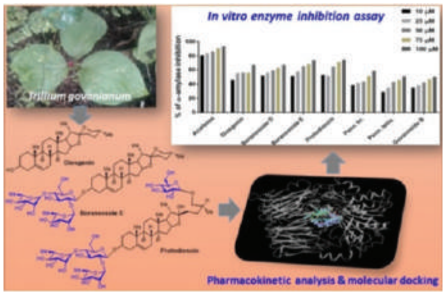


Steroidal Saponins from *Trillium govanianum* as *α*-Amylase, *α*-Glucosidase, and Dipeptidyl Peptidase IV Inhibitory Agents

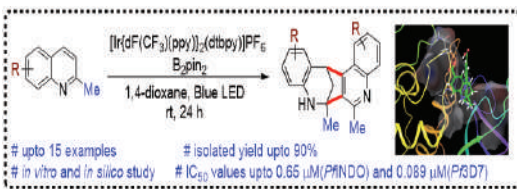
The *in vitro* enzyme inhibitory activity of the extract, fractions, and the isolated steroidal saponins from the rhizome part of *T. govanianum* was carried out against *α*-amylase, *α*-glucosidase, and DPP-IV. The molecular interactions, binding score, and pharmacokinetic parameters (ADME) of steroidal saponins were analyzed by the Schrodinger molecular docking software. The current study explained that the extract, fractions, and isolated steroidal saponins from *T. govanianum* possess good *α*-amylase and *α*-glucosidase inhibitory activity while moderate DPP-IV inhibitory activity. Moreover, *in vitro* results revealed that borassoside E (IC_{50} 7.15±1.78 µM), protodioscin (IC_{50} 6.72±0.04 µM), and diosgenin (IC_{50} 12.75±2.70 µM) are most effective in inhibiting the activity of *α*-amylase, *α*-glucosidase, and DPP-IV, respectively. Current *in silico* and *in vitro* studies established an association between the steroidal saponins from *T. govanianum* and their molecular interactions with *α*-amylase, *α*-glucosidase, and DPP-IV. The results of this investigation suggest that fractions and steroidal saponins from *T. govanianum* exhibit good antidiabetic activity which could be used as nutraceutical supplements for the management of systemic glucose level.

Photocatalytic Unsymmetrical Coupling of 2-Substituted Quinolines: Synthesis and Evaluation of Antiplasmodial Potential of *β*-norbenzomorphan Framework

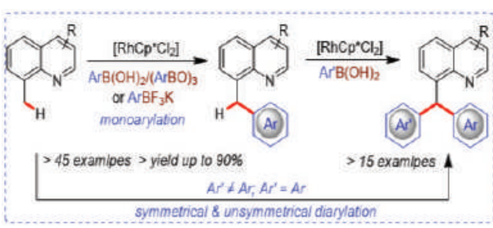
A sustainable unsymmetrical coupling of 2-methylquinolines under the blue LED light conditions using iridium-based photocatalyst. This methodology represents the direct synthetic method for *β*-norbenzomorphan skeleton from quinoline moiety. The current method is eco-friendly and efficient compared to the existing methods as manifested by Green metrics parameters.



Substituted quinoline gave the desired product with good to excellent yields. *In-vitro* study of isolated compounds against *P. falciparum* grown in human red blood cell using SYBR Green microtiter plate-based screening showed that two molecules have sub micromolar IC_{50}s against chloroquine-resistant *Pf*INDO strain. *In silico* docking scores for binding to Falcipin-2 were better for a few compounds than chloroquine.



Cp*Rh(III)-Catalyzed Sterically Controlled C(sp³)-H Selective Mono- and Diarylation of 8-Methylquinolines with Organoborons



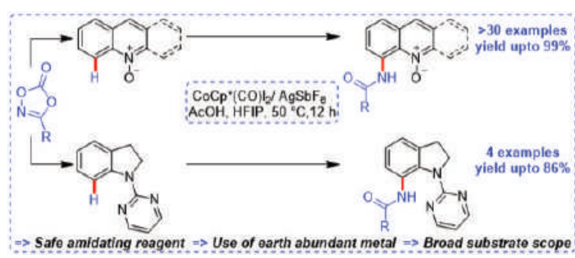
Rh(III)-catalyzed selective mono-arylation and diarylation (symmetrical and unsymmetrical) of 8-methylquinolines with organoboron reagents is disclosed. The selective monoarylation of the primary C(sp³)-H bond is achieved using the 7-substituted 8-methylquinolines or by changing the quantity of aryl boronic acids. The method is also applicable for the arylation of 2-ethylpyridine and heteroarylation with thiophene-2-ylboronic acid. Symmetrical and unsymmetrical diarylation of 8-methylquinolines has been carried out in a one-pot and sequential manner, respectively. Late-stage mono-arylation of oxime derivative and gram-scale synthesis of the mono-arylated product has also been carried out. The mechanistic study revealed that the current reaction is first order concerning both reactants and may involve a five-membered rhodacycle intermediate in the catalytic cycle.

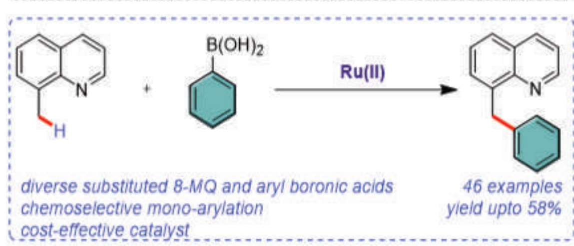
Co(III)-Catalyzed C-H Amidation of Nitrogen Containing Heterocycles with Dioxazolones under Mild Condition

A cobalt(III)-catalyzed C8 selective C-H amidation of quinoline *N*-oxide using dioxazolone as amidating reagent under mild condition is disclosed. The reaction proceeds efficiently with excellent functional group compatibility. The utility of current method is demonstrated by gram-scale synthesis of C8 amide quinoline *N*-oxide and by converting this amidated product into functionalized quinolines. Further, developed catalytic method is also applicable for C7 amidation of *N*-pyrimidylindolines and ortho-amidation of benzamides.

Ru(II)-Catalyzed Chemoselective C(sp³)-H Monoarylation of 8-Methyl Quinolines with Arylboronic Acids

The transition metal promoted C-H activation has emerged as a powerful tool for the synthesis of a wide array of organic molecules, but the cost of the metal catalyst and selectivity remains the major challenges. Herein, the first $[Cl_2Ru(p\text{-}cymene)]_2$-catalyzed direct mono-arylation of unactivated C(sp³)-H bond of 8-methyl quinolines with aryl boronic acids to synthesize diarylmethane compounds is presented. The transformation shows broad substrate scope with high chemoselectivity for the synthesis of 8-benzyl quinolines. In the preliminary mechanistic study-control experiments, deuterium labelling experiments and kinetic studies have been carried out.





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Exploration of anthocyanins in medicinal plants

The western Himalaya is portrayed by a rich legacy of wild eatable fruits and is a valuable gift from nature to the communities. Wild edible fruits have been recognized to have preferable dietary benefits over-developed organic fruits. However, these wild edible utilized by tribal communities are very little familiar to the urban networks. Wild edible fruits are rich in nutrients and phytochemicals, particularly antioxidants, and accordingly can have a significant function in delivering a healthfully balanced regimen. The polyphenols are the natural antioxidants known to be endowed with many claimed health-promoting effects and shielded the human system from various diseases. The wildly grown edible fruits have been shown a rich source of polyphenolics and antioxidants. *Myrica esculenta* (Myricaceae), commonly known as Himalayan bayberry, kaphal and distributed in the sub-tropical forest of Himalaya at the altitude of 900-2000 m. The fruits are considered one of the best wild fruits known for its taste in the sub-Himalayan region and are popular among local people. Fruits are processed into squash, jams and syrups and traditionally, have been known for their therapeutic properties for curing ulcers. The fruit also finds an effect in retaining of the placenta and bone fracture. The analysis of the fruits revealed the presence of essential nutrients (Carbohydrates, protein. Fibres), minerals (potassium, calcium, sodium, manganese, copper, iron and zinc), vitamins and also specialized metabolites (polyphenolics compounds, saponins, alkaloids and phytic acid). Additionally, the fruits are also known to be exhibited anticancer, antifungal and antimicrobial properties. *M. esculenta* gained much attention because of earnings from selling fruits (Rs. 14.00 lakh/season) by the local community from the Himalayan region.

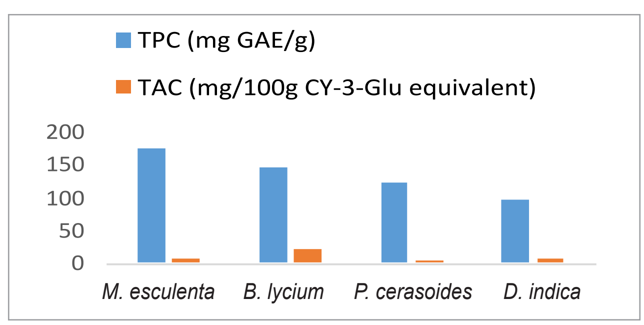
Duchesnea indica (Rosaceae), commonly known as Indian mock strawberry. In traditional Indian medicines, fruits are well known for treating weeping eczema, swellings, abscesses, insect bites, snake bites, and traumatic injury. *Prunus cerasoides* (Rosaceae) a wild Himalayan cherry found in forests of western Himalaya from India to China. The fruits are visually red and reportedly known to alleviate inflammatory stress. However, only one study exists on the quantitative phenolic composition including phenolic acids and flavonoids. *Berberis lycium* (Berberidaceae) is an evergreen shrub found in East Asia of Himalaya at an altitude of 2000–2700 m. The plant parts have been well explored, roots used to treat piles, eye complaints, and bacterial infections. It has been reported that the fruits are used as cooling laxative effects and for the treatment against intestinal and stomach aches. Additionally, the fruits are reported to contain phenolics and have antioxidants and anti-inflammatory effects.

Total anthocyanin content (TAC)

After purification of extract from wild berries, the amount of anthocyanin content determined by the pH differential method ranged from 3.83 to 20.58 mg cyanidin-3-*O*-glucoside equivalent per 100 g d.w. The total anthocyanin content were found to be highest in *B. lycium* (20.58 mg/100 g cyanidin-3-*O*-glucoside equivalent d.w) followed by *M. esculenta* (7.17 mg/100 g cyanidin-3-*O*-glucoside equivalent d.w), *D. indica* (7.06 mg/ 100 g cyanidin-3-*O*-glucoside equivalent d.w) and *P. cerosides* (3.83 mg/100 g cyanidin-3-*O*-glucoside equivalent d.w).

Total phenolics content (TPC)

A Folin-ciocalteu's method was used to determine total phenolics in purified fractions of selected edible berries. The total phenolic content in methanolic fractions of selected fruits was ranged from 49.69±1.74 and 176.54±9.14 mg Gallic acid equivalent (GAE)/g, respectively.



The whole fruits of *M. esculenta* contained a higher TPC (176.41 mg of Gallic acid equivalent /g) followed by *B. lycium* (148.06 mg GAE/g). At the same time, lowest total phenolic content was observed in the fruit of *D. indica* (96.20 mg GAE /g). According to previous reports, the total phenolic content of fruits of *M. esculenta* was 1.78-2.51 mg GAE/ g fresh weight, and *D. indica* fruits was 5.91± 0.31 mg/g.

Total phenolic contents and Total anthocyanin content in the selected wild edible berries.

Amelioration of cognitive deficit in zebrafish by an undescribed anthraquinone from *Juglans regia* L.

An undescribed anthraquinone assigned as 1-Hydroxy-5,5-dimethyl-5,6,7,8-tetrahydro-9,10-anthraquinone (compound 1) was isolated from ethylacetate extract of *Juglans regia*. The structure of the compound was established based on 1D, 2D NMR (HSQC, HMBC, COSY) spectroscopic and ESI-QTOF-MS/MS spectrometry techniques (Fig. 1).

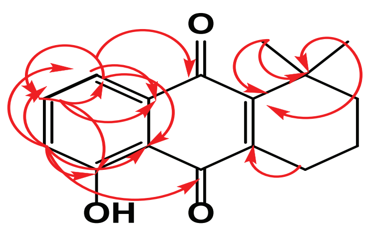


Fig. 1 HMBC (→) of compound (1)

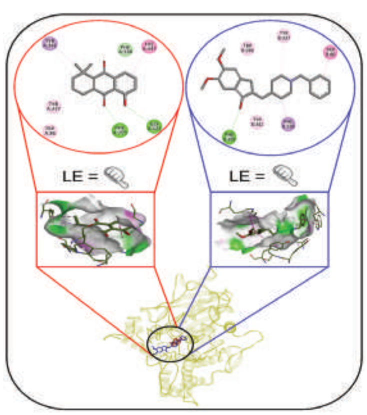


Fig. 2 Docked interactions and LE represented as circle and sphere for Compound 1 (red) and Donepezil (blue). The LE value is shown as thumb indicating medium-high efficiency of molecules

In addition, compound 1 was studied for *in-silico* interactions with proteins (Fig. 2) and tested using acetylcholinesterase inhibition assay, acrylamide-induced neurotoxicity test of zebrafish larva, and scopolamine-induced cognitive deficit model of adult zebrafish. Compound (**1**) showed potent acetylcholinesterase inhibition activity, prevented acrylamide-induced neurotoxicity, and improved learning and memory functions in the T-maze test.

Two undescribed diarylheptanoids from green husk of *Carya illinoinensis* as acetylcholinesterase inhibitors

Two undescribed diarylheptanoids, 3-(*R*)-acetyl-1-(3′,4′-dihydroxyphenyl)-7-(4′′-hydroxy-3′′ -methoxyphenyl)-heptane (2) and 11-Hydroxy-1,17-epoxy-7-(2-hydroxylphenyl)-13-(16-methoxyphenyl)-heptane (**3**) were isolated from ethyl acetate extract of the green husk of *Carya illinoinensis*. The structures of compounds were established based on IR, ^{1}H NMR, ^{13}C NMR, DEPT, HSQC, HMBC, COSY spectroscopic, and ESI-MS analysis. In addition, the isolated compounds were evaluated for AChE (acetylcholinesterase inhibition).

Compound (**2**) was obtained as white amorphous powder, and the observed optical rotation is $[\alpha]_{20}$ D = -.5290 (*c* 0.1, MeOH). The HRESI-QTOF-MS showed a molecular ion peak at *m/z* 388.1818 (calcd. 388.1886) in a positive ion mode corresponding to molecular formula $C_{22}H_{28}O_6$. The IR spectrum of (**2**) displayed strong absorption bands at 3456, 1743 and 2927 cm-^{1} corresponding to hydroxyl group, carbonyl and aromatic ring. The ^{1}H NMR spectrum of (**2**) revealed the presence of two 1,3,4-trisubstituted benzene rings [δ_H 5.6 (1H, d, *J*= 1.8 Hz, H-2′), 6.52 (1H, dd, H-6′), 6.77 (1H, d, *J*= 7.8 Hz, H-5′), 6.75 (1H, H-2′′), 6.78 (1H, dd, H-6′′)] and [δ_H 7.03 (1H, d, *J*= 7.8 Hz, H-5′′)]. The ^{1}H NMR data exhibited a singlet at δ_H 2.61 assignable to methoxy group and a singlet at δ_H 1.89 (OAc) assignable to methyl group. The decoupled ^{13}C NMR of compound (**2**) indicated the occurrence of two 1,3,4-trisubstituted aromatic rings [δ_C 131.7, 111.9, 146.8, 142.9, 114.1x2, 121.5, 139.8, 151.0, 142.2, 122.7, 120.4], one acetyl group (δc 169.8), one methyl group (δ_C 20.0), one methine (δ_C 72.4), six methylenes (δ_C 27.0, 32.1, 34.4, 34.7, 20.8 and 29.2) and one methoxy group at (δ_C 54.9). As evident from DEPT spectra, the above mentioned data revealed that the structure of (**2**) is of diarylheptanoid type. The structure of compound (**2**) was very closely resemble with 3,5-diacetoxy-1-(3′,4′-dihydroxyl phenyl)-7-(3′′,4′′-dihydroxy-5′′-meth- oxyphenyl) heptane. However, the distinctive difference between the earlier reported and compound (**2**) is observed in the absence of one hydroxyl and acetyl group at C-5′ and C-5 respectively. The presence of the acetate group was confirmed by the presence of ^{13}C signals at δ_C 20.0 and δ_C 169.8. The attachment of acetate function to C-3 was characterized by a downfield shift to δ_C 72.4. In HMBC, the methyl protons of acetate at δ_C 1.89 showed correlations with C-3 (δ_C 72.4) and δ_C 169.8 which confirmed the attachment of acetate at C-3. The attachment of acetate function at C-3 was also confirmed by the HMBC correlation of H-3 (δ_C 4.25) with δ_C 169.8 and δ_C 21.1. This was further supported by HSQC, HMBC and ^{1}H-^{1}H COSY correlations. In the HMBC spectrum, the long-range correlations between H-1 (δ_H 2.43) and H-2 (δ_H 1.55) with 131.7 (C-1′), 111.9 (C-2′) and 120.5 (C-6′) of tri-substituted aryl moiety and to C-3 (δ_C 72.4, oxymehiene) revealed that the aliphatic chain is linked to C-1′ of the aromatic rings. Similarly, the correlations of H-7 (δ_H 2.53, 2.63) with 139.8 (C-1″), 114.1 (C-2″), 120.4 (C-3″) showed that C-7 is linked to C-1″. The absolute configuration of compound (**2**) at position 3 was determined by comparing with previously reported optical rotation values (El-halawany & Hattori 2012). The negative value of optical rotation specified that the absolute configuration at C-3 was R. Hence, based on above spectroscopic data and comparison with literature, the compound 1 was unambiguously assigned as 3-(*R*)-acetyl-1-(3′,4′-dihydroxyphenyl)-7-(4″-hydroxy-3″-methoxyphenyl)-heptane (Fig. 3).

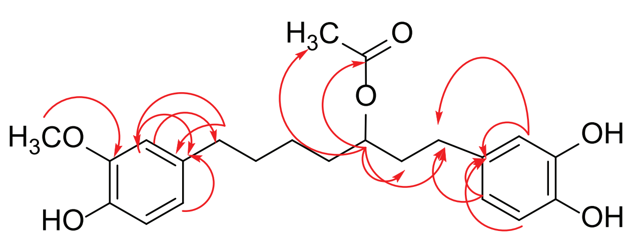


Fig. 3 HMBC (→) compound (2)

Compound (**3**) was obtained as a white amorphous powder. In HRESI-QTOF-MS, The pseudomolecular ion peak at *m/z* 351.1167 $[M+Na]^+$ (calcd. 351.1558) supports the molecular formula of $C_{20}H_{24}O_4$. The IR spectrum of (**3**) showed strong absorptions at 3432, 1516 and 1458 and 1256 cm^{-1} assignable to the hydroxylated aromatic ring and ether function. The ^{1}H NMR spectrum of compound (**3**) displayed six aromatic proton signals ascribed to two benzene rings at [δ_H 5.59 (1H, d, *J*= 1.5 Hz, H-6), δ_H 6.60 (1H, d, *J*= 8.0 Hz, H-3), δ_H 6.43, (1H, dd, H-4)] and [δ_H 6.98 (1H, d, *J*=7.9 Hz, H-18), δ_H 6.81(1H, d, *J*= 8.0 Hz, H-19), 6.84 (1H, s, H-15)] and shared the structure similar to acerogenin. The proton NMR spectrum further displayed a signal at δ_H 3.55, indicating the presence of a methoxy group. In 1,2,5 trisubstituted benzene ring A, the impressive characteristic upfield shift of H-6 i.e., δ_H 5.59 from the normal signals of aromatic rings, indicated that this shielding effect is due to the presence of diphenyl ether type diarylheptanoids.

Table 1. ^{1}H and ^{13}C NMR of compounds 2 (600 MHz, δ in ppm, *J* in HZ) in $CDCl_3$.

Position	δ_H (J in Hz)	δ_C
1	2.43 (m)	27.0
2	1.55 (m)	32.1
3	4.25 (m)	72.4
4	0.79 (m), 1.22 (m)	34.7
5	0.99 (m)	20.8
6	1.67 (m), 1.47 (m)	29.2
7	2.53 (m), 2.63 (m)	34.4
1′	-	131.7
2′	5.66 (s)	111.9
3′	-	146.8
4′	-	142.9
5′	6.77 (d, 7.8)	114.1
6′	6.52 (d, 9.2)	121.5
1″	-	139.8
2″	6.75 (m)	114.0
3″	-	151.0
4″	-	142.2
5″	7.03 (d, 7.8)	122.7
6″	6.78 (d, 9.2)	120.4
CO	-	169.8
COOMe	1.89 (s)	20.0
OMe	3.61 (s)	54.9

The decoupled ^{13}C NMR spectrum of (**2**) revealed 20 twenty carbon signals due to a diarylheptanoid skeleton. As evident from DEPT spectra, the ^{13}C NMR displayed signals for two aromatic rings [δ_C 112.7 (C-6), δ_C 115.4 (C-3), δ_C 115.3 (C-15), δ_C 121.4 (C-4), δ_C 121.3 (C-19), δ_C 123.5 (C-18)], six methylenes [δ_C 22.0 (C-9), 27.5 (C-7), 29.9 (C-13), 35.2 (C-8), 34.9 (C-12), 38.1 (C-10)], and one oxymethine (δ_C 70.9) further supports that compound (**3**) is diarylheptanoid type. In ^{1}H-^{1}H

COSY spectrum, correlations of aliphatic protons displayed connectives from H-7 to H-8, H-8 to H-9, H-10 to H-11, H-12 to H-13 and H-18 to H-19. In HMBC spectrum, the C-13 methylene protons at δ_H 1.41 and 1.70 showed correlations with C-14 (δ_H 140.0) and protons of aromatic ring B i.e. H-6 (δ_H 5.59) and H-4 (δ_H 6.43) showed correlations with C-7 (δ_C 27.5), thus confirming the linkage of alkyl chain to C-14 (δ_C 132.6) of benzene ring B. Similarly, the protons of benzene ring A i.e. H-3 (δ_H 6.60), H-6 (δ_H 5.59) of benzene ring A and H-7 & H-8 of alkyl chain showed correlations with C-5 (δ_C 132.6) directing that alkyl chain is linked to the C-5 of benzene ring A. Furthermore, the position of the methoxy group was confirmed by the HMBC correlations of methoxy protons (δ_H 3.55) with C-16 (δ_C 151.0) and C-15 (δ_C 115.3). Thus, based on the above spectroscopic analysis and comparison with earlier reports, compound 2 was assigned as 11-Hydroxy-1, 17-epoxy-7-(2-hydroxylphenyl)-13-(16-methoxyphenyl)-heptane (Fig. 4).

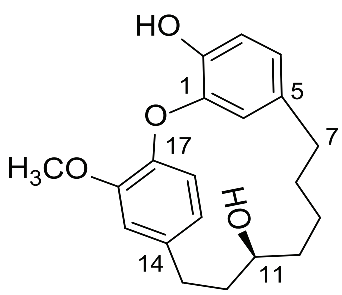


Fig. 4 Structure of compound (3)

Table 2. ^{1}H and ^{13}C NMR of compounds 3 (600 MHz, δ in ppm, *J* in HZ) in MeOD

Position	δ_H (*J* in Hz)	δ_C
1	-	143.6
2	-	148.2
3	6.60 (d, 8.0)	115.4
4	6.43 (dd)	121.4
5	-	132.6
6	5.59 (d, 1.5)	112.7
7	2.39 (m), 2.5 (m),	27.5
8	1.32 (m)	35.8
9	0.98 (m), 1.21 (m)	22.0
10	1.10 (m), 0.68 (m)	38.1
11	2.90 (m)	70.9
12	2.50 (m), 2.69 (m)	34.9
13	1.41 (m), 1.70 (m)	29.7
14	-	140.0
15	6.84 (s)	115.3
16	-	151.8
17	-	142.9
18	6.98 (d, 7.9)	123.5
19	6.81 (d, 8.0)	121.3
OMe	3.55 (s)	54.9

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NMR, Metabolomics and Natural Product Chemistry

Bioresources have been used to mitigate severe life complications from historical times and are still very substantial. The products derived from them have used a template or to harness value added products. Several secondary metabolites have been used for therapeutic uses. Therefore, understanding chemical nature, composition and alterations in biological matrices is the need of hours. Group is currently focusing on metabolomics, isolation and characterization of molecules, and the development of quality control strategies for medicinally valuable resources of Himalaya using NMR, LC-MS/MS, GC-MS, and HPTLC techniques. Moreover, the group is working to find out the possible mechanistic role of bioresource-derived products. Further, process and product development is also one of the focused strategic area.

Phenylethanoids, phenylpropanoids, and phenolic acids quantification vis-à-vis gene expression profiling in leaf and root derived callus lines of *Rhodiola imbricata* (Edgew.)

Medicinal plants cultivation under advanced conditions offers quality biomass production on a commercial scale as per consumer demand. *Rhodiola imbricata* is a medicinal herb of the trans-Himalayan Ladakh region of India. Since this herb's natural supply is rapidly decreasing due to its over-exploitation, high altitude region, and traditional usage in the Amchi system of medicine. Salidroside and rosavins are the most potent ingredients used in Rhodiola based herbal formulations. Group has developed friable callus culture from *R. imbricata* leaf and root explants. Further, phenylethanoids, phenylpropanoids, and phenolic acids were identified and quantified using UPLC. The maximum salidroside was 3.59 mg/g DW, in leaf-derived friable green calli followed by 2.31 mg/g DW, in leaf-derived friable white calli. While rosavin and rosarin were detected maximum in root-derived compact green calli and root-derived friable green calli (0.15 and 0.07 mg/g DW, rspectively). Genes encoding enzymes involved in salidroside and rosavins biosynthesis were also explored.

Growth kinetics, metabolite yield, and expression analysis of biosynthetic pathway genes in friable callus cell lines of *Rhodiola imbricata* (Edgew).

The plant cell culture provides an efficient technique for growth and production kinetics studies of plants' bioactive compounds. Therefore, specifc culture days were optimized and explored for higher metabolite yield in *R. imbricata*.

De novo transcriptome analysis of the critically endangered alpine Himalayan herb *Nardostachys jatamansi* reveals the biosynthesis pathway genes of tissue-specific secondary metabolites

Nardostachys jatamansi, a critically endangered medicinal plant of alpine Himalayas. This plant was explored for the de novo transcriptome analysis during the end of vegetative growth (August) yielded 48,411 unigenes. 74.45% of these were annotated using UNIPROT. UPLC-PDA analysis of *in vitro* plants revealed the temperature-dependent, tissue-specific differential distribution of various phenolics. Thus, compared to phenolic contents of leaves (gallic acid and rutin) and roots (*p*-coumaric acid and cinnamic acid) were found higher at 15 °C. In qRT-PCR of *in vitro* plants, secondary metabolite biosynthesis pathway genes showed higher expression at 15 °C and 14 h/10 h photoperiod (conditions representing the end of vegetative growth period). This provided the idea for *in vitro* modulation of identified metabolites. Such modulation of metabolites *in vitro* systems can eliminate the need for uprooting *N. jatamansi* from the wild. Hence, the study will help in effective plant conservation.

Exploration of plants for the chemical fingerprints and its important metabolies.

Camellia sinensis, *Picrorhiza kurrooa*, *Siraitia grosvenorii, Valeriana jatamansi, Stevia rebaudiana, Rhodiola* etc are explored for the chemical fingerprints and important chemical markers present under different conditions.

Reseach group: Shruti Sharma, Ranjana Sharma, Bindu Rawat, Vandana Kumari, Anil Kumar, Manish Kumar, Rishabh Kaundal, Rajinder Kumar, Shiv Kumar, Vijaylata Pathania, Ramesh Kumar and Pawan

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Chemical Engineering, Chemical Technology

Our group has been working mainly on the design and development of processes for pharmaceutical or herbal formulations, using engineering tools. Our main aim is to develop and optimise the process at a lab scale and then scale it up to the pilot level for industrial demonstration or to do the feasibility studies at a large scale.

Process Optimisation at lab scale for High-Intensity natural sweetener

The study aims to design a sustainable cost-effective process to get mogroside enriched extract for the diabetic or health-conscious group of our nation. Several studies state that overconsumption of sugar leads to the following adverse events: insulin resistance, metabolic syndrome, diabetes, fatty liver and high levels of free fatty acids. Therefore to limit the use of sugar, artificial sweeteners are finding widening applications in the past few years. Monk Fruit is native to China has been entirely exploited in the country for its potential in various forms. Many companies in China started working on Monk fruit like Hunan Nutramax, Inc., GLG Life Tech Corporation, Guilin GFS Monk Fruit Corp. etc. and started exporting the extracts to the rest of the world. Few companies eg. Biovittoria etc, from UK and USA, started a joint venture with Chinese companies too. But Monk Fruit is new for India, and with the successful cultivation of its fruits in CSIR-IHBT, there is a lot of scope of work in making India self-reliant in this area. So our work is aligned in that direction. Internationally a lot of work has been done on Monk Fruit. Through successful integration of agricultural sciences with engineering, farmers, entrepreneurs and small scale industries can be benefited. Initially, Chi-Hang Lee of General Foods Corporation, White Plains, 1974, reported the sweet component of Monk Fruit to be glycoside of triterpenoid. After that, several studies reported a number of major and minor glycosides, confirmed their structures using the NMR technique (**Ryoji Kasai *et al*.**, 1989, **Kazuhiro Matsumoto *et al*.**, 1990 Indra Prakash and VSP Chaturvedula, 2014 etc). Simultaneously different groups studied the isolation and purification methods for mogroside enriched extract (**Yan Xia *et al*.**, 2008, **Can Liu *et al*.**, 2011, VSP Chaturvedula and Indra Prakash, 2011, **Jing Jiu *et al*.**, 2011, **Bin Wang *et al*.**, 2019).

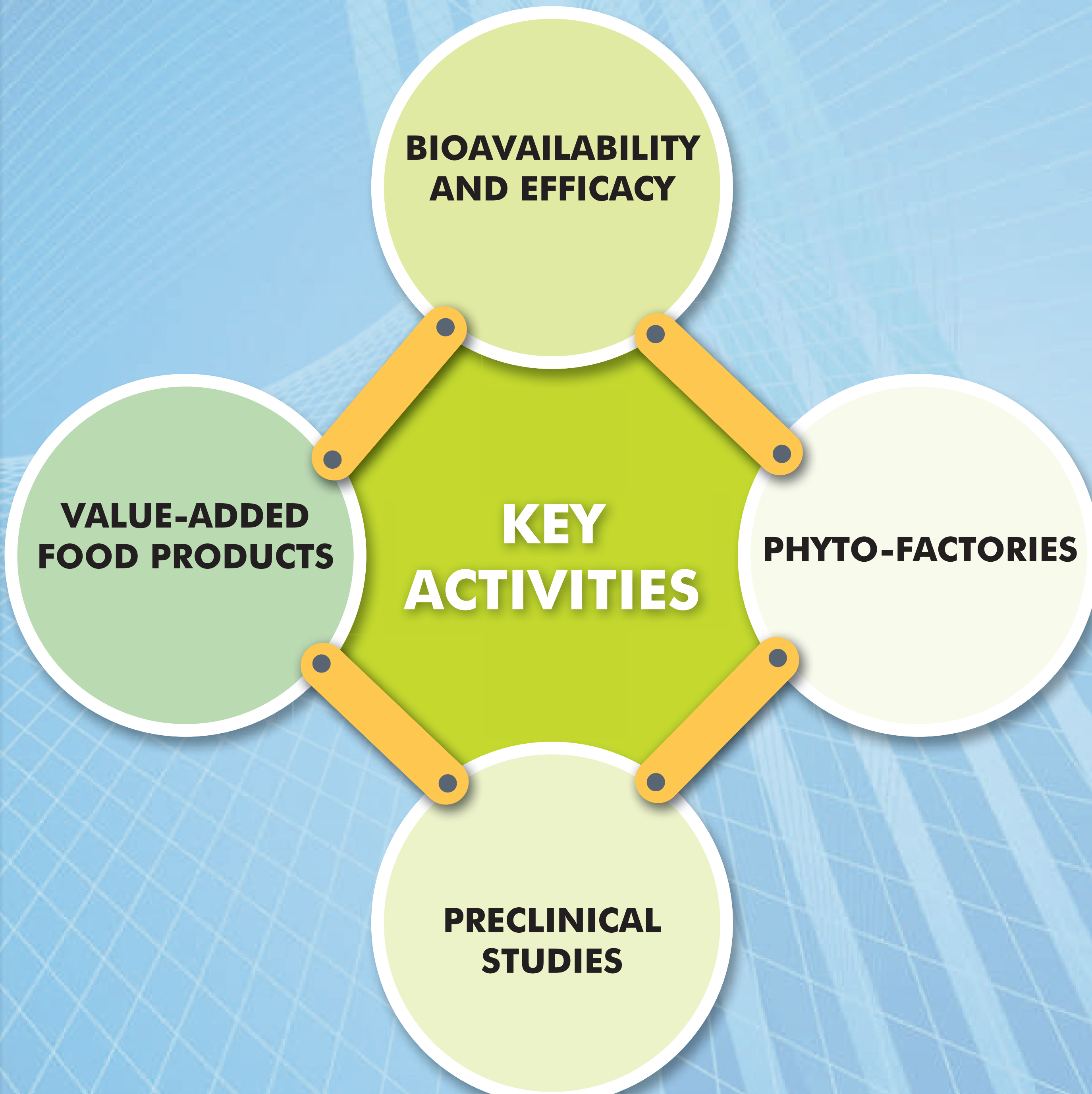
It is the first time that CSIR Scientists have successfully cultivated Monk fruit in India. But the fruit in its raw form contains a lot of soluble and insoluble impurities that limit its direct use. Therefore, I have submitted one Project on Monk Fruit in CSIR-FIRST. The project aims to design an extractor for the initial processing to get juice concentrate and then further purify it according to the needs of target consumers.

Wastewater treatment using natural plant material

The wastewater generated during the process at lab scale or pilot scale must be treated before its discharge into the environment. To be sustainable and have zero discharge policy, the wastewater generated was treated with a natural coagulant such that the secondary wastewater generated is not harmful to the environment. Currently, the synthetic coagulants used to treat water or wastewater are an alum, ferric chloride, chlorine etc., which has a huge challenge to humans on consumption as it remains in the treated water in residual form. Hence the use of natural coagulants becomes very important for safe human consumption.

Fig. 1 Dried Monk Fruit, Purification step and purified monk fruit extract at lab scale

DIETETICS AND NUTRITION TECHNOLOGY DIVISION



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Plant Cell and Tissue Culture

Alternative systems for production of phytoconstituents from Himalayan medicinal and aromatic plants

In continuance to our work on exploration of plant cells and organ culture as an alternative system for production of phytochemicals, the patent has been filed (Application No. 0064NF2021) on technology for the production of naphthoquinone red pigment using adventitious root culture of *Arnebia euchroma* (Fig. 1). The process variables were optimized under submerged cultivation for possible scale up in bioreactor system (Fig. 2). The salient features of the technology are:

- Shorter cultivation cycle (3-4 years vs 28 days)
- Not dependent on geographical and environmental barriers
- Ensured quality & yield, free from adulteration
- Sustainable production technology around the year

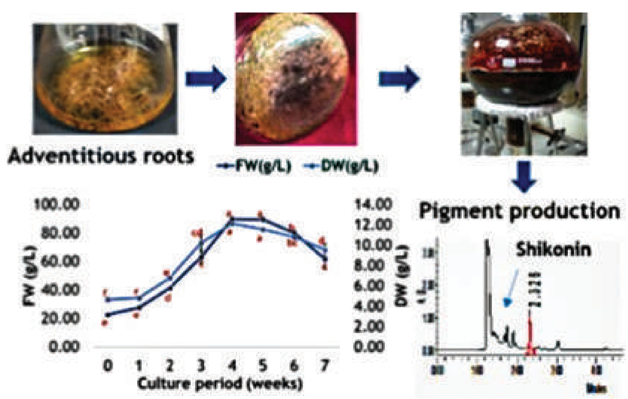

Fig. 1 *In vitro* production of nahthtoquionones red pigment by submerged cultivation of adventitious roots

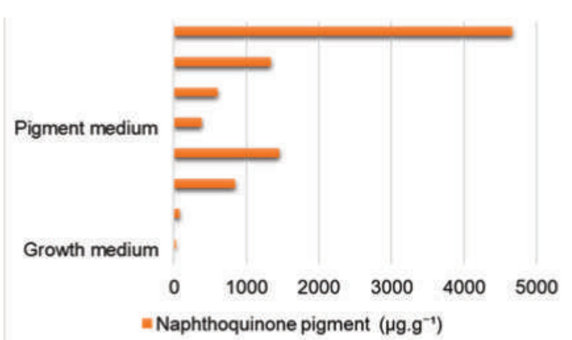

Fig. 2 Effect of cultivation medium on production of naphthoquinone pigments

Such technologies will not only provide a sustainable production system, but also help in conservation of valuable Himalayan medicinal plant species and reduce undue pressure through collection of raw material from natural habitat.

