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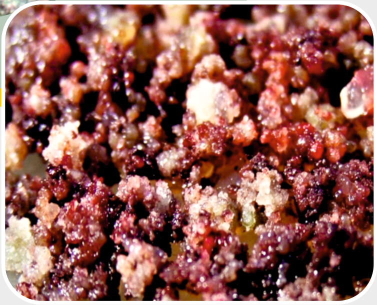
वार्षिक प्रतिवेदन
Annual Report
2022 - 23

Production in a bioreactor



Callus

Natural colour from *Arnebia euchroma*

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

सीएसआईआर
CSIR
भारत का नवाचार इंजन
The Innovation Engine of India

CSIR-IHBT INDIA 1983
उज्जवल भविष्य का नवोन्मेष हब
Innovation Hub for Better Tomorrow

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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ISSN-0971-8842

वार्षिक प्रतिवेदन
Annual Report
2022-23

With Best Compliments from

Dr. Sudesh Kumar Yadav
Director

सीएसआईआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान
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पालमपुर–176 061 (हि.प्र.) Palampur-176 061 (H.P.)

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CONTENTS

सीएसआईआर–आईएचबीटी का अवलोकन

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

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

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

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

श्री नरेन्द्र मोदी
माननीय प्रधानमंत्री भारत
अध्यक्ष, सीएसआईआर

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

डा. (श्रीमती) एन. कलैसेल्वी
सचिव, डीएसआईआर एवं महानिदेशक, सीएसआईआर

अनुसंधान परिषद → **निदेशक** ← **प्रबन्ध परिषद**

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- अतिथिगृह एवं छात्रावास
- प्रयोगिक फार्म

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Hon'ble Prime Minister of India
President, CSIR

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Minister of State for the Ministry of Science and Technology and Ministry of Earth Science and Minister of State for Prime Minister's Office; Personnel, Public Grievances and Pensions; Department of Atomic Energy and Department of Space
Vice President, CSIR

Dr. (Mrs.) N. Kalaiselvi
Secretary DSIR
& Director General, CSIR

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- Biotechnology
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- Dietetics & Nutrition Technology
- Environmental Technology

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

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

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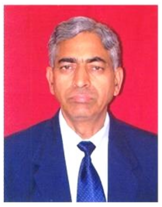
MEMBERS



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(1^{st} March, 2023 to 31^{st} March, 2023)
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Bioresource Technology,
Palampur– 176061 (HP)

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Director
(1st April, 2022 to 28th Feb, 2023)
CSIR-Institute of Himalayan
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Palampur– 176061 (HP)

Dr. Prabodh Kumar Trivedi
Director (Additional Charge)
(1st March, 2023 to 31st March, 2023)
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Palampur– 176061 (HP)

Sh. Yash Pal
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CSIR-Institute of Himalayan
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Palampur– 176061 (HP)
(01.04.2022 to 26.12.2022)

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Palampur– 176061 (HP)

Sh. B. P. Saw
Administrative Officer
CSIR-Institute of Himalayan
Bioresource Technology,
Palampur– 176061 (HP)
(01.04.2022 to 12.01.2023)

IMPRESSIONS

Date	Name & Address		Remarks
6/4/22	Datuk Zainal Abidin b. Abu Hassan Sec. Gen. MOSTI, Kuala Lumpur		Thank you ICSR-IHBT for warmest hospitality and sharing ideas for the benefit of community and prosperity of the world community Director, Dr Sanjay Kumar has always there to greet us and humble enough to ensure our visit very meaningful and full of memory. Hopefully the cooperation between Malaysia & India will prosper.
6/4	Anil Gupta ex GIAN, Ahmedabad CSIR Bhatnagar fellow (18-21)	9825014437	What a confluence of high science & community connect! I and my colleagues Anamika, CEO GIAN & Chetan, Secy SRISTI are immensely inspired to reconnect with the 'sahajbhav' with which grassroots innovators for J&K, Himachal & Punjab were received & assured all help. Looking forward to a closer relationship. Malaysian delegation from MOSTI is deeply appreciative of scientific rigour & social commitment of CSIR-IHBT. May you succeed in the your mission for the country's progress & global good
29.06.22	Prof. Shashi Kumar Dhiman Vice chancellor Himachal Pradesh Tech University Hamirpur	82196-76674	It is found that Himalayan Institute of Bioresource Technologies striving very hard to develop scientific technologies relating to organic farming, water management, Animal Health, rural Education ... and transferring these technologies successful to farmer of the country, particular the farmer of HP specially in tribal areas. It is excellence Institute of CSIR helping the poor farmer of the Himalayan region to enrich their incomes. Under Unnat Bharat Abhiyan scheme of GoI, IHBT has made great success, so I congratulate the Director, scientific staff and other staff. 29/06/22

Date	Name	Phone	Remarks
29/06/22	Praveen Ramadas. Secretary Vijnana Bharati New Delhi	9599432201	Really it was a great experience. This is my first visit to CSIR-IHBT Palampur. During my first visit I was introduced to lot of technologies developed by this lab for the farmers & Artisans. Felt elated hearing new initiatives in NER Region. The campus is very beautifully maintained the greenery is really mind blowing.
29.06.2022	Dr Ashwani Rana	70186-54558	I visited IHBT for the first time and got impressed. This institute is doing well under the leadership of Dr Sanjay K. Singh, Director IHBT. This institute is disseminating the technology to the rural people thereby really fulfilling the dream of our Honourable Prime Minister Under Unnat Bharat Abhiyan. Well done IHBT and more innovations are expected in the time ahead. Ashwani 29/6/2022
29.06.2022	Prof. Ranjana Aggarwal Director, CSIR-NIScPR New Delhi	9896740740	Huge compliments to CSIR-IHBT for holding the two days event of showcasing CSIR technologies for creation of livelihood for rural sector being organized by CSIR-NIScPR-UBA-VIBHA at your Campus. Under the dynamic leadership of Dr. Sanjay Kumar Director CSIR-IHBT, institute is identifying the issues which need scientific interventions and providing sustainable solutions. Campus is amazingly beautiful, people are warm and hospitality is awesome!! Once again congratulations to Dr Sanjay Kumar & his team for connecting Society with science. Ranjana 29/6/2022

2nd July '22	T. RAMASAMI, FORMER SECRETARY MINISTRY OF SCIENCE & TECHNOLOGY & DISTINGUISHED PROFESSOR OF EMINENCE ROOM NO 304, TECHNOLOGY ENABLING CENTRE, ACTECH CAMPUS ANNA UNIVERSITY, CHENNAI 600025	9940625329	It has been a pleasure to revisit IHBT after a lap of 10 years. What a transformational change that the Institute has undergone. I met some motivated young people full of energy and enthusiasm. I am truly moved and touched by what I experienced on the 40th foundation day of IHBT. The path travelled by so far has been eventful. The Institute bears the responsibility to emerge as the path finder for Sustainable Bioeconomy of Indian Himalayan Region. I am positive that the Institute would walk the path and make a defining contribution to Nation Building. Ramasami 2/7/22
4th July '22	B. Chandrasekaran, Former Director & Distinguished Scientist, CSIR-CLRI, Adyar, Chennai - 600 020	9840755655	It has been a rewarding experience of witnessing sea of transformation, since my last personal visit in 2017. Interaction with young, bright and committed personnel of IHBT becoms a more impactfull growth for the Institute. I see great potential for the Institute and the staffs making larger impacts on the Society blonging to IHR. I wish IHBT grow & glow in the National & International space from Ruby to Gold to Diamond and much beyond! B. Chandrasekaran 4/7/22
05/08/22	Prof. S.P. Bansal Vice-Chancellor, CUHP & HPU	9418141389	I am really impressed by the innovative and community approach which is adopted by the Institute under the able and dynamic guidance/personality of the Director, Prof. Sanjay Ji. The joint collaboration today signed between CUHP and IHBT will write new chapter and definitely fruitful for both the Institutes. My Best wishes for all future endeavours. 5/8/22

29.10.2022	Sridevi A. Singh CSIR-CFTRI	9449809946	Thank you for great hospitality. Wonderful and very cordial young team IHBT under the vibrant leadership of Director, Dr. Sanjay Kumar. Wish the institute a great future in contributing to India's growth. Sridevi Annapurna S.
29 OCT 2022	SRIDEVI JADE CSIR-4PI	9449065325	Excellently organised conference under the guidance of Director, IHBT. Very young, vibrant & enterprising team of IHBT made sure that it was a success. My best wishes to
29th oct 2022	Bhaskar Narayan, CSIR-IITR		Thank you for the excellent hospitality and the tremendous team work of CSIR-IHBT!! Kudos Dr. Sanjay for being the gracious host and a life time opportunity for meeting HH Dalai Lama!! My best wishes to Team-IHBT. Best 29/X
27th oct	K.J. SREERAM CSIR-CLRI		A wonderful opportunity to see the contributions of IHBT to the society, their professionalism and dedication. Great going Sreeram
29th Oct.	Prof. Manoranjan Parida, Director, CSIR-CRRI		This is my first visit to Palampur and must complement entire IHBT Team including Dr. Sanjay Kumar for the excellent arrangements for the Director's Conference 2022. All meeting sessions were very pleasing experience. The special arrangement of 'Audience with His Holiness Dalai Lama' is once in a life time opportunity. Need to mention Mr. Aman Kumar, Doctoral Candidate who was always with me as a local guide for all his kind assistance. Wish the IHBT to prosper and grow 29.10.2022

29/10/22	Dr Kannan Srinivasan CSIR-CSMCRI Bhavnagar, Gujarat, India.	0278-2569496	It was pleasure to be at Palampur for Directors' Conference. The arrangements made at the conference led by Dr. Sanjay, Director, IHBT has been amazing. His team deserves a special appreciation. The discussions at the conference is enriching & thought provoking. I wish Team CSIR-IHBT a great future.
29/10/22	Dr. SANJEEV KHOSLA CSIR-IMTECH	9999952300	It is always a pleasure visiting the Institute. ~~The~~ The cutting-edge science with societal relevance is a hallmark of IHBT and I wish them all the best for further successes in the future.
29/10/22	Dr Pradip K. Banerjee CSIR-CIMFR, Dhanbad	8108705596	Excellent experience! First time attended the CSIR Leadership conference & found it very informative & educating. A great platform for initiating networking & collaborating among the CSIR Labs. The hospitality of CSIR-IHBT was superb! Thank you.
29/10/22	Dr. ASHISH LELE CSIR-NCL & CSIR-NIIST	9960065550	Wonderful hospitality by IHBT team! I hope this Director's conference is a beginning of the effort to identify & focus on a few large & ambitious projects, which are carefully crafted by having insiders & outsiders inputs, and managed/executed with professional managers
29/10/22	R. SANKARANARAYANAN CSIR-CCMB, HYDERABAD	9866497744	Excellent hospitality that helped to have fantastic scientific deliberations. Thanks a lot for this!
29/10/22	Abhay Pashilkar CSIR-NAL, Bangalore	9449649393	I am overwhelmed by the warmth and hospitality received ~~by~~ from the entire IHBT team. The natural beauty is an added bonus. Thank you and best wishes for the future!
29/10/22	A·N·VAIDYA CSIR-NEERI, NAGPUR	9860201457	Excellent & scenic location ~~More excell~~ Moreover, excellent IHBT & its contribution to science & society, added with unparalleled hospitality. Kudos. Thank you & best wishes.

29/10/22	Arun Bandyopadhyay	9433516720	Outstanding program and the hospitality enjoyed during Director's conference arranged by CSIR-IHBT. The outreach activity we experienced with the villagers has added huge value to the program. ~~[illegible]~~ The sincerety of the team IHBT is commendable. They deserve huge appreciation.
29/10/22	NETTEM V CHOUDARY CSIR-IICT, HYDERABAD	9611909337	Excellent arrangements and programs. Every thing is well organized, there is nothing more we could ~~asked~~ for. Highlight is visit to H.H. Dalai lama ji. Beautiful place, people, weather everything is ~~so~~ nice. Thanks to Director IHBT and team for such wonderful arrangements.
29/10/22	Dr. C S Gopinath Outstanding Sci, CSIR-NCL	7028557277	Excellent arrangements by IHBT for Director's Conference and the credit should go to the entire team of Organizers. Visit to HH Dalai Lama was really a icing on the cake and heartfelt thanks for that. Wish all the best to IHBT and all the staff & students of IHBT.
29/10/22	Dr. Ram Vishwakarma Distinguished Scientist ~~CSIR~~ CSIR/CDRI	94191 82833	Excellent hospitality
29/10/22	Radha Rangarajan Director, CDRI	9005 44926	Excellent hospitality Beautiful ambience and great food! The organization of the activities and meetings was excellent. Special thanks to Dr Sanjay + team.
29/10/2022	Dolly Chaudhary Head(IT), CSIR HQs.	9818623573	Excellent Hospitality good food.
29/10/2022	KISHORE SREENIVASAN HEAD CSIR-URDIP, PUNE		EXCELLENT ARRANGEMENTS AND DELIBERATIONS
29/10/2022	VIBHA MALHOTRA SAWHNEY, CSIR Hqrs	9313627287	Excellent arrangements for the Conference. Congrats!