Understanding *in vitro* adventitious root mechanism

In pursuance of developing non-disruptive technology for the production of phytoconstituents, the available information on adventitious root induction and its possible use for commercial scale production is also comprehended. The ongoing R&D efforts revealed that *in vitro* adventitious roots can be a sustainable alternative for the production of industrially important phytoconstituents (Fig. 3), especially highly acclaimed plants presently categorized as Rare, Threatened and Endangered (RET) species.

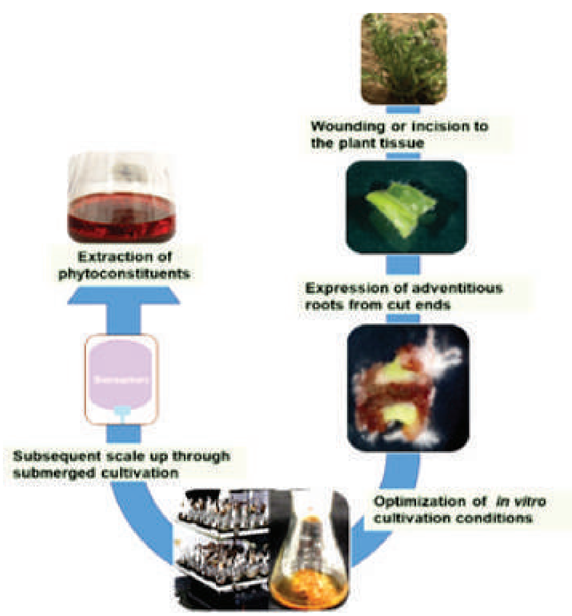

Fig. 3 Induction, cultivation and industrial scale production of phytoconstituents using adventitious roots

In contrast to genetically transformed hairy roots using *Agrobacterium rhizogenes* infection, the adventitious roots are induced from plant parts other than roots as a natural response to adverse environmental factors. Such roots have similar rate of growth and multiplications, and ease in submerged cultivation. The key points emerged out from the evaluation are:

- Adventitious roots have 3 distinct phases of development i.e. induction, initiation and expression
- Hormonal signals produced during wounding are crucial for transition of competent to founder cells
- Underlined the regulatory role of auxin for initiation of adventitious root formation from wounded tissues
- Induced adventitious roots have comparable metabolic profile

Value addition of industrial apple pomace

Technologies for value addition of industrial bio-waste and underutilized bioresources are of prime importance for sustainable utilization of natural wealth. 'Apple pomace' is an industrial residue generated during fruit juice, vinegar and concentrate manufacturing around the globe. Its open dumping, not only cost the industrial unit, but it also lead to public health threats. Nevertheless, considering a huge demand for natural food ingredients, bioresources like, apple pomace can be considered for extraction of phytochemicals such as phenolic compounds that have shown various biological activities and human health-promoting benefits.

In current year, different solvent mediated phenolic fractions obtained from industrial apple pomace were partitioned with ethyl acetate. The reverse-phase high-performance liquid chromatography (RP-HPLC) and electrospray-ionization quadrupole time-of-flight tandem mass spectrometry (ESI-QTOF-MS/MS) evaluation of different ethyl acetate fractions (aqueous acetone fraction (APA1), aqueous ethanol aqueous ethanol fraction (APE1) and aqueous methanol fraction (APM1)) primarily showed the phloridzin, phloretin, quercitrin and quercetin presence (Fig 4). To ascertain the biological activity, these extracts were investigated for antiproliferative activities in human cancer cell lines i.e. SiHa, KB and HT-29. Positive results were obtained for KB cells at time and dose dependent manner. The results showed that APA1, APE1 and APM1 extract showed significant cytotoxicity activity against KB cells (Fig 5). In case of SiHa cells, APA1, APE1 and APM1 extracts enable to inhibit the cellular growth over 50% at 400 µg/mL after 72 h.

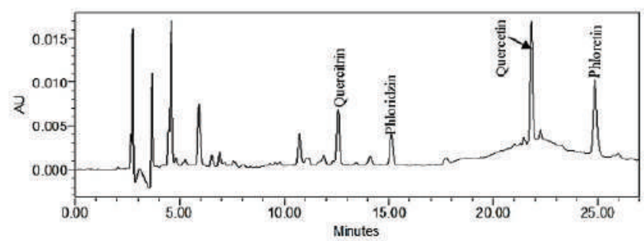

Fig. 4 HPLC chromatograms of ethyl acetate fractionated aqueous methanol fraction (APM1) extract

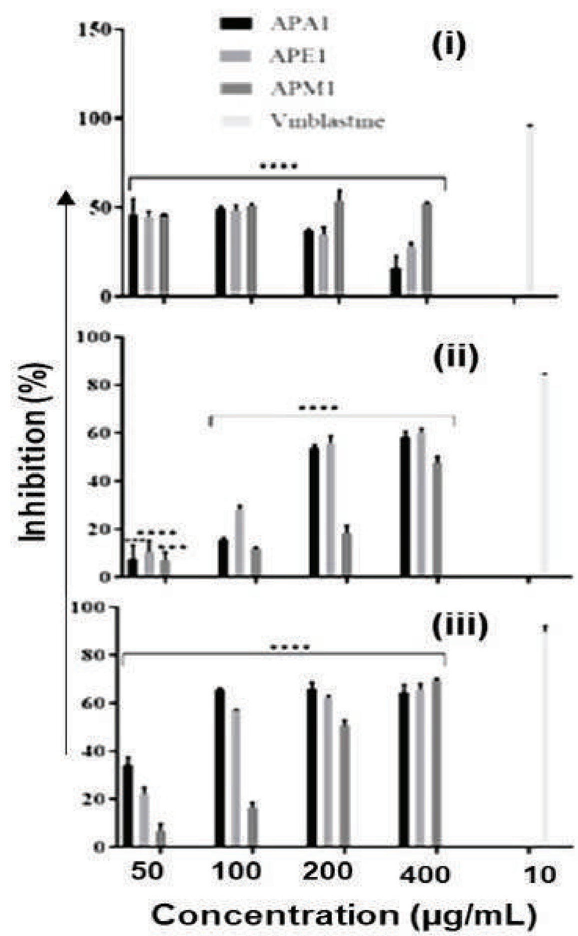

Fig. 5 Cytotoxic activity of ethyl acetate fractionated acetone (APA1), ethanol (APE1) and methanol (APM1) extract on (i) HT-29, (ii) SiHa and (iii) KB cell line after 72 h treatment

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Food Science and Technology

The research area includes development of functional food and nutraceutical, particularly nutritionally rich food products from traditional and underutilized food bioresources of Himalayan region.

Potential of *Murraya koenigii* and *Brassica oleracea var. botrytis* leaves as food ingredient

The current study aims at the prebiotic ability and antioxidant properties of *Murraya koenigii* and *Brassica oleracea* var. botrytis leaves extract on various lactobacilli strains. The high performance anion exchange chromatography (HPAEC) quantified various free sugars, with higher sucrose (34.16 mg/g) in a 50% ethanolic extract of *Murraya koenigii* and lesser amount of raffinose (0.002 mg/g) in a hot water extract of *Brassica oleracea*. As compared to the standard prebiotics fructo-oligosaccharide (FOS) and inulin, the different extracts demonstrated effective resistance to -amylase and artificial gastric juice hydrolysis. The hot water extract of *Brassica oleracea* and the 50% ethanolic extract of *Murraya koenigii* demonstrated the efficient activity required for the enhancement of almost all lactobacilli strains (Fig. 1).*In vitro* trials revealed that the volume of lactobacilli in medium supplemented with extract was substantially higher than in control and normal prebiotics ($p< 0.05$). The phenolic and flavonoid content, as well as the antioxidant property, were also estimated, with the highest content found in a 50% ethanol extract of *Murraya koenigii*. As a result, *Murraya koenigii* and *Brassica oleracea* var. botrytis leaf extract exhibits effective prebiotic and antioxidant activity and may be used as a functional food ingredient.

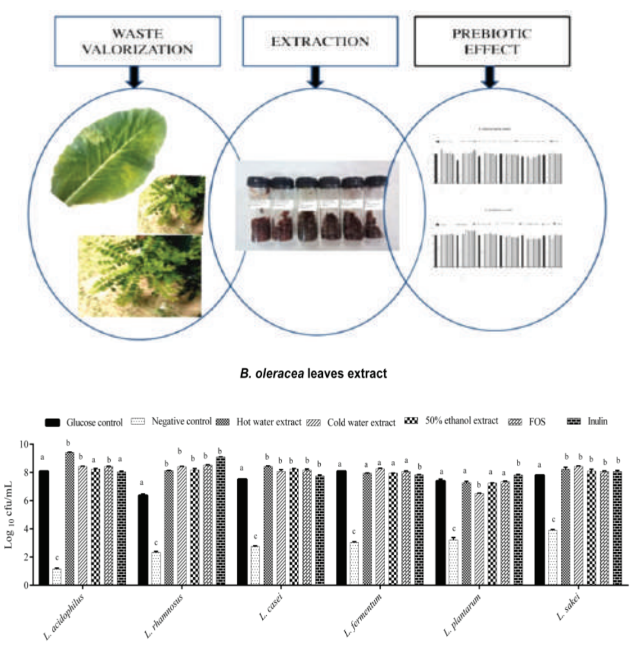

Fig. 1 Overview of prebiotic effect of leaf extract on different lactobacilli strains

Formulation of gluten muffins and its premix: Nutritional, physico-chemical and textural characteristics

In order to enhance the nutritive benefits of gluten-free muffins and their premix, amaranth

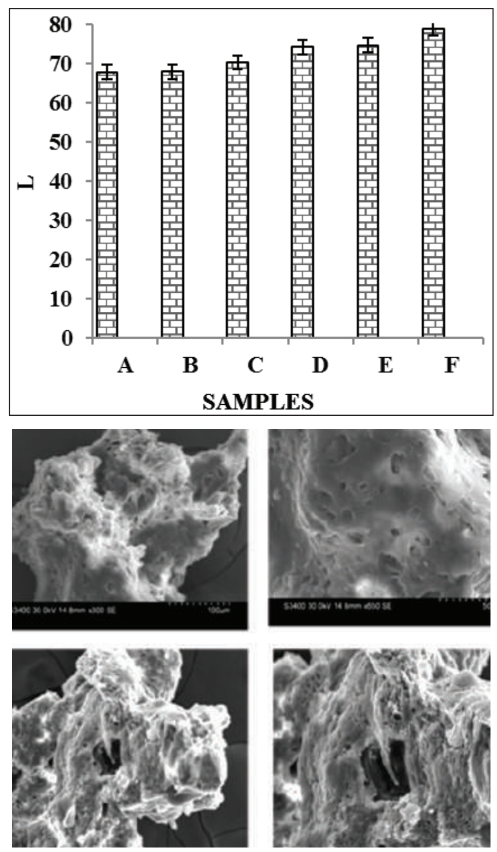

Fig. 2 Scanning electron microscopy analysis and luminance (L*) values of muffins and premix samples. A: Control black rice; B: Black rice+10% amaranth flour; C: Black rice+20% amaranth flour; D: Black rice+30% amaranth flour; E: Black rice+40% amaranth flour; F: Black rice+50% amaranth flour

flour was blended with black rice flour at various proportions (0 % as control, 10%, 20%, 30%, 40%, and 50%). Moisture, crude fibre, fat, crude protein, and functional properties increased significantly ($p < 0.05$) with rising amaranth flour content, with the highest content in the 50% substituted formulation. Total phenolics, flavonoid content, and antioxidant activities DPPH (2, 2-Diphenyl-1-picryl hydrazyl) and ABTS (2, 20-azinobis (3-ethylbenzothiazoline-6-sulphonic acid diammonium salt) for both muffins and their premix were found to be appreciable for the 50% substituted formulation. The addition of amaranth flour resulted in a change in microstructure, as shown by scanning electron microscopy (SEM) (Fig. 2). Muffins were also tested for shape, colour, and sensory properties. Muffins made with 50% amaranth and 50% black rice flour received the highest score from the panellists and demonstrated strong overall acceptability. As a result, this combination was suggested to make tasty gluten-free muffins with a variety of nutritious benefits.

Development of hull less barley based instant extruded noodles

The work was carried out to produce barley-based instant noodles using various ratios of barley flour (100 %, 85 %, 70 %, and 0 %) with rice flour. Noodles were prepared with extrusion cooking under pre-optimized conditions, and their nutritional, functional, textural, cooking and sensory attributes were investigated. Results demonstrated that barley noodles contain a significant amount of all major micronutrients, total phenolics, and flavonoids content (Fig. 3) higher than rice noodles. The extrusion process improved the digestibility of noodles. The total starch content was observed maximum in rice noodles *i.e.*, 77.89 g/100 g, and resistant starch of noodles was recorded between 2.98 g/100 g and 4.65 g/100 g. Barley noodles take less cooking time (1:45 min) and recorded minimum cooking losses (5.79%). Sensory analysis data indicated good acceptability of prepared noodles by the panelists. The functional and nutritional properties result demonstrated that developed products of barley and barley-rice noodles have excellent market potential, and this novel cereal-based product offers a healthy choice to consumers.

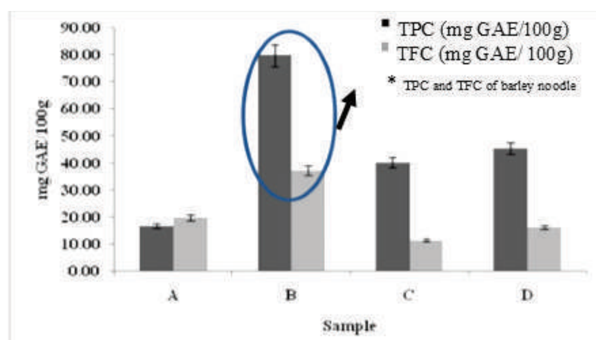

Fig. 3 Total phenolic content and total flavonoid content of noodles

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The laboratory worked 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.

Cell-free culture supernatant of probiotic lactobacillus fermentum prevents stress-induced premature senescence

Evidence on cellular anti-senescence potentials of probiotic bacteria vis-à-vis inflection of senescence-allied secretory phenotype (SASP) and mTOR signalling is very scanty. The study investigated anti-senescence attributes of secretory metabolites from probiotic *Lactobacillus fermentum* (*Lact. fermentum*) using H_2O_2-stimulated model of senescence in 3T3-L1 preadipocytes. Results revealed that treatment of H_2O_2 induced cellular senescence as indicated by enhanced cell size and SA-β-gal activity, instigation of SASP and reactive oxygen species (ROS), DNA damage response and induction of cell cycle inhibitors namely p53, p21WAF1, p16INK4a. Additionally, a strong and remarkable induction of the PI3K/Akt/mTOR cascade and AMPK signalling was also noticed in H_2O_2-induced cells (Fig. 1).

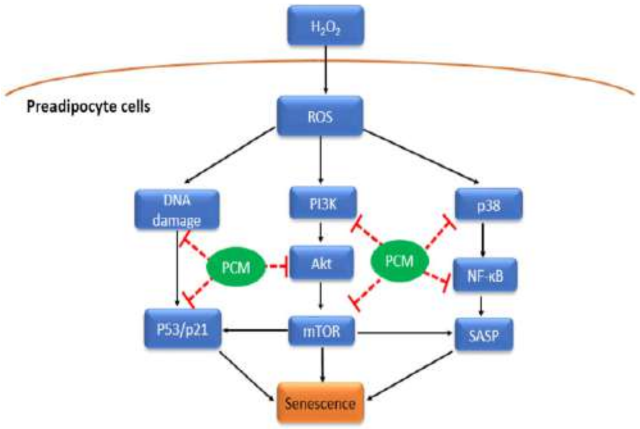

Fig. 1 Anti-senescence effects of probiotic conditioned media in H_2O_2-induced murine preadipocytes

On the contrary, exposure of cells to cell-free supernatant recovered from *Lact. fermentum* efficiently diminished activation of PI3K/Akt/mTOR signalling cascade and assuaged senescence markers such as p53, p21WAF1, SA-β-gal, p38MAPK, iNOS, cox-2, ROS, NF-κB, and DNA damage response. These findings signify that secretory metabolite of *Lact. fermentum* can alleviate the progress as well as severity of stress-induced senescence and suggests its utility as anti-aging or aging-delaying agent.

Berberine induces quiescence and apoptosis in lung cancer cells

Recent evidences revealed that administration of low concentration of plant-based phytomolecules can confer anti-proliferative attributes on tumour cells by activating senescence signalling. The alkaloid berberine is well-known for its anticancer potential but its efficacy to induce senescence in tumour cells is still uncovered. The present study investigated the governing mechanisms pertaining to dose-dependent antiproliferative potential of berberine in context of senescence and inflammation in human non-small cell lung cancer cell line (A549). Results demonstrated that, amongst the different tested bioactive phytomolecules such as rutin, magnoflorine, tetrahydropalmatine, phloretin, phloridzin, only berberine treatment suppressed the proliferation of A549 cells in a concentration independent manner. Application of low doses of berberine stimulated a weak SA-β-gal activity and p21WAF1expression but did not indicate evidence of SASP activation due to absence of NF-κB activation and expression of proinflammatory genes. However, treatment with higher dose of berberine showed no evidence of SA-β-gal activity or p21WAF1 expression, but instead induced apoptosis and suppressed the expression of cell cyclins. The proliferative capacity of berberine treated cells was at par with control cells and no SA-β-gal activity could be observed in first generation of berberine treated cells. mTOR pathway showed no distinct activation on account of berberine treatment thereby further emphasizing that low dose of berberine induced quiescence and not senescence in A549 cells. Altogether, our findings suggest that despite its robust antiproliferative effects, low dose berberine treatment could only stimulate transient changes akin to quiescence that needs to be considered before implying pro-senescence attributes of berberine in cancer therapeutics (Fig. 2).

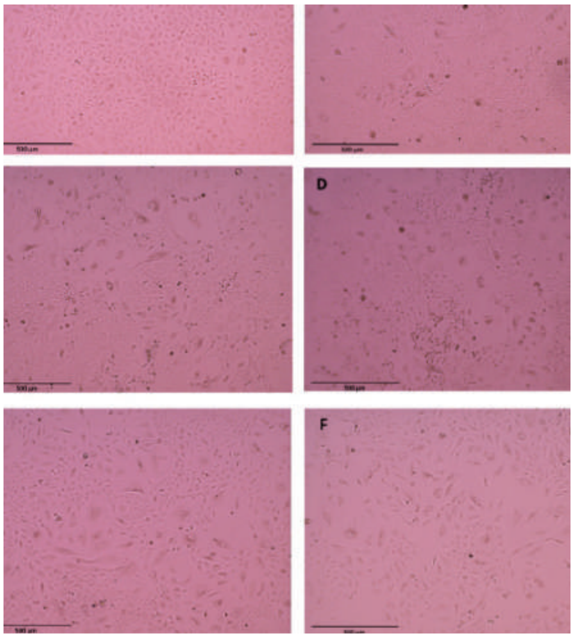

Fig. 2 Effect of berberine treatment on morphological changes in A549 cells. Cells were treated with berberine at respective concentration for 48 h and observed under microscope. Representative images of (A) Control (B) Berberine 3.125 µM (C) Berberine 6.25 µM (D) Berberine 12.5 µM (E) Berberine 25 µM (F) Berberine 50 µM. Scale bar: 500 µm

Role of phloretin and phloridzin in improving insulin sensitivity and glucose uptake in type II diabetes

Activators of peroxisome proliferator-activated receptor-γ (PPARγ) agonists are therapeutically promising candidates against insulin resistance and hyperglycemia. Synthetic PPARγ agonists are known to effectively enhance insulin sensitivity, but these are also associated with adverse side-effects and rising treatment cost. Therefore, natural PPARγ targeting ligands are desirable alternatives for the management of insulin resistance associated with type 2 diabetes. Phloretin (PT) and Phloridzin (PZ) are predominant apple phenolics, which are recognized for their various pharmacological functions. The present study assessed the potential of PT and PZ in enhancing insulin sensitivity and glucose uptake by inhibiting Cdk5 activation and corresponding PPARγ phosphorylation in differentiated 3T3L1 cells. In silico docking studies and subsequent validation using 3T3L1 cells revealed that PT and PZ not only block the ser273 site of PPARγ but also inhibit the activation of Cdk5 itself, thereby, indicating their potent PPARγ regulatory attributes. Corroborating this, application of PT and PZ significantly enhanced the accumulation of cellular triglycerides as well as expression of insulin-sensitizing genes in adipocytes ultimately resulting in improved glucose uptake. Taken together, the present study reports that PT and PZ inhibit Cdk5 activation, which could be directly influencing the apparent PPARγ inhibition at ser273, ultimately resulting in improved insulin sensitivity and glucose uptake (Fig. 3).

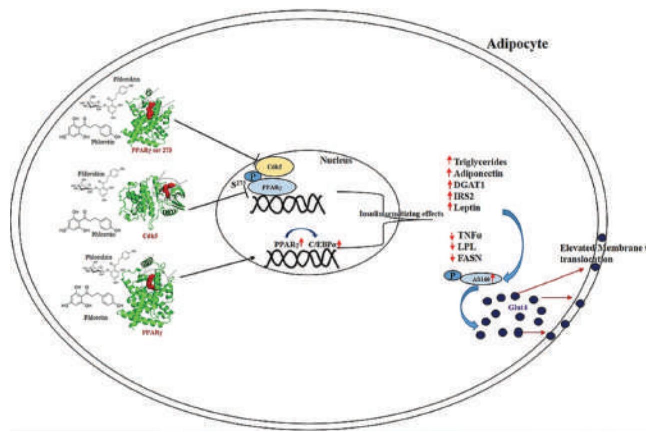

Fig. 3 Effects of phloretin on insulin resistante differentiated adipocytes

Research group: Shiv Kumar, Mahesh S., Rohit Sharma, Prince Anand, Shiv Patil, Abhishek Goel, Anamika Sharma, Jyoti Chhimwal, Kajal Sinha,Sanyukta Darnal, Smita and Ravi Thakur

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Our group works on the safety assessment and validation of natural products, nutraceuticals, and synthetic molecules for their therapeutic effects in animal models.

Tinospora cordifolia mitigates glomerular and tubular injury in diabetic kidney disease

Diabetic Kidney Disease (DKD) is a common complication in patients (30-40%) with prolonged hyperglycemia leading to end-stage renal disease (ESRD) worldwide. Prolonged diabetes activates many pathogenic pathways leading to declining glomerular filtration rate, albuminuria, glomerular hypertrophy and sclerosis, renal inflammation, and fibrosis. *Tinospora cordifolia* is an important medicinal plant, also mentioned in Ayurvedic P harmacopoeia as an antidiabetic herb. It mainly contains cordifolioside A, berberine, palmatine, syringin, tinocordiside, tembetarine, jatrorrhizine, choline, isocolumbin, and β-sitosterol. In our study, *Tinospora cordifolia* extract (TCE) improved the cell viability of high glucose treated renal mesangial and tubular cell lines. TC also restored the altered expressions of TGFβ and αSMA renal cell lines (Fig. 1).

In diabetic rats, TCE reduced the blood glucose, urea, and creatinine levels. In addition, the urine analysis indicated reduced levels of urine microalbumin in TCE-treated rats. Histopathological examination revealed that TCE prevented the glomerular hypertrophy mesangial matrix proliferation and degenerative changes in the renal tubules. Further studies indicated the anti-inflammatory and anti-fibrotic effects of TCE in DKD. The mRNA levels of various inflammatory and fibrotic genes confirmed the positive impact of TCE. Overall, TCE prevented the progression of DKD by anti-inflammatory and anti-fibrotic effects.

In a collaborative work, the potential of anthocyanins from *Ipomea nil* was explored as a potential food colorant. The well characterized anthocyanins from *Ipomea nil* was stabilized with different copigments and evaluated for its preclinical safety.

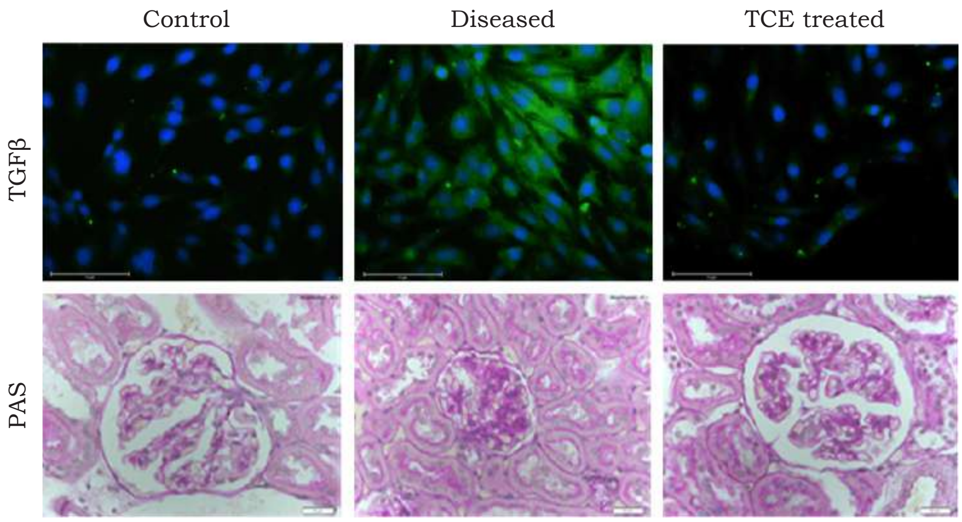

Fig. 1 Showing TGFβ expression in the renal cell line and mesangial proliferation by PAS (periodic acid Schiff) staining in kidney tissues of different groups

Research group: Swati Katoch, Vinesh Sharma, and Garima Dadhich

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Neuropharmacology

Development of a novel Zebrafish model of chronic epilepsy

Zebrafish has emerged as a potential animal model of acute convulsion for early screening of antiepileptic agents. There was a need for an alternative chronic zebrafish model of epilepsy with more correlation to the clinical condition. Hence to develop a chronic model, adult zebrafish were repeatedly exposed to a subeffective concentrations of PTZ, until appearance to tonic-clonic seizures, considered as kindled. Valproic acid (VPA) exposure was given during kindling and in kindled fish in 2 different groups. The neurotransmitters level and expression of the genes associated with kindling were studied in the fish brain. There was an increase in seizure severity score at 1.25 mM concentration of PTZ, and 66.66 % of fish achieved kindling after 22 days' exposure. A marked increase in *c-fos, crebbpa,* and *crebbpb* expression, and glutamate/ GABA level was observed in the brain of kindled fish. VPA inhibited the induction of PTZ-mediated kindling, and reduced seizure severity in kindled fish. Hence it was concluded that repeated exposure of 1.25 mM PTZ induced kindling in zebrafish, altering the brain neurotransmitter levels and gene expression. Inhibition of kindling induction and decrease in seizures in normal and kindled fish, respectively, by VPA validated application of the model for preclinical testing of agents against epilepsy.

Identification of key molecular regulators involved in epilepsy-associated cardiac damage

Sudden unexpected death in epilepsy (SUDEP) is the fatal outcome of the disease in epileptic patients. In our earlier experiment, we studied the alteration in cardiovascular functions in a chronic rat model of epilepsy. Continuing our work, we identified the key regulators involved in cardiac damage associated with epilepsy in a lithium-pilocarpine rat model. We used an integrated transcriptome and proteome approach to identify the genes and proteins involved. The tissue of epileptic animals was subjected to RNA-Seq, proteomics, and system biology analysis to study expression arrangements and network connections of genes and proteins. Overall, 1264 differentially expressed proteins, and 1157 genes were identified in the heart tissue through liquid chromatography with tandem mass spectrometry-based proteomic analysis and RNA-Seq, respectively. The observations were further validated using qRT-PCR analysis and Western blotting. The network analysis showed *Myc, STAT3, Erbb2, Fos, Erbb3, Mapk8*, and *Notch1* to be critical genes that played an essential role in seizure-mediated heart changes. Further, activation of the transforming growth factor β pathway was observed to be the primary pathogenic process. The study concluded that *Mapk8, Erbb*, and *STAT3* are the key regulators involved in epilepsy-linked heart changes that lead to SUDEP.

Research group: Arindam G. Mazumder, Supriya Sharma, Anil Kumar, Shubham N. Rahmatkar, Savita Kumari, Avantika Bhardwaj, Aditi Sharma, Amit Kumar, Ankush Chauhan and Pooja Sharma

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Vitex negundo L. extract alleviates inflammatory aggravation and lung injury

The role of traditional herbs in mitigating clinical conditions is well known. However, due to a lack of sufficient scientific validation, these herbs remain underutilized. Thus, we attempted to assess the effectiveness of *Vitex negundo* leaf extract (VNLE) in mitigation of ovalbumin-lipopolysaccharide (OVA-LPS)-induced allergic lung inflammation with emphasis to delineate its molecular mechanism(s). We found that VNLE administration effectively attenuated LPS-induced oxi-inflammatory stress in macrophages suggesting its anti-inflammatory potential. Further, VNLE showed protective effect in mitigating asthmatic lung damage as evident by reversing pathological changes, including inflammatory cells influx, congestion, fibrosis, bronchial thickness, and alveolar collapse observed in the allergen group (Fig. 1). VNLE suppressed expressions of inflammatory Th1/Th2 cytokines, chemokines, metalloproteases, iNOS, adhesion molecules, IL-4/IFN-g release with simultaneous enhancement in levels of IL-10, IFN-g, MUC3, and tight junction proteins. Subsequent mechanistic investigation revealed that OVA-LPS concomitantly enhanced the phosphorylation of NF-kB, PI3K, Akt, and p38MAPKs and downregulated AMPK, which was categorically counteracted by VNLE treatment. VNLE also suppressed OVA-LPS induced fibrosis, apoptosis, autophagy, and gap junction, which was confirmed by a reduction in TGF-β, Smad2/3/4, Caspase3/9, Bax, LC3A/B, connexin 50, connexin 43, and enhancement in Bcl2 expression. Additionally, suppression of alveolar macrophage activation, inflammatory cells in the blood, and elevation of splenic CD8+ T cells were demonstrated. UPLC-ESI-QTOF-MS/MS revealed the presence of iridoids glycoside and phenolics, which might contribute to these findings. Collectively, the protective effect of VNLE in attenuation of the inflammatory associated allergic airway is proven.

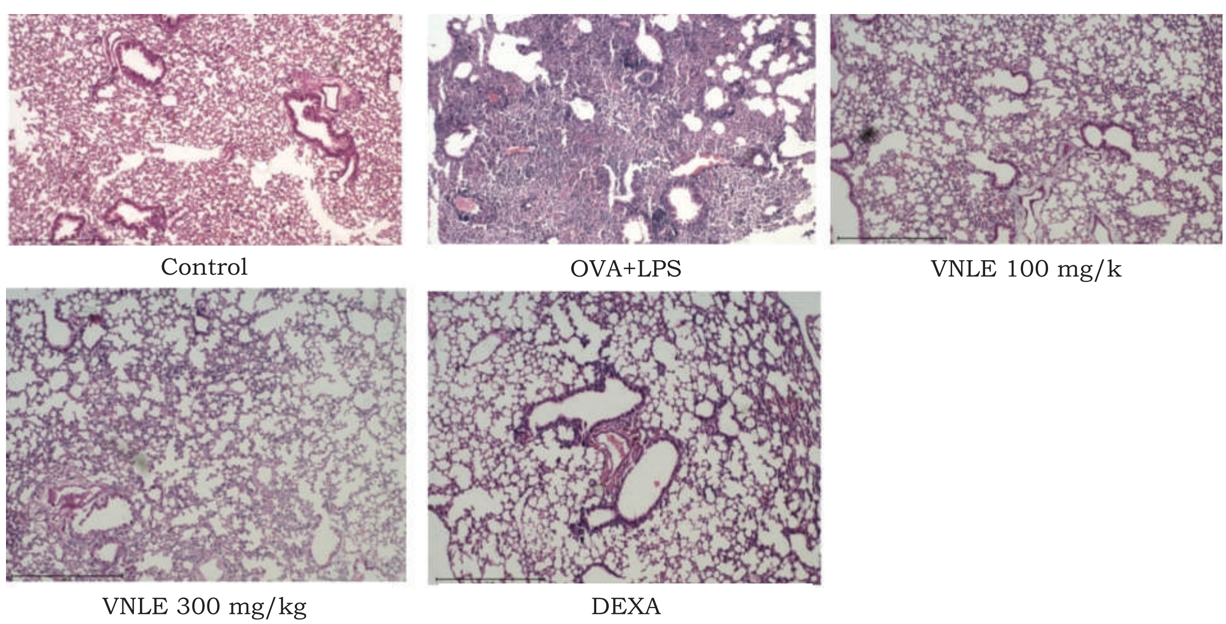

Fig. 1 Histopathological investigations of lung tissue of different grou

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Food and Nutraceuticals

Our laboratory worked on two aspects. The main emphasis was on the development of value added products from aromatics and herbals. Secondly, a focus was on the development of nutraceutical formulations for improvement of bioavailability and therapeutic efficacy.

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 to prepare drugs in various medicine systems, herbal cosmetics, and functional foods.

Further, essential oils from aromatic plants have also been extensively used in flavor, fragrance, cosmetics industries, and aromatherapy.

The main focus of our laboratory was to develop value-added products from medicinal and aromatic plants utilizing pharmaceutical technology (formulations) to produce commercially marketable products.

In this context, we worked on developing herbal topical formulations, including multipurpose cream, sunscreen, ointments utilizing Himalayan bioresources such as superoxide dismutase (SOD) and catechins.

Development of nutraceutical formulations for improvement of bioavailability and therapeutic efficacy

The consumption of bioactive metabolites has shown protection against chronic diseases such as diabetes, cardiovascular disease, cancer, and neurodegenerative diseases.

However, these phytochemicals have major therapeutic limitations of low aqueous solubility, low permeability, short half-life, and low bioavailability.

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 the therapeutic efficacy of nutraceuticals.

In this context, we are working on phloretin, one of the main bioactive constituents of apple, and exhibits a wide variety of pharmacological activities such as antidiabetic, antioxidative, anti-inflammatory, and anticancer.

However, its efficacy is greatly hampered due to poor aqueous solubility (20 μg/mL) and bioavailability, as it gets rapidly and extensively metabolized. Therefore, to overcome this issue, we utilized formulations-based approaches to improve the bioavailability of phloretin in view to enhance its therapeutic efficacy.

Further, the work is also going on to investigate novel formulation-based approaches for enhancing the bioavailability and therapeutic efficacy of bioactive tea constituents.

The work is also going on to explore targeted drug delivery approaches such as HER2, CD44, folic acid targeted delivery for augmenting the therapeutic efficacy of these molecules for anticancer activity (Fig. 1).

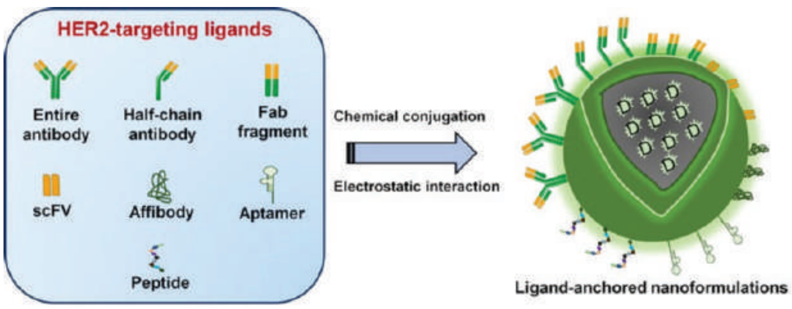

Fig. 1 Various artificial ligands have been explored for ligand- targeted HER2 delivery. These ligands can be anchored on to the surface of nano-formulations either through either covalent chemical bonding or through electrostatic interactions (Source: A. Saneja *et al.*, Expert opinion on drug delivery, 11(1) (2014) 121-38). [Dhritlahre RK, Saneja A (2020), Drug Discovery Today (in press) https://doi.org/10.1016/j.drudis.2020.12.014)

Research group: Rakesh Kumar Dhritlahre, Ruchika, Nabab Khan and Amit Sharma

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Biodiversity Conservation, Ecology, and Traditional Knowledge

Our research group is primarily field-oriented, we explore vascular plants, sample vegetation, prioritize traditional knowledge, and maintain repositories. A gist of the activities carried out during reporting period is presented below.

Floral surveys and specimen collection

We conducted 07 surveys to the hinterlands of Himachal Pradesh (HP) that include Chamba, Kinnaur, Kugti, Pangi, and Rohtang (Fig. 1). A total of 700 plant specimens representing 300 species were collected and are accessioned in the PLP herbarium. The majority of these belong to the family Asteraceae followed by Rosaceae, Poaceae, and Lamiaceae, etc. During surveys, localities rich in plant diversity such as Gai in Kangra and Sarni in Chamba were also identified.

Fig. 1 A survey team in the hinterlands of Himalaya

Population estimation of high value medicinal plants

Quantitive estimates on the population of 15 high value medicinal plants in the alpine regions of HP were generated (Fig. 2) through stratified random sampling. Amongst habitats, gentle slopes reported the highest species richness (13) while undulating meadows had the maximum diversity (H'=2.118). The Rapid Vulnerability Assessment (RVA) revealed *Aconitum heterophyllum* and *Fritillaria roylei*, to be the most vulnerable species (RVA values = 30 each).

Maintenance of ecosystem services

Ecosystem services and their valuation is emerging as a promising tool in resource management. We analysed a Payment of Ecosystem Services (PES) model currently operational in the Dhauladhar Range, HP, and documented the ecosystem services offered by three prevalent ecosystems of the area. Responses for provisioning, regulating and cultural services were presented by the respondents (Table 1). Stakeholder integration and capacity building are key for the smooth operation of PES.

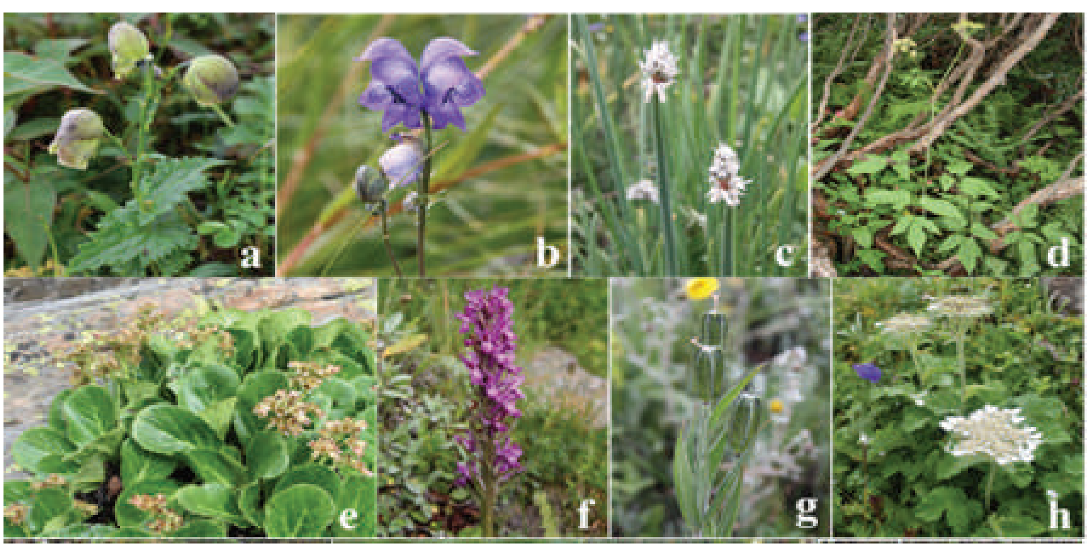

Fig. 2 Field photographs of some of the studied medicinal plants (a *A. heterophyllum;* b *A. violaceum;* c *A. stracheyi;* d *A. galuca;* e *B. stracheyi;* f *D. hatagirea;* g *F. roylei;* h *H. candicans*)

Table 1 Key ecosystem services identified by the villagers

Ecosystem	Services perceived (% response)	Sub-types
Forest	Provisioning (100)	Fodder, water, wild food, herbs
		Bamboo, wood for implement
		Fuelwood
	Regulating (46.97)	Spring recharge, erosion control
		Local rains
		Habitat, nursery function
	Cultural (18.18)	Temple
		PES model
Grassland	Provisioning (100)	Fodder
	Regulating (36.36)	Habitat, gene pool
		Prevent runoff, maintain soil fertility, nutrient cycling
	Cultural (13.64)	A place for village meetings
Agro-ecosystem	Provisioning (100)	Food, fodder
		Fuelwood
	Regulating (18.18)	Bind soil, maintain soil fertility
	Cultural (6.06)	Feels good

Vegetation monitoring

Through a time-lapse camera setup, phenological monitoring of a *Betula utilis* forest was continued. A total of 900 images were auto-clicked. Out of these 300 images were analyzed for phenological monitoring. Digital images store information in Red (R), Green (G), and Blue (B) channels. The RGB analyses revealed that greenup in *B. utilis* started during early May and continued till mid-June when the canopy attained maturity (Fig. 3). On the other hand, senescence started in early September and by mid-October, the trees became leafless.

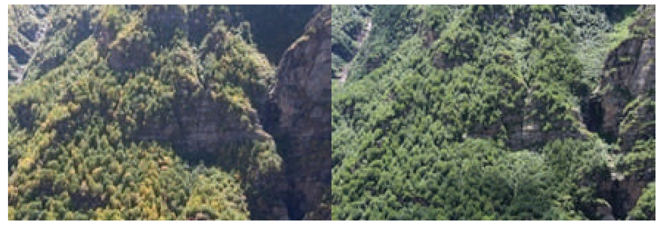

Fig. 3 Canopy maturity and start of senescence recorded through the setup

Traditional knowledge and practices

Traditional knowledge of the resident communities of HP and taboos prevalent in the society were documented and classified. For this, interactions with local people (n=210) and focus group discussions were held. A total of 22 taboos that mainly related to forest, water, farmland, and food resources were noted. Maximum of these belonged to the segment and method category taboos (32% each) while the minimum (5%) were species-specific taboos. Taboos were found to be a means of resource management and maintaining sanctity (Fig. 4).

Fig. 4 Taboos related to forests do not permit the extraction of resources from the *deobans*

Database creation

A database on wild edible plants and plants of cultural importance was updated. Information on data fields namely taxonomy, distribution, habit, habitat, uses, part(s) used, and mode of use was digitized. This was done as per the standard format of the Indian Bioresource Information Network of which the Institute is a part.

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Amit Kumar

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Remote Sensing and GIS

We are focusing on the conservation and management of Himalayan bioresources using ground and drone based multispectral, Hyperspectral and LiDAR remote sensing techniques. The ecological niche modeling is being followed for finding suitable habitats for threatened medicinal plants. We have also established long term ecological research plots for climate change studies for understanding alpine ecosystem response using *in-situ* and remote sensing data.

Standardization of protocols for spectral data acquisition in the field from plants using hand held sensor

Field spectroscopy using spectral data recorded with the help of handheld sensors is used to retrieve biophysical, biochemical and stress/health related parameters of vegetation in a non-destructive manner.

The quality of such data acquisition in the field is dependent on factors such as variations in light intensity; number of spectral readings per plant; distance between sensor and plant; impact of heating due to sun; wind, and wetness of plant. We studied the influence of the above factors on spectral data acquisition using a spectroradiometer. These facts are generally not taken care of properly as there are no such systematic studies reported erstwhile on standardization of methodologies of spectral data acquisitions. These standard operating practices are generally based on the similar work earlier carried out and reported by researchers in bits and pieces. Therefore, we have identified and quantified the effect of the above influencing factors by conducting experiments in simulated and controlled conditions (Fig. 1). The findings are:

- Calibration of sensor for sun light intensity is required when there is ±20% change in illumination from initial calibration.
- (=>)30 spectral readings are optimum for a specimen.
- Spectra recorded at 20-35cm distance from a sample are statistically similar and can be treated as standard spectra.
- The heating of samples due to sun; speed and direction of wind; and wetness of samples influenced the plant spectral reflectance.

It was thus concluded that in order to build a spectral repository of plants, care should be taken to avoid/minimize the errors produced due to above factors so that good quality spectral data is recorded from the field.

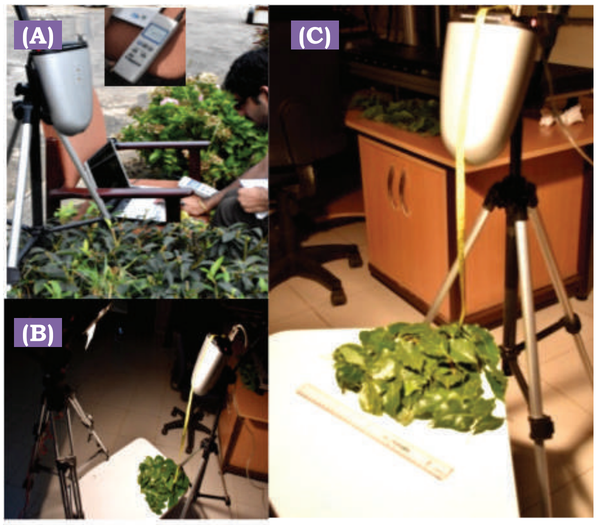

Fig. 1 (A) Impact of change in light intensity during recording of spectra (B) Optimization for number of spectral observations (C) Distance between sensor and leave samples (Vibrational spectroscopy, 2020, 111: 103159)

Onsite age-group discrimination of an endangered medicinal plant using field spectra

Non-destructive and onsite age discrimination of an endangered medicinal and aromatic plant species *Valeriana jatamansi* was carried out using field hyperspectral remote sensing and machine learning techniques.

The reflectance spectra in wavelength region 860, 870 to 874, 876 to 885 nm in NIR and 747 to 756 nm in red-edge region were identified suitable for age discrimination of 6, 12, 24, and 36 months old *V. jatamansi* (Fig. 2). Derived Artificial Neural Network (ANN) model was validated on 60 plants of various age group in farmer's field with 88% accuracy.

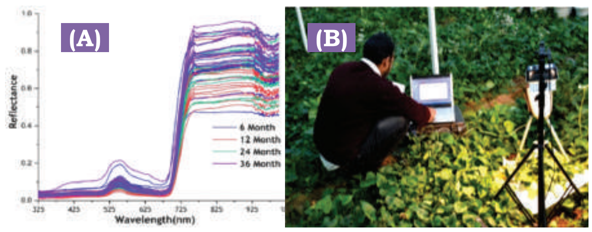

Fig. 2 (A) Spectral signatures of various age-groups of *V. jatamansi* (B) Spectral data acquisition in field (International Journal of Remote Sensing, 2021, 42:10, 3777-3796)

Drone based remote sensing

Land use map of *Rosa damascena* plantation was prepared at 1.5 cm/pixel ground resolution using multispectral image acquired from Micasense Altum sensor mounted on a quad-rotor multicopter drone. The Normalized Difference Vegetation Index (NDVI) map was prepared, where pixels having NDVI>0.2302 were classified as *Rosa damascena* class. The NDVI <=0.2302 and >0 were categorized as 'weeds and grasses', while NDVI <0 were grouped as 'open/barren areas'. The 39.82% area was found under *Rosa damascena*, while 31.62% represented 'open/ barren areas' and 28.43% 'weeds and grasses', respectively (Fig. 3).

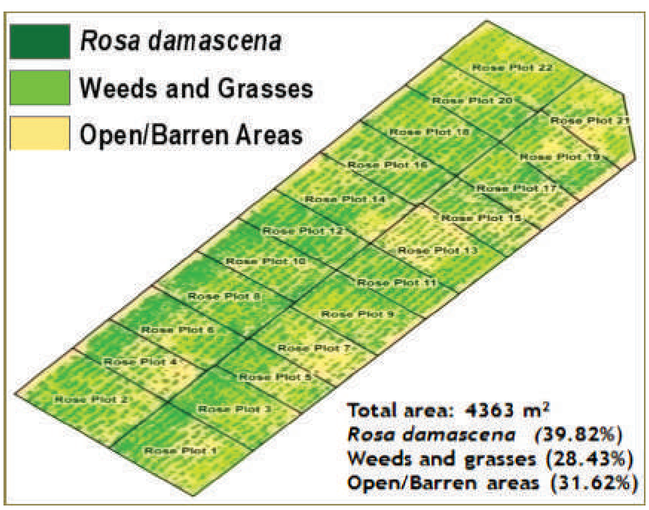

Fig. 3 Lanuse map of *Rosa damascena* plantations at CSIR-IHBT, Palampur, Himachal Pradesh (Journal of the Indian Society of Remote Sensing, 2021, https://doi.org/10.1007/s12524-020-01302-5)

Outcomes of the above work were found to be propitious having the potential to be replicated for other crops such as *Saussurea costus; Gingko biloba; Hypericum perforatum; Stevia rebaudiana*; *Tagetes minuta; Valeriana jatamansi*; etc.

Development of Geoecological Integrity Index (GII) for assessment and prioritization of watersheds

Geoecological Integrity Index (GII) was developed for the prioritization of watersheds of Indian north-western Himalaya. The GII was developed by integrating biotic, abiotic and anthropogenic factors of the watershed, which are generally treated in isolation in such types of studies. The above factors were termed as geoecological factors and they were integrated to arrive at cumulative weights (GII) for micro-watersheds for prioritization. Based on GII, the Baner river watershed in the Kangra district of Himachal Pradesh, which consists of 110 micro-watersheds, 11 were prioritized as very high actionable, 32 as high actionable, 52 as moderately actionable and 15 as of minimal action, requiring suitable actions for its conservation and management (Fig. 4).

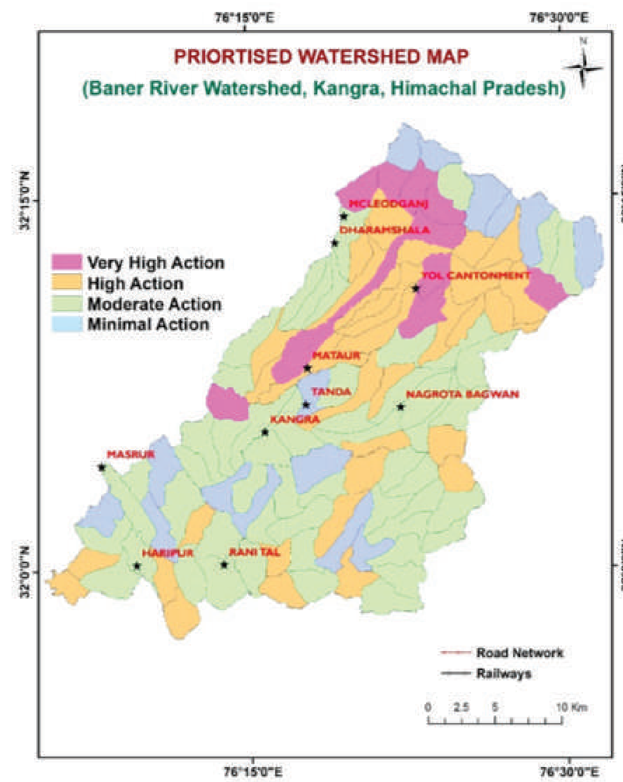

Fig. 4 Prioritisated watersheds map of Baner river watershed, Kangra district, Himachal Pradesh (Journal of Earth System Science, 2021, 130:19 https://doi.org/10.1007/s12040-020-01537-3)

The study provided an approach for geoecological assessment of mountainous watersheds which can also be replicated in any other watersheds having similar ecological conditions.

Climate change studies

In continuation to the previous year work under characterizing patterns and processes of alpine ecosystem in Indian Himalaya with special emphasis to Himachal Pradesh (SHRESTI), one long term ecological site was established at Chansal pass, Rohru, Shimla district, Himachal Pradesh during 13-19 October 2020 in addition to one site earlier established in the last year. Six quadrats of 20×20m size were permanently marked in this site (Fig. 5) following Global Observation Research Initiative in Alpine Environments (GLORIA) international protocols for climate change studies in collaboration with Space Applications Centre (SAC), ISRO, Ahmedabad.

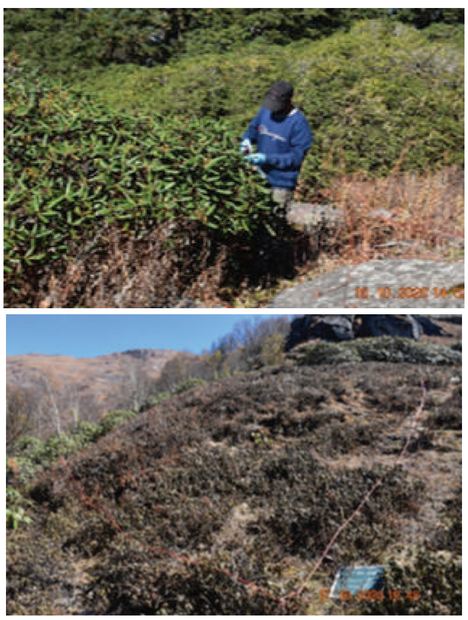

Fig. 5 Marking of 20×20m quadrats in the alpine ecotone

LiDAR based remote sensing for vegetation

The 3-dimensional point cloud data of *Crataegus oxyacantha* (Hawthorn) field was recorded using 3-DT LiDAR system in the CSIR-IHBT experimental farm. The plant belongs to the family Rosaceae and is used in the treatment of gastrointestinal and heart diseases.

The Digital Surface Model (DSM) derived from the above LIDAR data provided the elevation information of the plot which ranged from 1364 to 1374 m (Fig. 6). Using the DSM, the height of trees was also estimated and the maximum height of the tree was noted to be 10 m. The average height of the plants was found to be 5.8 m in the plot.

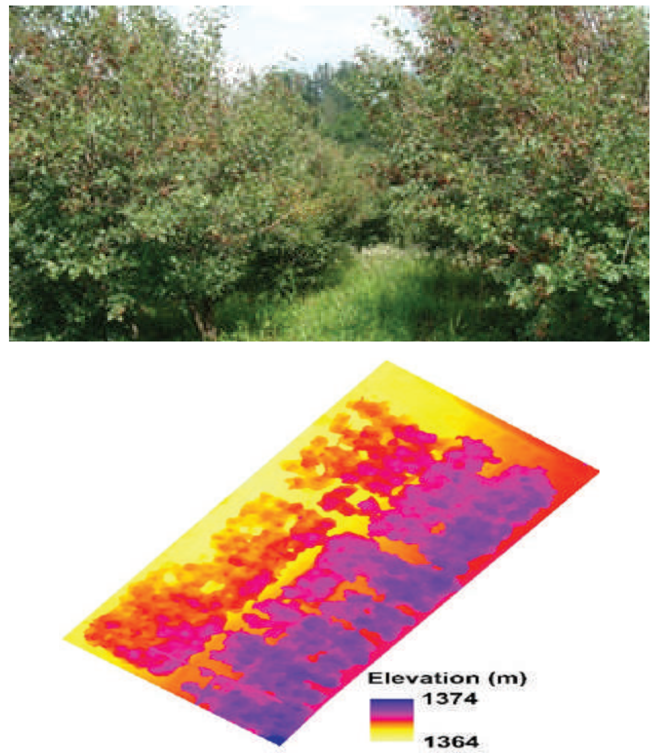

Fig. 6 Digital Surface Model (DSM) of *Crataegus oxyacantha* field in CSIR-IHBT prepared using 3D-point cloud LiDAR data

Ecological Niche Modelling (ENM) of threatened medicinal plants

Ecological Niche Modelling for finding out niche habitats of *Sinpodophyllum hexandrum* in northwestern Himalaya was carried out using Maxent software (Fig. 7). Total 10.12% area was found suitable for the occurrence of *S. hexandrum* (Ladakh= 2.09%, J&K = 2.70%, H.P. = 4.27% and UK = 1.06%). The Himachal Pradesh was identified to possess largest probable area of *S. hexandrum*.

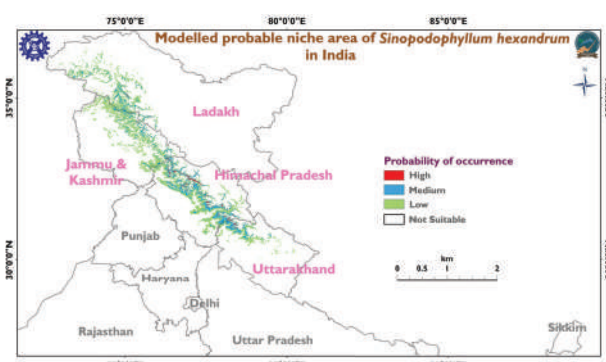

Fig. 7 Modelled niche habitat of *S. hexandrum* in northwestern Himalaya

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Ecology

Studying impact of climate change on treeline and alpine plants

(a) Monitoring of timberline forests

The nutrient cycling study was conducted in our previously established Long Term Ecological Research (LTER) sites. We found that the leaf litter decomposition process in timberlines species (*Betula utilis*) is slow with an average decay rate estimated as 0.22 year^{-1} (data from 03 sites that are under observation since 2015). Further, it was deduced that increase in N & decrease in C:N and lignin: N ratios with incubation time are the main processes governing litter decomposition. The observed changes indicated nutrient conservation and availability of essential nutrients in harsh conditions. The experiment is continued at these sites.

(b) Monitoring of alpine vegetation

Field studies and ecological monitoring were undertaken in LTER plots which were established along an elevation gradient at Rohtang (32°22' N 77°16' E). Replicate plots were also established at 4350 m elevation making a total of 4 elevations (3550m, 3850m, 4150m and 4350m) under study. The data on the phenology of dominant alpine species were collected along with population assessment and recording of vegetative and reproductive traits. In addition, we also investigated the role of alpine dwarf shrubs in habitat modification which influences the functional response of herbaceous communities.

Conservation of threatened medicinal plants

The ecological factors determining the distribution and abundance of *Dactylorhiza hatagirea* (D.Don) Soo, an endangered terrestrial orchid, were assessed using Ecological Niche Modelling (ENM) and field sampling. It was found that among the climatic and topographic factors, the precipitation of the coldest quarter (i.e. snowfall during Jan-Mar) is the most important factor governing its distribution across Himalaya. On the other hand, the edaphic factors especially the soil Ca content is more responsible for its population density. The ENM also revealed 'Western Himalaya' as the most suitable region with more probability of occurrence of its populations.

Further, the field genebank, established at CSIR-Centre for High Altitude Biology was strengthened with more accessions of targeted threatened medicinal plant species viz., *Dactylorhiza hatagirea*, *Aconitum heterophyllum* and *Arnebia euchroma*.

Research group:

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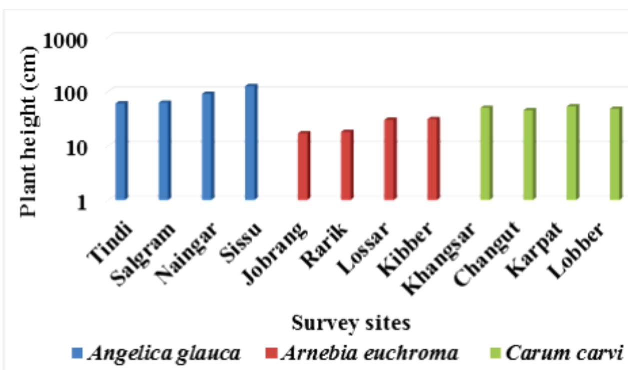
Plant Ecology

My work focusses on generating qualitative and quantitative information on threatened, and economically important plant species in the high altitude regions of Western Himalaya. Also, I am involved indeveloping field conservatories at *Centre for High Altitude Biology* (CeHAB of CSIR-IHBT) Ribling, Lahaul-Spiti (HP).

High altitude ecological research

Focused ecological studies on the targeted medicinal and aromatic plants were carried out. Different habitats in Lahaul-Spiti and Pangi valley were identified, and 30 sites along altitudinal range of 2600 to 4700 masl were sampled. Population of species such as *Angelica glauca, Carum carvi, Arnebia euchroma, Aconitum heterophyllum, Picrorhiza kurrooa, Sinopodophyllum hexandrum, Fritillaria roylei, Hippophae* spp, etc. were recorded (Fig. 1). Also samples of *Angelica glauca and Carum carvi* were collected from Shimla (HP) and Chamoli (Uttarakhand).



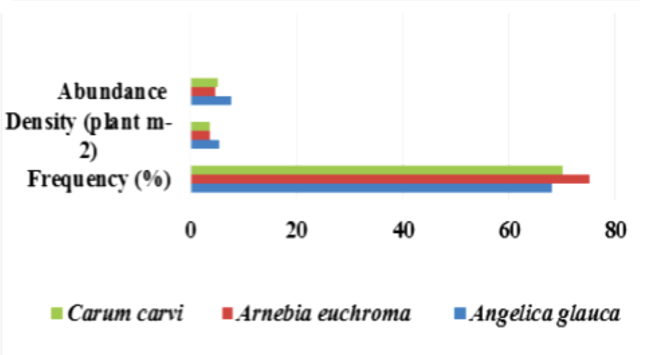


Fig. 1 The distribution pattern of threatened medicinal species in the Lahaul & Spiti (H.P.)

Field Gene-bank Conservatories of Medicinal and Aromatic Plants (MAP) at CeHAB Ribling, Lahaul-Spiti (HP), and CSIR-IHBT Palampur (HP)

Studies on the conservation of threatened species were conducted at CeHAB Ribling, Lahaul-Spiti, HP (3450 masl), and CSIR-IHBT Palampur (1328 masl).

Status of field gene-bank conservatory

***Angelica glauca*:** Conserved 21 different accessions collected from Western Himalaya. About 2000 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 14 accessions of *Carum carvi* in the CeHAB farm, farmers field at Lahaul and Kullu. Also, conserved 15000 plants and harvested 3 Kg seeds from the nursery at CeHAB of CSIR-IHBT Ribling, Lahaul-Spiti (HP).

***Arnebia euchroma*:** Conserved 20 different accessions and 1010 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 7000 plants in the field gene-bank at CeHAB Ribling, Lahaul-Spiti. Further harvested seeds (2.0 Kgs) from the CeHAB field genebank.

Sinopodophyllum hexandrum: A total of 35 accessions, 1720 plants, and 2.00 Kg seeds collected from different habitats were conservedin the field gene bank. Plants were raised with seeds and roots.

Picrorhiza kurrooa: Conserved and successfully raised 11000 plants of 5 accessions collected from the Chamba, Lahaul-Spiti in the field gene-bank at CeHAB.

***Fritillaria roylei*:** Conserved 4 accessions, 310 bulbs & plants in the field gene-bank at CeHAB Ribling, Lahaul-Spiti (HP), and Mohani Panchayat Banjar in Kullu (HP).

***Rheum australe*:** Conserved 4 accessions and 120 nursery raised plants in the field gene-bank at CeHAB Ribling (3450 masl).

Hippophae germplasm resource centre: Maintained varied accessions at CeHAB Ribling.

Other important threatened species like *Artemissia maritima, Saussurea costus, Inula racemosa, Valeriana jatamansi,* were also mass conserved in the genebank of CeHAB.

Herbal garden at CeHAB Ribling, Lahaul-Spiti H.P.: A total of 25 medicinal & aromatic plant species (including threatened species & endemic species) were conserved in the herbal garden at Lahaul & Spiti.

Characterization for the selections: Elite accessions in the wild population of *Arnebia euchroma* from Lossar, Spiti valley; *Carum carvi* from Khangsar, Lahaul; *Angelica glauca* from Sissu, Lahaul; *Sinopodophyllum hexandrum* from Hinsa, Lahaul; etc. were selected based on their physical appearances.

Technology demonstrated: Snow-water harvesting technology demonstrated to team from IPH department Keylong and local Panchayat members from Lahaul-Spiti in presence of invited guest Er. Sonum Wangchug.

Research group: Rajat Bhardwaj

Vikas Kumar

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Herbarium and Plant Taxonomy

My team focuses on the exploration of Himalayan biodiversity, their collection, inventorization, identification, documentation, characterization as well as maintaining plant repositories. We are also involved in the conservation of threatened medicinal plants of the Himalayan region.

Field exploration and collection of plant specimens

During 2020-21, three field tours were conducted to Kangra and Chamba districts and 883 samples were collected along with 1800 field photographs of plants and landscapes. Out of these, 516 specimens that belong to 71 families were identified. Besides, the germplasm of 13 threatened and medicinal plants of the Himalayas were also collected for *ex-situ* conservation. Further, under the JICA project, six one-day tours were undertaken in various sites of district Mandi for survey and collection of data on medicinal and aromatic plants. Some of the photographs of landscape, field activities, and collected plant species during the expedition tours are provided in Fig. 1.

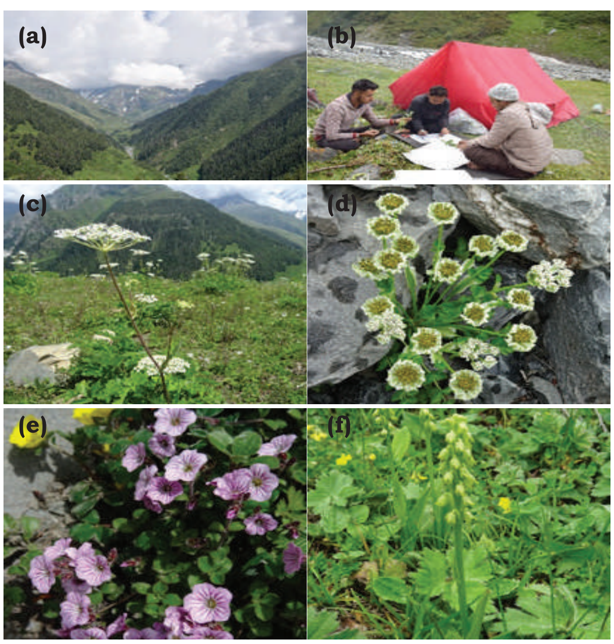

Fig. 1 a) Alpine vegetation of dist. Chamba; b) Drying and pressing of plant specimens; c). *Heracleum lanatum*; d) *Pleurospermum candollei*; e) *Gypsophila cerastioides*; and f) *Herminium monorchis*

Taxonomic studies of the genus *Cremanthodium*:

With regards to taxonomic characterization and geospatial distribution of the genus *Cremanthodium,* a checklist of species found in the political boundary of India was made based on literature survey and herbarium specimens housed at PLP and CAL. During field tours, one species was collected and photographs depicting the habit of the plants, close-up view of flowers, landscape vegetation, etc. were also taken.

Documentation and taxonomic characterization of tree resources at CSIR-IHBT

'*A Pictorial Field Guide to the Trees at CSIR-IHBT Campus*' was prepared as a part of the 'Trek and Learn Series' for dissemination of knowledge among visitors and students. In this guide, a total of 70 tree species conserved/planted at the CSIR-IHBT campus were enumerated with updated nomenclature. The taxonomic characterization of each species along with the phenological data, location map, and photographs of different parts were provided for easy identification (Fig 2).

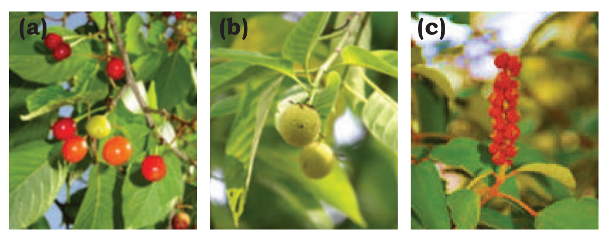

Fig. 2 Trees species conserved in CSIR-IHBT campus a) *Prunus cerosoides;* b) *Neolamarckia cadamba; and* c) *Mallotus philippensis*

Technique for the preservation of the herbarium

A herbarium is an important part of the research organization working on plant sciences which serves as an invaluable conservatory of plant material. For preparing herbarium, proper preservation technique and their maintenance are needed. Keeping this in mind, a manual for '*Plant Collection and Processing for Herbarium*' was prepared. The manual includes a step-wise procedure for the collection of various kinds of plants, their preservation, mounting, and incorporation, along with the photographs.

Maintenance of herbal garden

The data of medicinal plants conserved in Prakriti Kunj was digitized. The QR codes of 25 species have been developed. Besides, virtual photo-plate(s) of 86 species have also been prepared. These carry bilingual information on scientific, vernacular names, uses, etc.

Development of QR-based plant signage

The data of medicinal plants conserved in Prakriti Kunj were digitized. Further, QR-based plant nameplates have been developed for 25 species (Fig. 3). The scanning of which (QR code) through any multimedia device will provide bilingual information on scientific, vernacular names, uses, etc of the species along with its image(s).

Fig. 3 QR-based name plate of *Aloe vera* conserved in Prakriti Kunj

Research group: Shivendra Singh Yadav

CENTRE FOR HIGH ALTITUDE BIOLOGY (CeHAB)

ACTIVITIES AT CENTRE FOR HIGH ALTITUDE BIOLOGY (CeHAB)

Location: Tandi, Lahaul & 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

Background: Centre for High Altitude Biology (CeHAB) is unit of CSIR-IHBT located in District Lahaul & Spiti of Himachal Pradesh at an elevation of 3450 m. The Research Centre has been established with a mission to connect to innovate for ecology, economy and societies of higher Himalayas through fundamental and industrial research. This focusses on studies pertaining to bio-systems at high altitude vis-à-vis climate change, bioprospecting plants and microbes for industrially important metabolites and processes; introduction of high return commercial crops including floriculture; *ex situ* conservation and transferring knowledge to local communities for improving livelihoods and for inclusive growth. It has an infrastructure setup of research farm with green houses, shade nets, drying and storage areas, and a laboratory complex.

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.

PLANNING, PROJECT MONITORING AND EVALUATION (PPME)/ BUSINESS DEVELOPMENT AND MARKETING UNIT (BDMU)

PLANNING PROJECT MONITORING & EVALUATION

Institutional Research Planning

Facilitated formulation of documents sent to CSIR Headquarters, significant achievements of CSIR-IHBT for society meeting, details of significant event (2014 to 2020), ATR on the monthly meeting of DG CSIR with the Directors, Information on women-specific initiatives, Indian S&T Diaspora-Portal/Database, Information for NIRF 2021, Info about 'Aatma Nirbhar Bharat', Institute's interventions on agricultural improvement and in NER, etc. and action taken towards the achievement of goals were regularly furnished to the competent authority.

For constant updating, institutional data on the various domains, 34 proforma, and reports on a daily basis were uploaded to the C-DIS portal during 2020-21. PPME recorded the initiation of 47 new projects funded by various agencies (DBT, DST, NMHS, HIMCOSTE, etc.). As a part of routine activity, carried out updation and maintenance of databases pertaining to the project, staff, paper, patent, ECF, resource management, etc.

Resource Planning and Monitoring

Facilitated the fund allocation and expenditure as per the need and mandate of the Institute. Coordinated meetings to plan new infrastructures and equipment.

IT-based Activities

The information related to Institute's activities was promptly posted on social media (Facebook, Twitter, Youtube, etc.) and sent to CSIR Hqrs for its inclusion in CSIR in the Media news bulletin.

Right to Information

Furnished information on 78 queries under RTI Act and filed the quarterly report to RTI portal www.rti.gov.in.

Kuldeep Singh

Scientist
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R&D Management; Science Communication & Dissemination

Primarily engage in the Institute's research planning, project monitoring and evaluation activities and facilitate resource planning and financial management of Institute. Centrally involved in the formulation, recording, budgeting, and monitoring of in-house and externally funded projects. Our group carried out monitoring of institutional performance w.r.t projects, publications, ECF, patents, technology transfer and societal impact to facilitate decision makings. Coordinated meetings to plan new infrastructures and equipment. Further appropriate steps were also taken to seek approval and induct new human resources to cater Institute's requirements. Involved in conducting meeting of Research Council of the Institute and also supported the follow-up actions. Furnished information regarding 21 parliament questions received from the CSIR. Institute activities related information is regularly updated and flashed on institutional website and intranet. We are connecting the Institute with the society through timely dissemination of relevant information through press & media and social media sites. In addition, organized events of national importance viz, National Technology Day, International Tea Day, International Yoga Day, 38th CSIR-IHBT Foundation Day and Foundation week, CSIR Foundation Day, Curtain Raiser Ceremony as a part of the 6th India International Science Festival (IISF 2020), "Vigyan Yatra" as a part of the 6th India International Science Festival (IISF 2020), National Science Day, Visit of Hon'ble Minister of State for Finance and Corporate Affairs, Government of India, Shri Anurag Singh Thakur, on March 1, 2021 and International Women's Day.

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, Research and academic activities, processing of disseminating technologies and products to the society. It showcases and sales institute's R&D products.

During 2020-21, BDMU facilitated for signing 117 agreements/MoUs including, twenty five technology transfers, thirty nine material transfer agreements (MTAs), six consultancy agreements for establishment of drying sheds for storage godowns for medicinal herbs etc., and stevia consultation, twenty seven miscellaneous MoU' signed with different farmer societies, academic and R&D collaborations with government institutes/universities, NITs and twenty 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 MoU's with government institutes, responding queries of clients, raising expression of interest (EOI) for different technologies, raising FVC for timely payment of GST related to BDMU, socio-economic impact analysis of technologies/ services from third parties and providing inputs for drafting technology specific documents.