29/10/2022	N. KALAISELVI, DG, CSIR		"A place for everything & Everything in its place" Nature has blessed IHBT abundantly leadership, Team IHBT & Scholars added value to an appreciable extent "A role model lab to prove better centre-State relationship & Science for common man"
29/10/2022	Venu Gopal Achanta Director, CSIR-NPL		IHBT is in a place close to paradise. Staff are very friendly and eager to explain their work. Their hospitality is unparalleled. The breadth of work going on is excellent and the quality is outstanding.
29/10/2022	Prabodh Kumar Trivedi Director, CSIR-CIMAP, Lucknow		Thanks for organizing CSIR Directors' Conference 2022 in CSIR-IHBT. Beautiful place with unparalleled hospitality. Team CSIR-IHBT ~~is~~ very helping and welcoming. Keep the scientific temperament on top.
29/10/22	Dr Geetha Vani Rayasam. Head - HRDG.		Beautiful Location, friendly people, great hospitality and thank you for the excellent arrangements. A unique institute contributing immensely to national, regional and international S&T.
29/10/2022	Prof. Sunil Kumar Singh DIRECTOR, NIO, GOA	9607017855	It is great to such a fantastic director meeting. Great arrangements are made. Visit to village site was nice opportunity to visualise IHBT spread. Wishing you all the best for future endevour.
29/10/2022	Dr. Avanish Kumar Srivastava Director, AMPRI, Bhopal & Director (additional charg), NML, Jamshedpur	9891984027	Very important, informative and fruitful meeting. Many important discussions took place for future direction.
29/X/2022	Dr Purnima Rupal, Head - SCDD CSIR-Hqrs N. Delhi	9560908234	Excellently co-ordinated meetings led by Director, IHBT & his Team. Special Thanks for arranging the visit to H.H. Dalai Lama ji.

Date	Name & Address		
29/10/22	R.P. Singh, Head, IMD, CSIR Hqrs, New Delhi	9871824120	Excellent organization of CSIR-Directors' Conference-2022. Unparallel hospitality provided by Director and staff of CSIR-IHBT. Institute is doing well scientifically and has come out with many products. All the best for future!
29/10/2022	Prof. Ranjana Aggarwal Director CSIR-NISCPR New Delhi	9896740740	Sincere thanks to CSIR-IHBT for making excellent arrangements for the Director's conference. Everything is so well-organized and excellently managed. I would like to congratulate Director, Dr. Sanjay Kumar & his team particularly young researchers for taking care & warm hospitality Ranjana
29/X/22	Dr. PC Panchariya, CSIR-CEERI Pilani	9414743122	It has been a great event organized by the Dr. Sanjay Kumar ji. Great hospitality & nice arrangement. Great pleasure to be the part of meeting & we wish all the best.
29/10/22	Anjan Ray, CSIR-IIP	9818994186	Himalayan height of hospitality! Always special to visit here. Superb team effort & coordination.
29/10/22	Dr. Suman Kumari Mishra Director, CSIR-CGCRI CSIR-CMERI	9801541664	Very high quality work on societal and new plant species. I congratulate the team & leadership. Very warm hospitality at each stage. Thank you & wish many successes.
29/10/2022	N. ANANDAVALLI, Director, CSIR-SERC	9841691062	Very much impressed by their societal and new plants to our country, such as hing, tulip and empowering young enterprenuers. Equally impressed with their hospitality. Congratulations to Director and team CSIR-IHBT.

29/10/22	Vinay Kumar Nandicoori CCMB Director	Thank you. IHBT hospitality is unmatched. Thanks you for taking care of very small details to overall organization. Memorable experience. Look forward to future visits.
29/10/2022	Viswajanani J Sattigeri Head, CSIR-TKDL Unit	It's been a very memorable 3 days at CSIR-IHBT for the Directors' Conference. The coordination, hospitality and the conference arrangements are indeed exemplary. The highlight personally for me was the interaction with HH Dalai Lama. It's a dream come true for me, to have his blessings in person. I thank the Director and his team of CSIR-IHBT staff for this wonderful time at Palampur, Dharamsala and other places we visited. Best wishes to the team under the able leadership of Dr. Sanjay Kumar.

Date	Name & Address	
29/10/2022	Virendra M. Tiwari Director, CSIR-NGRI.	Knowing about IHBT, in detail now is great pleasure. So many Himalayan resources are being utilized for benefit of people through several programs. Stay during Director's conference is wonderful experience. Thanks to Director and all involved for this. Scientific program shown to us are very impressive. Congratulations & best wishes for many more achievements.

16/12/2022	A S Raghavendra Univ of Hyderabad		Quite impressed with the extensive work and its great relevance to farmers and the region. Wish the Director, Scientists, students and the staff all the best. A S Raghavendra
20/12/2022	T. Mohapatra ICAR, New Delhi		My first visit to the institute as part of RC was very enriching and quite successful. The overall progress is very impressive. The outreach activities undertaken by the institute are rewarding for all concerned. I had fruitful interactions with the scientists and Research Scholars. The dynamism of the leadership of the institute is visible. Hearty Congratulations for the excellent performance. My best wishes for success in future. [signature] 20/12/2022

निदेशकीय प्रतिवेदन

पिछला वर्ष संस्थान के लिए अत्यंत उल्लेखनीय रहा जिसमें समाज के लिए कई नए उत्पादों और प्रौद्योगिकियों का लोकापर्ण किया गया। मुझे वर्ष 2022–2023 के लिए सीएसआईआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान (सीएसआईआर–आईएचबीटी) की मुख्य उपलब्धियों को प्रस्तुत करते हुए अनंत हर्ष हो रहा है। हमारा संस्थान एससीआईमैगो रेटिंग के अनुसार सीएसआईआर के शीर्ष संस्थानों (सर्वोत्तम चतुर्थक, Q1) में लगातार बना हुआ है, यह बहुत ही प्रेरणादायक है। सीएसआईआर–आईएचबीटी का उद्देश्य सामाजिक, औद्योगिक, पर्यावरणीय, अकादमिक हित हेतु हिमालयी जैवसंपदा से प्रक्रमों, उत्पादों और प्रौद्योगिकियों की खोज, नवोन्मेष, विकास एवं प्रसार करना है। पिछले वर्ष की महत्वपूर्ण गतिविधियों एवं प्रगति का संक्षिप्त विवरण निम्नानुसार है।

सीएसआईआर–आईएचबीटी द्वारा इस वर्ष तीन प्रमुख मिशन मोड परियोजनाएं कार्यान्वित की गईं। वर्ष 2022–23 के दौरान, सीएसआईआर–अरोमा मिशन कार्यक्रम में सगंध फसलों की खेती का क्षेत्र 3000 हेक्टेयर तक बढ़ा दिया गया, किसानों के प्रक्षेत्रों में सत्रह अतिरिक्त आसवन इकाइयाँ (कुल 61 इकाइयाँ) स्थापित की गईं, जिसके माध्यम से कृषक समूहों को उनकी फसलों की उपज से सगंध तेल के उत्पादन में सशक्त बनाया गया। हिमाचल प्रदेश राज्य में लगभग 8.0 टन उच्च गुणवत्तायुक्त सगंध गेंदा (टैजेटिज) तेल का उत्पादन किया गया, जिससे ₹ 11.2 करोड़ रुपये का राजस्व प्राप्त हुआ तथा लगभग 2000 किसान लाभान्वित हुए। इस अवधि के दौरान, 3121 किसान, बेरोजगार युवा एवं उद्यमी सगंध फसलों की खेती, प्रसंस्करण तथा मूल्य संवर्धन में भागीदार रहे। कुल मिलाकर, सगंध फसलों की सात नई किस्में विकसित की गईं। सगंध फसलों की खेती के लिए तेरह कृषि प्रौद्योगिकियों को भी मानकीकृत किया गया। वर्ष 2022–23 में सगंध तेलों की बिक्री से ₹ 19.86 करोड़ राजस्व प्राप्त हुआ।

सीएसआईआर–फ्लोरीकल्चर मिशन के अंतर्गत, अप्रैल 2022 से मार्च 2023 तक पुष्प खेती और मूल्य संवर्धन प्रौद्योगिकियों पर अट्ठाईस जागरूकता एवं प्रशिक्षण कार्यक्रम आयोजित किए गए और 700 से अधिक बेरोजगार युवाओं, ग्रामीण महिलाओं तथा किसानों को प्रशिक्षित किया गया। पुष्प खेती के लिए 249.90 हेक्टेयर क्षेत्र तक विस्तार किया गया, जिससे 649 किसान लाभानवित हुए और ₹ 10.68 करोड़ के राजस्व प्राप्ति की संभावना है। इस मिशन के अन्तर्गत हिमाचल प्रदेश, उत्तराखंड, पंजाब और केंद्र शासित प्रदेशों जम्मू–कश्मीर और लद्दाख के किसानों को कॉर्म और जड़ युक्त पौधों के रूप में पुष्प फसलों की पंद्रह लाख रोपण सामग्री तैयार कर वितरित की गई। वर्ष के दौरान फ्लोरीकल्चर मिशन के मुख्य आकर्षणों में से एक हिमाचल प्रदेश में ट्यूलिप गार्डन की स्थापना रही, हिमाचल प्रदेश के माननीय मुख्यमंत्री श्री सुखविंदर सिंह सुक्खू ने 9 मार्च, 2023 को सीएसआईआर–आईएचबीटी परिसर में अपनी यात्रा के दौरान इसका भ्रमण किया तथा इसमें गहरी रुचि भी दिखाई। यह हिमाचल प्रदेश का पहला ट्यूलिप गार्डन है जिसमें संस्थान द्वारा लाहौल के शीत मरूस्थलीय क्षेत्रों में उगाए गए 45,000 ट्यूलिप बल्बों का उपयोग करके इसे विकसित किया गया। सीएसआईआर–आईएचबीटी के इस ट्यूलिप गार्डन में इस वर्ष 70,000 से अधिक पर्यटक आए और सोशल मीडिया पर इसे बीस लाख से अधिक बार देखा गया।

शहद उत्पादन के माध्यम से किसानों की अतिरिक्त आय को बढ़ावा देने के लिए, अब फ्लोरीकल्चर मिशन के अंतर्गत मधुमक्खी पालन को व्यापक रूप से बढ़ावा दिया जा रहा है। इस वर्ष के दौरान, विभिन्न किसान समूहों को मधुमक्खी पालन किट के साथ 1400 बी–हाइव बक्सों की आपूर्ति की गई।

सीएसआईआर मिशन "स्वास्थ्य और कल्याण के लिए पोषण और न्यूट्रास्यूटिकल्स के इम्यूनोमॉड्यूलेटरी फंक्शन" के अंतर्गत इम्यूनोमॉड्यूलेटिंग न्यूट्रास्यूटिकल्स तथा स्वास्थ्य पूरक प्रदान करने के

लिए, सीएसआईआर–आईएचबीटी ने मिशन के नोडल संस्थान के रूप में कार्य किया। प्रतिरक्षा को बढ़ावा देने के लिए देश भर में पारंपरिक ज्ञान पर आधारित न्यूट्रास्यूटिकल उत्पादों की एक श्रृंखला विकसित की गई। इसके अतिरिक्त, उपास्थि स्वास्थ्य, विटामिन डी की कमी, हृदय स्वास्थ्य और वृद्धों से जुड़े न्यूरोडीजेनेरेशन के लिए न्यूट्रास्यूटिकल्स को मान्य करने के लिए मानव हस्तक्षेप अध्ययन मूल्यांकन किए गए हैं। इस मिशन के अंतर्गत, स्थानीय फलों और सब्जियों की साक्ष्य–आधारित इम्यूनोमॉड्यूलेटरी क्षमता का दस्तावेजीकरण करने के लिए एक डिजिटल पोर्टल भी विकसित किया गया है।