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Senior Scientist

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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

Major activities of Business Development and Marketing unit include on Transfer of Technologies, Business Development, Techno-economics, 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 2020-21, CSIR-IHBT has signed twenty-five agreements for transfer of technology.

Besides, thirty-nine material transfer agreements (MTAs); six consultancy agreements; twenty-seven miscellaneous MoU' and twenty MoUs/ Agreements under "Chief Minister's Start up Scheme" for incubation and facility use of CSIR-IHBT were also streamlined by us.

Business development

New clients (more than 100 numbers) were added to the organization through ToT/MTA/ Consultancy agreement and technical service. Approximate more than 2000 number of queries (related to tea based technologies, hand sanitizer, 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. Prepared technology profile as per the format.

Facilitating industry partners/ startups to market outreach their CSIR-IHBT technology based products. Eight industry partners, and Eight startups launched their products (Natural soap, hand sanitizer, aloe vera juice drinks, Immunity booster, aromatic candles, ready to eat foods, spirulina bars, multigrain protein mix, shiitake mushroom and millet and cereals based bars) in the market.

Techno-economic feasibility evaluation of technologies

Evaluated the TRL (Technology Readiness Level) of technologies, and techno- economic feasibility/ cost of production of technologies for the cost effective.

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.

Co-ordinated Agritech Event under IISF-2020

Acted as Principal Coordinator of Agritech Event under IISF-2020. Organized Agritech Event (virtual), arranged for online meetings with farmers/ startups, videos (success stories of farmers, startups, entrepreneurs), talks, delivered lectures, students competition, and other arrangements.

Research group: Didar Singh Patial, Manish Verma, Saurabh Vyas, Babita Koundal and Ashish Kapoor

PROJECT SCIENTIST, WOMEN SCIENTISTS SCHEME (WOS-A), INSPIRE FACULTY, CSIR - POOL OFFICERS, SERB - NATIONAL POST DOCTORAL FELLOW

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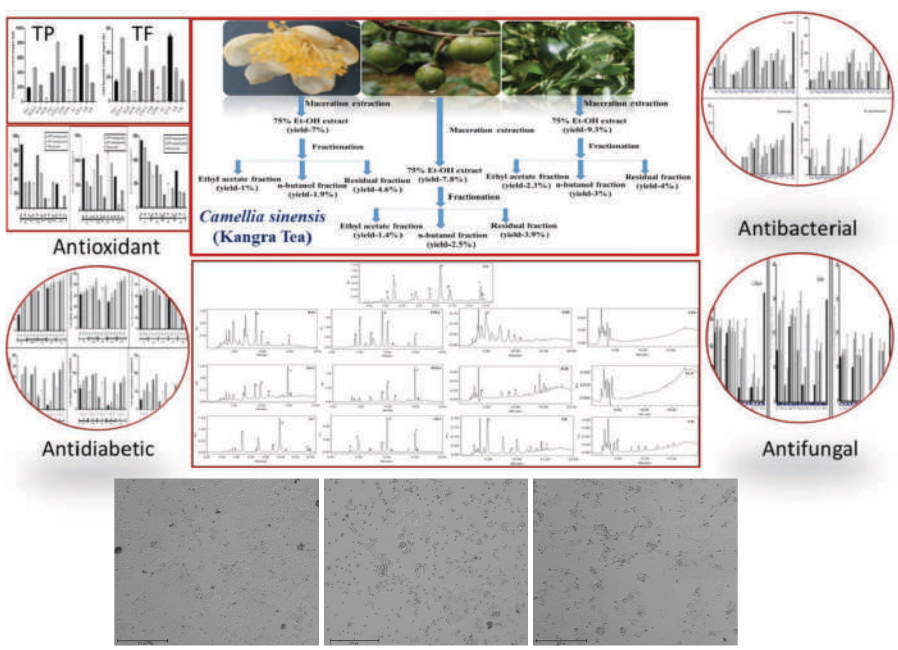
Chemical Technology Division

Chemical profiling and therapeutic insights of different tissues of *Camellia sinensis*

Camellia sinensis (tea) is an evergreen plant having bioactive phytochemicals associated with various pharmacological effects including anti-cancerous activity. These phytochemicals are translocated in different parts. Therefore, NMR based metabolomics combined with multivariate statistical approach was used to investigate the similarities and dissimilarities among the different tissues (leaf, flower and fruits) of *C. sinensis*. ^{1}H-NMR (1D and 2D) spectroscopy ambiguously identified 57 metabolites that represented majorly terpenes/saponins, amino acids, sugars, polyphenols, organic acids and methhylxanthes. The multivariate statistical analysis showed clear tissue specific similarities (26 metabolites) and variations. Moreover 4, 5 and 7 metabolites were found specific to leaves, flowers and fruits, respectively. Comparative analysis of polyphenols and flavonoid content among different extracts and fractions revealed the equivalent potential of fruit, flowers and mature leaves of *C. sinensis*. The quantification of catechins showed abundance in the leaf part followed by fruits and flowers. In addition, bioactive potential of all the extracts and fractions was considerable. Different antioxidant activities presented tea fruits and flowers as potential source of antioxidants after the leaves. Moreover, fruit and flower fractions also showed outstanding α-glucosidase & α-amylase enzyme inhibition potential. This indicates impending scope of antidiabetic agents from different parts of *C. sinensis*. Antimicrobial studies discovered excellent antibacterial and antifungal potential of fruits part followed by leaves and flowers. Antidiabetic and antimicrobial perspective of tea fruit has not been focused earlier however current results highlighted good potential. Furthermore, cytotoxicity studies against colorectal cancer cell lines presented the potential of neglected parts as chemotherapeutic agents against human colon cancer. Substantial bio-activities exhibited by green solvent extracts of all selected parts (flower, fruit and leaves) further provide good scope for their utilization in food, nutraceuticals and pharmaceutical sector (Fig. 1).



Cytotoxicity (HT-29, HCT -116)

Fig. 1 Phytochemicals and therapeutic potential of different parts of *Camellia sinensis*

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Ecology and Evolution

Evaluation of genetic consequences of climate change on high altitude specialist species at the elevational range limit of the Himalayan mountains

Ongoing accelerated rate of climate change has necessitated studies to examine the persistence of a species. Dispersal limited species with restricted range may be at a higher risk of range loss. We study Pikas (order Lagomorpha, family *Ochotonidae*) to understand the impact of past and ongoing climate change in the biodiversity rich Himalayan mountain.

Climatic fluctuation-induced range shifts can lead to changes at different scales from species to population. We are investigating the potential impact of the climate change at a species as well as population level, by comparing the genomes of species and population exposed to different climatic pressures. We are using a space-for-time approach where elevation is used as a proxy for different selection pressures.

We have generated short read sequences of six species (at an average coverage of 30 %, assuming genome size of 2.1 GB) and fourteen individuals (at an average coverage of 14%) for population level comparisons. We have estimated the genome sizes of these samples and characterized the repeat regions. The estimated genome sizes using kmers based method is between 2.1 to 2.5 GB for the six species. The repeat regions ranged between 20-30%. After characterization of the genomes, we aligned the generated sequence with the genome of closely related *Ochotona curzoniae* (assembled at scaffold level). We will explore possibilities of adaptive introgression between these species. For the population level data, we have sequenced *O. macrotis* from different populations of the Himalaya for which adaptive markers associated with these populations will be also explored.

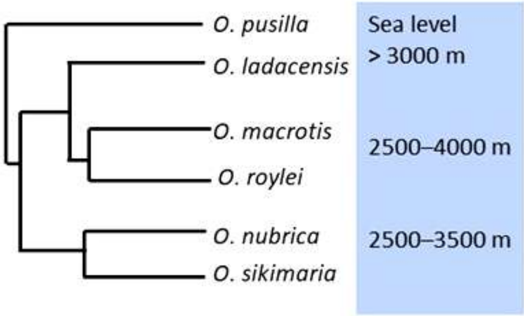

Fig. 1 Pictorial representation of phylogenetic relationship of sampled species with these populations will be also explored

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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 working on multi-locus genome wide association mapping of important phenotypic traits in plants.

Identification and expression profiling of cytosine-5 DNA methyltransferases

DNA methylation is a potential epigenetic mechanism that regulates genome stability, development, and stress mitigation in plants. It is mediated by cytosine-5 DNA methyltransferases (C5-MTases). We identified 52 wheat C5-MTases; and based on domain structure and phylogenetics, these 52 C5-MTases were classified into four sub-families including MET, CMT, DRM and DNMT2; and were distributed on 18 chromosomes (Fig. 1).

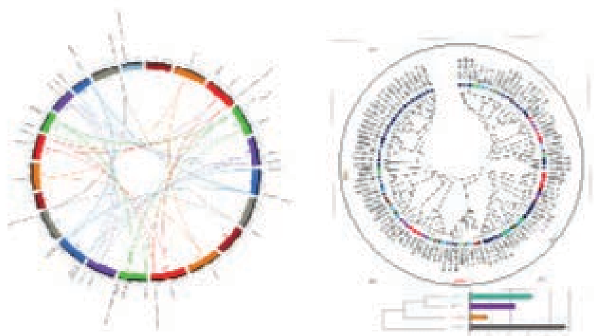

Fig. 1 Circos diagram showing chromosomal localizations of C5-MTase genes in wheat and phylogenetic relationship among various C5-MTases

Cis-acting regulatory elements analysis identified abiotic stress-responsive, phytohormone-responsive, development-related and light-related elements in the promoters of TaC5-MTases. The nuclear localization signal (NLS) analysis revealed that all wheat C5-MTase members contained either monopartite or bipartite or both types of NLSs. For example, 23 C5-MTases were predicted with both mono- and bipartite NLSs. Subcellular localization of the wheat C5-MTase proteins was also predicted with the CELLO program. It was observed that C5-MTase proteins exhibited nuclear and cytoplasmic localization. Further the predicted subcellular localization of one of the C5-MTase protein of wheat was confirmed by utilizing confocal microscopy. We selected a wheat DNMT2 gene (*TaDNMT21-3A*), since, DNMT2s is one of the most conserved C5-MTases in land plants. *TaDNMT21-3A* was observed to be uniformly distributed in both cytoplasm and nucleus (Fig. 2).

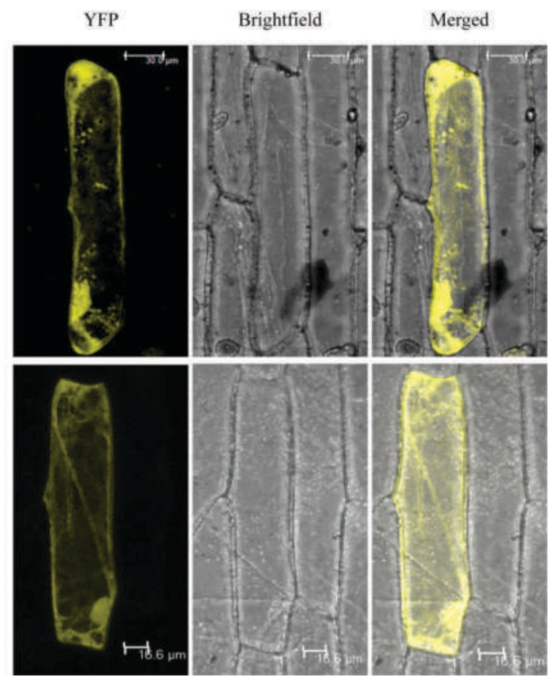

Fig. 2 Subcellular localization of wheat *TaDNMT2-3A*. Visualization of YFP fused *TaDNMT2-3A* as compared to pSITE-3CA control vector in onion epidermal cells

We also examined the transcript abundance of TaC5-MTases in different tissues, developmental stages and under abiotic stresses. Notably, most of the TaC5-MTases (*TaCMT2, TaCMT3b, TaCMT3c4, TaMET1, TaDRM10, TaDNMT21*) showed differential regulation of their transcript abundance during drought and heat stress.

However, further investigation into the role of each of member in plant development and abiotic stresses via DNA methylation could extend our knowledge and could be utilized in wheat improvement programs.

Epigenetic Control of Grain Filling in Wheat under Heat Stress

Reduced representation bisulfite sequencing (RRBS) using DNA samples extracted from grain tissues 15 days after anthesis (DAA) under control and heat stress conditions was performed. We discovered extensive DNA methylation at single-base resolution in wheat cultivars, identified the sequence context, and the extent of methylation at each site (Fig. 3). Now we are analyzing differentially methylated sites (DMSs) altered in response to heat stress in different wheat cultivars during the grain filling stage. We are also working on gene expression analysis using qPCR to reveal a constant relationship between the level of mCG methylation and the transcription abundance of some genes of potential importance in heat stress tolerance. These results will provide insights into interplay among DNA methylation and gene expression abundance, and suggest a role in heat stress adaptation during grain filling in wheat.

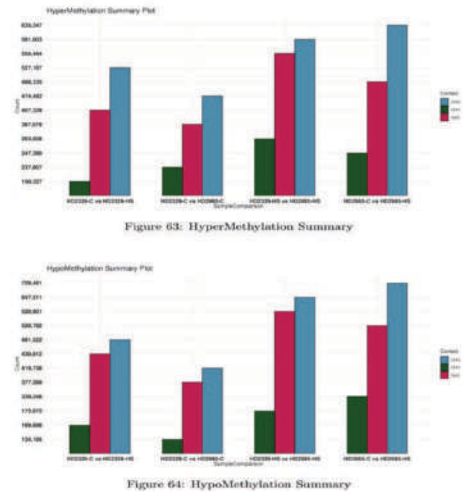

Fig. 3 Differential methylation in response to heat stress in wheat

Multi-locus GWAS of grain weight and related traits in wheat (*Triticum aestivum* L.)

Genome-wide Association Study (GWAS) for four traits including days to anthesis (DTA), grain filling duration (GFD), grain number per ear (GNPE) and grain weight per ear (GWPE) under different water regimes (irrigated and rain fed) was conducted. For this purpose, a core collection of 320 spring wheat accessions representing 28 different countries were evaluated under irrigated and rainfed conditions each with two replications. The 320 accessions were genotyped with ~10 K SNPs using genotyping by sequencing (GBS) approach. GWAS identified several SNPs associated with each of the four traits which may expedite breeding to develop drought resilient wheat through MAS (marker-assisted selection). We also identified candidate genes in the associated regions. Expression analysis suggested these candidate genes are playing a role under drought stress (Fig. 4). On the basis of our analysis, we could also identify tolerant accessions with maximum number of desirable alleles of associated loci. These markers and tolerant accessions will accelerate future wheat breeding programs to develop drought tolerant wheat varieties.

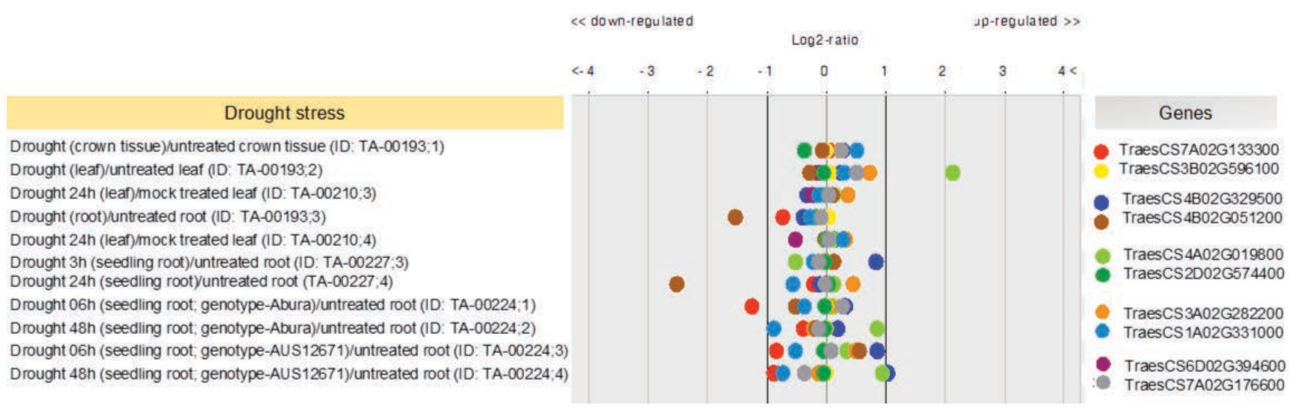

Fig. 4 Expression levels of ten candidate genes (CGs) at different wheat tissues under drought stress

Research group: Ekjot Kaur

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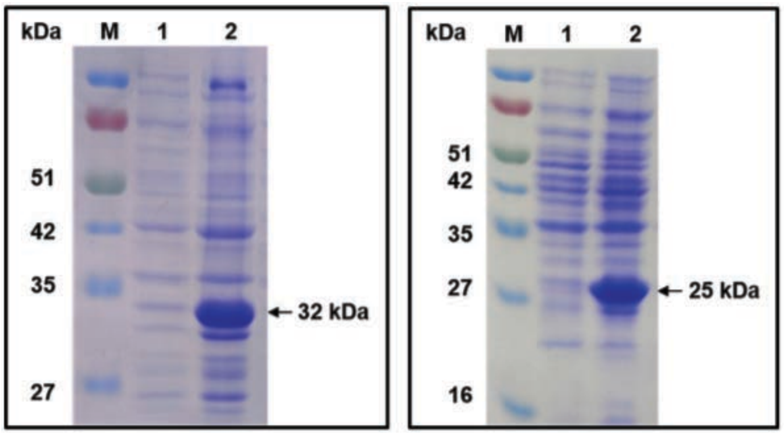
Plant Molecular Virology

Apple is the major commercial horticulture crop in Himachal Pradesh and other hill states of Jammu & Kashmir, Uttarakhand and some parts of Northeastern states of India. Tomato is the most widely cultivated crop in India. The field based diagnostics has been developed for very few plant viruses in India and it is required to develop for many important and emerging viruses infecting apple and tomato.

Development of diagnostics for viruses infecting apple and tomato crop

The present study showed the coat protein genes expression in bacteria (*E. coli.*) for the viruses infecting apple and tomato in order to produce antibodies in rabbit. The coat protein (CP) gene of *Tomato leaf curl virus* (ToLCV), *Apple chlorotic leaf spot virus* (ACLSV) and *Apple stem pitting virus* (ASPV) were cloned in pET28a (+) expression vector and transformed into BL21 (DE3) *E. coli* strain. The polyclonal antibody (PAb) was produced by injecting purified CP subcutaneously in New Zealand white rabbits for ACLSV and ASPV. The produced PAb will be further validated in ELISA and western blot and utilized for the development of immunostrip for field deployed detection of ASPV and ACLSV. This will make virus diagnosis easy to the end users such as farmers, nursery owners, tissue culture industries, seed company, breeder, quarantine authorities (Fig. 1).

Heterologous expression of coat proteins in *E. coli*



Tomato leaf curl virus ***Apple chlorotic leaf spot virus***

Fig. 1 SDS-PAGE showing coat protein expression of *Tomato leaf curl virus* (ToLCV) and *Apple chlorotic leaf spot virus* (ACLSV). Lane M: Marker; lane 1: uninduced cell protein; lane 2: induced cell protein

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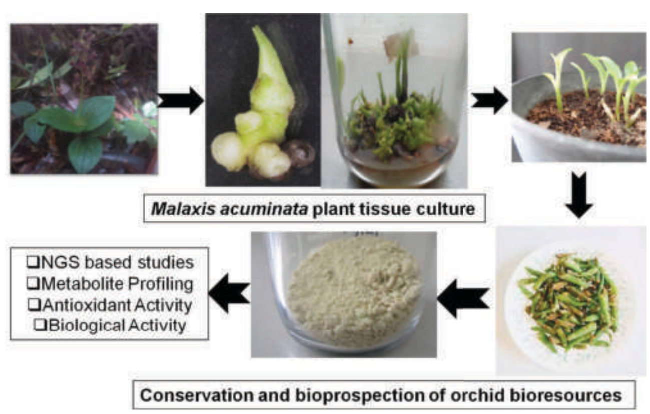
Plant Tissue Culture of RET MAPs
(Specialization-Orchid Biotechnology)

Orchids are one of the most diversified groups amongst the flowering plant families and are valued highly for their long-lasting flowers exhibiting an extensive diversity in color, shape, size and fragrance. Along with the flowering plants, orchids are of high value due to their use in various medicinal pharmacopeias worldwide. Amongst the various medicinal plant taxa used in different pharmacopeia worldwide, orchids have shown a tremendous phytomedicinal potential and have been used in various traditional pharmacopeia worldwide, including Ayurveda. In the traditional Indian medicine systems (Ayurveda), the Astavarga is a group of eight medicinal herbs, is of utmost importance, and in that formulation the use of four medicinal orchids namely *Malaxis muscifera* or Rishibak, *Habeneria intermedia* or Riddhi, *Habenaria edgeworthi* or Vridhi and *Malaxis acuminata* are used which deserves special mention.

Plants of *M. acuminata* were sampled from all possible geographical locations where they were documented to be distributed. A total of sixty plants were sampled from states of North-eastern India, Himachal Pradesh and Uttarakhand. In the present strategy of fast clonal propagation using aromatic cytokinin based plant growth regulator *meta*-topolin (*m*T) in congruence with a conventional auxin indole butyric acid (IBA) and phenolic elicitor-phloroglucinol we have achieved a considerable high degree of well-developed *M. acuminata* plantlets within a time period of ~7-8 months. Being a terrestrial orchid, the rate of seed germination in *M. acuminata* is extremely slow (less than 3%) and as the seeds lack endosperm therefore requires special fungal association to germinate. Successful branched rooting was induced using conventional auxin-based plant growth regulator indole-butyric acid (IBA). As the primary medicinal importance of this plant is reported in the pseudobulb, it was further magnified using phenolic elicitor phloroglucinol (PG). The plants were hardened and acclimatized successfully, and were maintained in the greenhouse of department of biotechnology, CSIR-IHBT. The total cycle of propagation was completed within a time span of approximately seven months, which in nature takes one and a half year.

Along with the development of fast clonal regeneration propagules using plant tissue culture, transcriptome profiling of *M. acuminata* and *M. muscifera* were also performed, and the putative genes involved in the biosynthesis of secondary metabolites of medicinal importance were determined and validated using qRT-PCR techniques. Along with that, we have also mapped the chemical bio constituents of *M. acuminata*. The module developed can be utilised in the transcriptome mapping and high-frequency regeneration of slow growing medicinally important orchids of biopharmaceutical importance. The plants were hardened and acclimatized successfully and were maintained in the greenhouse of department of biotechnology, CSIR-IHBT. The transcriptome analysis of *H. edgoworthi* is under progress along with up scaling the protocorm like bodies (PLB) formation and phytochemical production using elicitor mediated cell suspension culture techniques.



Vidya Rajendran

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Biochemistry, Biophysics and
Molecular Biology (Life Sciences)

Project summary

I have been working on this project since 14th of February 2020 till date. My project entitled "Comparative structural modeling and simulation approach to improve the bio-physicochemical properties of industrially important enzyme Superoxide dismutase obtained from *Potentilla atrosanguinea*" deals with the improvement of bio-physicochemical properties of the enzyme Superoxide dismutase obtained from *Potentilla atrosanguinea* through *in silico* approaches. Since this plant grows in the high altitude of western Himalayan region it undergoes a lot of environmental stress like frozen ground, ice/ snow cover, deficient precipitation, incidence of low illumination during the winter, and high UV radiation during summer owing to its habitat. As a result of this, high levels of reactive oxygen species (ROS) are produced which in turn accelerates superoxide dismutase (SOD) activities as well as cause high levels of peroxidase and glutathione reductase. Superoxide dismutase is a primary antioxidant enzyme and ubiquitous in nature present in all kinds of living organisms from Prokaryote to Eukaryote. For the last forty years, approximately 30,000 research articles have been published on the SOD and about 180 patents have been applied on the applications of SOD. Pharmacological application of SOD includes various disease like cancer, asthma, diabetes, arthritis, atherosclerosis, aging, infertility, neurological disorders, ischemia-reperfusion injury, transplant rejection, autoimmune diseases, rheumatoid arthritis, septic shock-induced tissue injury, etc. which involves the generation of ROS. Industrial applications of SOD includes the use of SOD formulation in bacco based products to minimize the free radical damage in respiratory tract and which can reduce the hangover after consumption of alcohol. The applications of SOD extended to cosmetic and manufacturing of other supplementary products to protect from free radical damages.

Because of its significance in industry, in our project we have decided to improve its bio-physicochemical properties through *in silico* approaches. Objectives of my study includes the collection and arrangement of thermophilic and psychrophilic plant protein structures from database. In this project we would like to develop multiple mutants by replacing amino acids at targeted positions and the improved phenomenon will be tested in *in-silico* experiments. *In silico* validation will be performed on potential mutants designed by protein engineering approach and by all atomic molecular dynamics simulations. We would like to develop a range of Pa-SOD variant which could show activity under freezing conditions as well as holding high thermal resistance. With this targeted properties, this enzyme could be useful for preventing the oxidation of refrigerated or frozen foods, as well as in the preparation of cosmetic and pharmaceutical products. The designed variant could be directly tested through wet-lab studies.

Work completed- During the past one year, we have built and analyzed a comprehensive list of mutations responsible for structural consequences (thermophilic and psychrophilic). 1800 single mutations were generated by acidic residues, 2700 generated by basic residues, 5400 by Polar amino acids and 2214 by Non-Polar amino acids. Out of this top ranked mutations showing high temperature tolerance (up to 200 °C) were being analyzed by Molecular dynamics simulations.

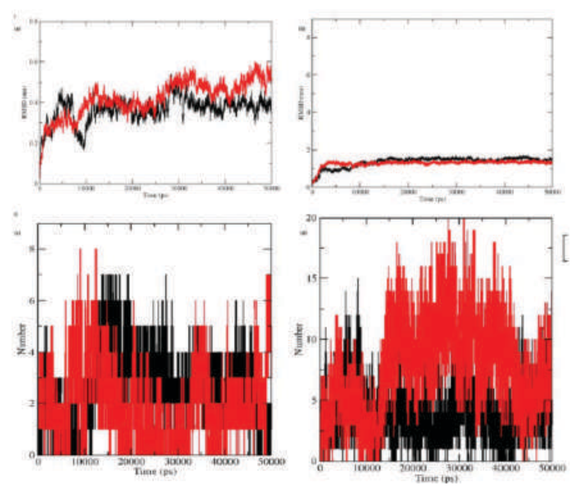

Fig. 1 Molecular dynamics simulation trajectories analysis (I) Root mean square deviation at 25°C (a) and at 200°C of native and mutant. (II) Number of hydrogen bond formation between monomer subunits during simulations at 25°C (a) and at 200°C. Colour coding indicates native in black and top thermophilic mutant in red color

Prakriti Kashyap

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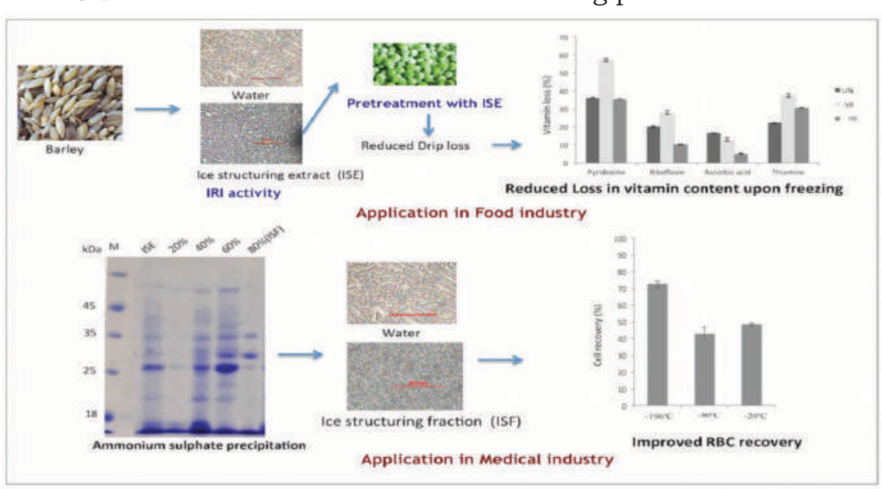
Plant Molecular Physiology

Extreme environment leads to a wealth of adaptations to life forms. In temperate regions, the temperature falls, as down as -20 to -40 °C, and the organisms are still adapted to survive due to the astonishingly brilliant physiology provided by nature. Antifreeze proteins (AFPs) are a gift to freeze-tolerant organisms by nature for their survival. During freezing, ice forms due to the crystallization of water molecules, and it grows due to ice recrystallization, i.e. larger molecules of ice grow at the expense of the smaller ones. Larger molecules of ice are lethal for cells because of the physical stress they cause to the plasma membrane, rupturing it, leading to the death of the cell. 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 the food and medical industry. As the Himalayan region is the third-largest body of snow on our planet, its flora and fauna might be a storehouse for these proteins. My research work is focused on exploring Himalayan grains for these proteins and evaluating their application potential.

Identification and purification of ice structuring proteins from Himalayan grains and unveiling their application in food and medical industry

ISPs have been reported in winter crops and one of the problems of using plant ISP is the limited supply of plant material. In order to ensure the continuous supply of plant material for experiments, we screened the Himalayan food grains 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) was analyzed for its application in the food industry. The recrystallization damages the food cellular structure and causes drip loss. This causes a loss of structure and texture of food material. But with the loss of water from frozen food, the loss in water-soluble vitamin content also occurs. Here, we pretreated the green peas with ISE, and the effect on freezing-induced vitamin loss was observed and quantified with UHPLC-PDA. The results indicated that pretreatment with ISE reduced the drip loss and prevented the freeze-induced loss in vitamin B4, vitamin B6, and vitamin C. Further, the ISE was fractionated with ammonium sulfate precipitation and an ice-structuring fraction (ISF) was obtained with remarkable IRI properties. The ISF was used as a cryoprotectant for the preservation of RBCs and resulted in 71% recovery of RBCs when cryopreserved liquid nitrogen (-196 °C). Similarly, the recovery was 41 and 49% when RBCs were cryopreserved at -80 °C and -20 °C respectively in presence of ISF.

Overall, the study opens the prospects for the use of *Hordeum vulgare* var. *dolma* as a potential source for the identification and application of ice-structuring proteins.



Rahul Jain

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Plant-Microbe Interactions

Contribution of plant associated microbiome in cold stress regulation in *Arnebia euchroma*, a high-altitude medicinal plant

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* could be responsible for the uniqueness of this plant species 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.

For the present work, we have isolated culturable (endo)microbiota associated with the root and leaf tissues of *Arnebia euchroma* collected from the Lahaul and Spiti district of Himachal Pradesh, India. The isolated endophytes showed various plant growth promoting characteristics such as phosphate and potassium solubilization, ACC deaminase, indole acetic acid, and siderophores production. we are using model plant *Arabidopsis thaliana* to study interaction of these isolated endophytes including bacteria and fungi under cold stress. The ongoing investigations showed that inoculation with several potential endophytes resulted in better growth performance (high F_v/F_m and chlorophyll, and low ROS contents) of the plants grown under cold stress (10 °C) as compared to the un-inoculated plants under same conditions (Fig. 1). The expression of cold stress responsive genes of Arabidopsis was quantified using q-RT PCR in plants inoculated with endophytes and compared with untreated plants exposed to cold stress. Overall, a low sensitivity to cold in inoculated plants was observed as compared to un-inoculated plants. To better understand these interactions, targeted and untargeted metabolomics studies are underway for evaluating the role and function of different metabolites and phytohormones in imparting microbial regulated cold tolerance in plants. Moreover, we are currently utilizing fluorescent microscopy-based techniques to study and localize plant-microbe interactions in roots and leaves.

Overall, these observations indicated a contribution of plant colonizing microbes especially endophytes in the fitness and health of plant under cold stress conditions. These microbes and their formulations can be utilized to design microbial synthetic communities (SynComs) as a vault for the propagation of various endangered medicinal plants in their natural habitat and production of climate resilient crops.

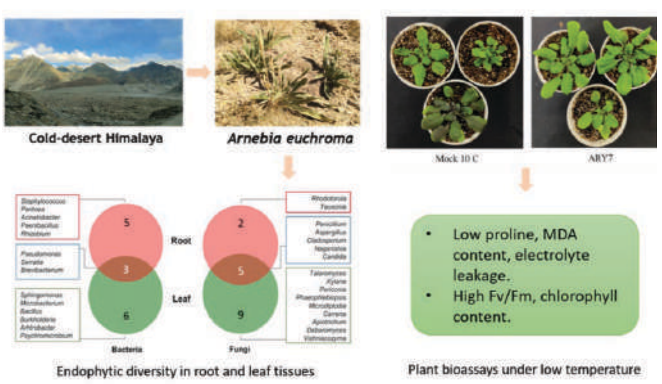
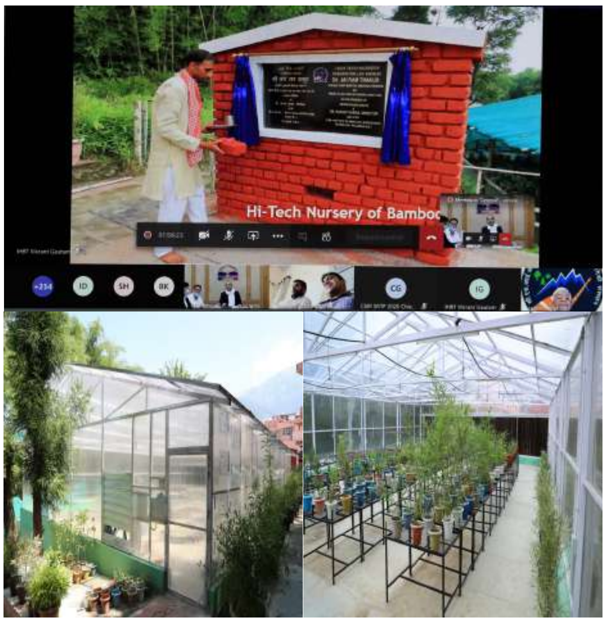


Fig. 1 Isolation of endophytes from *Arnebia euchroma* (left panel) and plant-microbial inoculation studies to investigate contribution of microbes in imparting cold tolerance in Arabidopsis (right panel)

SCIENCE & TECHNOLOGY SUPPORT SERVICES

ENGINEERING SERVICES UNIT

High Tech Nursery: Foundation stone of High tech. nursery laid on 3rd July, 2020 by Sh. Jai Ram Thakur Hon'ble Chief Minister Himachal Pradesh. The facility consists of Hi-Tech Green House for raising Bamboo Nursery plants.The area of the facility is 216 Sqm with estimated cost of Rs. 20.00 Lakh.



Protein Processing Centre: Protein Processing Centre was inaugurated by Sh. Jai Ram Thakur Hon'ble Chief Minister of Himachal Pradesh on 3rd July 2020.

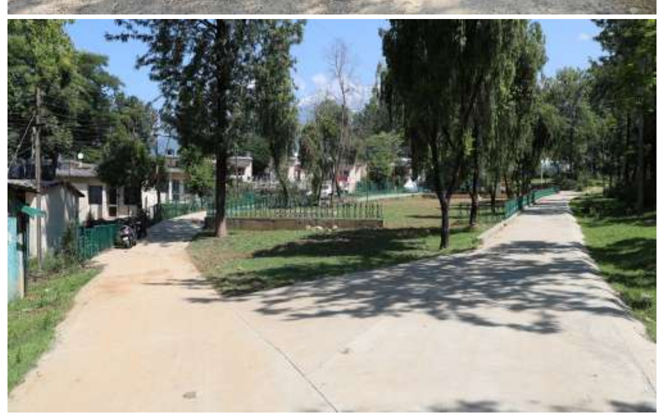
Tissue Culture Lab (Work in Progress): Foundation stone of Tissue Culture Unit laid on 3rd July 2020 by Sh. Jai Ram Thakur Hon'ble Chief Minister of Himachal Pradesh. The lab is mainly for Tissue Culture Work of *Heeng* & Kesar. The tentative area of the lab is 400 sqm. With estimated cost of Rs. 150.00 Lakh.

Residential Premises (Type IV-12 Houses): Foundation stone of 12 Houses Type-IV was laid on 1st March, 2021 by Sh. Anurag Singh Thakur Hon'ble Union Minister of State, Ministry of Finance and Ministry of Corporate Affairs with preliminary estimated cost of Rs. 850.00 Lakh.

Open Address Terrace with National Flag: Open address terrace with National Flag Inaugurated on 8th March 2021 by Dr. D.K. Aswal, Director, CSIR-NPL, New Delhi.

Construction of 120 Rooms Hostel at CSIR-IHBT (Work in Progress): The work was approved by CSIR with estimated cost of Rs. 30.20 Crore and was started in January 2021 and is in progress.

Concrete Road: The carpeting of existing road was done with Cement Concrete in Bharmat Colony. The existing ground was filled upto road level with protective railing around the ground. The total expenditure incurred on this work is Rs 37.00 Lacs



Cement Concrete Road link to Central Corridor in the institute

Corridor and Hi-tech Nursery

Farm Stores: Farm stores were constructed at various locations to meet the storing requirements of Farm activities with estimated cost of Rs. 35.00 Lacs

ADMINISTRATION

The Administration functions as Central Facilitation Office for handling all the administrative, legal and vigilance matters in addition to variety of support services in connection with R & D activities performed towards realization of the vision of CSIR-IHBT, Palampur. It also acts as Compliance Office to ensure the immediate implementation of various orders, advisories and guidelines etc. as issued from time to time by the Government of India, and CSIR, New Delhi.

The Administration plays critical role at every phase of career advancement for all the employees, right from their recruitment, orientation training, performance appraisal and various service matters to their superannuation. It also facilitates to all the employees including research scholars in their sphere of duty so that they can perform their task smoothly.

Other major activities performed by the administration may be enumerated as follows:

- Assists the authorities of this Institute, namely, the Director, the Head of Departments and the Principal Investigators on various issues and to take decisions of administrative nature. Maintaining liaison with CSIR Headquarter, New Delhi on administrative and legal matters.
- Implements policies in pursuance of guidelines as issued by the CSIR Headquarter, New Delhi.
- Formulates policies concerning to administrative procedures for smooth functioning at the institute level.
- Provide administrative support to various functional bodies (Committees/Functional groups) within the organization.
- Provides conducive working conditions and environment in the laboratory through interpretation as well as implementation of governing rules and regulation.

The Administration is headed by the Controller of Administration, who is the over all In-charge of its activities. He is supported by the Administrative Officer, Section Officers, a group of Assistant Section officers, Senior Secretariat Assistants, Junior Secretariat Assistants and supporting staff including Security Services and Rajbhasha Cell. The security section is responsible for the safety and security of the institute. In recent past, the Administration has undergone major transformation in terms of work culture and implementation of paperless processes. An improved work culture and decentralized leadership has been introduced at all levels to bring the desired changes. A trend of faster service delivery system has been inculcated in the staff to match the expectations of CSIR-Enterprise Transformation Initiative and to achieve their goals.

Achievements

- Played key role towards combating spread of COVID-19 inside the premises of this Institute with support of various internal teams/ committees constituted in this connection.
- Successfully completed first round of vaccination to prevent corona, of all the employees of this Institute in co-ordination with the Health and Family Welfare Department, Government of Himachal Pradesh.
- All the administrative processes were made operative through physical/digital mode without compromising with the efficiency in accordance with the various guidelines as issued from time to time by the Government of India, CSIR, New Delhi and the Government of Himachal Pradesh.
- Recruitment process for one Technical Assistant and one Junior Engineer (Civil) was completed on time.
- All the assessment promotion due up to 31.03.2020 at Institute level as has been completed on time.

Security Section

The security section is responsible for the complete safety and security of all the valuable resources inside the premise of this Institute. Keeping interest of this Institute at paramount, the alert security personnel deployed under supervision of the administration takes care of routine security issues and regulates visitors in respect of their coming into as well as exiting from this Institute.

The section strives to secure the premise of this Institute by patrolling, inspecting buildings on day to day basis and monitoring the various access points attentively through electronic surveillance system. It endeavors to prevent losses and damages by reporting the indiscretions to the competent authorities of this Institute. It also briefs the violators about the policy and procedures of the Institute towards security measures as approved by the competent authority of this Institute.

The section has successfully restrained the trespassers through continuous attentive vigil. It maintains the record of movement of visitors as well as materials coming inside and exiting the premise of this Institute. In addition, it provides other essential assistance as and when required at the main entrance of this Institute.

Administration group: Sh. Alok Sharma, Sh. Amarjeet, Sh. Sanjay Kumar, Sh. Ved Prakash, Sh. Parveen Singh, Smt. Santosh Kumari, Sh. Baldev, Sh. Kiran Kumar, Smt. Pooja Awasthi, Sh. Sandeep Kumar, Sh. Mukul Sharma, Sh. Ajay Singh Kaundal, Sh. Boni Kumar, Sh. Trilok Nath, Sh. Baleshwar Parsad, Sh. Thaman Bahadur

FINANCE & ACCOUNTS SECTION

Finance & Account Division plays a pivotal role in managing day-to-day affairs related to financial and accounting matters of the institute. Through various activities are being handled by Finance & Accounts Division in time targeted manner in order to achieve smooth and effective attainment of the goals with financial prudence, some of them are listed below:

- Exercising financial propriety in day-to-day work.
- Compilation of the budget document (RE-BE), ensuring utilization of grant.
- Coordination with Head, PPME in Project monitoring and other project-related activities, etc.
- Financial concurrence of all proposals, including service matters.
- Coordination with CSIR and sending all monthly and quarterly returns.
- Liasioning and Coordination with CAG and CSIR in settlement of all CAG and Internal Audit Paras.
- Acting as an ex-officio member in several committees as per statutory requirements.
- Ensuring that the economic instructions of the Government of India are scrupulously followed and exercising necessary budgetary control.
- Examination of the various administrative proposal and according to concurrence.
- Preparation of Annual Accounts and submitting to CSIR thereof.
- To ensure timely payments to all and maintaining statutory records.
- Investment of surplus funds as per CSIR instructions.
- Handling all issues of Pension disbursements, New Pension Scheme, etc.
- Ensuring modernization and computerization of Finance & Accounts functions.
- To render advice to the Director on all financial matters and providing support services to all the Scientific staff and bench level scientists.
- Any other work assigned by CSIR/ Director.

Finance group: Sh. Yah Pal, Ms. Aruna Kumari and Sh. Deepak Sood

STORE AND PURCHASE

Stores & Purchase Section meets the material requirements of R&D and other infrastructure divisions in time. Apart from meeting the routine & regular requirements of the Institute, the S&P Section procured Ready to Eat Food (RTE) for distribution among Migrant Workers due to COVID - 19 pandemic and also to 'AMPHAN' Flood victims of Orissa and West Bengal. It also procured required materials in time for the establishment of the COVID-19 testing facility. It ensured full utilization of funds during the Financial Year and procured the following significant items during 2020-21.

The above items were procured in time, although limitations due to COVID-19 pandemic lockdown conditions prevailed from time to time.

1	-80 Freezers
2	Automatic High Efficiency Distillation System
3	Bio Reactor
4	Continuous Centrifuge
5	Distillation Units
6	Fume Hoods
7	Gel Imaging System
8	High Pressure Homogenizer.
9	High Pressure Reactor
10	Incubator Shakers
11	Lyophilizer
12	UHP Gas Generators
13	Unmanned Aerial Vehicle
14	UPS 100 KVA

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 45 managed switches and 72 indoor and outdoor wireless access points. All the Internet users are managed centrally with the help of an authenticator.

Network Security hardware used for LAN & WAN comprises 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 facilitated Virtual Classroom and Video-Conferencing facilities for the Institute. As a routine job, this cell constantly extends services related to networks, computers, and peripherals over Local Area Network and coordinates AMC for Computer & Peripherals.

KNOWLEDGE RESOURCE CENTRE (KRC): LIBRARY

The KRC support research & development and educational activities through the procurement and management of scientific and technical knowledge resources. During the year more than 2500+ knowledge resources including scientific journals, books, databases were subscribed in print and online mode. A variety of different types of reference queries from scientific & technical professionals and walk in user's from the other institutions related to specific information on a topic of research, impact factor, citations and publishers publishing policy were attended. User orientation has been continuously provided new scientists, research scholars, technicals, project staff etc. joined the institute. The library website (http://library.ihbt.res.in.) updated time to time with resourceful links to facilitate researchers. In this year, a number of 2549 visitors including scientists, students, research scholars and faculty members visited the library from several academic and R&D institutions to consult and access knowledge resources.

Database: The database of books, journals and other documents prepared in KOHA software was updated with new additions during the year. In the KOHA database the documents of library having availability on internet through its publisher can be viewed their physical structure and layouts. The Online Public Access Catalogue (OPAC) can be accessed and searched online through http://14.139.59.218/. The OPAC database has facilities of view on-line checkout status, reservation of books, and recommendation of new books, journals, etc. The database can be searched by keywords, author, title, publisher, accession number, subject, ISBN, etc.

Similarity and Grammar Check: A number of 708 scientific & technical documents were checked with the iThenticate database for detection of similarity/plagiarism and provided reports thereof to the scientist and scholars. The various documents were also checked with the database of Grammarly for grammar correction and plagiarism and reports of the same were provided for further improvement of those documents.

Printing and Photocopy: The library continued to provide printing, photocopy and scanning of different types of the documents such as scientific & technical brochures, advertising materials, flyers of technology developed, official documents, project proposals & reports to the scientists, scholars and staff of the institute, binding of documents is also being facilitated. Coordinated compilation and layout setting of the annual report, technical brochures, manuals, banners, products stickers, etc.

Press and Media: Coordinated 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.

Sixteen newspapers of Hindi and English languages subscribed in the library were scanned for relevant news items appeared therein. Further, news clips scanned and communicated to directorate and related scientists for their information. In addition, online sites were also searched for the information related to the institute published online. Library is managing newspaper clippings blog at- http://ihbtinnews.blogspot.in/.

Library group: Sh. Mukhtiar Singh, Sh. Saurabh Sharma, Smt. Jasveer Kaur and Smt. Rujala Devi

PHOTOGRAPHY UNIT

This unit provides comprehensive photographic and videography services in the Institute, including recording research activities both in the labs and in the demonstration plots involving scientists and scholars. It strives to achieve the highest standards converging traditional skills and modern technologies with high production values and commitment to quality to ensure the best reproduction in these and publications. During the year, extensive photography was conducted in hilly terrain spanning from Bharmour (Dist. Chamba) to Kwaring (Lahaul & Spiti) to cover the activities spearheaded by the Institute, particularly in the successful laying of demonstration plots of saffron and *Heeng*.

A: Photography and Videography

Institute is actively contributing to Aroma Mission and catalyzing the local economy by cultivating Wild marigold, *Valeriana jatamansi, Rosa damascena*. The activities, including crop sowing, farm management, harvesting, processing for distillation of essential oil, and farmer interactions, have been captured at farmers' fields and intuitional experimental farms.




Scientific experiments and results were captured through photography and videography for key medicinal plants like *Picrorhiza kurrooa, Crataegus spp., Ginkgo biloba,* etc., and commercially important crops on a routine basis like Stevia, monk fruit, and bamboo.




Our Institute is widely credited for popularizing commercial floriculture in the region. Under the Floriculture Mission, the growing cycle of important crops like Lillium, Gerbera, Carnation, Chrysanthemum, Rose, Alstroemeria, etc., was captured through still photography and videography. Also, the glimpses of apiculture being practiced along with Floriculture Mission were also locked through the camera.


Lilium


Gladiolus


Chrysanthemum


Carnation


Bird of Paradise


Alstroemeria


HT Rose


Gerbera

On a routine basis, different stages of several important high altitude plants like *Fritillaria sp. Picrorhiza kurrooa, Ferula assa-foetida,* etc., being raised through tissue culture, were meticulously photographed.

B. Designs & layout:

- Coffee-book of Technology Profile Vol. II of CSIR-IHBT
- Books cover pages of Bamboo Resources at CSIR-IHBT, Prakriti Kunj, Aromatic crops at CSIR-IHBT and Tea germplasm.
- Annual Report Cover page and layout and photographic inputs (2019-20)
- Assisted of Product based leaflet
- E-cards for different occasions
- Assisted of Posters for presentation
- Labels of various CSIR-IHBT products
- Infographics and e-banners for various training programmes, workshops, conferences, symposia etc.
- Certificates for participants of various training programmes, workshops, conference, symposia etc.
- Start-Up profile of CSIR-IHBT. It is *ongoing assignment…*

C. As our Institutional activities are vibrant and dynamic, so is our Institutional song, this year we released “Sansthan Gaan”-Vol.2.

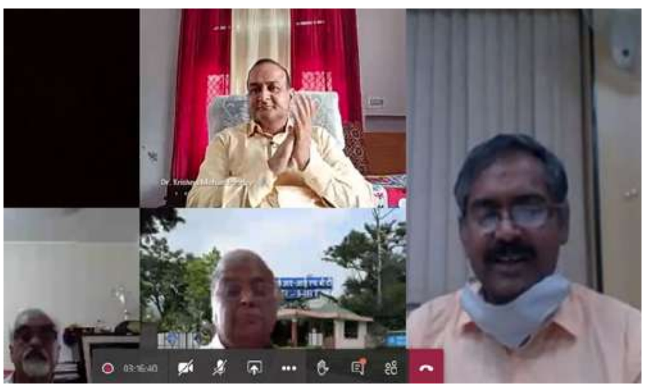
राजभाषा

राजभाषा गतिविधियां

हिंदी सप्ताह समारोह

संस्थान में हिंदी सप्ताह समारोह का मुख्य समारोह दिनांक 14 सितम्बर 2020 को ऑनलाइन माध्यम से बड़े हर्षोल्लास के साथ मनाया गया। समारोह का शुभारंभ संस्थान गान के साथ हुआ।

समारोह के मुख्य अतिथि डा. प्रदीप शर्मा, पूर्व कुलपति, शेरे कश्मीर कृषि विज्ञान एवं प्रौद्योगिकी, विश्वविद्यालय, जम्मू एवं चन्द्रशेखर आजाद कश्मीर कृषि विज्ञान एवं प्रौद्योगिकी, विश्वविद्यालय, कानपुर ने हिंदी दिवस की बधाई देते हुए राजभाषा से संबन्धित विभिन्न पहलुओं पर प्रकाश डाला। अपने प्रशासनिक, शैक्षणिक अनुभव को साझा करते हुए राजभाषा की स्वीकार्यता के महत्व को बताते हुए राजभाषा हिंदी में कार्य करने का आह्वान भी किया।



इस अवसर पर डा. कृष्ण मोहन पाण्डेय, आचार्य एवं वेद विशेषज्ञ ने राजभाषा हिंदी के राष्ट्रीय, ऐतिहासिक परिदृश्य पर महत्वपूर्ण एवं ज्ञानवर्धक व्याख्यान दिया। अपने संबोधन में डा. पाण्डेय ने भाषा के उद्भव, क्रमिक विकास, चुनौतियों और संभावनाओं पर प्रकाश डाला इसके अतिरिक्त उन्होंने वेदों में व्याप्त ज्ञान, विज्ञान और जीवन दर्शन पर मार्गदर्शन एवं आत्मचिंतन के लिए प्रेरित किया।

संस्थान के निदेशक डा. संजय कुमार ने अपने अध्यक्षीय संबोधन में विज्ञान को जन–जन तक पंहुचाने की दिशा में किए जा रहे प्रयासों की जानकारी दी। संस्थान द्वारा विकसित प्रौद्योगिकियों को उसके उपयोगकर्ता तक पंहुचाने के लिए सरल एवं जन भाषा का उपयोग करते हुए हम आगे बढ़ रहे हैं। उन्होंने आगे बताया कि यह प्रयास इसलिए भी आवश्यक है ताकि हम जैवआर्थिकी के उन्नयन हेतु प्रौद्योगिकीय उद्भवता एवं विकास में हिमालयी जैवसंपदा के संपोषणीय उपयोग द्वारा विश्व स्तर पर अग्रणी होने की संस्थान की परिकल्पना को साकार कर सके तथा सर्वोत्कृष्ट विज्ञान एवं प्रौद्योगिकी द्वारा हिमालयी जैवसंपदा से प्रक्रम और उत्पादों की खोज, विकास एवं व्यवसायीकरण के उद्देश्य को पूरा कर सकें।

इस अवसर पर हिंदी सप्ताह के अन्तर्गत आयोजित हिंदी प्रतियोगिताओं के विजेताओं तथा हिंदी में मौलिक काम करने वाले कार्मिकों को प्रोत्साहित भी किया गया। संस्थान के प्रशासन अधिकारी श्री आलोक शर्मा ने धन्यवाद ज्ञापन किया तथा कार्यक्रम का संचालन हिंदी अधिकारी श्री संजय कुमार ने किया।

हिंदी सप्ताह के दौरान आयोजित प्रतियोगिताओं तथा हिंदी टिप्पण/आलेखन प्रोत्साहन योजना के विजेताओं की सूची

हिन्दी समारोह–2020

हिन्दी टिप्पण लेखन प्रतियोगिता

पुरस्कारः

प्रथम पुरस्कार	श्री बोनी कुमार
द्वितीय पुरस्कार	श्री मुकुल शर्मा
तृतीय पुरस्कार	श्री संदीप कुमार

हिन्दी लोकप्रियविज्ञान लेखन प्रतियोगिता

पुरस्कारः

प्रथम पुरस्कार	डा. अशोक गहलोत
द्वितीय पुरस्कार	डा. धर्म सिंह
	श्री मोहित स्वर्णकार
तृतीय पुरस्कार	डा. विपिन हल्लन
	श्री मुकुल शर्मा

विज्ञान के क्षेत्र में हिन्दी माध्यम से श्रेष्ठ कार्य के लिए पुरस्कार

स्मृति चिन्ह डा. राकेश कुमार हिन्दी टिप्पण प्रोत्साहन योजना के अन्तर्गत वर्ष 2019–20

1 श्री ईश्वर दास	प्रथम पुरस्कार
2 श्री मुकुल शर्मा	प्रथम पुरस्कार
3 डा. शशी भूषण	द्वितीय पुरस्कार
4 श्रीमती संतोष	द्वितीय पुरस्कार
5 श्री बलदेव	द्वितीय पुरस्कार
6 डा. अशोक गहलोत	तृतीय पुरस्कार
7 श्रीमती अरुणा कुमारी	तृतीय पुरस्कार
8 श्री किरण कुमार	तृतीय पुरस्कार
9 श्री बोनी कुमार	तृतीय पुरस्कार
10 श्री प्रवीण कुमार	तृतीय पुरस्कार
11 श्री संदीप कुमार	सांत्वना पुरस्कार
12 श्री अजय सिंह कौंडल	सांत्वना पुरस्कार

राजभाषा संबन्धी कार्यान्वय

संस्थान के शोध छात्रों के पीएच.डी. थिसीज की समरी के अनुवाद एवं संपादन में सहयोग।

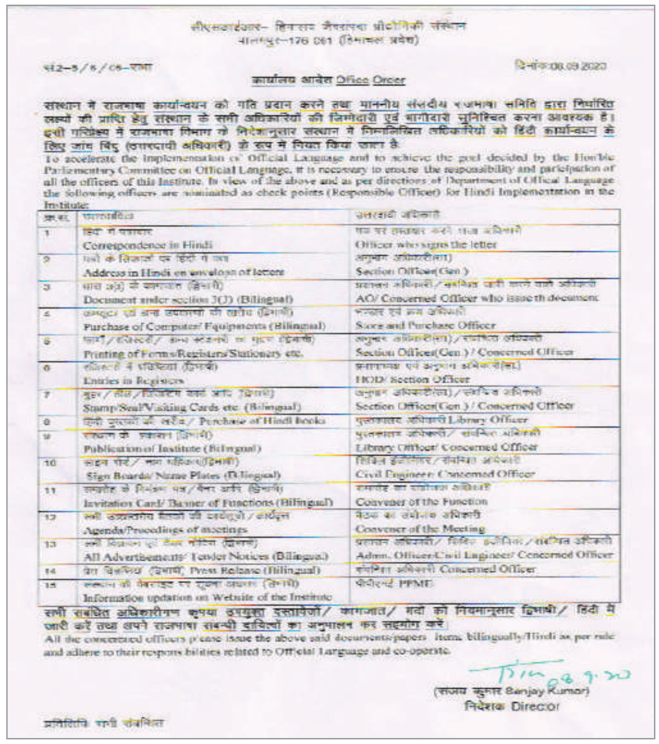
संस्थान द्वारा किये जा रहे शोध कार्यो को आम जनता तक पहुंचाने के उद्देश्य से ब्रोशर आदि के लिए सामग्री का अनुवाद, संपादन एवं प्रकाशन में सहयोग किया गया।

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।

विविध कार्य

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



सीएसआईआर– हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
पालमपुर–176 061 (हिमाचल प्रदेश)

सं2–5/6/05–रामा

दिनांक:08.09.2020

कार्यालय आदेश Office Order

संस्थान में राजभाषा कार्यान्वयन को गति प्रदान करने तथा माननीय संसदीय राजभाषा समिति द्वारा निर्धारित लक्ष्यों की प्राप्ति हेतु संस्थान के सभी अधिकारियों की जिम्मेदारी एवं भागीदारी सुनिश्चित करना आवश्यक है। इसी परिप्रेक्ष्य में राजभाषा विभाग के निदेशानुसार संस्थान में निम्नलिखित अधिकारियों को हिंदी कार्यान्वयन के लिए जांच बिंदु (उत्तरदायी अधिकारी) के रूप में नियत किया जाता है।

To accelerate the implementation of Official Language and to achieve the goal decided by the Hon'ble Parliamentary Committee on Official Language, it is necessary to ensure the responsibility and participation of all the officers of this Institute. In view of the above and as per directions of Department of Offical Language the following officers are nominated as check points (Responsible Officer) for Hindi Implementation in the Institute:

क्र.सं.	[illegible]	उत्तरदायी अधिकारी
1	Correspondence in Hindi	Officer who signs the letter
2	Address in Hindi on envelope of letters	Section Officer(Gen.)
3	Document under section 3(3) (Bilingual)	AO/ Concerned Officer who issue the document
4	Purchase of Computer/ Equipments (Bilingual)	Store and Purchase Officer
5	Printing of Forms/Registers/Stationary etc.	Section Officer(Gen.)/ Concerned Officer
6	Entries in Registers	HOD/ Section Officer
7	Stamp/Seal/Visiting Cards etc. (Bilingual)	Section Officer(Gen.)/ Concerned Officer
8	Purchase of Hindi books	Library Officer
9	Publication of Institute (Bilingual)	Library Officer/ Concerned Officer
10	Sign Boards/ Name Plates (Bilingual)	Civil Engineer/ Concerned Officer
11	Invitation Card/ Banner of Functions (Bilingual)	Convener of the Function
12	Agenda/Proceedings of meetings	Convener of the Meeting
13	All Advertisements/ Tender Notices (Bilingual)	Admn. Officer/Civil Engineer/ Concerned Officer
14	Press Release (Bilingual)	Concerned Officer
15	Information updation on Website of the Institute	पीएमई PPME

सभी संबंधित अधिकारीगण कृपया उपर्युक्त दस्तावेजों/ कागजात/ मदों को नियमानुसार द्विभाषी/ हिंदी में जारी करें तथा अपने राजभाषा संबन्धी दायित्वों का अनुपालन कर सहयोग करें।

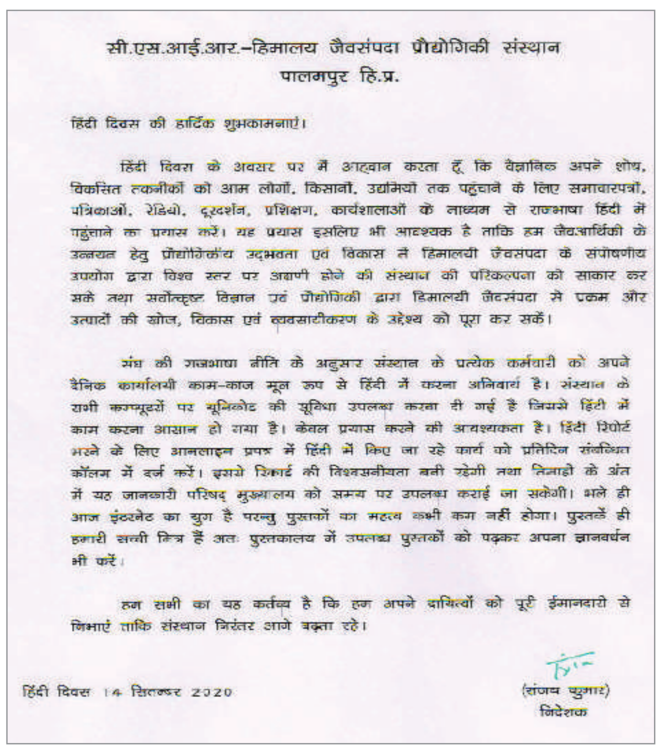
All the concerned officers please issue the above said documents/papers items bilingually/Hindi as per rule and adhere to their responsibilities related to Official Language and co-operate.

08.9.20

(संजय कुमार Sanjay Kumar)
निदेशक Director

प्रतिलिपि सभी संबंधित

निदेशक की ओर से कार्यालय आदेश



सी.एस.आई.आर.–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
पालमपुर हि.प्र.

हिंदी दिवस की हार्दिक शुभकामनाएं।

हिंदी दिवस के अवसर पर मैं आह्वान करता हूं कि वैज्ञानिक अपने शोध, विकसित तकनीकों को आम लोगों, किसानों, उद्यमियों तक पहुंचाने के लिए समाचारपत्रों, पत्रिकाओं, रेडियो, दूरदर्शन, प्रशिक्षण, कार्यशालाओं के माध्यम से राजभाषा हिंदी में पहुंचाने का प्रयास करें। यह प्रयास इसलिए भी आवश्यक है ताकि हम जैवआर्थिकी के उन्नयन हेतु प्रौद्योगिकीय उद्भवता एवं विकास में हिमालयी जैवसंपदा के संपोषणीय उपयोग द्वारा विश्व स्तर पर अग्रणी होने की संस्थान की परिकल्पना को साकार कर सके तथा सर्वोत्कृष्ट विज्ञान एवं प्रौद्योगिकी द्वारा हिमालयी जैवसंपदा से प्रक्रम और उत्पादों की खोज, विकास एवं व्यवसायीकरण के उद्देश्य को पूरा कर सकें।

संघ की राजभाषा नीति के अनुसार संस्थान के प्रत्येक कर्मचारी को अपने दैनिक कार्यालयी काम–काज मूल रूप से हिंदी में करना अनिवार्य है। संस्थान के सभी कम्प्यूटरों पर यूनिकोड की सुविधा उपलब्ध करवा दी गई है जिससे हिंदी में काम करना आसान हो गया है। केवल प्रयास करने की आवश्यकता है। हिंदी रिपोर्ट भरने के लिए आनलाइन प्रपत्र में हिंदी में किए जा रहे कार्य को प्रतिदिन संबन्धित कॉलम में दर्ज करें। इससे रिकार्ड की विश्वसनीयता बनी रहेगी तथा तिमाही के अंत में यह जानकारी परिषद् मुख्यालय को समय पर उपलब्ध कराई जा सकेगी। भले ही आज इंटरनेट का युग है परन्तु पुस्तकों का महत्व कभी कम नहीं होगा। पुस्तकें ही हमारी सच्ची मित्र हैं अतः पुस्तकालय में उपलब्ध पुस्तकों को पढ़कर अपना ज्ञानवर्धन भी करें।

हम सभी का यह कर्तव्य है कि हम अपने दायित्वों को पूरी ईमानदारी से निभाएं ताकि संस्थान निरंतर आगे बढ़ता रहे।

हिंदी दिवस 14 सितम्बर 2020

(संजय कुमार)
निदेशक

हिंदी दिवस पर निदेशक महोदय का संदेश

CSIR SKILL DEVELOPMENT PROGRAMS - JIGYASA - INCUBATION CENTRE - AcSIR - IMPORTANT EVENTS

JIGYASA PROGRAM AT CSIR-IHBT, PALAMPUR

CSIR-Institute of Himalayan Bioresource Technology organized various activities under the Jigyasa programme. It 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, different online activities were conducted under this programme to motivate students towards science.

This year, a total of 9238 participants participated in JIGYASA programme in different activities:

Activities	Speaker Name & Designation	Organized on	YouTube Channel Link	No. of participants
Webinar: Bioprospecting biodiversity of Himalayas	Dr. Sanjay Kumar, Director, CSIR-IHBT	08-06-2020	https://www.youtube.com/watch?v=rvLQ9KsrXls	6,586 YouTube views
Curtain Raiser Ceremony of the 6th IISF 2020-Welcome Address and Opening Remarks	Dr. Sanjay Kumar, Director, CSIR-IHBT	26-11-2020	https://www.youtube.com/watch?v=Wos8NI705Vc&t=5678s	398 (300+ Participants on Microsoft Teams and 98+ YouTube views)
"Science and Technology for Empowering the Rural Sector"	Dr. Anil Prakash Joshi, Founder, Himalayan Environmental Studies and Conservation Organization (HESCO) Dehradun, UK, India			
Presidential Address	Dr. Shekhar C Mande, Secretary DSIR & DG CSIR			
Role of Science and Technology in Healthcare	Dr. Anil Koul, Vice President & Head, Global Public Health & Infectious Discovery Research, Johnson and Johnson, Belgium			
Address and introduction about Vijnana Bharati	Dr. Ashwani Rana, President, Vijnana Bharati, Himachal Pradesh Chapter And Associate Professor, NIT Hamirpur, HP			
Vigyan Yatra' as a part of the 6th India International Science Festival (IISF 2020)-Welcome Address and Opening Remarks	Dr. Sanjay Kumar, Director, CSIR-IHBT	05-12-2020	https://www.youtube.com/watch?v=Giepe3YrJuo&t=804s	1547 (300+ Participants on Microsoft Teams and 1247 YouTube views)
India's contribution in Science and Technology	Prof. Shashi Kumar Dhiman, Former VC, HPTU, Hamirpur, and Professor, HPU, Shimla, HP			
Introduction of the progamme	Dr. Ashwani Rana, Associate Professor, NIT Hamirpur and President, Vijnana Bharati, HP Chapter			
National Science Day Celebrations-"Fog Computing and Challenges"	Prof. Lalit K. Awasthi, Director, Dr. B.R. Ambedkar NIT Jalandhar	28-02-2021	https://www.youtube.com/watch?v=QrI3rDMu4fk&t=3200s	707 (300+ Participants on Microsoft Teams and 407 YouTube views)
			Grand Total	**9238**

*** Details of these activities are uploaded on JIGYASA website: http://csirjigyasa.niscair.res.in/**

Online activities conducted under JIGYASA Programme

Under JIGYASA programme, a five days' exposure cum hands on training was imparted to 12th standard student of Step by Step School, Noida in the field of Functional/ Applied Genomics by CSIR-IHBT scientist, Dr. Gaurav Zinta.

New Initiatives-CSIR Virtual Laboratory of JIGYASA

Jigyasa-Virtual Laboratory

CSIR-IHBT has initiated production of videos under "Pilot implementation of CSIR-Virtual Laboratory (for school students) on the following topics disseminate R&D activities of CSIR-IHBT to school students and their teachers through online mode:

- Conservation and mass propagation of rare endangered and threatened (RETs) plants
- Enzymes from microbial world
- Mapping and exploring rich Himalayan biodiversity using remote sensing and other techniques
- Soil-less cultivation to boost farmer's income
- All about natural products: Isolation, identification, characterizations and bio prospection
- These videos will be uploaded on the NET, by using virtual platform of IIT Bombay.

CSIR-IHBT has selected and is adopting 10 Atal Tinkering Lab Schools (ATLs) of H.P. with NITI Aayog.

ATL Schools selected for adoption by CSIR-IHBT, Palampur

S. No.	ATL CODE	School and Address
1	b598777	Kendriya Vidyalaya, Dharamshala Cantt Distt. Kangra (HP) 176216
2	31103065	Kendriya Vidyalaya, Palampur Holta Camp Tehsil Palampur (HP) 176061
3	15653146	Kendriya Vidyalaya, Yol Cantt Tehsil Dharamshala Distt Kangra (HP) 176052
4	14044099	Kendriya Vidyalaya, Bhanala at Gohju Po Basnoor Via Rait Tehsil Shahpur Distt. Kangra (HP)
5	14524431	Kendriya Vidyalaya, Naleti V.P.O.- Naleti Tehsil- Dehra Distt. Kangra (HP)
6	152617262	Government Senior Secondary School, Thural Kangra (HP) 176107
7	265014497	Government Senior Secondary School, Dharampur Gsss Dharampur Po & Teh-Dharampur Mandi (HP)
8	99583358	Government Senior Secondary School, Bir VPO Bir, Tehsil Baijnath, Distt. Kangra, (HP) 176077
9	118810885	Govt Sr Sec School, Garsa VPO Garsa Tehsil Bhunter Distt Kullu (HP) 175141
10	22252670	Government Senior Secondary School, Matroo Village & Post Office-Matroo Tehsil-Joginder Nagar, District-Mandi (HP)

A new project has been sanctioned by CSIR for the year (2021-22) for preparation of different educational materials (Quiz, Games, Webinars, Videos, State Level Competitions, Lab visits, Outreach activities) for school students

Under New Education Policy CSIR-IHBT is in the process of signing an MoU with JNV Paprola for Skill program.

SKILL DEVELOPMENT ACTIVITIES

Keeping in view the Covid-19 pandemic situation, first batch of Quality Control Biologist (15 No.) and Lab Technician/ Assistant (10 No.) was selected for three months' online courses under Skill Vigyan programme sponsored by DBT-HIMCOSTE. Some training activities were conducted under CSIR-Integrated Skill Initiative programme.

Summer and winter trainings at CSIR-IHBT

Institute is providing trainings to Graduate/ Post Graduate/ Ph.D. students from different Institutes, Universities and affiliated colleges. Following guidelines in order to combat Covid-19 pandemic, this year 38 students were selected for training at CSIR-IHBT for different time durations *viz.* one month, three months, six months and one year. Out of these, 19 students completed the training and 19 are ongoing.

Details of trainings provided to Graduate/ Post Graduate/ Ph.D. students (April, 2020-March, 2021)

S. No.	Trainee	Affiliation	Class/ Course	Duration (months)	Supervisor	Title
1	Mr. Navneet Thakur	Chandigarh College of Pharmacy, Landran, PB	M.Pharma	12	Dr. Vikram Patial	To study the effect of IHBT-VP against non-alcoholic fatty liver disease in the zebrafish model
2	Mr. Shiv Kumar Saini	Chandigarh College of Pharmacy, Landran, PB	M.Pharma	12	Dr. Damanpreet Singh	IHBT-PT-01 prevents neuronal damage via modulation of oxidative stress and inflammatory pathways in a Zebrafish model of hemorrhagic stroke
3	Mr. Aashish Sharma	Chandigarh College of Pharmacy, Landran, PB	M.Pharma	12	Dr. Dinesh Kumar	Development and evaluation of dithranol incorporated nanocrystals based topical cream for the treatment of psoriasis
4	Mr. Rohit Sharma	Chandigarh College of Pharmacy, Landran, PB	M.Pharma	6	Dr. Dinesh Kumar	Extraction and sample preparation for analytical techniques
5	Ms. Jasmeet Kaur	Amity University, Noida, UP	B.Sc. Biotechnology	1	Dr. Dharam Singh	Hands on basic techniques in molecular microbiology
6	Ms. Dipankshi Patel	Jaipur National University, RJ	B.Tech Biotechnology	6	Dr. Rohit Joshi	Comparative analysis of micropropagation, physiochemical properties, anatomical structure and transcript abundance of five bamboo species

S. No.	Trainee	Affiliation	Class/ Course	Duration (months)	Supervisor	Title
7	Mr. Gurbir Singh	Lovely Professional University, Phagwara, Punjab	B.Tech Biotechnology	6	Dr. Vipin Hallan	Basic techniques in plant molecular biology
8	Mr. Sagar Gupta	University of Allahabad, Prayagraj, UP	M.Sc. Bioinformatics	6	Dr. Ravi Shankar	Detection of long non-coding RNAs through machine learning by implementing xgboost algorithm
9	Mr. Pradyumna K	Bharathidasan University Tiruchirappalli, Tamil Nadu	M.Tech. Gioinformatics	6	Dr. Amit Kumar	Study on landscape phenology *of Pinus roxburghii* forests in relation to topography, climate, and forest fire in the western Himalaya
10	Ms. Printy I C	Bharathidasan University Tiruchirappalli, Tamil Nadu	M.Tech. Gioinformatics	6	Dr. Amit Kumar	Comparative assessment of terrestrial LiDAR and UAV mounted multispectral sensor through retrieving tree structural parameters of *Ginkgo biloba*
11	Ms. Kanchan Devi	DAV University, Jalandhar, PB	M.Sc. Botany	6	Dr. Amit Chawla	Ecological techniques for assessing bioresources
12	Ms. Savita Lohar	Balkavi Bairagi Mahavidyalaya, MP	M.Sc. Biotechnology	6	Dr. Vipin Hallan	Cloning of 2b (CMV) Protein gene in pGEM®-T Easy Vector and study the survivability of 2b transcript in white fly (*Trialeurodes vaporariorum*)
13	Mr. Sidharth	Balkavi Bairagi Mahavidyalaya, MP	M.Sc. Biotechnology	6	Dr. Kunal Singh	PCR amplification, cloning and transformation of *StTNL41857* in Agrobacterium GV3101
14	Ms. Heena Choudhary	Balkavi Bairagi Mahavidyalaya, MP	M.Sc. Biotechnology	6	Dr. Dharam Singh	Identification and molecular characterization of pigments producing bacteria from high altitude regions of Himalaya

S. No.	Trainee	Affiliation	Class/ Course	Duration (months)	Supervisor	Title
15	Mr. Shivam Sahu	Jiwaji University, Gwalior, MP	M.Sc. Biotechnology	6	Dr. Vipin Hallan	Estimate of inorganic phosphate content and their relationship in two genotypes of rose
16	Mr. Deepak Kumar Sharma	JIIT, Noida, UP	B.Tech+ M.Tech Biotechnology	6	Dr. Vidyashankar Srivatsan	Utilization of commercially important microalgae for production of edible proteins
17	Ms. Shiwani Randhawa	GNDU, Amritsar, PB	M.Sc. Human Genetics	1	Dr. Yogendra Padwad	Introduction to experimental animals and techniques in Animal Cell Culture
18	Ms. Sharda Negi	SDSUTG, Dehradun, UK	M.Sc. Food Technology	3	Dr. Vidyashankar Srivatsan	Basic techniques in molecular biology
19	Mr. Arpit Mahajan	CSKHPKV, Palampur, HP	B.Tech Food Technology	6	Dr. Mahesh Gupta	Nutritional analysis of prepared canned food items

Under CSIR-Integrated Skill Initiative programme, Dr. Monika Sharma, Assistant Professor in the School of Veterinary Sciences, Abhilashi University, Chailchowk, Distt. Mandi, HP has undergone 10 days' skill development training on the topic "Handling, breeding and maintenance of laboratory animals" under the supervision of CSIR-IHBT Scientist, Dr. Vikram Patial.