भारत में वाणिज्यिक दृष्टि से हींग (*फेरूला एस्सा–फोएटिडा* एल.) शीर्ष मसालों और औषधीय पौधों में से एक है। देश में हींग की खेती को पौधशाला (50,000 पौधे उगाए गए), किसानों को रोपण सामग्री की आपूर्ति (2.18 हेक्टेयर क्षेत्र को खेती के अंतर्गत लाते हुए 14,536 पौधों की आपूर्ति की गई), किसानों का प्रशिक्षण (402 किसान) और हिमाचल प्रदेश, उत्तराखंड राज्यों एवं केंद्र शासित प्रदेशों जम्मू–कश्मीर तथा लद्दाख में किसानों तक बेहतर पहुंच के लिए कृषि अधिकारियों (56 अधिकारी) की क्षमता निर्माण के माध्यम से सुदृढ़ किया गया।

सीएसआईआर–आईएचबीटी और हिमाचल प्रदेश राज्य कृषि विभाग के संयुक्त सहयोग कार्यक्रम के अंतर्गत, केसर की खेती एवं उत्पादन को बढ़ावा देने के लिए किन्नौर, मंडी, चंबा, कांगड़ा और कुल्लू जिलों में 6 स्थानों पर किसानों को 3524 किलोग्राम केसर के कंदों की आपूर्ति की गई है।

वर्ष 2016 में सीएसआईआर–आईएचबीटी द्वारा उत्तर पूर्वी राज्यों में सेब की लो चिलिंग किस्मों की शुरुआत के बाद, इस वर्ष इन किस्मों का मिजोरम और मणिपुर राज्यों में आगे विस्तार किया गया है। सेब की खेती का कुल क्षेत्रफल अब बढ़कर 137.5 एकड़ हो गया है।

एक नई पहल के अन्तर्गत, सीएसआईआर–आईएचबीटी ने हिमाचल प्रदेश में दालचीनी (*सिनामोमम वेरम*) की व्यवस्थित खेती एवं प्रसंस्करण की शुरुआत की। हमारा देश श्रीलंका और वियतनाम समेत कई देशों से प्रति वर्ष ₹ 900 करोड़ की ~45,000 टन दालचीनी का आयात करता है, इसे देखते हुए एक पायलट परियोजना को शुरू किया गया है। हमने किसानों को गुणवत्तापूर्ण रोपण सामग्री की आपूर्ति की (37 स्थानों पर 9 हेक्टेयर क्षेत्र को कवर करते हुए 10000 पौधों की आपूर्ति की गई है)।

सीएसआईआर–आईएचबीटी पालमपुर को स्फूर्ति योजना के अंतर्गत क्लस्टर विकास के लिए दो नोडल एजेंसियों खादी एवं ग्रामोद्योग आयोग (केवीआईसी), मुंबई और एमएसएमई क्लस्टर फाउंडेशन (एफएमसी), नई दिल्ली को तकनीकी सहायता प्रदान करने के लिए नामित किया गया है।

उच्च–मूल्य वाले रसायनों के उत्पादन के क्षेत्र मे, हमने अनुपचारित बायोमास जैसे की मकई–भुट्टा, गन्नाखोई, चावल–भूसा, और मकई–भूसा को डाइमिथाइल कार्बोनेट (डीएमसी) विलायक मे दबावयुक्त हाइड्रोथर्मल स्टील रिएक्टर का प्रयोग करके एक–पॉट प्रक्रिया द्वारा सीधे 5–हाइड्रोक्सीमिथाइलफरफुरल और फरफुरल में परिवर्तित किया है।

जैव सूचना विज्ञान के क्षेत्र में काम करने वाले शोधकर्ताओं ने आर्टिफिशियलइंटेलिजेंस और मशीन–लर्निंग का उपयोग करके आधुनिक जीव विज्ञान की कुछ चुनौतीपूर्ण मौलिक अनुसंधान समस्याओं का समाधान किया। एक तरफ DeepPlnc सॉफ़्टवेयर विकसित किया गया, जिसने विभिन्न डेटासेटों के परीक्षण के दौरान 98% के सटीकता स्तर को तोड़ दिया, जो कि किसी भी मौजूदा सॉफ़्टवेयर द्वारा प्राप्त किया जाने वाला दुर्लभ स्कोर है। इसके अतिरिक्त, मौजूदा सॉफ़्टवेयर के विपरीत, DeepPlnc सॉफ़्टवेयर अधूरे अनुक्रमों में भी समान सटीकता के साथ प्रदर्शन करता है। हमारे वैज्ञानिक ने एक उन्नत वीएस फ्रेमवर्क विकसित किया है – स्वचालित हिट पहचान और अनुकूलन उपकरण (ए–एचआईओटी) में पहचान के लिए रासायनिक अंतरिक्ष–संचालित स्टैक्ड पहनावा और निश्चित प्रोटीन रिसेप्टर्स के लिए विशिष्ट हिट की एक श्रृंखला के अनुकूलन के लिए प्रोटीन अंतरिक्ष–संचालित गहन शिक्षण आर्किटेक्चर शामिल हैं। हमारी शोध टीम ने प्रोटीन–4 युक्त मानव ब्रोमोडोमैन के पहले ब्रोमोडोमैन के विरूद्ध संभावित अवरोधकों का सुझाव देने के लिए इन–हाउस प्लांट–व्युत्पन्न बेंजोसुबेरिन–सल्फोन अणुओं की भी जांच की। क्विनोलीन डेरिवेटिव

से बने हुए दूसरे सेट के अणुओं की V30M को स्थायी करने और प्रोटीन–लिगैंड इंटरैक्शन में लिगैंड बाइंडिंग के प्रभाव को समझने के लिए जांच की गई। इसके अतिरिक्त बहुस्तरीय (1000 एनएस) स्पष्ट विलायक और अंब्रेला सैंपलिंग मोलिक्यूलर डायनमिक का उपयोग बीटा–साइक्लोडेक्सट्रिन डेरिवेटिव और फॉर्मोनोनेटिन के मध्य समावेश यौगिक बनने के दौरान परस्पर क्रिया और उष्मागतिकी मापदंडो को जानने में किया गया।

हमारे पारिस्थितिक समूह ने, भारत में 84 वर्षों के अंतराल के बाद अरुणाचल प्रदेश के पूर्वी हिमालय का सर्वेक्षण करते हुए, एक संकटग्रस्त प्रजाति *मोरिना लुडलोवी* (एम.जे. कैनन) डी.वाई. हांग को फिर से खोज निकाला है। उन्होंने भारत से पहली बार *सैक्सीफ्रागा बर्जेनियोइड्स* सी. मार्क्वांड को भी एकत्रित कर इसकी रिपोर्ट की है। सीएसआईआर–आईएचबीटी भू–सूचना विज्ञान टीम और एसएसी (इसरो) ने जलवायु परिवर्तन के प्रभाव का अध्ययन करने के लिए आपसी सहयोग से हिमाचल प्रदेश के हमीरपुर के दियोटसिद्ध में बाबा बालकनाथ मंदिर में एक फेनोमेट प्रणाली स्थापित की है। चीड़ के जंगल की फेनोलॉजी पर जलवायु परिवर्तन के प्रभाव को समझने का यह अपनी तरह का पहला प्रयास है। पश्चिमी हिमालय के वन अग्नि हॉटस्पॉट को रिमोट सेंसिंग तकनीकों के द्वारा मैप किया गया है, जो अधिक ऊंचाई वाले क्षेत्रों की ओर आग के फैलाव का संकेत देता है। उन्होंने पारिस्थितिक मॉडलिंग के माध्यम से भारत में केसर (*क्रोकस सैटाइवस* एल) की खेती के लिए उपयुक्त गैर–पारंपरिक क्षेत्रों की पहचान भी की गई है। सीएसआईआर–टीकेडीएल पॉइंट–ऑफ–प्रेजेंस के द्वारा बनाई जा रही ट्रांस–हिमालय चिकित्सा प्रणाली (सोवा रिग्पा) को लक्षित करने वाले डेटाबेस में लगभग 600 नए रिकॉर्ड जोड़े गए। पौधों के संरक्षण पहलू को लक्षित करते हुए, हिमाचल प्रदेश में संकटग्रस्त औषधीय पौधे *डैक्टिलोराइजा हैटेजेरिया* के लिए सहायक उपनिवेशीकरण (एसी) क्षेत्रों की पहचान हेतु पारिस्थितिक मॉडलिंग की गई। इसके लिए राज्य में मौजूदा संरक्षित क्षेत्र नेटवर्क और इसकी वर्तमान और भविष्य के वितरण को मापदंड बनाया गया।

पिछले वर्षों की भांति निरंतरता में, 5 सितंबर 2022 को शोधार्थियों द्वारा 6वीं छात्र संगोष्ठी श्रृंखला का आयोजन किया गया जिसका विषय "विज्ञानमः भविष्य के जैव संसाधनों के विज्ञान की खोज, विकास और प्रसार" था। इस वर्ष श्रृंखला का आयोजन एक संगोष्ठी प्रारूप में किया गया, जहां मौखिक और पोस्टर प्रस्तुतियों के साथ–साथ, कलात्मक अनुसंधान के लिए वैज्ञानिक लेखन (एसडब्ल्यूएआर), वैज्ञानिक फोटोग्राफी और वैज्ञानिक मीम जैसे कार्यक्रम शामिल किए गए। परिणामस्वरूप, छात्र संगोष्ठी श्रृंखला –2022 को वैश्विक पहचान मिली। संस्थान के छात्रों के अतिरिक्त, सीएसआईआर–आईआईआईएम, जम्मू, शूलिनी विश्वविद्यालय, सोलन; पशुपालन विभाग, हिमाचल प्रदेश; चौधरी बंसीलाल विश्वविद्यालय, भिवानी; पंजाब विश्वविद्यालय, चंडीगढ़; भारतीय विज्ञान संस्थान, बैंगलोर; राष्ट्रीय पादप जीनोम अनुसंधान संस्थान, नई दिल्ली; क्षेत्रीय जैव प्रौद्योगिकी केंद्र, फ़रीदाबाद, एमिटी विश्वविद्यालय, नोएडा; नेशनल इंस्टीट्यूट ऑफ फार्मास्युटिकल एजुकेशन एंड रिसर्च, अहमदाबाद; पर्ड्यू स्कूल ऑफ इंजीनियरिंग एंड टेक्नोलॉजी, इंडियाना यूनिवर्सिटी–पर्ड्यू यूनिवर्सिटी, यूएसए; शंघाई सेंटर फॉर प्लांट स्ट्रेस बायोलॉजी, चीन; चेक एकेडमी ऑफ साइंसेज के वनस्पति विज्ञान संस्थान, चेक सहित राष्ट्रीय और अंतर्राष्ट्रीय संस्थानों के शोधार्थियों ने भी प्रतिभागिता की तथा अपना शोध कार्य प्रस्तुत किया। इसके साथ–साथ इस वर्ष सीएसआईआर–आईएचबीटी के पूर्व छात्रों को भी आमंत्रित किया गया था और तीन पूर्व छात्रों ने युवाओं को प्रेरित करने के लिए आमंत्रित व्याख्यान दिए। कार्यक्रम की अध्यक्षता हिमाचल प्रदेश केंद्रीय विश्वविद्यालय के कुलपति माननीय डॉ. सतप्रकाश बंसल ने की, जिन्होंने मुख्य भाषण भी दिया।

अनुसंधान, शिक्षा, उद्योग और समाज के बीच संबंध स्थापित करने की दिशा में अपने प्रयासों को जारी रखते हुए, संस्थान ने विभिन्न राष्ट्रीय और अंतर्राष्ट्रीय व्यापार मेलों और संगोष्ठियों में अनुसंधान उत्पादों और प्रौद्योगिकियों में भाग लिया और प्रदर्शित किया। हमारे वैज्ञानिकों ने 4.927 के औसत इंपेक्ट फैक्टर के साथ 236 शोध लेख प्रकाशित किए। संस्थान ने विभिन्न कृषि–संगठनों और शैक्षणिक अनुसंधान एवं विकास संस्थानों/विश्वविद्यालयों के