INCUBATION CENTRE AT CSIR-IHBT

The Common Research and Technology Development Hubs (CRTDHs) have been established by the Department of Scientific and Industrial Research (DSIR) with an objective to foster industry-institution interaction and address the above problems faced in translational research by the MSEs. The incubation centre has been set up in the area of 'Affordable Health' to carry out quality R&D in frontier areas of healthcare product.

Department of Industry, Himachal Pradesh signed an MoU for implementation of H.P. 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, awareness and up-scaling in the area of food processing, nutraceutical, tissue culture, floriculture, aromatic crops, chemical processing, honey processing, enzymes and biofertilizer development.

Major processing facilities at CSIR-IHBT campus are available for usage by the MSMEs is:

- Canning unit for ready-to-eat food products
- Crispy fruit making pilot scale unit
- Distillation of essential oils from medicinal and aromatic crops
- Extraction of steviosides from stevia
- Extraction of dietary fibers from apple pomace, pomegranate, amla and other fruits.
- Bamboo candies and other value added products from bamboo
- Tea based beverages: Tea concentrates for preparation of soft drinks, tea wines, black and green herbal teas
- Extraction of catechins from tea leaves
- Raising of tissue culture plants for RET MAPs, ornamentals, apple, bamboo, potato, rose, etc
- Soil testing
- Animal testing and preclinical trials
- Pac Bio analysis
- Pesticide residue analysis

Total 43 startups joined CSIR-IHBT, Palampur and 20 startups already completed their tenure and also launching their products. Currently 23 startups are actively working in the area of process development, food processing, tea, tissue culture, aeroponics, floriculture, honey processing, aromatic crops, herbal products and e-marketing under the CM Startup Scheme. CSIR-IHBT has also demonstrated the incubation facilities in various events organized at state and national level for encouraging young potential incubators for new start-ups.

ACADEMY OF SCIENTIFIC AND INNOVATIVE RESEARCH (AcSIR), CSIR-IHBT

The Academy of Scientific and Innovative Research (AcSIR) was established in 2011 (by a resolution of the Government of India on 17th July, 2010) and formalized by an Act of Parliament; that is the Academy of Scientific and Innovative Research Act, 2011 vide The Gazette of India (dated 7th February, 2012) and notified on 3rd April, 2012 as an Institution of National Importance. It has been set up based on a 'Hub and Spoke' model where hub (AcSIR Offices) is responsible for centralized administrative functions. The spokes are located in the 37 laboratories and 6 units of CSIR spread along the length and breadth of India, which act as actual campuses for different subjects or areas.

Since January 2011, under the banner of Academy of Scientific and Innovative Research (AcSIR), CSIR- IHBT has initiated Ph.D. programme in Biological and Chemical Sciences. Table-I contains the details of the courses being taught at CSIR-IHBT.

Table-I Details of AcSIR courses curriculum at CSIR-IHBT

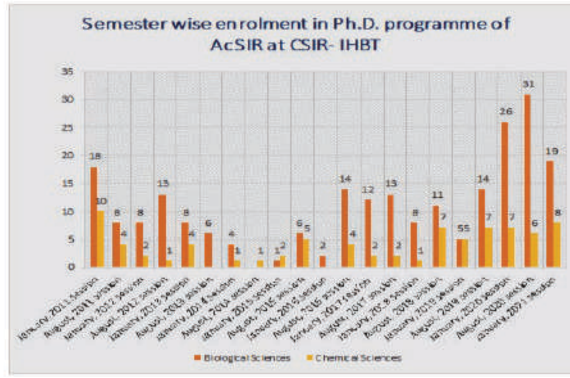
No. of Courses	Course Code	Course Name
1	AcSIR-33-RM	Research Methodology
2	AcSIR-33-RPE	Research Publication and Ethics
3	AcSIR-33-ID-001	Animal models in Biomedical Research
4	AcSIR-33-ID-003	Biology for Chemist
5	AcSIR-33-ID-004	Bioresources and Biodiversity
6	AcSIR-33-ID-006	Computational Biology & Bioinformatics
7	AcSIR-33-ID-007	Nanobiology & Nanobiotechnology
8	AcSIR-33-BS-AD-001	Advances in Crop Production System
9	AcSIR-33-BS-AD-004	Genomics and Epigenetics
10	AcSIR-33-BS-AD-006	Pharmacology and Toxicology
11	AcSIR-33-BS-AD-007	Plant Conservation and Reproductive Biology
12	AcSIR-33-BS-AD-010	Remote Sensing and GIS
13	AcSIR-33-CS-AD-003	Advances in Natural Products
14	AcSIR-33-SP	Societal Program: Problem Understanding and Analysis
15	AcSIR-33-ID-002	Basic Chemistry
16	AcSIR-33-ID-005	Cancer Biology
17	AcSIR-33-ID-008	Nutraceutical & Nutrigenomics
18	AcSIR-33-ID-009	Pathogenesis and applications of plant viruses
19	AcSIR-33-ID-010	Plant Cell & Tissue Engineering
20	AcSIR-33-BS-AD-002	Biology of Infection
21	AcSIR-33-BS-AD-003	Crop Protection & Insect Toxicology
22	AcSIR-33-BS-AD-005	Molecular Breeding of Plants
23	AcSIR-33-BS-AD-008	Plant-Microbe Interaction
24	AcSIR-33-BS-AD-009	Protein Science and Proteomics
25	AcSIR-33-CS-AD-001	Isolation and Spectroscopic Techniques
26	AcSIR-33-CS-AD-002	Advanced Synthetic Organic Chemistry

During the year 2020–21, following key activities were performed at CSIR-IHBT:

- During the lockdown due to the COVID-19 pandemic, academic activities at CSIR-IHBT like interviews, classes, examinations, DAC meetings, Comprehensive Examinations and Viva Voce Examinations were conducted digitally through electronic communication mode.
- AcSIR course work under the faculty of Biological Sciences and Chemical Sciences was restructured as per the guidelines.
- 250 online links were generated and same number of students were interviewed online for PhD admissions during the COVID-19 pandemic out of which 66 students were selected for PhD admissions under AcSIR at CSIR-IHBT.

- More than 100 online links were generated and communicated to the students, guides and DAC members for conducting the DAC meetings during the COVID-19 pandemic.
- More than 30 online links were generated and communicated to the students, guides, DAC members and external examiners for conducting the Comprehensive Examinations during the COVID-19 pandemic.
- More than 1000 links were created for conducting the online classes and examinations during the COVID-19 pandemic.
- In August session, 164 candidates were interviewed through digital communication mode and 37 were selected for PhD enrolment & in January session, 113 candidates were interviewed through digital communication mode and 27 were selected for PhD enrolment under AcSIR.

Till date, 307 students were enrolled for Ph.D. at CSIR-IHBT in the Ph.D. Program in Biological Sciences & Chemical Sciences (Fig. I) and 78 students had successfully defended their thesis during the viva voce examinations.



During 2020-21, 6 students successfully defended their thesis during the Viva Voce Examinations and were awarded doctoral degree as per the following details:

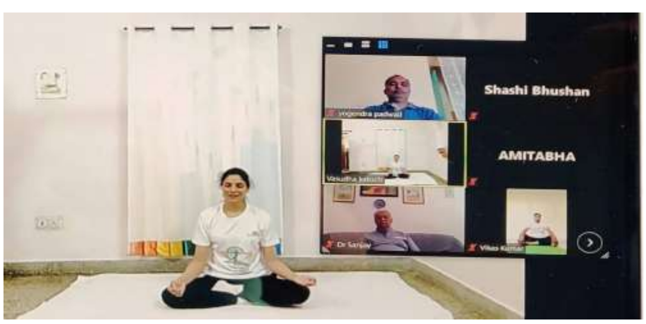
Sr. No.	Name of the Student (Registration #)	Faculty	Supervisor
1	Tanvi Sharma (10BB14J33005)	Biological Sciences	Dr. Sanjay Kumar
2	Meenakshi Thakur (10CC16A33010)	Biological Sciences	Dr. Rakesh Kumar
3	Ruchi Sharma (10BB11J33017)	Biological Sciences	Dr. Gireesh Nadda
4	Anamika Sharma (10BB16A33001)	Biological Sciences	Dr. Y. S. Padwad
5	Anika (10BB15A33006)	Biological Sciences	Dr. Amitabha Acharya
6	Gopal Singh (10BB15A33003)	Biological Sciences	Dr. R. K. Sharma

IMPORTANT EVENTS

National Technology Day Celebrations: CSIR-IHBT, Palampur, and CSIR-CSIO Chandigarh jointly celebrated National Technology Day through video conferencing (MS Team) on May 11, 2020. Scientists, staff, and scholars of both institutes participated in the program. Dr. Sanjay Kumar, Director, CSIR-IHBT, addressed the audience and highlighted the importance of technologies developed by CSIR-IHBT and CSIR-CSIO.

International Tea Day Celebrations at CSIR-IHBT: CSIR-IHBT celebrated International Tea Day through video conferencing (MS Team) on May 21, 2020. Dr. Sanjay Kumar, the Director, delivered International Tea Day lecture on the topic "Importance of tea & tea products for fighting COVID-19 pandemic". Shri D.C. Rana, Member Secretary (EC), HP Council for Science, Technology & Environment, and Director-cum-Special Secretary, HP Secretariat, was the chief Guest. The tea planters, Tea Board officials, entrepreneurs, technology partners, and scientists & staff of the institutes attended the online event.

6th International Yoga Day 2020: 6th International Yoga Day was celebrated through a virtual session at CSIR-IHBT, Palampur, on June 21, 2020. The Director and staff of the institute joined online and performed the yoga asanas with the yoga instructors Ms. Vasudha Katoch and Shri Uday Ji, from Art of Living Centre.



CSIR-IHBT Foundation Day Celebrations: Institute celebrated its 38th Foundation Day on July 2, 2020. Dr. Renu Swarup, Secretary, DBT Govt of India, was the Chief Guest and delivered a lecture on "Driving Bio-economy Growth: Our Strength and Opportunities." Dr. Shekhar C. Mande, DG CSIR and Secretary, DSIR, presided over the function.

Institute released the following publications on 38th Foundation Day

- Annual Report (2019-20)
- Tree Resources at CSIR-IHBT
- Technology Profile (Volume II)
- Medicinal Plants at CSIR-IHBT

Inaugurations of the following facilities were also held

- Vertical Aeroponics
- Prakriti Kunj

38th Foundation Week Celebrations: Shri Jai Ram Thakur, Chief Minister of Himachal Pradesh, addressed the Institute staff & guests, as a part of the 38th Foundation Week celebrations of the institute, through MS Teams on July 3, 2020.

Following publications were also released during 38th Foundation Week celebrations:

- Bamboo Resources at CSIR-IHBT
- Tea Germplasm at CSIR-IHBT (Volume-I)
- Technical Brochure - *Heeng*

The Chief Minister of Himachal Pradesh also inaugurated Protein Processing Center and laid the foundation stone of Tissue culture unit and Hi-Tech nursery of bamboo.

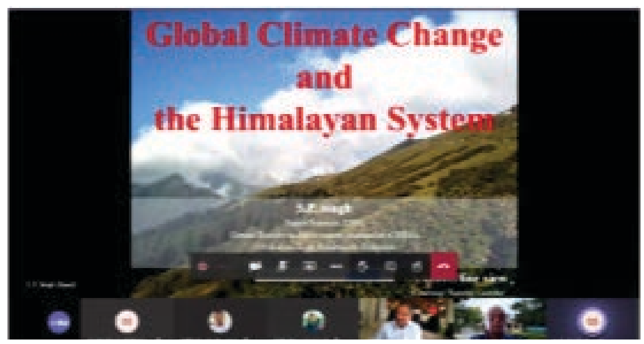
The Hon'ble Governor of Himachal Pradesh, Shri Bandaru Dattatraya, presided over the Valedictory Function of CSIR-IHBT 38th Foundation Week Celebrations through MS Teams and addressed the Institute staff & guests on July 9, 2020.

On this occasion, Prof. S.S. Handa, Former Director, CSIR-IIIM Jammu, delivered the keynote address on “Phytopharmaceutical Drug Development - New Regulations”.

Following publications were released during Valedictory Function of its 38th Foundation Week Celebrations:

- Flower Crop Resources at CSIR-IHBT
- Aromatic Crop Resources at CSIR-IHBT
- Stevia Germplasm at CSIR-IHBT
- Brochure on Monk Fruit

Himalayan Day Celebrations: CSIR-IHBT celebrated Himalayan Day on September 9, 2020 through the MS team. The Chief Guest of the function, Dr. V.B. Mathur, Chairman, National Biodiversity Authority, India, addressed the august gathering on “Himalayan Specific Development and Livelihood Issues in the Himalayas”. On this occasion, Prof. SP Singh, Former VC, HNB Garhwal University, Srinagar (Uttarakhand), delivered the Presidential address on the topic “Global Climate Change and the Himalayan System”. Dr. Sanjay Kumar, Director, CSIR-IHBT, highlighted the activities and technologies of CSIR-IHBT contributing towards conservation and sustainable utilization of Himalayan bioresources.

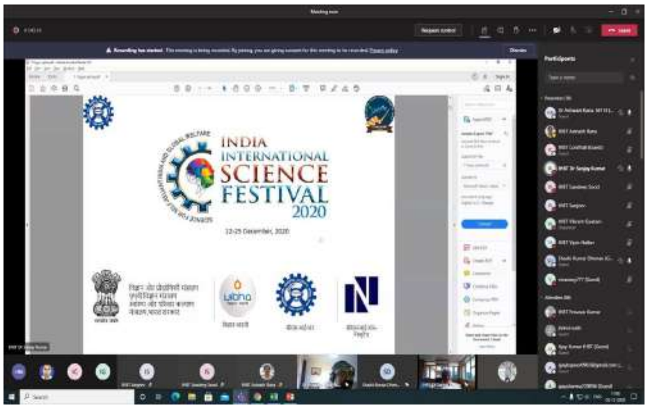


CSIR Foundation Day Celebrations: CSIR-Institute of Himalayan Bioresource Technology (IHBT), Palampur, celebrated the 79th CSIR Foundation Day on September 26, 2020. On the auspicious occasion of CSIR Foundation Day, CSIR-IHBT has launched the ‘Poshan Maitree - Food Supplementation Programme’ in association with ICDS Poshan Abhiyan of the government. ‘Spice Cultivation Programme’ was also launched with the distribution of planting material for the cultivation of *Heeng* in Lahaul & Spiti and Saffron in Chamba, Kullu, and Mandi districts. The foundation day program was graced by Shri Lok Nath Sharma, Hon’ble Minister, Agriculture, Horticulture, Animal Husbandry, IPR & Printing, Government of Sikkim. The Chief Guest of the function, Prof. Anil K Gupta, CSIR Bhatnagar Fellow, and the Founder of Honey Bee Network, SRISTI, GIAN, and NIF delivered the foundation day lecture on “Learning and Leveraging Grassroots Innovations and Traditional Knowledge Systems & Institutions” through MS teams. Dr. Shekhar C Mande, Director General, CSIR and Secretary, Department of Scientific & Industrial Research, Govt. of India, presided over the function.

Visit of Dr. Shekhar C Mande: Dr. Shekhar C Mande, Secretary, DSIR, and Director General, CSIR, visited district Mandi of Himachal Pradesh on November 8, 2020 along with Dr. Sanjay Kumar, Director CSIR-IHBT, and Dr. N K Badhan, Director Agriculture, Government of Himachal Pradesh. Dr. Mande participated in farmers and scientist's interaction meet at Janjehli along with local leaders. Dr. Mande inaugurated *Heeng* and Saffron cultivation in Janjehli, Mandi. *Heeng* and Saffron cultivation was initiated for the first time in district Mandi. Dr. Mande also interacted with newly joined scientists of CSIR-IHBT.

Curtain Raiser Ceremony of 6th India International Science Festival (IISF): CSIR-IHBT organized the Curtain Raiser Ceremony of the 6th India International Science Festival (IISF) 2020 on November 26, 2020. Dr. Shekhar C. Mande, DG Csir & Secretary DSIR, Government of India, presided over the ceremony and graced the occasion. Dr. Anil Koul, Vice President & Head, Global Public Health & Infectious Discovery Research, Johnson and Johnson, Belgium, delivered a lecture on "Role of Science and Technology in Healthcare". Dr. Anil Prakash Joshi, Founder, Himalayan Environmental Studies and Conservation Organization (HESCO), Dehradun addressed "Science and Technology for Empowering the Rural Sector". Dr. Ashwani Rana, President, Vijnana Bharati, Himachal Pradesh Chapter & Associate Professor, National Institute of Technology, Hamirpur (HP) shared the vision and goals of Vijnana Bharati.

Vigyan Yatra of 6th India International Science Festival (IISF): CSIR IHBT organized 'Vigyan Yatra' as a part of the 6th India International Science Festival (IISF) 2020 on December 5 2020. On this occasion, Prof. Shashi K Dhiman, Organizing Secretary, Vijnana Bharati, HP Prant, Founder VC, Himachal Pradesh Technical University, Hamirpur & Professor, Himachal Pradesh University, Shimla, HP delivered the Keynote address on "India's contribution in Science and Technology". Scientists, Research Scholars, Entrepreneurs, Farmers, and Students from many schools & colleges across HP participated in this event.



National Science Day Celebrations: CSIR-Institute of Himalayan Bioresource Technology, Palampur, celebrated National Science Day on February 28, 2021. The Chief Guest of the day, Prof. Lalit Kumar Awasthi, Director, Dr. B.R. Ambedkar National Institute of Technology, Jalandhar, delivered his lecture on 'Fog Computing and Challenges'. Professor Chandra Shakher, Honorary Professor, Indian Institute of Technology, New Delhi, graced MS Teams' function.

Visit of Shri Anurag Singh Thakur: Shri Anurag Singh Thakur, Hon'ble Minister of State for Finance and Corporate Affairs, Government of India, visited CSIR- Institute of Himalayan Bioresource Technology, Palampur on March 1, 2021. Dr. Sanjay Kumar, Director, CSIR-IHBT, welcomed the honorable minister and apprised him about the research and development activities of the institute.

In the presence of the Honorable Minister, the institute signed MoUs with #NIT Jalandhar (Punjab) and Hamirpur (H.P.) for mutual cooperation on academic and research. Four agreements were also signed with entrepreneurs for technology transfer & product development in different areas. During the visit, Sh. Anurag Thakur also interacted with students, startups, incubatees, and entrepreneurs. He also distributed the wild marigold seeds and the planting material of Gladiolus and Alstroemeria to the farmers. Brochures on 'Tulip Agro-techniques' and 'Saffron Agro-techniques in Non-Traditional Areas' were also released by the Honorable Minister. Sh. Anurag Thakur also laid the foundation stone for constructing new houses on the campus and planting a tree.

International Women's Day: CSIR-IHBT celebrated International Women's Day on March 8, 2021. On this occasion, Dr. D. K. Aswal, Director, CSIR-National Physical Laboratory, New Delhi, delivered a talk on "Leadership for Institution Building: Story of National Physical laboratory".

Visit of Sh. Virender Kanwar: Sh. Virender Kanwar, Honorable Minister of Rural Development, and Panchayati Raj visited the CSIR- Institute of Himalayan Bioresource Technology, Palampur, on March 30, 2021. On this occasion, the honorable minister gets informed about the research activities and technologies of the institute.

Er. Sonam Wangchuk, Director Himalayan Institute of Alternatives Ladakh, with his team member, EXIN IPH Keylong, Pardhan gram Panchayat Tandi visited CeHAB, regarding issues for the solution of water problems and necessary R&D collaboration issues in the area, on October 2020.

STUDENT SEMINAR SERIES

STUDENT SEMINAR SERIES 2020

The Student Seminar Series (SSS) is a scientific programme organized by the students of the Institute wherein they share their research to foster collaboration and enhance communication. The SSS started in the year 2017 and the day 5th September was purposefully chosen to honour the mentors (Teachers' Day).

The fourth edition of the SSS was held on 5th September 2020 via MS Teams on the theme *"COVID 19: A Cancel Culture or a Window of Opportunities".* In addition to the students from the CSIR-IHBT; students from IIT, Ropar; IIT, Mandi; Panjab University, Chandigarh; and Shoolini University, Solan presented their work in the seminar series. Altogether, a total of 20 presentations were made that includes 05 invited talks.The programme was presided over by Dr. SC Mande, Director General CSIR & Secretary DSIR while Prof. RK Kohli, former VC Central University, Punjab delivered the key note address. A photography competition was also held on this day wherein 20 entries were received.

PATENTS/PUBLICATIONS

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3. Das P, Chauhan AS and Kumar A (2021) Metal catalyst and hydrogen gas free approaches for selective reduction of aldehyde to methyl group of different substituted furans. (Patent Application No. NFNO. 0143NF2019/WO. Application No. PCT/IN2021/050157, Filed on 19-February-2021)
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12. Sharma R, Gupta M, Kumari M, Gulati A and Padwad YS (2021) Synbiotic composition for improving immune response and antioxidant capacity during aging. (Patent Application No. NFNO. 0072NF2018/US, Application No. 17/260052, Filed on 13-January-2021, NFNO. 0072NF2018/GB, Application No. 2101006.1, Filed on 26-January-2021)
13. Das P, Chauhan AS, Kumar A (2020) Metal free approaches for selective reduction of aldehyde to methyl group of different substituted furans. (Patent Application No. IN202011007068 2019, Filed on 19-February-2020)

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22. Singh R, Joshi R, Munaiz E, Kumar S and Kumar A (2021) Application of metabolomics to food systems. In: Foodomics: Omic Strategies and Applications in Food Science. (Ed. J. Barros-Velazquez, Royal Society of Chemistry, London, UK) p. 416-442.
23. Singh S and Kumar A (2020) Tea Germplasm at CSIR-IHBT Vol-1. CSIR-IHBT, Palampur, July 03.
24. Suresh PS, Bhatt V, Singh PP, and U Sharma (2021) Steroidal sapogenins from genus trillium: chemistry, synthesis, and opportunities in neuro-active steroids designing. In: Studies in Natural Product Chemistry (Elsevier), Vol. 68, Chapter 3, pp 67-95. doi.org/10.1016/B978-0-12-819485-0.00004-9.
25. Verma A, Chawla A, Singh CP and Kumar A (2020) Long term monitoring of the alpine plant communities of western Himalaya for assessing the impact of changing climate, 33, Remote Sensing for Environment Monitoring & Climate Change Assessment: Opportunities and Challenges, Annual Conventions of Indian Society of Remote Sensing (ISRS) & Indian Society of Geomatics (ISG), 33.
26. Verma M, Shukla AK and Acharya A (2020) Lectin nanoconjugates for targeted therapeutic applications. In: Nanomaterial - based biomedical applications in molecular imaging, diagnostics and therapy. (Ed. Acharya A, Springer Nature, Singapore,) p. 103-127.
27. Walia S, Sharma C and Acharya A (2020) Biocompatible fluorescent nanomaterials for molecular imaging applications. In: Nanomaterial - based biomedical applications in molecular imaging, diagnostics and therapy. (Ed. Acharya A, Springer Nature, Singapore) p. 27-53.
28. भागर्व भव्य, कुमारी पूनम , सिंह सनतसुजात एवं कुमार अशोक (2020) व्यावसायिक पुष्प उत्पादन, खंड 1, सी.एस. आई.आर– हिमालय जैवसंपदा प्रौद्योगिकी संस्थान, पालमपुर.
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Technical Brochures/Manual

Ashok Kumar, Sanatsujat Singh and Ramesh Kumar (2020) देश में हींग की खेतीः एक नई पहल (हींग की उत्पादन तकनीक) CSIR-IHBT Publication Released by Hon'ble CM Shri Jai Ram Thakur on 3rd July, 2020 on the occasion of CSIR-IHBT 38th Foundation week Celebrations.

Ashok Kumar, Sanatsujat Singh, Probir Kumar Pal, Rakesh Kumar, Ram Kumar Sharma and Dinesh Kumar (2020) Wild marigold (*Tagetes minuta*) variety: Him Swarnima (CSIR-IHBT-TM-09). CSIR-IHBT Palampur.

Sanatsujat Singh, Ashok Kumar, Probir Kumar Pal, Rakesh Kumar, Ram Kumar Sharma and Dinesh Kumar (2020) Damask rose (*Rosa damascena*) cultivar: Him Basant (CSIR-IHBT-RD-04). CSIR-IHBT Publication.

Sanatsujat Singh, Ashok Kumar, Probir Kumar Pal, Ram Kumar Sharm and Dinesh Kumar (2020) Indian valerian (*Valeriana jatamansi*) variety Him Surbhit (CSIR-IHBT-VJ-05). CSIR-IHBT Palampur.

Ashok Kumar, Sanatsujat Singh, Rakesh Kumar, Ram Kumar Sharma and Dinesh Kumar (2020) Sea wormwood (*Artemisia maritima*) variety Him Devsugandh (CSIR-IHBT-AM-02). CSIR-IHBT Palampur.

Ashok Kumar, Sanatsujat Singh, Probir Kumar Pal, Ram Kumar Sharma and Dinesh Kumar (2020) White dragonhead (*Dracocephalum heterophyllum*) variety Him Sugandh (CSIR-IHBT-DH-04). CSIR-IHBT Palampur.

Ashok Kumar, Sanatsujat Singh, Bhavya Bhargav and Ram Kumar Sharma (2020) Chrysanthemum cultivars: Him Aditya, Him Ujjwala, Him Shringar, Him Pushkar and Him Shikhar. CSIR-IHBT Palampur.

Ashok Kumar, Sanatsujat Singh, Probir Kumar Pal, Rakesh Kumar, Ram Kumar Sharma and Dinesh Kumar (2020) जंगली गेंदा (*Tagetes minuta*) की किस्मः हिम स्वर्णिमा (CSIR-IHBT-TM-09). CSIR-IHBT Palampur.

Sanatsujat Singh, Ashok Kumar, Probir Kumar Pal, Rakesh Kumar, Ram Kumar Sharma and Dinesh Kumar (2020) दमस्क गुलाब (*Rosa damascena*) की किस्मः हिम बसंत (CSIR-IHBT-RD-04). CSIR-IHBT Palampur.

Sanatsujat Singh, Ashok Kumar, Probir Kumar Pal, Ram Kumar Sharma and Dinesh Kumar (2020) भारतीय वेलेरियन *(Valeriana jatamansi*) की किस्मः हिम सुरभित (CSIR-IHBT-VJ-05). CSIR-IHBT Palampur.

Ashok Kumar, Sanatsujat Singh, Rakesh Kumar, Ram Kumar Sharma and Dinesh Kumar (2020) सी वर्म वूड *(Artemisia maritima*) की किस्मः हिम देवसुगंध (CSIR-IHBT-AM-02). CSIR-IHBT Palampur.

Ashok Kumar, Sanatsujat Singh, Probir Kumar Pal, Ram Kumar Sharma and Dinesh Kumar (2020) सफेद ड्रैगनहैड *(Dracocephalum heterophyllum*) की किस्म हिम देवसुगंध (CSIR-IHBT-DH-04). CSIR-IHBT Palampur.

Ashok Kumar, Sanatsujat Singh, Bhavya Bhargav and Ram Kumar Sharma (2020) गुलदाऊदी की किस्में: हिम आदित्य, हिम पुष्कर, हिम शिखर, हिम उज्जवला, हिम श्रृंगार-CSIR-IHBT Palampur.

Probir Kumar Pal (2020) Agrotechnology of Monk Fruit (*Siraitia grosvenorii*): A Natural Zero-Calorie Sweetener. CSIR-IHBT Palampur.

Rakesh Kumar, Ashok Kumar, Sanatsujat Singh and Ramesh (2020) Training manual for Capacity Building programme of Agriculture Officers, Department of Agriculture, H.P. on "Production Technology of Saffron and *Heeng*, July 20-22.

Registration of Germplasm

Ashok Kumar (2020) Registered four chrysanthemum germplasm "CSIR-IHBT-CH-14-1" of IC0635436, INGR20106, "CSIR-IHBT-CH-14-2" of IC0635437, INGR20107, "CSIR-IHBT-CH-14-4" of IC0635438, INGR20108 and "CSIR-IHBT-CH-14-8" of IC0635439, INGR20109, at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research, December 21.

Ashok Kumar (2020) Registered two *Tagetes minuta* germplasm "CSIR-IHBT-TM-09" (wild marigold) of IC0630603, INGR20103 and "CSIR-IHBT-TM-031" (wild marigold) of IC0630602, INGR20104at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research, December 21.

Ashok Kumar (2020) Registered two Gerbera germplasm "CSIR-IHBT-Gr-11-6" of IC0630601, INGR20100 and "CSIR-IHBT-Gr-Y-1" of IC0630600, INGR20101 at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research, December 21.

Ashok Kumar (2020) Registered one *Stevia rebaudiana* germplasm "CSIR-IHBT-ST-03" (tetraploid) of IC0635703, INGR20095 at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research, December 21.

Ashok Kumar (2020) Registered one *Valeriana jatamansi* germplasm "CSIR-IHBT-VJ-05" (Indian valerian / Tagar) of IC0630604, INGR20096 at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research, December 21.

Ashok Kumar (2020) Registered one Damask rose germplasm "CSIR-IHBT-RD-04" of IC0635435, INGR20105 at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research, December 21.

Ashok Kumar (2020) Registered one Gerbera germplasm "CSIR-IHBTGr-29-1" of IC0630599, INGR20064at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research, September 29.

Ashok Kumar (2020) Registered one *Valeriana jatamansi* germplasm "CSIR-IHBT-VJ-08" (Indian valerian) of IC0630605, INGR20057at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research on, September 29.

Ashok Kumar (2020) Registered one *Artemisia maritima* germplasm "CSIR-IHBT-AM-02" (Seaworm wood) ofIC0635705, INGR20060 at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research, September 29.

Ashok Kumar (2020) Registered one *Dracocephalum heterophyllum* germplasm "CSIR-IHBT-DH-04" (white dragon head) of IC0635704, INGR20059 at National Bureau of Plant Genetic Resources (NBPGR) by Plant Germplasm Registration Committee (PGRC) of Indian Council of Agricultural Research , September 29.

Thesis/Dissertations

Ph.D

Tanvi Sharma (2021) Development and analysis of draft genome sequence of *Piccrorhiza kurrooa* royal exbenth. Academy of Scientific and Innovative Research. Supervised by Dr. Sanjay Kumar.

Meenakshi Thakur (2020) Studies of microclimate modification and pruning time on growth, yield and quality of damask rose (*Rosa damascena* Mill.). Supervised by Dr Rakesh Kumar.

Ms. Ruchi Sharma (2021) "Biology, seasonal incidence and management of cottony camellia scale, *Pulvinaria floccifera* (Westwood) (Hemiptera: Coccidae) in tea". Supervised by Dr Gireesh Nadda.

M.Sc./M.Pharma/B.Sc./B.Pharma/B.Tech.

Simran Katle (2020) Optimization of axillary shoot proliferation and biochemical characterization of giant bamboo, *Dendrocalamus giganteus* Wall. Ex Munro". D.Y. Patil University, Mumbai, (11-11-2019 to 10-07-2020). Supervised by Dr. Rohit Joshi.

Dipaknashi Patel (2020) Comparative analysis of micropropagation, physiochemical properties, anatomical structure and transcript abundance of five bamboo species. Biotechnology, School of Engineering and Technology, Jaipur National University, Jaipur, (11-08-2020 to 23-02-2021). Supervised by Dr. Rohit Joshi.

Des Raj (2020) An experimental & phyto-pharmacognostical study on chirayata (*Swertia purpurascens* wall) to evaluate its hepatoprotective activity, MD (Ayu.), R.G. Govt. P.G. Ayurvedic College & Hospital, Paprola, Dist. Kangra (H.P.), Co-supervised by Dr. Vikram Patial.

Ashwani Kumar (2020) Clinical and experimental study of hepatoprotective properties of apamarg yog with management of kamla w.s.r. to deha prakriti nidan, MD (Ayu.) thesis, R.G. Govt. P.G. Ayurvedic College & Hospital, Paprola, Dist. Kangra (H.P.), Co-supervised by Dr. Vikram Patial.

Navneet Sharma (2020) To study the effect of IHBT-VP against non-alcoholic fatty liver disease in the zebrafish model, M Pharm thesis, Chandigarh College of Pharmacy, Landran, Supervised by Dr. Vikram Patial.

Membership of Professional Bodies/ Organizations

Dr. Vijai Kant Agnihotri Member of Course Coordination Committee AcSIR-IHBT Chemical Sciences.

Dr. Vijai Kant Agnihotri Member of Bureau of Indian Standard Committee (PCD 18).

Conference/ Training/ Workshop/ Symposium presentations

Kumar R and Kumar A (2020) Organized Capacity Building of Agriculture Officers, Department of Agriculture, HP on Production Technology of Saffron and *Heeng* at CSIR-IHBT Palampur, July 20-22.

Dogra V (2020) Plant-environment interactions: The emerging role of chloroplast. In international virtual seminar on technologies for environmental sustainability and smart agriculture-2020, organized by Jaypee University of Information Technology, Waknaghat, India, September 18.

Hallan V (2020) Delivered the Invited talk under the Theme: Virus vector relationship on Role of whitefly and plant proteins in the transmission of apple scar skin viroid in the International E-Conference on Multidisciplinary approaches for plant disease management in achieving sustainability in agriculture organized by Department of Plant Pathology, College of Horticulture, Bengaluru, University of Horticultural Sciences, Bagalkot, October 6-9.

Kumar R and Sharma M (2020) Organized training program on agro and process technology of wild marigold at Village Parwai, Chowari block, Chamba HP, October 28.

Kumar R, Singh S and Sharma M (2020) Organized training program on agro and process technology of wild marigold at Village Talla, Shiunta, Chamba, HP, November 07.

Kumar R (2020) Organized training on cultivation of saffron at Janjehli, Mandi, HP, November 08.

Dogra V, Gosh D, Sharma T, Kim C (2020) Plant-environment interactions: Altered chloroplast homeostasis induces stress responses via retrograde signaling in *Arabidopsis thaliana. In* Prospects of Plant Physiology for Climate Proofing Agriculture, International Plant Physiology Virtual Conference-2020, organized by Indian Society of Plant Physiology, New Delhi, India, December 07.

Kumar R and Pal PK (2020) Organized one day training programme on agrotechnologies of aromatic plants to the farmers of Dharampur and Ladhbhadol of Mandi, HP, December 23.

Pal PK (2020) India International Science Festival (IISF) 2020: Speaker on natural sweetener, December 22-25.

Kumar R, Singh S, Reddy SGE, Sharma M and Bhargav B (2021) Organized One day workshop on Agriculture Diversification Through CSIR-IHBT Technologies, at Chamba, HP February 23.

Kumar R and Bhargav B (2021) Organized one day workshop on Crop diversification in HP through cultivation of aromatic and floriculture crops at CSIR-IHBT Palampur, March 01.

Kumar R (2021) Organized training training cum awareness program on agro and process technology of aromatic plants at Namhol, Bilaspur, HP, March 23.

Kumar R (2021) Organized training cum awareness program on agro and process technology of aromatic plants at Chirgaon, Shimla, HP, March 24.

Conference/ Training/ Workshop/ Meeting attended

Kumar A (2020) Attended training programme on Flow-cytometry in flow-cytometry solutions Pvt. Ltd. Jaipur from May 6-9.

Kumari P (2020) Participated in the National Webinar on Harnessing the Potential of Indigenous Ornamentals: Post COVID19 Pandemic. Organized jointly by Horticultural Science Division, ICAR-New Delhi and ICAR-Directorate of Floricultural Research, Pune, Maharashtra, June 18.

Kumari P (2020) Attended the International Webinar on 'Achieving Land Degradation Neutrality". Organized by Indian Association of Soil and Water Conservation, Dehradun in collaboration with ICAR- Indian Institute of Soil and water Conservation, Indian Council of Forestry Research and Education, Dehradun, July 22-24.

Patial, V (2020) International e-Conference on "Paradigm shift in Animal Disease Diagnostics: Veracious path in Disease prevention and Control" organized by VCRI, Tirunelveli, October 07-09.

Patial, V (2020) National Webinar on Advancements in Veterinary Diagnostics-A Journey in Veterinary Pathology conducted by RJUVAS, Bikaner and IAVP, October 14.

Kumar R (2020) Attended third Inter Ministerial Committee meeting for medicinal and aromatic plants (MAPs) for NER, October 23.

Agnihotri VK (2020) Delivered a lecture in webinar series stage-2 entitled An important treasure of North-Western Himalayas Organized by Department of chemistry, University of Kashmir, Hazratbal, Srinagar-190006, India, November 2020.

Devi J and Bhushan S (2020) *Arnebia euchroma* leaf induced *in vitro* adventitious roots: an alternate source of naphthoquinones. In: The 1st International Electronic Conference on Plant Science, Switzerland. December 01-15.

Agnihotri VK (2020) Attended the meeting of key stakeholders on Aatmanirbhar India with Indian Standards and Regulations for Fragrances & Flavours, at virtual platform. The meeting was addressed by Hn'ble minister Nitin Gadkari ji and was chaired by Dr. Ram A Vishwakarma ji. December 26.

Patial, V (2020) Online International Veterinary Pathology Congress 2020- International Symposium on Role on Veterinary Pathology in Controlling Emerging & Re-Emerging Diseases of Livestock & Poultry: One Health Approach organized by Dept. of Veterinary Pathology, Nagpur Veterinary College, MAFSU, Nagpur, December 26-29.

Joshi R (2021) Represented CSIR-IHBT in the meeting with Sri Pradeep Thakur (Chief Conservator of Forests, Dharmshala), Smt. Basu Kaushal (Deputy Conservtor of Forest, H.P.), Sri Sanjeev Kumar (Divisional Forest Officer, Dharmshala), Sri Praveen Kumar (Divisional Forest Officer, Nurpur) and Sri Nitin Patil (Divisional Forest Officer, Palampur), at Forest Department, Dharmshala, for development of project entitled "Establishment of tissue culture facility at Forest Training School Kuther, Distt. Kangra (H.P.) for training and propagation of sandalwood and other medicinal and aromatic plants". January 07.

Patial, V (2021) Training Programme for Nominees of CPCSEA organized by CPCSEA, MFAH&D, New Delhi, January 21-22.

Kumari P (2021) Participated in 37^{th} induction training program for newly recruited scientists conducted by CSIR HRDG at Ghaziabad, February 15-24.

Singh A (2021) Attended a 1-day virtual workshop program on the topic "Forestry Research, Sustainable Forest Management, and Livelihood" organized by ICFRE-HFRI Shimla and sponsored by NABARD Shimla, March 17.

Kumar R (2021) Attended virtual workshop forestry research, sustainable forest management & livelihood and delivered a lecture entitled "Cultivation and conservation of medicinal and aromatic plants". organized by HFRI, Shimla, March 17.

Sud RK (2020-21) Attended monthly meetings of Kangra Valley Tea Planters Association.

Sud RK (2020-21) Attended Annual Review Meeting of Tea Board of India.

Conference/ Training/ Workshop/ Meeting organized

Singh A (2020) Organized traning programme on Production Technology of Saffron and *Hing* by Capacity building of Agriculture Officers, Department of Agriculture, H.P, July 20-22.

Joshi R (2020) Capacity building program of Agriculture Officers on *Heeng* and Saffron held at CSIR-IHBT, Plamapur, July 20-22.

Singh S (2020) On farm training organized on *Heeng* Cultivation was imparted to 79 farmers of Janjehali, Majakhal, Kataru, Ghayan (Mandi), September 07.

Joshi R (2020) One-month tissue culture training to Mr. Ankit Shandil, Vill. Jahri, P.O. Naswal, The. Ghumarwin, Distt, Bilaspur, H.P., September 1-30.

Singh A and Ramesh (2020) On farm training organized on *Heeng* cultivation was imparted to 89 farmers of Kwaring, Keylong, Madgran, Beeling, Lahual & Spiti, October 12-15.

Singh A and Ramesh (2020) On farm training organized on *Heeng* cultivation was imparted to 79 farmers of Janjehali, Majakhal, Kataru, Ghayan, Mandi, November 07-09.

Singh S (2020) On farm training organized on *Heeng* Cultivation was imparted to 34 farmers of Ralli, Moorang (Kinnaur), November 21-22.

Singh A and Ramesh (2020) On farm training organized on *Heeng* cultivation was imparted to 34 farmers of Ralli, Moorang, Kinnaur, November 21-22.

Singh S (2021) On farm training organized on *Heeng* cultivation was imparted to 34 farmers of Kwaring, Jagla, Gondhla, Keylong, Madgran (Lahaul & Spiti), January 22.

Singh A and Ramesh (2021) On farm training organized on *Heeng* cultivation was imparted to 34 farmers of Kwaring, Keylong, Madgran, Beeling, Lahual & Spiti, January 22.

Singh S (2021) On farm training organized on cultivation of aromatic crops was imparted to 17 farmers of Talha, Sinhuta (Chamba), February 08.

Lectures invited/delivered

Dr. Sanjay Kumar (2020) Tech day lecture on Roles of CSIR-CSIO and CSIR-IHBT for combating COVID-19, May 11.

Dr. Sanjay Kumar (2020) Traditional Medicinal Knowledge in Himachal Pradesh: Research Challenges and Opportunities in महर्षि कणाद व्याख्यानमाला, Central University of Himachal Pradesh, June 02.

Dr. Sanjay Kumar (2020) Bio-economy: Challenges and Opportunities for Nations with Rich Biodiversity in World Environment Day, International Student chapter of American Chemical Society at CSIR-CSIO, Chandigarh, June 04-05.

Dr. Sanjay Kumar (2020) "Bioprospecting Biodiversity of Himalayas" JIGYASA, June 8.

Dr. Sanjay Kumar (2020) Chief Guest of BIIS-9 (Biotech Innovation Ignition School-9) Valedictory program organised by Society for Research and Initiatives for Sustainable Technologies and Institutions (SRISTI), Ahmedabad, Gujarat, June 09.

Dr. Sanjay Kumar (2020) Chief Guest of Foundation Day of Clean and Green Environmental Society, Green Villa, Gomti Nagar, Lucknow, July 08.

Dr. Sanjay Kumar (2020) Himalayan Opportunities: What and Where- A role of Science and Technology in Delivery as a Chief Guest in Valedictory Function in On line national workshop on Relevance of Indigenous and Translational Approach in Scientific Research organised by students for holistic development of humanity (shodh), Himachal Pradesh and Himachal Pradesh University, Shimla, July 19.

Dr. Sanjay Kumar (2020) Chief Guest in Valedictory Function in On line national workshop on Relevance of Indigenous and Translational Approach in Scientific Research, organised by students for holistic development of humanity (shodh), Himachal Pradesh and Himachal Pradesh University, Shimla, 19 July.

Dr. Sanjay Kumar (2020) Integrative View on Plant Responses to Global Climate Change: Learnings from Plant Functioning in Himalayas. International Conference (online) on Climate Change Adaptations in Dryland Agriculture in Semi-Arid Areas, July 23.

Dr. Sanjay Kumar (2020) Chemistry and Biology of Medicinal Plants of Himalayas Plenary Lecture in Webinar on Chemistry and Biology of Natural Products organised by CSIR-North East Institute of Science & Technology (CSIR-NEIST), Jorhat (India), July 24.

Dr. Sanjay Kumar (2020) Empowering Rural Masses Through Science & Technology Interventions in International Web Panel Discussion on "Relevance of Gandhian Model of Rural Development in 21st Century: In Context of Developing Economies of India and its Neighboring Nations Organised by H.N.B. Garhwal University in Collaboration with University of Dhaka, Bangladesh and Kathmandu University, Nepal, August 03.

Dr. Upendra Sharma (2020) Traditional knowledge and modern spectroscopic techniques: unique combination for the discovery of bioactive molecules from medicinal plants. E-Conference on Phytopharmaceuticals: Development, Regulatory, IPR & Marketing Challenges School of Pharmaceutical Education and Research, Jamia Hamdard, New Delhi, August 6.

Dr. Rohit Joshi (2020) Speaker of Eminence in the Workshop on Genome Assisted Strategies for Climate Resilient Crops, organized by Department of Biotechnology, AKS University, Satna, September 12-13.

Dr. Rohit Joshi (2020) Keynote speaker in the panel discussion on Climate Change, Risk Resilience and Livelihood Development in Contemporary world, organized by Green Up Club of Department of HSE & Civil Engineering, University of Petroleum and Energy Studies, Dehradun, September 15.

Dr. Sanjay Kumar (2020) Inaugural Address in the CSIR-HRDC Programme on Planning, Monitoring and Evaluation of R&D Projects, November 05.

Dr. Pralay Das (2020) Delivered a lecture on Catalytic approaches for CO/CO_2 fixation reactions using oxalic acid as bench stable C1 surrogate for online webinar entitled *Recent Trends in Experimental & Theoretical Chemistry* organized by National Institute of Technology, Manipur, December 5-10.

Dr Sukhjinder Singh (2020) Delivered a talk on Aatamnirbhar Bharat through Scientific Interventions in a Webinar organized by Press Information Bureau and Regional Outreach Bureau, Chandigarh on IISF 2020: Science and Atmanirbhar Bharat" on December 11.

Dr. Upendra Sharma (2020) Utilizing plant traditional knowledge for the discovery of bioactives. Young Scientist Conference, IISF-2020. Organized by CSIR, December 22-25.

Dr. Upendra Sharma (2021) C-H activation: a sustainable approach for the direct functionalization of quinolines. Virtual International Conference nn Physical Sciences (ICPS – 2021). Jointly organized by Department of Physics, Chemistry and Applied Mathematics & Humanities, SVNIT, February 5-6.

Dr. Pralay Das (2021) Delivered a lecture on catalytic approaches for CO/ CO_2 fixation reactions using oxalic acid as bench stable C1 surrogate for interdisciplinary refresher course entitled Emerging trends at the interface of chemistry & biology organized by UGC, Human Resource Development Centre, University of North Bengal, February 11-24.

Dr. Pralay Das (2021) Delivered a lecture on Lignocellulosic biomass conversion to furan compounds as high value chemicals for interdisciplinary refresher course entitled Emerging trends at the interface of chemistry & biology organized by UGC, Human Resource Development Centre, University of North Bengal , February 11-24.

Dr. Ashok Singh (2021) Delivered a lecture in Hindi topic हिमाचल प्रदेश राज्य के उच्च तुंगता क्षेत्र में पाए जाने वाले संभावित व्यावसायिक जड़ी बूटियों की वहास्थान सरंक्षण व विशिष्ट चिन्हित बीजों द्वारा जीन संग्रह organized by GBPNIHE Himachal Regional Centre, Mohal-Kullu under the NMHS-PMU funded project, venue at Bathad-Banjar Kullu, February 22.

Dr. Ashok Singh (2021) Delivered a lecture on the topic Seabuckthorn (*Hippophae salicifolia* D. Don.): as a potential source of Fuel wood and Small timber for the people of the Cold Desert area of Lahaul-Spiti district in Himachal Pradesh, India" during the workshop meeting *'Creation of Seabuckthorn Value Chain in Trans Himalaya'*, organized by GBPNIHE Himachal Regional Centre, Mohal-Kullu under program of the funded project from NMHS-PMU, March 05.

Dr Sukhjinder Singh (2021) Delivered a lecture on, Technologies available at CSIR-IHBT on Medicinal and Aromatic Plants Sector in an online programme organised by MPCON Limited, Bhopal (sponsored by DST, Govt. of India), March 15.

Dr. Poonam Kumari (2021) Delivered online guest lecture on post harvest handling of cut and loose flowers in GSSS, Jaree Kullu, March 22.

ONLINE TALK

Dr Rohit Joshi (2020) For wider dissemination of bamboo propagation technologies, I participated as speaker in the India International Science Festival 2020", organized by Ministry of Science and Technology, Ministry of Health and Family Welfare, Vijnana Bharti and CSIR on behalf of our institute and presented under "agri-tech sector on different cultivation strategies of bamboo species. December 22-25.

R.K Sharma (2021) Genetic improvement of Kangra tea. invited talk delivered on January 22, 2021 during National Symposium on Genetic Improvement of Tea through virtual webinar organized by National Tea Research Foundation, Tea Board, Kolkata & NIPB, New Delhi on January 22, 2021.

Dr. Sanjay Kumar (2021) Discussion on Floriculture Mission on DD National, March 05.

Dr. Sanjay Kumar (2021) Eureka on Rajya Sabha TV telecasted (https://youtu.be/L0ikjtTkHnU), March 06.

Dr. Sanjay Kumar (2020) Lecture on "Climate Change" in the progamme "Badte Kadam" telecasted by Shimla Doordarshan, (HP), July 02.

Dr. Sukhjinder singh (2020) Virtual interaction with farmers related to success stories of "Wild marigold" Chamba, December 23 (https://youtu.be/LVE6qaKtfYI).

Dr. Sukhjinder singh (2020) Virtual interaction with farmers related to success stories of "Stevia farming" Chamba, December 23 (https://youtu.be/2O3A6NR2zc0).

Abstracts presented

Patial M, Devi K, Pal PK, Kumar S and Joshi R (2021) An efficient en masse shoot production of female Siraitia grosvenorii. 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.

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.

Katle SS, Kumari A and Joshi R (2020) Studies on optimization of axillary shoot proliferation and control of oxidative browning in in vitro cultures of Dendrocalamus giganteus Wall ex. Munro. International Plant Physiology Virtual Conference-2020. Sher-e-Kashmir University of Agricultural Sciences and Technology, Jammu, December 06-07.

Katoch S and Patial V (2020) Fructose induces steatohepatitis in zebrafish through modulation of PPAY/mTOR signalling. Online International Veterinary Pathology Congress-2020, organised by Dept. of Veterinary Pathology, Nagpur Veterinary College, MAFSU, Nagpur, December 26-29.

Patial V (2020) Zebrafish as a promising tool for liver disease research. Online International Veterinary Pathology Congress-2020, organised by Dept. of Veterinary Pathology, Nagpur Veterinary College, MAFSU, Nagpur, December 26-29.

Kumar A, Asrani RK, Kumar R, Patial V, Patil RD, Kumar A and Gupta VK (2020) Effects of root extract of Saussurea lappa on chemical-induced liver damage in rats. Online International Veterinary Pathology Congress-2020, organised by Dept. of Veterinary Pathology, Nagpur Veterinary College, MAFSU, Nagpur December 26-29.

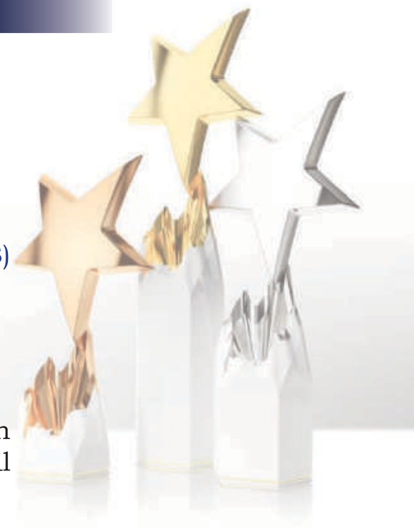
Participation in Exhibition

Dr Rakesh Kumar (2020) Participated (virtually) in India International Science Festival (IISF-2020) delivered a lecture on the topic entitled Floriculture and Medicinal Aromatic Plants as a New Enterprise on December 22.

Joshi R (2020) Elected Member of Plant Tissue Culture Association of India, PTCA(I), November 6.

AWARDS AND RECOGNITIONS

MAJOR AWARDS



Social Sciences

National Academy of Agriculture Sciences (NAAS) "Associate" - 2020

Dr Vishal Acharya

Dr. Vishal Acharya's research work focuses on Big-Data analysis of plant genomes using Artificial Intelligence (AI) approaches

Biological Sciences

CSIR Young Scientist Awards 2020

Dr Vandana Jaiswal

For her significant contribution towards identification of genomic regions harbouring Genes/QTLs for agronomic traits in wheat and development of molecular markers for wheat improvement program.

Bio-medical Sciences

NASI-Young Scientist Platinum Jubilee Award – 2020

Dr Rohit Sharma

Dr. Rohit Sharma, INSPIRE Faculty awarded with NASI-Young Scientist Platinum Jubilee Award, 2020 in the field of Bio-medical, Molecular Biology and Biotechnology

RECOGNITIONS

Joshi R (2020) Received as InSc Young Researcher Award by Institute of Scholars (InSc), Bengaluru, Karnataka.

Joshi R (2020) Academic Editor; PloS ONE.

Joshi R (2020) Review Editor; Pantnagar Journal of Research.

Joshi R (2020) Nominated a Life Member of The society for science of climate change and sustainable environment, New Delhi, India.

Uniyal SK (2020) Nominated a Member of the Research Advisory Council of the Himalayan Forest Research Institute, Shimla, HP.

Kumar S (2020) Lecture on "Climate Change" in the progamme "Badte Kadam" telecasted by Shimla Doordarshan, (HP).

Uniyal SK (2020) Nominated a Coordinator of the Group: Agro-ecology in Himalayan states with special emphasis on marketing- An Initiative of the NITI Aayog being implemented by the HNB Garhwal University and funded by UGC, New Delhi.

Das P (2020) Recognized as an honorary "Rosalind Member of London Journals Press" (membership ID #UB66344) for his paper "Polystyrene Supported Palladium Nanoparticles Catalyzed Cinnamic Acid Synthesis Using Maleic Anhydride as a Substitute for Acrylic Acid" and "Palladium-Catalyzed Ortho-Halogen-Induced Deoxygenative Approach of Alkyl Aryl Ketones to 2-Vinylbenzoic Acidsn".

Kumar S (2021) Discussion on Floriculture Mission on DD National.

Das P (2021) Nominated the affiliate member of the Royal Society of Chemistry.

Kumar S (2021) Eureka on Rajya Sabha TV telecasted (https://youtu.be/L0ikjtTkHnU).

Sud RK (2020-21) CSIR nominee for recommending candidates for the award of Raman Research Fellowships for the year 2020-21.

Sud RK (2020-21) CSIR Media Nodal Scientist

Sud RK (2020-21) Chairman for assessment of technical staff of CSIR-IIIM, Jammu.

Sud RK (2020-21) Member of Collegium and Empowered Committee for CSIR-IIIM, Jammu.

Sud RK (2020-21) Expert Member for selection of post of Asstt. Professors in Dr YS Parmar University of Horticulture & Forestry, Solan.

Sud RK (2020-21) Continued to be the Member of RAG of HFRI, Shimla and the Member of Innovation and Entrepreneurship Development Centre at NIT Hamirpur.

Sud RK (2020-21) Expert member in the meeting of Tea Office (Tea) of State Agriculture Department.

LINKAGES

1. International Linkages:

- Volt Research LLC, 1201Jacobson Ave, Ashland Ohio, USA
- OMICS lab at Kent State University (OKSU), Ohio, USA

2. Government Organization/Institution:

- Directorate of Agriculture, Government of Himachal Pradesh, Krishi Bhawan, Boileauganj, Shimla
- Department of Ayurvedic Pharmacy, Jogindernagar, District Mandi (H.P.)
- Chief Project Director (JICA), Project for Improvement of Himachal Pradesh Forest Ecosystems Management & Livelihoods and Himachal Pradesh Forest Department (HPFD), Talland, Shimla (H.P.)
- Director Ayurveda-cum-Member Secretary State Medicinal Plant Board, SDA Complex, Block No. 26, Kasumpti Shimla
- Foundation for MSME Industries, New Delhi
- The Director, ICAR–Central Potato Research Institute, Shimla (H.P.)
- Department of Forestry and Natural resources college of Horticulture and Forestry, PAU Ludhiana
- G.B. Pant National Institute of Himalayan Environment (GBPNIHE), Himachal Regional Centre, Mohal, Kullu, Himachal Pradesh
- Jawaharlal Nehru Tropical Botanic Garden and Research Institute, KSCSTE-JNTBGRI, Karimancode P.O. Palode, Thiruvananthapuram, Kerala
- Delhi Pharmaceutical Science and Research University (DPSRU), Mehrauli-Badarpur Road, PushpVihar, Sector 3, New Delhi
- Himachal Pradesh Council for Science, Technology & Environment "HIMCOSTE", Bemloe, Shimla, Government of Himachal Pradesh
- Post Graduate Institution of Medical Education and Research (PGIMER), Sector 12, Chandigarh
- Gyalshing Municipal Council, P.O. Gyalshing Bazar, West Sikkim
- Nagar Panchayat Baijnath-Paprola, 4th Floor, Mini Secretariat, Baijnath
- National Medicinal Plants Board, Ministry of AYUSH, Government of India, Indian Red Cross Society (IRCS), Annexe Building, 1st & 2nd floor,1 Red Cross Road, New Delhi
- Deputy Commissioner, Chamba, Himachal Pradesh, Deputy Commissioner Office Chamba at Chamba, Himachal Pradesh
- National Institute of Technology Hamirpur (Himachal Pradesh)
- National Institute of Technology Jalandhar (Punjab)

3. Private Industries:

- M/s Nature Green Chamba Herbs, Village Sutrar, Tehsil Nurpur, Dist. Kangra (H.P.)
- M/s VLCARE Health, 53, Gurudwara Area, Bistupur, Jamshedpur, District East Singhbhum, Jharkhand
- M/s Baijnath Pharmaceuticals Pvt. Ltd., Paprola, Tehsil Baijnath, District Kangra (H.P.)
- M/s Daziran Health Products, 31, Lgb Nagar, Sivanandhapuram, Ganapathy, Coimbatore
- Lok Seva Trust (NGO), Meerut (U.P.)
- M/s Mount leaf, Ghurkari khas, Kangra, (H.P)
- M/s Kash I wish, Sidhbari, Dharmshala (H.P.)
- M/s Singh Agritech, Plot No. 115-A, Mauakheraganj, Nandnanagar Ind. Estate, Phase II, Kashipur (U.K.)
- M/s Geo Care, V.P.O Bheth Jhikli, Tehsil Baijnath, District Kangra (H.P.)
- M/s SS Vitran Healthcare Pvt. Ltd., Opposite Arya Vanprastha Ashram, Arya Nagar, Jwalapur, Haridwar
- Moonew Tareybhir Enriched Composting / Vermicomposting Cluster (MECC), West District, Sikkim
- Triloki Enriched Composting/Vermicomposting Cluster (TECC), Sirmour District, Himachal Pradesh
- M/s Sumati Foods, Village Juddi Kalan, Baddi, Tehsil Baddi, District Solan, H.P.

- M/s Taqgene Training and Research Enterprise (TGTRE), Near Subhatri Hospital, Kotda Santoor, Nanda Ki Chowki, Prem Nagar (Uttarakhand)
- Norbu Choeiling shittake Mushroom and Other Food Processing Cluster (NCSMC), South Sikkim, Block Namthang
- Sumbuk Shittake Mushroom and Other Food Processing Cluster (SSMC), Sumbuk South Sikkim
- West Sikkim Shiitake Mushroom & Other Food Processing Cluster (WSSMC), Sikkim
- M/s Carol's Formulations, C/o Noble Product, 39, Kanganiwal Industrial Area, Jandu Singha Road, Jalandhar (Punjab)
- The Mak Biotek, K-22, Sawan Park Ashok Vihar, Phase-3, New Delhi
- TAKE Farms, Proprietor Development Area, Gangtok, Sikkim
- Sh. Akshat Goel 172, Sukhdev Vihar, New Delhi
- M/s Vigada Care Private Limited Ground Floor, K-19A, Kalkaji, New Delhi, South East Delhi
- Ras Vaidyashala, Jobner, Jaipur (Rajsthan)
- Hydrocrops India Pvt. Ltd., Jalandhar (Punjab)

4. Farmers/Farmer Societies and NGO:

- Society for Technology & Development, Village Malori, P.O. Behna, Distt. Mandi (H.P.)
- Himalayan Phytochemical & Grower Association, V.P.O Baggi, District Mandi (H.P.)
- Society for Technology & Development, Village Malori, P.O. Behna, Distt. Mandi (H.P.)
- Shiva Kisan Samiti, Village Bhatera, PO JolLambri, Tehsil Sujanpur, District Hamirpur (H.P.)
- Sh. Umesh Singh V.P.O Pukhri Tehsil and District Chamba (H.P.)
- M/s UTL, Kanta Complex, Tehsil Road, Derabassi, District SAS Nagar, Mohali, Punjab
- Professor Sheikh Bilal Ahmed, Regional Director, RCFC North II-NMPB, SKUAST-Kashmir, Wadura, Sopore (J&K)
- Sh. Raj Kumar, Village& Post Office Saloh, Ward No., Saloh Uperla, Una (H.P.)
- Preeti Abbi (Director, GLT Infrastructure Private Limited), 58 – Ekta Nagar, Roorkee Road, Meerut (U.P.)
- Mr. Nishant Bansal, House No. 4, Gian Colony, Patiala, Punjab
- Sh. Chirag Sharma, Village Dohg, Post Office Lower Ghallour, Tehsil Jwalamukhi, District Kangra (H.P.)
- Nirmal Society, Village Tanda, Post Office Rajpur, Tehsil Palampur, District Kangra, (H.P.)
- Panchayat Kolsar, Block Pouni, Tehsil & Distt Reasi, Kolsar (J&K)
- Colonel Rajesh Sharma, S/o Major O.P. Sharma, Village Bhavetar. P.O. Kohala, Tehsil Jwalamukhi, Kangra (H.P.)
- Mr. Rajiv Arora Jia Khas, Palampur, (H.P.)
- AFORD (Action Society for development), Bramhapuri, District Chandrapur (M.H)
- M/s Taqgene Training and Research Enterprise (TGTRE), Kotda Santoor, Nanda Ki Chowki, Prem Nagar (Uttarakhand)
- Dr. Hitesh Kumar, Village Bhoor, PO Jhangi, Tehsil Sandhol, District Mandi (H.P.)
- Ms. Swaroop Sharma w/o Mr. Vinod Sharm, TeekaGarhi, V.P.O Thana Bargram, Baroh, District Kangra (H.P.)
- M/s Future Grapes Plantech Private Limited., 1102/8, Behind Police Head Quarter, At Post Adgaon, Nashik (M.H.)
- Farmalogist Essence and Organic LLP, A-200, Lower Ground Floor, Lajpat Nagar, Part- 1, New Delhi
- Reena Thakur, V.P.O Averi, Tehsil Baijnath, District Kangra, (H.P.)
- DL Herbal Farms Group, E-45, 2nd Floor, Masjid Moth, G.K. 3, New Delhi
- Ms. Supriya Sharma, Village Gural, Post office Bharwai, Tehsil Dehra, District Kangra (H.P.)
- M/s Sivani Stevia Industry, Ward no. 10, Green Road, Chandmari, Golaghat, Assam
- Mr. Rattan Singh Guleria, VPO Sidhpurghar, Tehsil, Jawali. Kangra (H.P.)

- Sh. Amandeep Singh S/o Sh. Gurdip Singh Village Bhangwan, P.O Dalelpur, Tehsil and District Gurdaspur Punjab
- Farmers School of Organic Farming, Village Janitpura, DeraBassi, District Mohali
- Mr. Neeraj Kumar Pandey, House No 35, New Adarsh Colony, Mundian- Kalan, Ludhiana
- The Eco Friendly Society of Farmers (Regd.), Vill. & P.O. RureKe Kalan, Tehsil, Tapa, District Barnala, Punjab
- Mr. Anupam Sharma, House No. 192, NFL enclave, Sector 48 A, Chandigarh
- Rami Bibi Dhou Dhou, Organic Centre, Village Bhagwan, Tehsil Kalanaur. District Gurdaspur, Punjab
- Farmers School of Organic Farming, Mohali (Punjab)
- Association for peoples Advancement and Action Research (APAAR) C/o VSMD Enterprises, 1-97, Lajpat Nagar 1, New Delhi
- Himalayan Phytochemical & Growers Association is a registered society, Baggi, Tehsil Sadar District Mandi (H.P.)
- Samagra Adivasi Medicinal Plants Development Association, Kondagaon, Bastar, Chhattisgarh
- Farmalogist Essence and Organic LLP, A-200, Lower Ground Floor, Lajpat Nagar, New Delhi
- Progressive Farmers Association, Rattan Villa, IPH Colony, Ghumarwin, District Bilaspur (H.P.)
- M/s Tojo Vikas International Pvt. Ltd., 4 Adchini, Mehrauli Road, New Delhi
- Hrudaya Foundation, I-97, LGF Lajpat Nagar 1, New Delhi
- M/s Komal Innovation and Wellness Initiatives (KIWI), Shed No. 4, Phase II, Industrial Area, Nagrota Bhagwan (H.P.)
- VSRF, No 67 MRS Compound Vakkil Street, Kovilpatti, Thoothukkudi District, Tamil Nadu
- M/s Jaishree Enterprises, Block No. D, Plot No. 18 Sector 4B, Adipur Gujarat
- M/s Komal Innovation and Wellness Initiatives (KIWI), having official address at Shed No. 4, Phase II, Industrial Area, Nagrota Bhagwan (H.P.)
- M/s Vigada Care Pvt. Ltd., Ground Floor, K-19A, Kalka Ji, New Delhi, South East Delhi
- Kisaan Vikas Committee, Village Khal P.O. Bhanad Tehsil Salooni Distt. Chamba (H.P.)
- EWOK Society, IIT Mandi, Kamand, Mandi (H.P.)
- BB Bhumi Vikas Sabha, Teeka Garhi, VPO Thana Bargran, Tehsil Baroh, District Kangra (H.P.)
- Choo Mata Uthaan Society, Village Bar, PO Tikri, Tehsil Sihunta, Chamba (H.P.)
- Vikas Committee Suppa, Village Suppa P.O Ghared Tehsil Bharmour District Chamba (H.P.)
- Human Advancement for Rural Masses(HARM) VPO Kona Palampur Distt Kangra (H.P.)
- Jai Maa Kokila (SHG), Baram Post District Pithoragarh, Uttarakhand

5. Start-Up Incubation

- Mr. Rahul Sharma Village Chakrog P.O. Drubbal, Tehsil Joginder Nagar Distt. Mandi (H.P.)
- Mr. Bharat Mohan S/o Sh. Surender Mohan, 50 C, Post Office Baggi, Tehsil Sadar, Mandi (H.P.)
- Mr. Rajan Minhas S/o Punjab Singh Minhas, 232, Near Dhauladhar Colony, V.P.O Maranda, Tehsil Palampur, District Kangra (H.P.)
- Mr. Sunil Kumar, Address Village Upli Majhetly P.O. Pathiar, Tehsil Nagrota Bagwan District Kangra (H.P)
- Mr. Kanishak Kaushal House No. 11, Ward No. 2, V.P.O. Nagrota Bagwan, Teh. Nagrota Bagwan, Dist.- Kangra, (H.P.)
- Mr. Roushan Kumar C/o Vinod Patial, Near Depot, above Monal Hostel, Village Bharmat, Palampur (H.P.)
- Mr. Jagdeep Singh, V.P.O Averi 78 Mile, Tehsil Baijnath, District Kangra (H.P.)
- Mr. Kushal Kumar S/o SatpalSoni, Ward No. 11, Rania, Tehsil Rania, District Sirsa, Haryana
- Mr. Rajneesh Kanwar, Village Baroha, Post office Dugga, Tehsil and District Hamirpur (H.P.)

- Mr. Anup Sood, c/o M/s A B Scientific Solutions, Green Valley, Lohna, Palampur (H.P.)
- Dr. Ishan Kashyap, S/o Bhagat Raj Sharma, 35/9, Bhagwan Street, P.O. Mandi, Tehsil Sadar, District Mandi (H.P.)
- Mr. Surender Mohan S/o Late Sh. Sant Ram Gupta V.P.O Baggi, Teshil Sunder Nagar, District Mandi (H.P.)
- M/s Iotech World AvigationPvt. Ltd.Plot#1643, Sector-52, Gurgaon, Haryana
- Mr. Amarjeet S/o Late Sh. Bir Singh, V.P.O Keylong, District Lahaul & Spiti (H.P.)
- M/s Golden Rise, V.P.O. Patti, Tehsil Palampur District Kangra (H.P.)
- Mr. Ashveen Khatri, S/o Sh. Oman Singh, CSIR-IHBT Apartments, Post Box No. 6, Palampur (H.P.)
- Mr. Sanjeev Katoch, S/o Late Kaptan Chand Katoch Village Ram Chowk, Ghuggar (Behind IVRI Colony), PO and Tehsil Palampur, District Kangra (H.P.)
- Mr. Sanjeev Thakur, Village Bisht Behar, P.O. Kais, Tehsil & District Kullu (H.P.)
- Mr. Ajay Kumar, S/o Sh. Sardar Singh, Village & Post Office Trehal, Tehsil Baijnath, Kangra (H.P.)
- Mrs. Reena Thakur, V.P.O Averi, Tehsil Baijnath, District Kangra (H.P.)

STAFF

STAFF

Director

Dr. Sanjay Kumar

Chief Scientist

Dr. R.K. Sud

Er. K.K. Singh

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

Principal Scientist

Dr. Shashi Bhushan

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 (Joined on 20.04.2020)

Dr. Gaurav Zinta (Joined on 13.05.2020)

Dr. Rajesh Kumar Singh (Joined on 12.06.2020)

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

Dr. Kuldeep Singh (Joined on 16.09.2020)

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
Dr. Pankaj Markand Kulurkar

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
Sh. Anil Chaudhary
Sh. Arvind Kumar Verma
Sh. Pawan Kumar

Technical Assistant

Dr. Rimpy Diman
Sh. Virat Abhishek
Sh. Saurabh Sharma
Sh. Rajeev Kumar Koundal (Joined on 16.02.2021)
Sh. Vikas Soni (Joined on 19.02.2021)

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

Technician (2)

Sh. Sandeep Sood
Sh. Ranjeet Singh
Sh. Ajay Kumar
Sh. Surjeet Singh
Sh. Arvind Kant
Smt. Jasveer Kaur
Sh. Vikas Kumar

Technician (1)

Sh. Sanjeev Kumar
Sh. Sanjeet Kumar
Sh. Monu Kumar
Sh. Ishwar Dass

Lab. Assistant

Sh. Rakesh Chand
Sh. Baldev Singh

Lab. Attendant (2)

Mrs. Anupama Saini
Sh. Shamsher Singh
Sh. Uttam Chand
Sh. Balak Ram
Sh. Kuldip Singh
Sh. Balwant Raj
Sh. Girja Nand
Sh. Deepak Sood

Controller of Administration

Sh. Alok Sharma

Administration Officer

Sh. Amarjeet

Finance & Accounts Officer

Sh. Yash Pal

Sr. Controller of Store and Purchase

Sh. S. Gnanaprakasam

Section Officer (S&P)

Sh. Ram Singh

Hindi Officer

Sh. Sanjay Kumar

Private Secretary

Sh. Didar Singh Patial

Assistant Section Officer (G.)

Sh. Ved Prakash

Sh. Parveen Singh

Smt. Santosh Kumari

Sh. Baldev

Assistant Section Officer (F&A)

Smt. Aruna Kumari

Assistant Section Officer (S&P)

Sh. Rajeev Sood

Senior Secretariat Assistant (G.)