साथ समझौतों/एमओयू पर हस्ताक्षर किए। इसके अलावा, 13 प्रौद्योगिकी हस्तांतरण और कई सामग्री हस्तांतरण समझौते भी किए गए।

वैज्ञानिक सामाजिक उत्तरदायित्व गतिविधियों के अंतर्गत, आईएचबीटी ने छात्रों को विज्ञान में अपना कैरियर बनाने के लिए प्रेरित और प्रोत्साहित करने के लिए "जिज्ञासा 2.0 वर्चुअल प्रयोगशाला कार्यक्रम" के अंतर्गत विभिन्न गतिविधियों का आयोजन किया। इस वर्ष, विभिन्न सरकारी और निजी स्कूलों के कुल 6083 छात्रों और शिक्षकों ने इन गतिविधियों में भाग लिया। इसके साथ–साथ इस वर्ष के दौरान 08 विभिन्न राज्यों और केंद्रशासित प्रदेशों के विभिन्न विश्वविद्यालयों, संस्थानों और कॉलेजों के 1519 छात्रों और शिक्षकों ने संस्थान का दौरा किया।

वर्ष 2022–23 के दौरान, सीएसआईआर–एकीकृत कौशल पहल चरण–II, डीबीटी–हिमकोस्ट के कौशल विज्ञान कार्यक्रम, हिमाचल प्रदेश राज्य कृषि विभाग और स्व–प्रायोजित विभिन्न कौशल विकास कार्यक्रमों के अंतर्गत कुल 659 व्यक्तियों को प्रशिक्षित किया गया। इसके अतिरिक्त, विभिन्न विश्वविद्यालयों/कॉलेजों के छात्रों को व्यावहारिक प्रशिक्षण भी प्रदान किया गया।

सीएसआईआर–मुख्यालय, प्रबंधन परिषद, विभिन्न वित्त पोषण एजेंसियों और राज्य सरकार ने हमें वैज्ञानिक उत्कृष्टता प्राप्त करने, नई प्रौद्योगिकियों और उद्यमिता विकसित करने और सामाजिक/राष्ट्रीय दायित्वों का निर्वहन करने के लिए सहयोग और प्रेरणा के क्रम को जारी रखा। हम अपने संस्थान के अनुसंधान एवं विकास कार्यक्रमों के मार्गदर्शन में उनके महत्वपूर्ण और सकारात्मक योगदान के लिए अनुसंधान परिषद के प्रति अपना आभार व्यक्त करते हैं। हमारे वैज्ञानिकों और स्टाफ सदस्यों का वार्षिक प्रतिवेदन के लिए समय पर इनपुट देने में सराहनीय योगदान है तथा इसे समय रहते संकलित करने के लिए संपादकीय समिति के सदस्यों का भी विशेष आभार है। हम आर्थिक, वैज्ञानिक, औद्योगिक, सामाजिक और पर्यावरणीय मुद्दों पर वैज्ञानिक समाधान प्रस्तुत करके राष्ट्र निर्माण और विकास के लिए खुद को समर्पित करने के लिए प्रतिबद्ध हैं।

जय हिंद!

(सुदेश कुमार यादव)

FROM THE DIRECTOR'S DESK

The past year has been an eventful one for the institute, with several new products and technologies being released to the society. Hereby, I am delighted to present the salient achievements of the CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT) for the year 2022-2023. It was inspiring to note that the institute continues to be among the top institutes (best quartile, Q1) of CSIR as per the SCImago rating. The mission of CSIR-IHBT is to discover, innovate, develop and disseminate the processes, products, and technologies from the Himalayan bioresources for society, environment and academia. The following is a summary of the most important events and developments that have taken place over the past year.

CSIR-IHBT implemented three major mission mode projects this year. During 2022-23, the area under cultivation of aromatic crops was extended to 3000 ha in the CSIR-Aroma Mission program, seventeen additional distillation units were installed (overall 61 units) at farmers' fields, empowering farmer groups in the production of essential oil from their produce of aromatic crops. Nearly 8.0 tonnes of high grade aromatic marigold (Tagetes) oil was produced in the state of Himachal Pradesh leading to revenue generation of ₹ 11.2 crores and benefitting 2000 farmers. During the period, 3121 farmers, unemployed youth, entrepreneurs were involved in cultivation, processing and value addition of aromatic crops. Overall, seven new varieties of aromatic crops were developed while thirteen agrotechnologies for cultivation of aromatic crops were also standardized. The revenue generation through the sale of essential oils in 2022-23 was ₹ 19.86 crores.

Under CSIR-Floriculture Mission, Twenty-eight awareness cum training programmes on cultivation and value addition technologies of floricultural crops were conducted from April 2022 to March 2023 and more than 700 unemployed youth, rural women and farmers were trained. The area coverage of floriculture crops was extended to 249.90 ha benefitting 649 farmers with a potential of generating revenue worth ₹ 10.68 crores. Five lakh planting materials of floriculture crops in the form of corms and rooted plants were generated and supplied to the farmers of Himachal Pradesh, Uttarakhand, Punjab, West Bengal and union territories of Jammu & Kashmir and Ladakh as a part of the mission. One of the main attractions of the floriculture mission during the current year was the establishment of the Tulip Garden in Himachal Pradesh, which was visited by the Hon'ble Chief Minister of Himachal Pradesh, Shri Sukhvinder Singh Sukhu on 9th March, 2023, at CSIR-IHBT campus and evinced keen interest in it. This is the first Tulip garden in Himachal Pradesh where 45,000 tulip bulbs, raised by the institute in cold desert areas of Lahaul were used to develop it. More than 70,000 visitors came this year and ₹ 20 lakhs views on social media for the Tulip garden at CSIR-IHBT.

In order to boost additional income of farmers through honey production, apiculture is now being aggressively promoted under the floriculture mission. During this year, 1400 bee-hive boxes along with beekeeping kits were supplied to the various farmer groups.

Under the CSIR Mission of "Immunomodulatory Functions of Nutritionals and Nutraceuticals for Health and Wellness" to provide immunomodulating nutraceuticals and health supplements, CSIR-IHBT acted as the nodal institute of the mission. An array of nutraceutical products based on traditional knowledge were developed from across the country to promote immunity. In addition, human intervention studies of the nutraceuticals for cartilage health, vitamin D deficiency, cardiac health and aged-linked neurodegeneration were conducted. Under this mission, a digital portal is also developed to document the evidence-based immunomodulatory potential of native fruits and vegetables.

Heeng (*Ferula assa-foetida* L.) is one of the top spice and medicinal plant traded in India. Heeng cultivation in the country was strengthened in terms of the layout of nurseries (50,000 plants raised), supply of planting material to farmers (14,536 plants have been supplied covering 2.18 ha area), training of farmers (402 farmers) and capacity building of Agriculture Officers (56 officers) for better outreach of farmers in the states of Himachal Pradesh, Uttarakhand and Union Territories of Jammu & Kashmir and Ladakh.

Under the joint collaboration programme of CSIR-IHBT and the State Department of Agriculture, Himachal Pradesh for the cultivation of saffron, 3524 kg corms of saffron were supplied to farmers at 6 locations in Kinnaur, Mandi, Chamba, Kangra and Kullu districts to boost production of saffron.

Following the introduction of low-chilling varieties of apple in the North Eastern states by CSIR-IHBT in the year 2016, these varieties have further been extended this year in the states of Mizoram and Manipur. This year the total area under apples has now increased to 137.5 acres.

In a new initiative, CSIR-IHBT introduced organized cultivation and processing of cinnamon (*Cinnamomum verum*) in Himachal Pradesh. A pilot project was initiated with the background that India imports ~45,000 tonnes of cinnamon worth ₹ 900 crores annually from several countries including Sri Lanka and Vietnam. We supplied quality planting material to farmers (10000 plants have been supplied covering 9 ha area at 37 locations).

CSIR-IHBT Palampur has been designated to provide technical assistance for two nodal agencies *viz.* Khadi and Village Industries Commission (KVIC), Mumbai and the Foundation of MSME Clusters (FMC), New Delhi for cluster development under the SFURTI Scheme. Under the scheme, scientifically validated technologies developed at CSIR-IHBT, Palampur, such as "Vitamin D_2 enriched *shiitake* mushroom production and processing," "Efficient bacterial formulations for enriched compost in cold hilly region," are being implemented in the five clusters in rural areas of Sikkim and Himachal Pradesh. The clusters are aspiring to provide employment to 1150 beneficiaries. A new cluster at Chumoukedima, Nagaland has been sanctioned this year.

In the area of biomass utilization for high-value chemicals, a one-pot process has been developed for the direct conversion of untreated biomass (corn-cob, sugarcane bagasse, rice-straw, and corn-straw) into 5- hydroxymethylfurfural (HMF) and furfural (FF) synthesis in dimethyl carbonate (DMC) solvent conditions under a pressurized hydrothermal steel vial system.

Researchers working in the area of Bioinformatics addressed some of the challenging fundamental research problems in modern biology using artificial intelligence and machine-learning. At one side DeepPlnc software was developed, which breached the accuracy level of 98% while being tested across a huge volume of different datasets, a rare score ever achieved by any existing software. Also, unlike the existing pool of software, DeepPlnc can perform with equal accuracy even across incomplete sequences. Our scientist developed an advanced VS framework - automated hit identification and optimization tool (A-HIOT) comprises of chemical space-driven stacked ensemble for identification and protein space-driven deep learning architectures for optimization of an array of specific hits for fixed protein receptors. Our research team also screened in-house plant-derived benzosuberene-sulfone molecules to suggest potential inhibitors against the first bromodomain of the human bromodomain containing protein-4. A second set of molecules comprising quinoline derivatives were accessed to stabilize the V30M Transthyretin structure and analyze the impact of ligand binding on protein-ligand interactions. Moreover, multiscale (1000 ns) explicit solvent and umbrella sampling molecular dynamics simulations were employed to study the interactions and thermodynamic parameters of inclusion complex formation between formononetin and the five most commonly used Beta-cyclodextrin derivatives.

Our ecological group, while surveying the eastern Himalayas of Arunachal Pradesh, has rediscovered a threatened species *Morina ludlowii* (M.J. Cannon) D.Y. Hong after a gap of 84 years in India. They have also collected and reported *Saxifraga bergenioides* C. Marquand for the first time from India. The geoinformatics team of CSIR-IHBT and SAC (ISRO) joined hands to study the impact of climate change and has installed a PhenoMet system at Baba Balaknath Temple in Deotsidh, Hamirpur, Himachal Pradesh. This is first of its kind effort to understand the influence of climate change on phenology of Chir Pine forest. The Western Himalayan Forest fire hotspots were mapped using remote sensing techniques which indicated the progression of fires toward higher elevation regions. They have also identified suitable non-conventional niches for the cultivation of Saffron (*Crocus sativus* L.) in India through ecological niche modelling. Close to 600 new records were added to the database targeting the trans-Himalaya system of medicine (Sowa Rigpa) in the CSIR-TKDL point-of-presence. On the conservation aspect, ecological niche modelling was undertaken to locate suitable areas for Assisted Colonization (AC) areas in Himachal Pradesh for a threatened medicinal plant, *Dactylorhiza hatagirea*. The AC areas in the State were delineated taking into account the existing Protected Area network in the State and the current and future distribution on its populations.

In continuation to previous years, the 6th edition of student seminar series (SSS) was organized by the research scholars on 5th September 2022. The theme of the 6th edition was "*Vigyanam: Discover, Develop and Disseminate Science of Future Bioresources*". This year the SSS was organized in a symposium format where besides oral and poster presentations, events such as scientific writing for articulating research (SWAR), scientific photography, and scientific meme, were included. As a result, SSS-2022 got a global attention, and besides the students of CSIR-IHBT, students from national and international institutions, including CSIR-IIIM, Jammu; Shoolini University, Solan; Department of Animal Husbandry, Himachal Pradesh; Chaudhary Bansilal University, Bhiwani; Panjab University, Chandigarh; Indian Institute of Science, Bangalore; National Institute of Plant Genome Research, New Delhi; Regional Centre for Biotechnology, Faridabad, Amity University, Noida; National Institute of Pharmaceutical Education and Research, Ahmedabad; Purdue School of Engineering and Technology, Indiana University-Purdue University, USA; Shanghai Center for Plant Stress Biology, China; Institute of Botany of the Czech Academy of Sciences, Czech participated and presented their work. In addition, this year, alumni of CSIR-IHBT were also invited, and three alumni gave invited talks to motivate the young generation. The program was presided over by the honorable Dr. Satprakash Bansal, Vice Chancellor, Central University of Himachal Pradesh, who delivered the keynote address.

Continuing our efforts toward establishing linkages between research, academia, industry and society, the institute participated and displayed research products and technologies in various national and international trade fairs and symposia. Our scientists published 236 research articles with an average impact factor of 4.927. The institute signed many agreements/MoUs with different farming-societies, entrepreneurs and academic R&D institutes/universities. Moreover, thirteen technology transfers and several material transfer agreements were carried out.

Under Scientific Social Responsibility activities, IHBT organized various activities under "Jigyasa 2.0 Virtual Laboratory Program" to motivate and encourage students to pursue their carrier in science. This year, a total of 6083 students and teachers from various government and private schools participated in these activities. Besides, 1519 students and teachers of various universities, institutes and colleges from 08 different states and UTs visited the institute during this year.

During 2022-23, a total of 659 persons were trained under different skill development programs *viz.* CSIR-Integrated Skill Initiative Phase-II, Skill Vigyan program, sponsored by DBT-HIMCOSTE, HP State Department of Agriculture and self-sponsored skill programmes. Besides, hands-on training was also provided to different Universities/ colleges students.

The CSIR headquarters, Management Council, funding agencies, and state government have continuously supported and motivated us to achieve scientific excellence, develop new technologies and entrepreneurship, and fulfill social and national responsibilities. We express our gratitude to the Research Council for their crucial and positive contribution to guiding the R&D programs of our institute. Hereby, appreciating our scientists and staff members for their timely inputs for annual report and special thanks to the editorial committee members for compiling it well before time. We are dedicated to devoting ourselves to the growth and development of the nation by providing scientific solutions to economic, scientific, industrial, societal, and environmental issues.

Jai Hind !

Sudesh

(Sudesh Kumar Yadav)

TECHNOLOGIES AVAILABE AND ROLLED OUT

TECHNOLOGY TRANSFER AGREEMENTS

S. No.	Title of agreement	Name of party	Date of signing
	BIOTECHNOLOGY		
1.	Technology of Compost Booster- Single solution for stabilization of night soil/kitchen waste" containing cold-tolerant efficient hydrolytic bacteria supplemented with plant growth promoters.	M/s Amalgam Biotech, A division of Amalgam Engineering Veerbhadra Nagar, Baner, Pune, (MS), India	11.05.2022
2.	Technology on the (i) cultivation of Shiitake/ Oyster mushroom and (ii) indigenous cold-tolerant efficient hydrolytic bacterial formulation supplemented with biofertilizers for preparation of enriched compost/ vermicompost for its implementation at a large scale	Sikkim State Council of Science and Technology (SSCS&T), Deorali, Gangtok-737102, East-Sikkim	02.07.2022
3.	Tissue culture technology of Saffron	M/s Sharma Biotech, V.P.O Samoh District Bilaspur Himachal - 174031	02.07.2022
4.	Technology for manufacturing/ processing of multigrain protein powder products/ variants	Maatritava Foods, Khasra no 514-518, Ram Niwas, Chhoti Haler, Kangra H.P	14.07.2022
5.	Technology to establish facility for process for production of dual bio-products (bioplastic and violacein pigment) from Himalayan bacterial isolate PCH194	M/s HAUCH Ecovations Pvt. Ltd., Ludhiana (Pb.)	15.11.2022
6.	Technology for cultivation of Lentinula edodes (Shiitake mushroom) in synthetic logs and Pleurotus Ostreatus (Oyster) in wheat/rice straw bags and development of vitamin D2 enriched Shiitake and oyster mushroom	Sikkim Social Welfare Youth Association (SSWYA) Rumtek East Sikkim-737135	28.02.2023
	CHEMICAL TECHNOLOGY		
1.	Technology for fabricating distillation units of 5 kg to 250 kg per batch capacity and use the trademark "HerbostillTM" for 5 kg and 10 Kg capacity distillation units	M/s GAK Equipments & Technologies, Head office Plot No: 54, Sector 82, JLPL, S.A.S. Nagar Mohali, Punjab (India)-160062	04.07.2022
2.	Technology for manufacturing/ processing of (i) Granola/protein/energy bars - (millet and cereals, protein based) PRODUCTS, and (ii) instant protein beverage mixes products/ variants	M/s Ketav's Ayush Health Care Products, Plot No. 5,6,7,8 Phase 1, Industrial Area, Nagrota Bagwan District Kangra 176047	12.07.2022
3.	Technology for Instant Tea	M/s Ketav's Ayush, Plot No. 5,6,7,8 Phase 1, Industrial Area, Nagrota Bagwan District Kangra 176047	12.07.2022
4.	Technology transfer agreement for making herbal incense cones and sticks from temple waste flowers.	Jagriti Self Help Group, Village Malghota. PO Kharanal Tehsil Baijnath District Kangra (H.P.)	21.09.2022
5.	Technology for extraction of steviol gylcosides	M/s RJ Saints, VPO Singan Tehsil Haroli District Una	27.02.2023
6.	Technology transfer agreement for making herbal incense cones	Durga Shakti SHG, Village Batiana. PO Ghanghot Tehsil Barsar Distict Hamirpur	28.02.2023

	AGROTECHNOLOGY		
1.	Technology for Artifact making using dry flowers	Baba Kathak Mahila Mandal, Village Sakdi (Baba Kathak) Tehsil Baijnath Distt. Kangra (H.P.)	20.02.2023

MATERIAL TRANSFER AGREEMENT

S. No.	Title of agreement	Name of party	Date of signing
	AGROTECHNOLOGY		
1.	Material Transfer Agreement (MTA) to take up gerbera, gladiolus, chrysanthemum, asiatic lilium and oriental lilium.	M/s Darjeeling Gardens Pvt. Ltd, 3rd Floor, Janpath House,Seth Srilal Market, Sevoke More, Siliguri, (W.B)	01.04.2022
2.	Material Transfer Agreement (MTA) to take up limonium plants.	Mr. Umesh Kumar S/o Kundan LaL, Chachyot, Salahar (144), Devdhar, Mandi, (H.P.)	06.04.2022
3.	Material Transfer Agreement (MTA) to take up limonium plants.	Mr. Nek Ram S/o Chet Ram, Tehsil - Chachyot, Majhothi (122), Devdhar, Mandi, (H.P.)	06.04.2022
4.	Material Transfer Agreement (MTA) to take up limonium plants.	Mr. Jagjeet Singh S/o Moti Ram, Tehsil Thunag, Sharan (96) Bagsaid, Mandi, (H.P.)	06.04.2022
5.	Material Transfer Agreement (MTA) to take up limonium plants.	Mr. Mohan Singh S/o Kahanu Ram, Tehsil-Thunag Badin (127) Bagsaid, Mandi, (H.P.)	06.04.2022
6.	Material Transfer Agreement (MTA) to take up tuberose bulbs, gypsophilla plants and limonium plants.	Mr. Raj Kumar S/o Shri Satnam, S/o Satnam, Vijaypur Dhamola, Nainital, Uttarakhand	06.04.2022
7.	Material Transfer Agreement (MTA) to take up tuberose bulbs gypsophilla plants and limonium plants.	Mr. Mahesh Lal S/o Bali Ram, Bohra kot, Nainital, Ramgarh, Uttarakhand	06.04.2022
8.	Material Transfer Agreement (MTA) to take up tuberose bulbs, gypsophilla plants and limonium plants.	Mr. Sarwan Kumar S/o Sawan Ram, Barhaini, Udham Singh Nagar, Bazpur, Uttarakhand	06.04.2022
9.	Material Transfer Agreement (MTA) to take up tuberose bulbs and limonium plants.	Mr. Balvinder Singh S/o Ranjeet Singh, EWS B-31, Avas Vikas, Udham Singh Nagar, Uttarakhand	06.04.2022
10.	Material Transfer Agreement (MTA) to take up tuberose bulbs limonium plants and loose rose cuttings.	Mr. Ramesh Singh S/o Tara Singh, 23, Ward No 02, Kaladhugi, Nainital, Uttarakhand-263140	06.04.2022
11.	Material Transfer Agreement (MTA) to take up tuberose bulbs and limonium plants.	Mr. Nitin Kumar S/o Dinesh Kumar, Kurpankha, Nainital, Uttarakhand	06.04.2022
12.	Material Transfer Agreement (MTA) for establishment of Floriculture gardens to create awareness among school children and college students under "CSIR Floriculture Mission.	St. Paul Sr. Secondary School, Palampur, (H.P.)	27.04.2022
13.	Material Transfer Agreement (MTA) for establishment of Floriculture gardens to create awareness among school children and college students under "CSIR Floriculture Mission.	Govt. Sr. Secondary School, Thandol - Jaisinghpur Road, Thandol, (H.P.)	27.04.2022

S. No.	Title of agreement	Name of party	Date of signing
14.	Material Transfer Agreement (MTA) for establishment of Floriculture gardens to create awareness among school children and college students under "CSIR Floriculture Mission.	Govt. Sr. Sec. School, Didwin District Hamirpur, (H.P.)	27.04.2022
15.	Material Transfer Agreement (MTA) for establishment of Floriculture gardens to create awareness among school children and college students under "CSIR Floriculture Mission.	Airport Authority of India, Gaggal, Dharamshala Distt. Kangra, (H.P.)	28.04.2022
16.	Material Transfer Agreement (MTA) to take up cultivation of Monk fruit plants for research and development trials at their site in Dharmshala.	Mrs. Simrata Sekhon w/o Gulbagh Singh Mauja Ser, Tehsil Dharamshala, District Kangra	28.04.2022
17.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Nirmal Kumar S/o Shri Devi Ram, Near Kot, Vill. Kufri, PO Sadhupul, Tehsil Shimla	06.05.2022
18.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Rejender Kumar C/o Devi Ram, Village Kot Kufri, Shogi, Shimla.	06.05.2022
19.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Manohar Lal S/o Shri Baldev Singh, Vill. Kufri PO Sadhupul Tehsil Shimla	06.05.2022
20.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mohan Singh S/o Tule Ram, Badin, Bagsiad, Mandi	06.05.2022
21.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Maya Ram S/o Alamu Ram, Village Khunagi, Bagsiad, Mandi	06.05.2022
22.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Gokul Chand S/o Durga Singh, Tehsil Thunag, Kandhi, Bagsiad	06.05.2022
23.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Luder Mani S/o Lal Man, Tehsil - Thunag, Surah (85) Bagsaid, Mandi	06.05.2022
24.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Jai Parkash S/o Molak Ram Tehsil Thunag, Bagsiad	06.05.2022
25.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Jeeva Nand S/o Lal Man, Teshi, Thunag, Surah (85) Bagsaid, Mandi	06.05.2022
26.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Sudershan Singh S/o Karam Singh, Kandhi, Mandi	06.05.2022
27.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Bhupinder Singh S/o Charan Singh, Khursropur, Sidhwan Dona, Kapurthala, Punjab	06.05.2022
28.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Anshul Rana S/o Om Prakash Rana, House No 64, Ward No. 6 Vill Post Office Paraur	06.05.2022