Sh. Kiran Kumar

Smt. Pooja Awasthi

Sh. Praveen Kumar

Sh. Sandeep Kumar

Sh. Mukul Sharma

Sh. Ajay Singh Kaundal

Senior Secretariat Assistant (S&P)

Sh. Rajinder Singh

Junior Stenographer

Sh. Boni Kumar

Security Assistant

Sh. Trilok Nath

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 Superannuated

Dr. Amita Bhattacharya

Chief Scientist: 31.08.2020

Emeritus Scientist

Dr. Bikram Singh

Dr. Surender Kumar Vats

INSPIRE Faculty

Dr. Yogita Maheshwari

Dr. Nishma Dahal

Dr. Vijay Gehlot

Young Scientist

Dr. Virender Kumar

Dr. Vijay Kumar

Dr. Prakriti Kashyap

Pool Scientist

Dr. Paromik Bhattacharya

Women Scientist

Ms. Ritu Sharma

Ms. Ranjana Sharma

Ms. Usha Kumari Rattan

Ms. Rashim Kumari

PDF & NPDF

Dr. Rahul Jain

Dr. Vidya Rajendran

Dr. Sapna Thakur

ISWP

Mr. Prakash Kumar

Ms. Gowsalyadevi A

Project Scientist-II

Dr. Arbind Kumar

Dr. Sharad Thakur

Dr. Varun Chauhan

Dr. Surender Kumar

Project Scientist-I

Dr. Aashish Sharma

Dr. Narender Kumar

Project Scientist

Dr. Ajay Rana

RA

Dr. Shalika Rana

Dr. Deepali Katoch

Dr. Heena Gupta

Mr. Sandeep Kumar

Ms. Anamika Sharma

SRF

Mr. Rohit Rana

Ms. Sanyukta Darnal

Mr. Sachin Kumar

Ms. Jyoti Devi

Ms. Jyoti Chhimwal

Mr. Ram Chander

Mr. Mahinder Partap

Ms. Nang Elennie Hopak

Ms. Chandni Sharma

Mr. Ashish Kumar Shukla

Ms. Poonam Pal

Mr. Patil Shivprasad Suresh

Ms. Poonam Bharti

Ms. Supriya Sharma

Ms. Mitali Mahajan

Ms. Eshita Sharma

Ms. Kiran Dindhoria

Ms. Anjali Chaudhary

Mr. Dinesh Kumar

Ms. Surekha Kumari

Ms. Meetal Sharma

Ms. Himani Agrawal

Ms. Amita Kumari

Mr. Ankit Kumar Dhiman

Mr. Vikas Thakur

Ms. Sudh Kirti Dolma

Mr. Mustaqeem Ahmad

Mr. Rohit Kumar

Mr. Rahul Upadhyay
Ms. Shaifali
Ms. Namo Dubey
Mr. Lakhbeer Singh
Mr. Shiv Rattan
Ms. Kanchan Yadav
Ms. Shruti Sinai Borker
Ms. Manglesh Kumari
Ms. Kajal Sinha
Mr. Neeraj Kumar
Ms. Sheetal
Mr. Bittu Ram
Ms. Pooja
Ms. Diksha Parmar
Mr. Anil Kumar Rana
Ms. Ambika
Mr. Prince Anand
Ms. Arti Sharma
Ms. Bipasha Bhattacharjee
Mr. Ajay Kumar Sharma
Mr. Arvind Singh Chauhan
Ms. Mohini Verma
Ms. Shweta Guleria
Mr. Subhash Kumar
Ms. Deepika Nag
Ms. Pallavi Sharma
Ms. Smita Kapoor
Ms. Nitu Gautam
Mr. Vikas Dadwal
Ms. Vijeta Patial
Ms. Shriya Bhatt
Mr. Ravi Kumar
Ms. Aakriti Sharma
Ms. Monika Kumari
Ms. Neha Baliyan
Mr. Anupam Bhatt
Ms. Srijana Mukhia
Mr. Syed Murtuza Sayeed Abidi
Ms. Ashrita
Mr. Anil Kumar
Ms. Kamini Kapoor

JRF

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CSIR-IHBT IN PRINT AND ELECTRONIC MEDIA

लाहुल–स्पीति में हींग से मालामाल होंगे किसान

कवायद

- आइएचबीटी पालमपुर ने लाहुल घाटी में लगाया हींग का पौधा
- हिमाचलियों ने खेती करने के लिए प्रशिक्षण भी दिया

सुगंधित फसलों की खेती से बढ़ेगी किसानों की आय : डा. शेखर

पटटी गांव में केसर उगाने पर वयवधाई विज्ञानियों की पीठ

हींग और केसर की खेती से कमाएं लाखों : डॉ शेखर

चेतन लता। जंजैहली

ग्राम पंचायत डीम कटारू के अंतर्गत एक दिवसीय हींग और केसर की खेती का प्रशिक्षण दिया गया। इस प्रशिक्षण शिविर में सीएसआईआर दिल्ली से आए हुए महानिदेशक एवं सचिव भारत सरकार डॉ. शेखर सी ...

... टन हींग की खपत होती है। जबकि देश में प्रतिवर्ष 600 करोड़ रुपये से अधिक हींग के आयात पर खर्च किए जाते हैं।

डॉ. मांडे ने किसानों का आह्वान किया कि हींग और केसर की खेती करके वे लाखों कमा सकते है। इस अवसर पर हींग के पौधों का रोपण ...

हींग की खेती से हिमाचली किसान होंगे संपन्न

सरकार ने शुरू की कृषि से संपन्नता योजना, डीपीआर तैयार

● प्रदेश के 4 जिले हींग की खेती के लिए अनुकूल

10 करोड़ रुपये होंगे खर्च

मुहिम संस्थान के निदेशक डॉ. संजय कुमार ने लाहौल-स्पीति से की शुरुआत

आईएचबीटी ने उठाया हींग की खेती शुरू करने का बीड़ा

आई.एच.बी.टी. ने लाहौल में की हींग की खेती की शुरूआत

पालमपुर : हींग की खेती के प्रशिक्षण शिविर में प्रशिक्षुओं के साथ संस्थान के निदेशक डा. संजय कुमार। (भृगु)

पालमपुर, 17 अक्तूबर (भृगु): शीत मरुस्थल का क्षेत्र करोड़ों की उपज का गवाह बनेगा। प्रदेश में पहली बार कृषि की शुरूआत शीत मरुस्थल लाहौल–स्पीति से की गई है। ऐसे में प्रतिवर्ष लगभग 600 करोड़ रुपए का हींग आयात करने वाले देश के लिए शीत मरुस्थल से हींग की उपलब्धता सुनिश्चित बनाई जाएगी। वर्तमान में 600 करोड़ रुपए के लगभग 1200 मीट्रिक टन कच्ची हींग अफगानिस्तान, ईरान व उज्बेकिस्तान से आयात की जाती है। हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर ने प्रदेश में पहली बार हींग की खेती की शुरूआत करने के प्रयास आरंभ किए हैं।

लाहौल-स्पीति में हींग तो चम्बा, कुल्लू व मंडी में केसर की रोपण सामग्री का वितरण शुरू

वैज्ञानिक तथा औद्योगिक अनुसंधान परिषद के स्थापना दिवस पर किया शुभारंभ

पालमपुर, 26 सितम्बर (ब्यूरो): हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर में वैज्ञानिक तथा औद्योगिक अनुसंधान ... रोपण सामग्री के वितरण के साथ व्यवसायिक रूप से महत्वपूर्ण मसाला फसलों की खेती के कार्यक्रम का भी शुभारंभ किया गया। सिक्किम सरकार में कृषि, पशुपालन और पशु चिकित्सा, सूचना और जनसंपर्क और स्टेशनरी मंत्री लोकनाथ शर्मा समारोह में मुख्यातिथि के रूप में उपस्थित रहे। सी.एस.आई.आर.- ... की कि सिक्किम के ग्रामीण क्षेत्रों के किसानों की आर्जीविका को बढ़ाने के लिए सी.एस.आई.आर.-आई.एच.बी.टी. द्वारा विकसित प्रौद्योगिकियां अवश्य ही कारगर सिद्ध होंगी। डा. शेखरसी. मांडे, महानिदेशक (सी.एस.आई.आर.) एवं सचिव, वैज्ञानिक एवं औद्योगिक अनुसंधान विभाग, भारत सरकार ने अपने संबोधन में कहा कि ... हनी बी नैटवर्क, सृष्टि, एवं एन.आई.एफ. ने लर्निंग एंड लेवरेजिंग ग्रास रूट इनोवेशंस एंड ट्रैडिशनलनॉलेज सिस्टम्स एंड इंस्टीच्यूशन्स विषय पर अपना संभाषण दिया। इससे पूर्व संस्थान के निदेशक डा. संजय कुमार ने ऑनलाइन माध्यम से जुड़े हुए अतिथियों का स्वागत किया तथा संस्थान की प्रमुख गतिविधियों एवं उपलब्धियों का संक्षिप्त विवरण ...

लाहौल घाटी के क्वारिंग गांव में रोपा देश का पहला हींग का पौधा

आईएचबीटी संस्थान पालमपुर ने रिसर्च सेंटर में तैयार की हींग की किस्में, भारत में होती है दुनिया की सबसे अधिक हींग की खपत

लाहुल-स्पीति में हींग की खेती शुरू

आईएचबीटी पालमपुर ने उठाया बीड़ा, शीत मरुस्थल से हुई शुरुआत

3.5 में केसर, 302 हेक्टेयर में उगेगी हींग

● खेती के लिए प्रदेश सरकार ने रखा लक्ष्य : वीरेंद्र कंवर

देश को हींग की खेती की राह दिखाएगा हिमाचल

विनोद राणा

आईएचबीटी संस्थान पालमपुर ने ईरान से बीज लाकर तैयार की पौध

पालमपुर (कांगड़ा)। ईरान और अफगानिस्तान से आने वाले हींग की खेती अब भारत में ही होगी। देश को यह राह पहाड़ी राज्य हिमाचल दिखाएगा। प्रदेश के जनजातीय जिले किन्नौर से इसकी शुरुआत होगी। कांगड़ा जिले के पालमपुर स्थित सीएसआईआर-आईएचबीटी संस्थान ने हींग की खेती को लेकर बड़ी कामयाबी हासिल कर ली है। संस्थान विदेशी बीज से तैयार हींग की पौध अब किन्नौर में अब लगाने को तैयार है।

ईरान से हींग पौधे का बीज मंगाकर संस्थान में इस पर लंबा शोध किया गया। हींग के पौधे उगाने और अनुकूल जलवायु को लेकर आईएचबीटी ने व्यापक शोध के बाद विदेशी बीज से यह पौध तैयार

होता है। एक अनुमान के मुताबिक हर साल 1100 टन हींग अफगानिस्तान व ईरान से मंगाई जाती है। हींग के निर्यात पर देश की करीब 70 मिलियन डालर की मुद्रा खर्च होती है। इसे देखते हुए देश में हींग की खेती की शुरुआत कृषि क्षेत्र में बड़ी कामयाबी होगी।

सीएसआईआर-आईएचबीटी के निदेशक डा. संजय कुमार ने कहा कि देश में हींग की खेती की राह गहन शोध से खुली है। शोध के लिए ईरान से बीज लाया गया था। हींग की पौध तैयार करने, उगाने,

देश में पैदा होगा हींग, खेती से बदलेंगे लाहुल के किसानों के दिन

हिमालय जैवसंपदा प्रौद्योगिकी संस्थान ने लाहुल में की हींग की खेती की शुरुआत

से आयात की जाती है। राष्ट्रीय पादप आनुवंशिकी संसाधन ब्यूरो ने इस बात की पुष्टि की है कि पिछले तीस वर्षों में हींग के बीज का आयात हमारे देश में नहीं हुआ है और यह प्रथम प्रयास है जब हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर ने हींग के बीज का आयात किया है। अब संस्थान ने कृषि विभाग, हिमाचल प्रदेश के साथ

देने के लिए हाथ मिलाया है। किसानों की आय को बढ़ने के लिए हींग की खेती एक मील का पत्थर साबित हो सकती है तथा आयात पर होने वाले खर्च में भी कमी आएगी। संस्थान के वैज्ञानिक डॉ. अशोक कुमार तथा डॉ. रमेश ने लाहुल स्पीति के मडग्रां, बीलिंग, केलांग तथा क्वारिंग क्षेत्रों में किसानों को कृषि विभाग के अधिकारियों की उपस्थिति में हींग की खेती पर प्रशिक्षण दिया तथा हींग के बीज उत्पादन हेतु परदर्शनी क्षेत्र स्थापित किया। डॉ. अशोक कुमार ने बताया कि हींग एक बहुवर्षीय पौधा है तथा पांच वर्ष के उपरांत इसकी जड़ों से ओलिओ गम रेजिन निकलता है, जिसे शुद्ध हींग कहते है। इसकी खेती के लिए यहां कि जलवायु उपयुक्त है तथा इसकी खेती आसानी से की जा सकती है। इसकी खेती के लिए ठंड के साथ पर्याप्त धूप का होना अति आवश्यक है। डॉ. रमेश ने हींग की विभिन्न कृषि तकनीकों के बारे में विस्तृत

हिमाचल में तैयार हींग से आत्मनिर्भर बनेगा भारत

बहुत कम लोगों को पता होगा कि दुनिया में हींग की सबसे ज्यादा खपत भारत में होती है, पर इसकी पैदावार यहां नहीं होती, लेकिन अब हिमाचल में हींग उगाने की अनूठी कवायद शुरू हुई, जिससे पूरा देश हिमाचल पर फख्र करेगा। पेश है यह रिपोर्ट

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Wild hing makes India's heart sing as favourite spice is home-grown at last

Asafoetida is a mainstay of the country's cuisine, but only now are the first saplings being planted on Indian soil

Villagers in Kwaring, Himachal Pradesh, will look after the first hing crop in India. Photograph: Courtesy of CSIR-IHBT

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Asafoetida: The smelly spice India loves but never grew

GETTY IMAGES

Asafoetida, a smelly, acrid spice beloved by Indians, has been used to lace their food for centuries. But it was never cultivated in the region - until now.

Last week, scientists planted about 800 saplings of the plant in Lahaul and Spiti, a cold desert nestled in the Himalayan mountains, exactly two years after India's Council of Scientific and Industrial Research (CSIR) imported six varieties of seeds from Iran.

"We are confident it will work," says Dr Ashok Kumar, one of the scientists who painstakingly germinated the seeds in a lab. He says this was necessary

BBC NEWS | हिन्दी
होम पेज कोरोनावायरस भारत विदेश मनोरंजन खेल विज्ञान-टेक्नॉलॉजी सोशल

हींग की खेती भारत में पहली बार, खाने में इसका इस्तेमाल कितना अनिवार्य

22 अक्तूबर 2020

GETTY IMAGES

तेज़ गंध और छोटे कंकड़ की तरह दिखने वाले हींग की बहुत थोड़ी सी मात्रा भी खाने का स्वाद बदल देती है. भारत में रसोई घरों में रहने वाली यह एक ज़रूरी मसाला है.

THE TIMES OF INDIA
INDIA
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India takes up cultivation of Heeng for the first time, the move will be game changer in cold desert region

Vishwa Mohan | TNN | Updated: Oct 21, 2020, 14:14 IST

NEW DELHI: Heeng (asafoetida) is being used in Indian cuisine since time immemorial, but one of the most valuable spices of the

The Indian EXPRESS

Thursday, March 11, 2021

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Explained: Why scientists are trying to cultivate asafoetida or heeng in the Indian Himalayas

How was the asafoetida (heeng) cultivation project set in motion? In how many years will we know if the experiment has been a success?

Asafoetida, or heeng, is a common ingredient in most Indian kitchens — so much so that the country imports Rs 600 crore worth of this pungent flavoured herb every year.

Now, scientists at CSIR Institute of Himalayan Bioresource, Palampur (IHBT), are on a mission to grow heeng in the Indian Himalayas. The first sapling has been planted

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Heeng (Asafoetida) cultivation started for the first time in India with trial plantation in Himachal Pradesh

18 October, 2020 — OpIndia

ZEE NEWS

ASAFOETIDA

In a first, scientists take up cultivation of asafoetida in India

India imports about 1,200 tonnes of raw asafoetida annually from Afghanistan, Iran and Uzbekistan and spends approximately USD 100 million per year for it.

Photo courtesy: Twitter/@CSIR_IHBT

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India starts cultivation of Hing which it imports in its raw form for USD 100 million

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1/5 Hing cultivation

Farmers of the remote Lahaul Valley in Himachal Pradesh have started taking up cultivation of asafoetida (hing), mainly due to the efforts of the Institute of Himalayan Bioresource Technology, using the vast wasteland in the cold desert conditions of the region, the CSIR said.

India will now cultivate heeng locally for first time; check out where

Scientists from CSIR-Institute of Himalayan Bioresource Technology (IHBT), Palampur have planted saplings of the condiment in Himachal Pradesh in the hope that heeng cultivation will become a standard practice in India

BusinessToday.In | October 20, 2020 | Updated 15:08 IST

Asafoetida is one of the top spice crops and is a high-value condiment in India

Indian kitchen staple Heeng or asafoetida which has never been grown locally, is now going to be cultivated in the country. Scientists from CSIR-Institute of Himalayan Bioresource Technology (IHBT), Palampur have planted saplings of the condiment in Himachal Pradesh in the hope that heeng cultivation will become a standard practice in India.

Scientists sow 'pure' heeng seeds to help farmers reap benefits

ARCHANA JYOTI ■ NEW DELHI

For the first time, in high altitudes of Himachal Pradesh's Lahaul & Spiti, Indian scientists have successfully sown high-quality seeds of Asafoetida locally known as heeng (botanical name: *Ferula assa-foetida L.*), imported from Iran, to help the cold deserts' farmers to commercially grow the much-sought after high valued spice.

Given that currently India imports about 1,145 tonnes of raw Heeng annually from Afghanistan (73 per cent), Iran (14 per cent) and Uzbekistan (13 per cent) incurring approximately $77 million per year, all eyes are now on the indigenous project undertaken by the scientists from the CSIR-Institute of Himalayan Bio-resource Technology (IHBT), Palampur.

Though, some farmers have taken initiative to grow the heeng herb in their land privately, it is of inferior quality or adulterated which are not good for health, said Dr Sanjay Kumar, Director of the IHBT.

Whereas, he pointed out, the heeng seeds procured by our institute ... by the national authorised body, ICAR-National Bureau of Plant Genetic Resources (NBPGR), declaring them to be healthy and free of pests.

"The seeds have been quarantined so that they are weed-free. We have sown them in a tract at our Centre for High Altitude Biology (CeHAB) at Ribling, Lahaul & Spiti as well as at our lab in Palampur. "While at the local lab, seeds have been already germinated, we are now waiting for the snow to melt at the CeHAB centre where seeds will germinate in natural cold conditions," said Dr Sanjay Kumar.

In India, it can be cultivated in a wide range of sub-Himalayan region of northern India, viz. Himachal Pradesh, Jammu & Kashmir and Uttarakhand, added Dr Ashok Kumar, Scientist, Agrotechnology of Medicinal, Aromatic and Commercially Important Plants Division, IHBT.

Once it is commercially cultivated, the spice has potential to not only provide jobs to unemployed youths, boost the income of the ... substitute to regular crops which are facing animal menace or extreme weather conditions.

"Once the heeng project kicks-off, we will also work on improving the technology for extracting resin efficiently as well as conduct ... in the lower altitudes also," said Dr Ashok Kumar.

Heeng or Asafoetida is a perennial herb that produces pungently flavoured oleo-gum resin in its fleshy roots which has medicinal properties related to digestive ... the gastro-intestinal tract, Dr Ashok Kumar said.

The international value crop has high demand in the pharmaceutical sector. This plant takes five years for maturing shrubs and producing ...

Heeng seeds tracts covered with snow at IHBT's lab at CeHAB at Lahaul Spiti

- The crop is generally harvested during August-October
- Heeng is extracted from the roots of the plant by a cut on the rhizome part of the root. The milk that oozes out is stored in containers. It is then sun dried and then mixed with other edible items like starch and gum to be sold in the market
- Its farming would boost the economy of farmers as it has high value in domestic as well as global market
- Heeng is widely used in spices and medicines in India
- Self-pollinating heeng plant is native of higher altitude regions or in cold deserts

जागरण सिटी कांगड़ा

आइएचबीटी व कृषि विभाग संयुक्त रूप से करेंगे केसर व हींग की खेती

महत्वपूर्ण करार पर हस्ताक्षर कृषि आय और ग्रामीण विकास के दिशे उद्देश्य

छह से सात टन होता है औसत उत्पादन

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4 PALAMPUR • TUESDAY • 19.2.2019

देश में पहली बार होगी हींग की पैदावार

हिमालय जैव संपदा प्रौद्योगिकी संस्थान ने की पहल

पालमपुर : हिमालय जैव संपदा प्रौद्योगिकी संस्थान पालमपुर द्वारा उपलब्ध करवाए गए हींग के बीज तथा लाहौल-स्पीति के रिबलिंग में की गई हींग की खेती।

हिमाचल-उत्तराखंड के पहाड़ों से आएगी हींग

नई दिल्ली | मदन जैड़ा

हर वर्ष देश में पांच अरब की हींग का आयात

किसानों की आय में भी इजाफा होगा

प्रयोगशाला में परीक्षण

हींग उत्पादन की तैयारी

हींग उत्पादन में देश होगा आत्मनिर्भर, CSIR-IHBT पालमपुर के वैज्ञानिकों ने तैयार की पौध

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गुणवत्तायुक्त हींग की कृषि तकनीक विकसित करने की तैयारी में आईएचबीटी

राष्ट्रीय विज्ञान दिवस पर निदेशक डॉ. संजय ने दी जानकारी

हिमाचल दस्तक। पालमपुर

प्राकृतिक तेल की विश्व में भारी मांग : डॉ. सुरिंद्र

एंटी एच.आई.वी. दवा की अपेक्षा टी कैमिकल कोरोना वायरस पर अधिक कारगर

IHBT develops sanitiser with natural flavours

PALAMPUR, MARCH 19

The CSIR-Institute of Himalayan Bioresource Technology (IHBT) has developed a hand sanitiser that contains natural flavours, active tea constituents and alcohol content as per WHO guidelines. The product is free from parabens, triclosan, synthetic fragrance and phthalates.

The technology will be transferred to a private unit through an agreement between the institute and AB Scientific Solutions.

The firm, that has a strong marketing network, will establish a facility at Palampur and market hand sanitisers and other disinfectants in all major cities across the country. — OC

पालमपुर : हिमालय जैव संपदा प्रौद्योगिकी संस्थान द्वारा तैयार प्लांटिंग मैटीरियल किसानों के लिए ले जाते हुए।

प्रयोगशाला से अब किसान के खेतों में पहुंचा हींग

प्रदेश में पहली बार अपने खेतों में हींग उगाने जा रहे किसान

प्रत्येक क्षेत्र में सत्यनिष्ठा को करें प्रोत्साहित

शुगर घटाएगी, इम्युनिटी बढ़ाएगी खिचड़ी

दवा की गोलियां नहीं, चॉकलेट बार दूर करेंगे बच्चों में पोषक तत्वों की कमी

बंजर भूमि से निकाला समृद्धि का तेल

आईएचबीटी ने बनाया रसायनमुक्त हैंड सेनेटाइजर

हृदय रोग से बचाएगा कांगड़ा चाय का कैप्सूल

कपास ही नहीं, खरपतवार से भी बनेगा धागा

सीएसआईआर पालमपुर के वैज्ञानिकों ने ईजाद की तकनीक, पौधे का फाइबर होगा इस्तेमाल

विनोद राणा

सीएसआईआर की ओर से नई तकनीक से तैयार धागा।

हिमालय के ऊंचे और मध्य पर्वतीय क्षेत्रों में पाए जाने वाले रेशेदार पौधों पर किया शोध

ख्वास ख्वबर

पालमपुर (कांगड़ा)। देश में कपास से बनने वाला धागा अब खरपतवार के रेशेदार पौधों से भी बनेगा। यह तकनीक हिमालय जैवसंपदा प्रौद्योगिकी संस्थान (सीएसआईआर) और हिमालयी बायोसाइट्स प्रौद्योगिकी संस्थान (आईएचबीटी) पालमपुर ने तैयार की है।

हिमालय क्षेत्र के ऊंचे व मध्य व ऊंचाई वाले इलाकों में पाए जाने वाले रेशेदार पौधों से धागा बनाने की तकनीक लंबे शोध के बाद संस्थान ने तैयार की है। बिना किसी काम के आने वाले पौधों (खरपतवार) से निकलने वाले फाइबर से धागा तैयार किया गया है। इससे आने वाले दिनों में लघु उद्योग और किसानों को रोजगार मिलेगा। इस धागे का इस्तेमाल कपड़ा बनाने में होगा। सीएसआईआर के निदेशक डा. संजय कुमार ने इसकी पुष्टि की है। खास बात यह है कि इन पौधों से निकलने वाले फाइबर से पर्यावरण को कोई खतरा नहीं है। पौधों से लिए जाने वाला यह फाइबर करीब आठ से दस घंटे में निकाल लिया जाता है, जबकि पारंपरिक तरीकों से रेशेदार पौधों से फाइबर निकालने के लिए तीन से चार हफ्ते लगते हैं। पर्यावरण के अनुकूल फाइबर की राष्ट्रीय और अंतरराष्ट्रीय बाजारों बहुत अच्छी मांग है और रोजगार सृज के लिए बड़े अवसर प्रदान कर सक हैं। सीएसआईआर के वैज्ञानिकों की मानें तो प्रदेश के हिमालय क्षेत्र पौधे मध्य और ऊंचाई वा जाते हैं। केंद्र सरकार के कार्यक्रम में सीएसआईआ लाभदायक साबित होगा, प्रोसेस पेटेंट फाइल किया

अब पालमपुर में भी होगी कोविड-19 के नमूनों की जांच

- आईएचबीटी संस्थान को मिली मान्यता
- संस्थान में पहले दिन हमीरपुर से 24 मंडी से 14 सैंपल पहुंचे

पहले दिन पालमपुर पहुंचे 38 सैंपल

आईएचबीटी में कोरोना सैंपल टेस्ट लैब को मंजूरी मिलने के बाद काम शुरू

सीएसआइआर में पहले दिन जांच के लिए पहुंचे 38 सैंपल

एंटी एच.आई.वी. दवा की अपेक्षा टी कैमिकल कोरोना वायरस पर अधिक कारगर

पालमपुर, 21 मई (भृगु): चाय में पाए जाने वाला रसायन एंटी एच.आई.वी. दवा की अपेक्षा कोरोना वायरस की गतिविधि को रोकने में अधिक कारगर है। कम्प्यूटर आधारित मॉडल का उपयोग करते हुए वैज्ञानिकों ने 65 बायोएक्टिव रसायनों या पॉलीफेनोल्स की जांच की, जो एक विशिष्ट वायरल प्रोटीन को एंटी-एच.आई.वी. दवाओं जो कोविड-19 रोगियों के उपचार के लिए अनुमोदित है, की तुलना में अधिक बेहतर ढंग से रोकने में सक्षम है। ये रसायन वायरल प्रोटीन की गतिविधि को अवरुद्ध करते हैं जो वायरस को मानव कोशिकाओं के अंदर पनपने में सहायता करता है।

यह जानकारी हिमालय जैव संपदा प्रौद्योगिकी संस्थान के निदेशक डा. संजय कुमार ने अंतर्राष्ट्रीय चाय दिवस पर आयोजित कार्यक्रम में दी। हैंड सैनिटाइजर व हर्बल साबुन विकसित किए जाने के बारे में जानकारी देते हुए बताया कि यह साबुन एंटी फंगल, एंटी बैक्टीरियल है वहीं इसमें एस.एल.ई.एस. व एस.डी.एस. तथा मिनरल ऑयल का उपयोग नहीं किया गया है।

इससे पहले कांगड़ा चाय उत्पादक संगठन के अरुण ठाकुर तथा को-आप्रेटिव टी फैक्टरी के अध्यक्ष राजेंद्र ठाकुर ने कांगड़ा चाय के समक्ष उभरी चुनौतियों से अवगत करवाया तथा बताया कि संस्थान द्वारा चाय के क्षेत्र में मशीनीकरण का लाभ उत्पादकों को प्राप्त हो रहा है। यद्यपि उन्होंने इस मशीन की उपलब्धता के आर्थिक पक्ष को लेकर अपना पक्ष भी रखा। उन्होंने प्रदेश में चीड़ के वृक्षों के स्थान पर कांगड़ा का विस्तारीकरण करने को लेकर अपना पक्ष भी रखा। उन्होंने तर्क दिया कि चाय को पौध

सीएम–विस अध्यक्ष तक पहुंचा आईएचबीटी का हैंड सेनेटाइजर

कार्यालय संवाददाता - पालमपुर

पालमपुर स्थित सीएसआईआर–आईएचबीटी द्वारा विकसित हैंड सेनेटाइजर राज्य और बाहर विभिन्न एजेंसियों एवं अधिकारियों को वितरित किया जा रहा है। सेनेटाइजर को डीसी राणा, विशेष सचिव राजस्व व आपदा प्रबंधन के माध्यम से मुख्यमंत्री को सौंपा गया। सीएसआईआर–आईएचबीटी के निदेशक डा. संजय कुमार के अनुसार सेनेटाइजर सिविल अस्पताल पालमपुर को दिया गया के कार्यालयों तथा विधानसभा के स्पीकर को भी दिया गया है। संस्थान द्वारा विकसित अल्कोहल आधारित हैंड सेनेटाइजर में सक्रिय चाय घटक व प्राकृतिक सुगंधित तेल हैं तथा यह उत्पाद पैराबेंस, ट्राइक्लोसन, फथलेट्स और सिंथेटिक सुगंध से मुक्त है। इसमें अल्कोहल की मात्रा विश्व स्वास्थ्य संगठन के दिशानिर्देशों के अनुसार है। संस्थान ने इसके उत्पादन हेतु प्रौद्योगिकी को मेसर्ज, बी साइंटिफिक

खुशबूदार सैनिटाइजर में अल्कोहल, लेमन ग्रास समेत कई चीजों का मिश्रण

आईएचबीटी ने बनाई हैंड सैनिटाइजर की तकनीक

सीएसआईआर-आईएचबीटी में अटल विज्ञान पर्व में विज्ञान से राष्ट्र निर्माण

आत्मनिर्भर भारत में हींग-केसर का अहम रोल

दैनिक जीवन में वैज्ञानिक दृष्टिकोण अपनाने की जरूरत

पालमपुर, 26 नवम्बर (भृगु): हिमालय जैव संपदा प्रौद्योगिकी संस्थान पालमपुर में छठे भारतीय अंतर्राष्ट्रीय विज्ञान महोत्सव का एक पूर्व-भूमिका समारोह का एम.एस.-टीम के माध्यम से आयोजन किया गया। आई.एच.बी.टी. पालमपुर के निदेशक डा. संजय कुमार ने समारोह में उपस्थित अतिथियों और प्रतिभागियों का स्वागत करते हुए विज्ञान पर्व के महत्व के बारे में बताया। डा. संजय कुमार ने विज्ञान को बढ़ावा देने के लिए संस्थान द्वारा किए जिज्ञासा, विज्ञान मेले एवं प्रदर्शनियों, वैज्ञानिक-छात्र-अध्यापक संपर्क कार्यक्रमों, वैज्ञानिकों द्वारा स्कूलों में लोकप्रिय वैज्ञानिक संभाषण द्वारा विज्ञान के प्रति जिज्ञासा उत्पन्न करने, किसानों एवं उद्यमियों को वैज्ञानिक तकनीकों का प्रशिक्षण जैसे प्रयासों का विवरण दिया। इसके अतिरिक्त संस्थान की प्रमुख उपलब्धियों एवं गतिविधियों की जानकारी भी दी।

इस मौके पर डा. शेखर सी. मांडे सचिव वैज्ञानिक और औद्योगिक अनुसंधान विभाग एवं महानिदेशक वैज्ञानिक और औद्योगिक अनुसंधान परिषद नई दिल्ली ने कहा कि विज्ञान को लोकप्रिय बनाने एवं जन-जन तक पहुंचाने में भारतीय अंतर्राष्ट्रीय विज्ञान पर्व का बहुत अधिक महत्व है। इसके लिए उन्होंने भारतीय अंतर्राष्ट्रीय विज्ञान महोत्सव के योगदान एवं भूमिका पर प्रकाश डाला। समारोह के मुख्यातिथि डा. अनिल प्रकाश जोशी संस्थापक हिमालयन पर्यावरण अध्ययन और संरक्षण संगठन देहरादून उत्तराखंड ने ग्रामीण भारत की दशकों तक उपेक्षा पर चिन्ता व्यक्त करते हुए बताया कि भारत आत्मनिर्भर तभी हो सकता है जब हम अपने ग्रामीण भारत को इसमें शामिल करेंगे।

डा. अनिल कौल उपाध्यक्ष एवं प्रमुख ग्लोबल पब्लिक हैल्थ एंड डिस्कवरी रिसर्च, जॉनसन एंड जॉनसन ने स्वास्थ्य के क्षेत्र में विज्ञान और प्रौद्योगिकी की भूमिका विषय पर अपनी प्रस्तुति में विषाणु रोगों के निवारण में दवा निर्माण के क्षेत्र में किए गए कुछ नवोन्मेष अनुसंधान के बारे में विवरण प्रस्तुत किया।

सीएसआईआर-आईएचबीटी ने टांडा अस्पताल में स्थापित किया क्यूआरटी-पीसीआर उपकरण

● टांडा मैडीकल कालेज में कोविड-19 के तेजी से परीक्षण में मिलेगी सुविधा

Participants attend the programme on Saturday. TRIBUNE PHOTO

'Vigyan Yatra' marks online science fest

PALAMPUR, DECEMBER 5

The "Vigyan Yatra" programme under the 6th Indian International Science Festival (IISF-2020) was organised through MS-Team and YouTube today at CSIR-Himalayan Institute of Bioresource Technology, Palampur.

Dr Sanjay Kumar, Director, CSIR-IHBT, said the introduction of 'heeng' and saffron crops in the state would be a milestone to make self-reliant India. He said the institute had played an important role in strengthening the economy of farmers by introducing apple cultivation in Mizoram and north-eastern states of the country.

Kumar informed the audience about the efforts of the CSIR-IHBT in cultivating aromatic crops and installing aromatic oil extraction units across the state, which led to Himachal emerging as the largest producer of wild marigold oil in the country.

The institute developed food products enriched in iron, protein and fiber, vitamin-D enriched Shittake mushroom for combating malnutrition. It also developed a technology of alcohol-based hand sanitizer and herbal soap. — OC

हिमालयन जैव प्रौद्योगिकी संस्थान पालमपुर ने भी दिया योगदान

फूड के पैकेट देते संस्थान के अधिकारी।

पालमपुर, 13 अप्रैल (गोपाल सूद) : हिमालयन जैव प्रौद्योगिकी संस्थान पालमपुर ने आज एक हजार सैनिटाइजर, 100 रिफिल सेनिटाइजर तथा 1500 रेडीमेड खाने के पैकेट एसडीएम पालमपुर धर्मेश रामोत्रा को सौंपे। एसडीएम ने आईएचबीटी के निदेशक, संजय कुमार का संकट की घड़ी में बहुत बड़ी सहायता के लिए आभार प्रकट किया। उन्होंने कहा कि इस खाने के पैकेट में एक आदमी के लिये भरपूर भोजन है। उन्होंने कहा कि इन फूड पैकेट का उपयोग कोरोना के विरुद्ध फ्रंट लाइन पर लड़ाई लड़ रहे योद्धाओं के लिए भोजन के रूप में हो सकेगा। उन्होंने कहा कि पालमपुर के लोगों का

चम्बा की समस्याओं एवं चुनौतियों पर चर्चा

● चम्बा जिला के विकास के लिए सीएसआईआर-आईएचबीटी व उपायुक्त बीच समझौता ज्ञापन

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आइएचबीटी में मनाया अं

संवाद सहयोगी, पालमपुर : सीएसआइआर (वैज्ञानिक एवं औद्योगिक अनुसंधान परिषद) के हिमालयन जैवसंपदा प्रौद्योगिकी संस्थान (आइएचबीटी) पालमपुर में वीरवार को अंतरराष्ट्रीय चाय दिवस को वीडियो कांफ्रेंस के माध्यम से मनाया गया। इसमें चाय बागान मालिकों, विभागीय उपनिदेशक, कर्मचारियों, उद्यमियों, प्रौद्योगिकी भागीदारों और संस्थानों के वैज्ञानिकों व कर्मचारियों ने भाग लिया। सदस्य सचिव, एचपी काउंसिल फॉर साइंस, टेक्नोलॉजी एंड एनवायरनमेंट और निदेशक सह विशेष सचिव, एचपी सचिवालय डीसी राणा ने बतौर मुख्य अतिथि शिरकत की। संस्थान

आइएचबीटी व कृषि विभाग संयुक्त रूप से करेंगे केसर व हींग की खेती

महत्वपूर्ण करार पर हस्ताक्षर कृषि आय और ग्रामीण विकास के दिखेंगे उद्देश्य

छह से सात टन होता है औसत उत्पादन

सीएसआईआर-आईएचबीटी में सतर्कता जागरूकता सप्ताह का शुभारंभ, विकास कार्यों की भी होगी समीक्षा

विक्रेताओं के लिए 'वेंडर समागम'

परिकल्पना: 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, नवोन्मेष, विकास एवं प्रसार

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

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