S. No.	Title of agreement	Name of party	Date of signing
29.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Mr. Devi Singh S/o Dugla Ram, main bazar Pandoh, Post office pandoh, Tehsil sadar Mandi	06.05.2022
30.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings.	Darjeeling Floritech, H.O. Gokul Appartment, Haidar Para word No.- 40, Siliguri	06.05.2022
31.	Material Transfer Agreement (MTA) to takeup 50 gm monk fruit seed.	Hortitech Organic, A-2/54, Basement Safdarjung Enclave, New Delhi-27	09.05.2022
32.	Material Transfer Agreement (MTA) to take up Aromatic Marigold (30 kg seed.	Himachal Pradesh Agro Industry Corpoartion Limited (HPAIC) Ground Floor, Nigam Vihar Complex Shimla	09.05.2022
33.	Material Transfer Agreement (MTA) for landscaping and garden development.	Delhi Public School, Palampur, Himachal Pradesh	10.05.2022
34.	Material Transfer Agreement (MTA) for landscaping and garden development.	Netaji Subash Chandra Nursing College, Palampur, Himachal Pradesh	10.05.2022
35.	Material Transfer Agreement (MTA) for landscaping and garden development.	Chaina Ram Sant Ram Filling station, Palampur, H. P	17.05.2022
36.	Material Transfer Agreement (MTA) for landscaping and garden development.	Govt. Sr. Sec. School, Ladraur, Distt Hamirpur, H.P.	19.05.2022
37.	Material Transfer Agreement (MTA) for landscaping and garden development.	Govt. Sr. Sec. School Manoh, Dist – Hamirpur	19.05.20222
38.	Material Transfer Agreement (MTA) for landscaping and garden development.	Govt. Sr. Sec. School Choru, Distt. Hamirpur, H.P.	19.05.2022
39.	Material Transfer Agreement (MTA) to take up Aromatic marigold 25 Kg.	Jai Bhawani Krishi Vikas Sangh Challa Dochi, Village Challa Dochi, Sirmour	20.05.2022
40.	Material Transfer Agreement (MTA) for landscaping and garden development.	Municipal Corporation, Palampur, Himachal Pradesh	23.05.2022
41.	Material Transfer Agreement (MTA) for landscaping and garden development.	Govt. Middle School, Putriyal Distt. Hamirpur, H.P.	23.05.2022
42.	Material Transfer Agreement (MTA) to take up 200 bee hive boxes with colonies along with one honey extractor and one bee keeping kit.	Bee Keeping Cluster, Flower Growers Social Welfare Trust, Nainital Uttarakhand	24.05.2022
43.	Material Transfer Agreement (MTA) to take up 200 bee hive boxes with colonies along with one honey extractor and one bee keeping kit.	Bee Keeping Cluster, Jwalamukhi Block – Dehra, District - Kangra, H.P. 176031	24.05.2022
44.	Material Transfer Agreement (MTA) to take up 200 bee hive boxes with colonies along with one honey extractor and one bee keeping kit.	Bee Keeping Cluster, Manher P.O Jonta Teh. Nurpur, Distt Kangra, 176205	24.05.2022
45.	Material Transfer Agreement (MTA) to take up 200 bee hive boxes with colonies along with one honey extractor and one bee keeping kit.	Bee Keeping Cluster, Tureta, P.O Tanoh, Tehsil - Bangana, Dist. - Una, 174308	24.05.2022
46.	Material Transfer Agreement (MTA) to take up 200 bee hive boxes with colonies along with one honey extractor and one bee keeping kit.	Bee Keeping Cluster, Vill. Choru, Teh. Nadaun, Dist. Hamirpur, 177033	24.05.2022

S. No.	Title of agreement	Name of party	Date of signing
47.	MTA to take up 10 Nos. of Monk Fruit plants to evaluate performance of Monk Fruit	AAGAAS Federation, Pipalkoti, District- Chamoli, Uttarakhand	27.05.2022
48.	Material Transfer Agreement (MTA) for landscaping and garden development.	Govt. Sr. Sec. School Balduhak, Distt. Hamirpur, Himachal Pradesh	31.05.2022
49.	Material Transfer Agreement (MTA) for landscaping and garden development.	Govt. Sr. Sec. School Bhareri, Distt. Hamirpur, Himachal Pradesh - 177024	31.05.2022
50.	Material Transfer Agreement (MTA) to take up 100 bee hive boxes with colonies along with one honey extractor and one bee keeping kit	Bee Keeping Clusters, Baroh	09.06.2022
51.	Material Transfer Agreement (MTA) to take up 200 bee hive boxes with colonies along with one honey extractor and one bee keeping kit. `	Bee Keeping Clusters, Lahaul	09.06.2022
52.	Material Transfer Agreement (MTA) to provide aromatic marigold seeds.	Progressive Farmers Associations, Ghumarwin, Dist. Bilaspur H.P.	13.06.2022
53.	Material Transfer Agreement (MTA) to provide aromatic marigold seeds.	Mahesh Kumar Sharma, Ward no. 4, Ram Chowk, Palampur, Dist. Kangra H.P.	13.06.2022
54.	Material Transfer Agreement (MTA) to provide saffron, Stevia, aromatic marigold, Monk fruit, Heeng planting material/seed material.	Rinchin Tsering, Monyul Charitable Society, Bomdila, Arunachal Pradesh	13.06.2022
55.	Material Transfer Agreement (MTA) for landscaping and garden development.	Govt. Girls Sr. Sec. School, Nadaun, Dist - Hamirpur, Himachal Pradesh – 177033	20.06.2022
56.	Material Transfer Agreement (MTA) to take up Aromatic Marigold seeds variety Him Swarnima.	Mr. Rajnish Acharya S/o Sh. Ram Prakash, VPO Sagoor Teh Baijnath Distt. Kangra (H.P)	22.06.2022
57.	Material Transfer Agreement (MTA) for landscaping and garden development.	Moravian Mission School, Leh	22.06.2022
58.	Material Transfer Agreement (MTA) for landscaping and garden development.	Lamdon Model Senior Secondary School, Leh	22.06.2022
59.	Material Transfer Agreement (MTA) for landscaping and garden development.	Kendriya Vidyalaya, Leh	22.06.2022
60.	Material Transfer Agreement (MTA) for landscaping and garden development.	Mahabodhi Residential School, Leh	22.06.2022
61.	Material Transfer Agreement (MTA) for landscaping and garden development.	Wakha Public School, Wakha	22.06.2022
62.	Material Transfer Agreement (MTA) for landscaping and garden development.	Munshi Habibullah Mission School, Kargil	22.06.2022
63.	Material Transfer Agreement (MTA) for landscaping and garden development.	Mutahhary Public School, Baroo	22.06.2022
64.	Material Transfer Agreement (MTA) for landscaping and garden development.	Government Degree College, Kargil	22.06.2022
65.	Material Transfer Agreement (MTA) for landscaping and garden development.	Council Model High School, Goma	22.06.2022
66.	Material Transfer Agreement (MTA) for landscaping and garden development.	Suru Valley Public High School, Kargil	22.06.2022
67.	Material Transfer Agreement (MTA) for landscaping and garden development.	Jaffaria Academy of Modern Education, Kargil	22.06.2022

S. No.	Title of agreement	Name of party	Date of signing
68.	Material Transfer Agreement (MTA) for landscaping and garden development.	University of Ladakh	22.06.2022
69.	Material Transfer Agreement (MTA) for landscaping and garden development.	District Industry Office, Leh	22.06.2022
70.	Material Transfer Agreement (MTA) for landscaping and garden development.	Hill Council Office, Leh	22.06.2022
71.	Material Transfer Agreement (MTA) for landscaping.	National Institute of Technology, Hamirpur H.P.	04.07.2022
72.	Material Transfer Agreement (MTA) for landscaping.	Govt. Sr. Sec. School, Bagwara, Dist - Hamirpur H.P.	04.07.2022
73.	Material Transfer Agreement (MTA) to take up cut roses plants.	Trilok Chand S/o Rattan Lal, Village Kaseh, Tehsil Jhandutta, Auhan (459), Bilaspur H.P.	05.07.2022
74.	Material Transfer Agreement (MTA) to take up cut roses plant.s	Vimla Devi W/o Balwant Singh Village Beeri, Dasolan P.O. Behna Jattan, Tehsil Jhandutta, Gulani, Bilaspur H.P.	05.07.2022
75.	Material Transfer Agreement (MTA) to take up cut roses plants	Mahesh Gautam S/o Som Parkash, Village Riyana, Tehsil Jhandutta, Riyana, Bilaspur H.P.	05.07.2022
76.	Material Transfer Agreement (MTA) to take up cut roses plants	Meena Kumari W/o Sunil Kumar, Village Beri, Tehsil Jhandutta, Beri Darolan (179), Bilaspur, H.P.	05.07.2022
77.	Material Transfer Agreement (MTA) to take up cut roses plants	Khema Nand S/o Nanda Ballabh, Bhagartola, Jageshwar Range, Almora Jayeshwar, Uttarakhand	06.07.2022
78.	Material Transfer Agreement (MTA) to take up cut roses plants.	Satish Chandra Pandey S/o Khemanand Pandey, Village Kala kotuli, Dist. Almora, Uttarakhand	06.07.2022
79.	Material Transfer Agreement (MTA) to take up cut roses chrysanthemum and gladiolus corms.	Flower Growers Social Welfare Trust, Village Nayagaon Chandan Singh, Kaladhungi, Kamola, Nainital, Uttarakhand	06.07.2022
80.	Material Transfer Agreement (MTA) to provide seedlings of eight medicinal plants (*Valeriana jatamansi, Picrorhiza kurroa, Bacopa MTA to monnieri, Aloe vera, Stevia rebaudiana, Cinnamomum verum, Siraitia grosvenorii, and Hippophae rhamnoides*), and quality seed/ rhizomes of three medicinal plants (Stevia rebaudiana, Inula racemose, and Hedychium spicatum)	Regional-cum- Facilitation Centre, Northern Region 1 (RCFC NR1), Joginder Nagar, Distt. Mandi, (H.P) – 175 015	08.07.2022
81.	Material Transfer Agreement (MTA) to take up 3 lakhs lemongrass slips	Nagrota Surian Farmers Producer Company Limited, VPO Darkati, Tehsil Jawali, District Kangra, (H.P.)	12.07.2022
82.	Material Transfer Agreement (MTA) to take up chrysanthemum.	Gurwinder Singh S/o Gurdeep Singh, Village Nanowal Khurd, P.O. Nanowal Kalan, Khamanon Kalan, Fathegarh sahib, Punjab	13.07.2022
83.	Material Transfer Agreement (MTA) to take up gladiolus corms.	Ved Prakash S/o Rikhi Ram, Mahog, Solan (471) H.P.	13.07.2022

S. No.	Title of agreement	Name of party	Date of signing
84.	Material Transfer Agreement (MTA) to take up 20,000 lemongrass plants	Sh. Vijay Singh Rana, Village Kanghain P.O. Barram, Tehsil Jaisinghpur Distt. Kangra (H.P.) -176 097	15.07.2022
85.	Material Transfer Agreement (MTA) for landscaping.	Government Primary School, Bajoon, Block Bhimtal, Dist. Nainital, Uttarakhand	20.07.2022
86.	Material Transfer Agreement (MTA) for landscaping.	Government Girls Inter College, Khurpatal, Block Bhimtal, Dist. Nainital, Uttarakhand	20.07.2022
87.	Material Transfer Agreement (MTA) for landscaping.	Government Primary School, Bhimpuri, Block-Kotabagh, Dist.-Nainital, Uttarakhand	20.07.2022
88.	Material Transfer Agreement (MTA) for landscaping.	Government Junior High School, Bhimpuri, Block Kotabagh, Dist. Nainital, Uttarakhand	20.07.2022
89.	Material Transfer Agreement (MTA) for landscaping.	Government Primary School, Nayagaon, Block- Kotabagh, Dist. Nainital, Uttarakhand	20.07.2022
90.	Material Transfer Agreement (MTA) for landscaping.	Government Higher Primary School, Kamola, Block-Kotabagh, Dist. Nainital, Uttarakhand	20.07.2022
91.	Material Transfer Agreement (MTA) to takeup 20,000 lemongrass slips	Sh. Dinesh Kumar, S/o Sh. Sarwan Kumar, VPO Tourkhola, Tehsil Sandhole Distt. Mandi (H.P.)	21.07.2022
92.	Material Transfer Agreement (MTA) to take up aromatic Marigold Variety Him Swarnima (3 kg seed)	Sh. Hemraj S/o Sh. Jonde Ram, Village Dharer P.O Kandi, Tehsil Palampur, District Kangra – 176 061	21.07.2022
93.	Material Transfer Agreement (MTA) to take up 3 lakhs lemongrass slips	Shivalik Medicinal and Aromatic Plants Cultivation Society, VPO Chauki Maniar, Bangana District Una (H.P.)	21.07.2022
94.	Material Transfer Agreement (MTA) to take up marigold seedlings and loose rose cuttings.	Smt. Anita Kumari, W/o Trilok Chand, Village Ladoh, P.O. Panchrukhi, Tehsil Palampur, Kangra H.P.	01.08.2022
95.	Material Transfer Agreement (MTA) to take up marigold seedlings.	Mr. Brijbhushan S/o Gyan Singh Thakur, Ward No. 3, Matt, Sungal Palampur, Kangra H.P.	01.08.2022
96.	Material Transfer Agreement (MTA) to take up loose rose plants.	Mr. Chuni Lal, S/o Late Shri Delip Singh, V.P.O. Samela, Tehsil Kangra H.P.	01.08.2022
97.	Material Transfer Agreement (MTA) to take up marigold seedlings and chrysanthemum rooted cuttings.	Mr. Mukesh Sharma, S/o Late Sh. Sansar Chand Ward No. 4, V.P.O Busal, Tehsil Baroh, District Kangra H.P.	01.08.2022
98.	Material Transfer Agreement (MTA) to take up loose rose cuttings.	Mr. Rajesh Kumar, S/o Raghunath Singh, Ward No. 2 Village Gharoon, P.O. Dehan Tehsil Palampur, Dehan Khas (685), Kangra, H.P.	01.08.2022

S. No.	Title of agreement	Name of party	Date of signing
99.	Material Transfer Agreement (MTA) to take up chrysanthemum rooted cuttings.	Mr. Manoj Kumar S/o Puranchand, Sukera khera, Abub Shahar (271) Abubshahar, Sirsa, Dabwali, Haryana	01.08.2022
100.	Material Transfer Agreement (MTA) to take up chrysanthemum rooted cuttings.	Mr. Sanjay Sharma S/o Mast Ram Sharma, 58/4 Post office Bhojpur, Tehsil Sunder Nagar, Bhojpur, Mandi H.P.	01.08.2022
101.	Material Transfer Agreement (MTA) to take up 200 bee hive boxes with colonies along with one honey extractor and one bee keeping kit free of cost under "CSIR Floriculture Mission".	Bee Keeping Cluster, Pragati Kisan Kalyan Samiti, Chamba Vill. Tala, P.O. Samot, Teh. Sihunta, Dist. Chamba, H.P.	01.08.2022
102.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Zonal Hospital, Dharamshala H.P.	01.08.2022
103.	Material Transfer Agreement (MTA) to takeup *Ginkgo biloba*, Lavandin, Lavender, Rose geranium, Stevia, Viola odorata, *Valeriana jatamansi* for research and development.	Netaji Subhas University of Techhnology, NH-50, Azad Hind Fauj Marg Sector 3, Dwarka, New Delhi 110 078	16.08.2022
104.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	AIIMS, Bilaspur H.P.	17.08.2022
105.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	KV, Hamirpur H.P.	17.08.2022
106.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Forest Office, Palampur H.P.	22.08.2022
107.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Aasan Kalan, Panipat, Haryana	22.08.2022
108.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Babail, Panipat, Haryana	22.08.2022
109.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Barauli, Panipat, Haryana	22.08.2022
110.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Chandoli, Panipat, Haryana	22.08.2022
111.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Model Sanskriti Senior Secondary School, G T Road, Panipat, Haryana	22.08.2022
112.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Jattal, Panipat, Haryana	22.08.2022
113.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Jhatipur, Panipat, Haryana	22.08.2022
114.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Kabri, Panipat, Haryana	22.08.2022

S. No.	Title of agreement	Name of party	Date of signing
115.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Khotpura, Panipat, Haryana	22.08.2022
116.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Girls Senior Secondary School, Model Town, Panipat Haryana	22.08.2022
117.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School Nangal Kheri, Panipat, Haryana	22.08.2022
118.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Model Senior Secondary School, Raja Kheri, Panipat, Haryana	22.08.2022
119.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Rajapur, Panipat, Haryana	22.08.2022
120.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Sewah, Panipat, Haryana	22.08.2022
121.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Girls Senior Secondary School, Sewah, Panipat, Haryana	22.08.2022
122.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School Sondhapur, Panipat, Haryana	22.08.2022
123.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government High School, Barana, Panipat, Haryana	22.08.2022
124.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government High School, Binjhol, Panipat, Haryana	22.08.2022
125.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission" .	Government Girls Senior Secondary School, Manana, Panipat, Haryana	22.08.2022
126.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government High School, Canal camp, Panipat, Haryana	22.08.2022
127.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Manila, Dist. Fatehgarh Sahib, Tehsil Khamano, Punjab	22.08.2022
128.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Rattangarh Ratto, Dist. Fatehgarh Sahib, Tehsil Khamano, Punjab	22.08.2022
129.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Bades Khurd, Dist. Fatehgarh Sahib, Tehsil Khamano, Punjab	22.08.2022
130.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Khamano Art, Dist. Fatehgarh Sahib, Tehsil Khamano Punjab	22.08.2022
131.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Middle School, Mansurpur, Dist. Fatehgarh Sahib, Tehsil Khamano, Punjab	22.08.2022
132.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Khamano Kamli, Dist. Fatehgarh Sahib, Tehsil Khamano, Punjab	22.08.2022

S. No.	Title of agreement	Name of party	Date of signing
133.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Middle School, Fatehgarh, Dist. Fatehgarh Sahib, Tehsil Khamano, Punjab	22.08.2022
134.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Manali Dhanola, Dist. Fatehgarh Sahib, Tehsil Khamano, Punjab	22.08.2022
135.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Salana Basti, Dist. Fatehgarh Sahib, Tehsil Khamano, Punjab	22.08.2022
136.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Bades Kalan, Dist. Fatehgarh Sahib, Tehsil Khamano, Punjab	22.08.2022
137.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Samloti, Dist. Kangra, H.P.	22.08.2022
138.	Material Transfer Agreement (MTA) to take up chrysanthemum rooted cuttings.	Mr. Murari Sah, s/o Heera Lal Shah, Ramgarh Bohra, Kote Nainital, Uttarakhand	25.08.2022
139.	Material Transfer Agreement (MTA) to take up chrysanthemum rooted cuttings.	Mr. Sanjay Pandey, s/o Bhairavdatt Pandey, Jhutiya, Nainital, Uttarakhand	25.08.2022
140.	Material Transfer Agreement (MTA) to take up chrysanthemum rooted cuttings.	Mr. Ajay Joshi, s/o Narayan Dutt Joshi, Umagarh, Nainital, Uttarakhand	25.08.2022
141.	Material Transfer Agreement (MTA) to take up chrysanthemum rooted cuttings.	Mr. Mahesh Lal, s/o Bali Ram Bohra, Kot Nainital Ramgarh, Uttarakhand	25.08.2022
142.	Material Transfer Agreement (MTA) to take up marigold seedlings.	Mr. Sunil s/o Dulo Ram, Chowki khalat, Kangra H.P.	29.08.2022
143.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government High School, Gopalpur Block- Palampur, Kangra, H.P.	29.08.2022
144.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Middle School, Chachian Block- Palampur, Kangra, H.P.	29.08.2022
145.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Dadh Block- Palampur, Kangra, H.P.	29.08.2022
146.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Lahla, Block - Palampur, Dist. Kangra, H.P.	29.08.2022
147.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Dadh Block- Palampur, Kangra, H.P.	29.08.2022
148.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	SRK Government Senior Secondary School, Chachian, Block- Palampur, Kangra, H.P.	29.08.2022
149.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Veterinary Hospital, Saliana, Tehsil Palampur, Kangra, H.P.	29.08.2022
150.	Material Transfer Agreement (MTA) to take up gladiolus corms.	Mr. Trilok Chand S/o Varyam chand, Rajpura No.2, Udham Singh Nagar, Jhagarpuri, Uttarakhand	30.08.2022

S. No.	Title of agreement	Name of party	Date of signing
151.	Material Transfer Agreement (MTA) to take up gladiolus corms.	Mr. Harnam Chand S/o Punnu ram, Rajpura no. 2, Rajpura No.2 Udham Singh Nagar, Jhagrpuri, Uttarakhand	30.08.2022
152.	Material Transfer Agreement (MTA) to take up gladiolus corms.	Mr. Breet Kumar S/o Bhagwan Das, Abdullah Nagar, Bakainiya, Subhash Nagar, Udham Singh Nagar Uttrakhand	30.08.2022
153.	Material Transfer Agreement (MTA) to take up gladiolus corms.	Mr. Mahender Pratap S/o Shukhvinder Kumar, Village Bareilly Nagar No. 2, Sarovar Nagar, Udham Singh Nagar, Uttrakhand	30.08.2022
154.	Material Transfer Agreement (MTA) to take up gladiolus corms.	Mr. Mahanga Ram S/o Bhagvan Das, Post office Subhash Nagar, Kuan Khera, Udham singh Nagar	30.08.2022
155.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Mr. Anurag Sharma S/o Mast Ram, 58/4, Post Office Bhojpur, tehsil sundernagar, Bhojpur, Mandi, H.P.	06.09.2022
156.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Mr. Kishore Sharma S/o Gur Dyal, Tehsil Sunni Dalana, Shimla H.P.	06.09.2022
157.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Mr.Naresh Kumar S/o Gurdayal, Tehsil Sunni Ward No. 1, Dalana (81), Khatnol, Shimla H.P. on 06.09.2022	06.09.2022
158.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Mr. Jagdeesh Chander S/o Ghanshyam Singh, Village Chaloge, P.O. Majhiwar Bhad (122), Shimla H.P.	06.09.2022
159.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Mr. Vinay Thakur S/o Puran Dass, 20/1, Tehsil Sunni, Dayangil (68), Shimla H.P.	06.09.2022
160.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Ms. Seema Devi W/o Pankaj Kumar, Village Kyarlu, Mashobra, Shimla H.P.	06.09.2022
161.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Mr. Godhan Ram S/o Hari Ram, Badi Banj, Village Salkuli, P.O. Simrar, Nainital, Uttarakhand	06.09.2022
162.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Ms. Mamta Sah W/o Murari Lal, house no. 191, Boharkot, bhowali, bohra kote, Nainital Uttrakhand	06.09.2022
163.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Ms. Kavita Sah W/o Deepak Sah, House No. 220 Naya Bazaar Tallital Nainital, Uttarakhand	06.09.2022
164.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Mr. Vipin Chandra Joshi S/o Jay Dutt Joshi, Gram Kishanpur Sakuliya Post Motahaldu, Haldwani, Nainital, Uttrakhand	06.09.2022
165.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Mr. Naveen Chandra S/o Trilochan, Vill. Suyalghar, P.O. Simrar Nathuakan, Nainital, Uttrakhand	06.09.2022

S. No.	Title of agreement	Name of party	Date of signing
166.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (5,000 Nos.).	Mr. Kishan Singh Negi S/o Jarman Singh, Bichkhali Badi baja Simrar Nainital, Uttarakhand	06.09.2022
167.	Material Transfer Agreement (MTA) to take up gerbera plants (3,200 Nos.).	Mr. Jaswant Singh S/o Jogender Lal, Ludhpura, Rani Nagal, Udham Singh Nagar, Fauzi Colony, Uttarakhand	06.09.2022
168.	Material Transfer Agreement (MTA) to take up gerbera plants (3,600 Nos.).	Mr. Lalit Mohan C/o Harish Chandra H. No 13, Vill Bajun 164Lagga Bhela, High court, Nainital, Uttarakhand	06.09.2022
169.	Material Transfer Agreement (MTA) to take up gerbera plants (1,500 Nos.).	Mr. Harish Kumar S/o Dinanath, Vill. Tair P.O. Khurwain Tehsil Bangana Tiera, (6/14), Una H.P.	06.09.2022
170.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Kendriya Vidyalaya, Yol Cantt H.P.	06.09.2022
171.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Tang Narwana, Block-Dharamshala, Kangra H.P.	06.09.2022
172.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Tang Narwana, Block-Dharamshala, Kangra H.P.	09.09.2022
173.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government High School, Arth Palampur, Kangra H.P.	09.09.2022
174.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Arth Palampur, Kangra H.P.	09.09.2022
175.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government High School, Rauwal Melak kangan, Moga, Punjab	09.09.2022
176.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Middle School, Booh Gujjran, Makhu, Ferozepur, Punjab	09.09.2022
177.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Public School, Lalleh, Ferozepur	09.09.2022
178.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government High School, Kot Ise Khan, Moga, Punjab	09.09.2022
179.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government High School, Mansoordeva, Zira, Ferozepur, Punjab	09.09.2022
180.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Pir Mohammad, Makhu, Ferozepur, Punjab	09.09.2022
181.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Mansoordeva, Zira, Ferozepur, Punjab	09.09.2022
182.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Amit Kumar S/o Om Prakash Mahog, (471), Chail, Solan, H.P.	16.09.2022

S. No.	Title of agreement	Name of party	Date of signing
183.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Om Prakash, S/o Rikhi Ram, Mahog, (471), Chail, Solan, H.P.	16.09.2022
184.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Rajneesh Kumar, S/o Madan Mohan, Mahog, (471), Chail, Solan, H.P.	16.09.2022
185.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Vinod Kumar, S/o Om Prakash Mahog, (471), Chail, Solan, H.P.	16.09.2022
186.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Ajay Kumar, at S/o Surjeet Singh, Vill. Karlatu, Jhajha (451), Kandaghat Solan H.P.	16.09.2022
187.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Anil Kumar, at S/o Surjeet Singh, Vill. Karlatu, Jhajha (451), Kandaghat Solan H.P.	16.09.2022
188.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Attam Swaroop, S/o Hari Krishan, Mahog, (471), Solan, H.P.	16.09.2022
189.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Chetan Kumar, S/o Krishan, Sakori (470) Chail, Solan H.P.	16.09.2022
190.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Nand Ram Verma, S/o Het Ram, Jhajha, (451), Jhajha, Solan Kandaghat H.P.	16.09.2022
191.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Naveen Verma, S/o Geeta Ram Verma, Jhajha (451), Jhajha, Solan, Kandaghat H.P.	16.09.2022
192.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos..).	Mr. Neeraj Kumar, S/o Roop Singh, Sakori (470) Solan, H.P.	16.09.2022
193.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Pradeep Kumar, S/o Krishan, Sakori (470) Chail, Solan Kandaghat H.P.	16.09.2022
194.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Raj Verma, S/o Geeta Ram Verma, Jhajha (451), Jhajha, Solan, Kandaghat H.P.	16.09.2022
195.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Sandeep Kumar, S/o Roop Singh, Vill. Nagali Tehsil Kandaghat Solan H.P.	16.09.2022
196.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Vikul Verma, S/o Geeta Ram Verma, Jhajha (451), Jhajha, Solan, Kandaghat H.P.	16.09.2022
197.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Chail, Dist. Solan H.P.	16.09.2022
198.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government High School, Sahori, Village Sakori, P.O. Chail, Tehsil Kandaghat, Dist. Solan, H.P.	16.09.2022
199.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Middle School, Nagali Chail, Village Nagali, P.O. Nagali, Dist. Solan H.P.	16.09.2022
200.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Khatrol, VPO Khatrol, Tehsil Sunni, Dist. Shimla H.P.	16.09.2022

S. No.	Title of agreement	Name of party	Date of signing
201.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Chobin, District Kangra, H.P.	19.09.2022
202.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Krishana Nagar, District Kangra, H.P.	19.09.2022
203.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Krishana Nagar, District Kangra, H.P.	19.09.2022
204.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Chobin, District Kangra, H.P.	19.09.2022
205.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Nagehar, District Kangra, H.P.	19.09.2022
206.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Khalainu, Baijnath, District Kangra, H.P.	19.09.2022
207.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Banghiar, Dist. Kangra H.P.	21.09.2022
208.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Dehan, Dist. Kangra H.P.	21.09.2022
209.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Parour, Dist. Kangra H.P.	21.09.2022
210.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Saloh, Dist. Kangra H.P.	21.09.2022
211.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Dehan, Dist. Kangra H.P.	21.09.2022
212.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Middle School, Khopa, Baijnath, District Kangra, H.P.	21.09.2022
213.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Middle School, Chobu, Nagehar, Baijnath, District Kangra, H.P.	21.09.2022
214.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Middle School, Mahakal, Baijnath, District Kangra, H.P.	21.09.2022
215.	MTA for garden establishment under "CSIR Floriculture Mission"	Government Primary School, Chobu, Nagehar, Baijnath, District Kangra, H.P.	21.09.2022
216.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Khopa, Bandian, District Kangra, H.P.	21.09.2022
217.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Kunsal, Baijnath, District Kangra, H.P.	21.09.2022
218.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Deputy Director of Horticulture Office, Mandi H.P.	21.09.2022

S. No.	Title of agreement	Name of party	Date of signing
219.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Kullu Manali Airport, Bhuntar, Dist. Kullu H.P.	21.09.2022
220.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government High School, Bhattu Samula, District Kangra, H.P. on	26.09.2022
221.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Dharot, District Kangra, H.P.	26.09.2022
222.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Primary School, Pharer, District Kangra, H.P.	26.09.2022
223.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Bhawarna, District Kangra, H.P.	26.0-9.2022
224.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission".	Government Senior Secondary School, Sullah, District Kangra, H.P.	26.09.2022
225.	Material Transfer Agreement (MTA) to take up gladiolus corms (50,000 Nos.).	Mr. Abhishek, S/o Gayan swaroop, Village Katal, Tehsil-Kandaghat, Gauhra (513), Solan, H.P.	26.09.2022
226.	Material Transfer Agreement (MTA) to take up gladiolus corms (12,000 Nos.).	Mr. Surender Pal, S/o Kanshi Ram, Village Luhnu Kanaita, Bilaspur, H.P.	26.09.2022
227.	Material Transfer Agreement (MTA) to take up gladiolus corms (50,000 Nos.).	Mr. Dalip Singh, S/o Chet Ram, Chandol (31) Simaur, H.P.	26.09.2022
228.	Material Transfer Agreement (MTA) to take up marigold seedlings (5,000 Nos.).	Mr. Pawan Kumar, S/o Daulat Ram Badui, Binna (267), Patka, Chamba, H.P.	26.09.2022
229.	Material Transfer Agreement (MTA) to take up marigold seedlings (4,000 Nos.).	Mr. Surender Kumar, S/o Hari Ram, Ward No. 3 Vill. Upper Brohal, Tehsil Palampur, Kangra H.P.	26.09.2022
230.	Material Transfer Agreement (MTA) to take up marigold seedlings (2,000 Nos.).	Mr. Suresh Kumar, S/o Madan Lal, Near Guru Gorakh Nath Mandir Vill. Narwana Bazar Post Office Yol Cantt Tehsil Dharamshala, Narwana (494/6), Kangra, H.P.	26.09.2022
231.	Material Transfer Agreement (MTA) to take up lilium bulbs (2,600 Nos.).	Mr. Rohit Thakur, S/o Balvir Singh Tehsil Solan H.P.	26.09.2022
232.	Material Transfer Agreement (MTA) to provide 1.5 kg seed of aromatic crop German chamomile (*Matricaria chamomilla*) under "CSIR Aroma Mission Phase-II".	Unnati cluster, Village Tang, Tehsil Dharamshala district Kangra HP – 176052	11.10.2022
233.	Material Transfer Agreement (MTA) to provide One lakh lemongrass slips under "CSIR Aroma Mission Phase-II".	The Laughing Flower Cooperative Multipurpose Society, Rohtak, Haryana	11.10.2022
234.	Material Transfer Agreement (MTA) to provide 1.5 lakh lemongrass slips under "CSIR Aroma Mission Phase-II".	PRK Agrotech Society Ambala, Haryana	11.10.2022

S. No.	Title of agreement	Name of party	Date of signing
235.	Material Transfer Agreement (MTA) to provide two lakh lemongrass slips under "CSIR Aroma Mission Phase-II".	Glen Leu Women Service Cooperative Society Ltd. Sumbuk, South Sikkim – 737 128	11.10.2022
236.	Material Transfer Agreement (MTA) for providing compost booster quantity of 10 kg or more, and 10 L of effective microbial (EM) solution per month to solve the problem of compostable waste.	Manav Kalyan Sanstha having the registered office at Village and Post Office Banuri, District Kangra (H.P.)	13.10.2022
237.	Material Transfer Agreement (MTA) to provide 10 plants of *Hing (Ferula assa-foetida)* free of cost for research and development purpose for the societal benefits.	Dr. Thomas K. Sebastian, Poonvanchy, Kanjirappally (Kerala)-686507	14.10.2022
238.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission"..	Government Girls Senior Secondary School, District Fatehgarh Sahib, Punjab	20.10.2022
239.	Material Transfer Agreement (MTA) for garden establishment under "CSIR Floriculture Mission"..	Government High School, Sirhind City, District Fatehgarh Sahib, Punjab	20.10.2022
240.	Material Transfer Agreement (MTA) to take up damask rose, rosemary, geranium, ginkgo bioloba, oregano and lemaon balm.	Er. Karamjit Singh, 405, Sector 71, Mohali(Pb.)	23.11.2022
241.	Material Transfer Agreement (MTA) for garden establishment provide Syngonium (white) (18 Nos.), Syngonium (pink) (12 Nos.), Tradenscatia (06 Nos.), Zebrina (46 Nos.), Money Plant (golden) (20 Nos.), Money Plant (variegated) (18 Nos.), Spider Plant (66 Nos.), Panels (62 Nos.) and Pots (186 Nos.) free of cost under "CSIR Floriculture Mission.	Dr. Charu Sharma, BAMS, Tal Hamirpur, H.P.	16.12.2022
242.	Material Transfer Agreement (MTA) for garden establishment provide Asparagus (42 nos.), Tradescantia (45 nos.), Money plant (51 nos.), Zebrina (45 nos.), Spider plant (15 nos.), Syngonium pink (12 nos.), Syngonium white (16 nos.), Pots (228 nos.) and Panels (76 nos.) free of cost under "CSIR Floriculture Mission".	Dr. Shivani Guleria, Medical officer, Primary Health Center, Banuri, Palampur, Kangra H.P.	16.12.2022
243.	Material Transfer Agreement (MTA) for garden establishment provide Golden money plant (40 Nos.), Variegated money plant (40 Nos.), Spider plant (44 Nos.), Syngonium pink (46 Nos.), Syngonium white (20 Nos.), Asparagus (20 Nos.) Panels (70 Nos.) and Pots (210 Nos.) free of cost under "CSIR Floriculture Mission".	Mr. Charan Dass, Pradhan, Gram Panchayat, Tal Hamirpur, H.P.	16.12.2022
244.	Material Transfer Agreement (MTA) for garden establishment provide Rohio (54 Nos.), Syngonium (white) (134 Nos.), Syngonium (pink) (174 Nos.), Tradenscatia (34 Nos.), Money Plant (variegated) (54 Nos.), Panels (150 Nos.) and Pots (450 Nos.) free of cost under "CSIR Floriculture Mission".	Dr. Lalit kalia, BMO, Block Medical Officers Office, Bhoranj, Hamirpur, H.P.	16.12.2022

S. No.	Title of agreement	Name of party	Date of signing
245.	Material Transfer Agreement (MTA) to take up 200 bee hive boxes with colonies along with one honey extractor and one bee keeping kit (bee veil, bee smoker, hive tool and uncapping knife). free of cost under "CSIR Floriculture Mission".	Bee Keeping Cluster, Anni, V.P.O. Chowai, Distt. Kullu, H.P.	10.01.2023
246.	Material Transfer Agreement (MTA) to take up 200 bee hive boxes with colonies along with one honey extractor and one bee keeping kit (bee veil, bee smoker, hive tool and uncapping knife) free of cost under "CSIR Floriculture Mission".	Bee Keeping Cluster, Rohru, V.P.O. Seri Rohru, Tehsil Rohru, Dist. Shimla H.P.	10.01.2023
247.	Material Transfer Agreement (MTA) for garden establishment to take up Hydrangea (05 Nos.), Syngonium (05 Nos.), Green Cyprus (05 Nos.), Golden Cyprus (01 Nos.), Araucaria (01 Nos.), Schffelera (02 Nos.), Rose (05 Nos.), Spider Lily (02 Nos.), Pencil Pine (02 Nos.) and Agave (02 Nos.) plants free of cost under "CSIR Floriculture Mission" on 16.01.2023.	Government Senior Secondary School, Chandpur, Palampur, Kangra H.P.	16.01.2023
248.	Material Transfer Agreement (MTA) for garden establishment agrees to take up Hydrangea (05 Nos.), Syngonium (05 Nos.), Green Cyprus (05 Nos.), Golden Cyprus (01 Nos.), Araucaria (01 Nos.), Schffelera (02 Nos.), Rose (05 Nos.), Spider Lily (02 Nos.), Pencil Pine (02 Nos.) and Agave (02 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School, Chandpur, Palampur, Kangra H.P.	16.01.2023
249.	Material Transfer Agreement (MTA) for garden establishment to take up Hydrangea (05 Nos.), Syngonium (05 Nos.), Green Cyprus (05 Nos.), Golden Cyprus (01 Nos.), Araucaria (01 Nos.), Schffelera (02 Nos.), Rose (05 Nos.), Spider Lily (02 Nos.) and Pencil Pine (02 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government High School, Langa, Palampur, Kangra H.P.	16.01.2023
250.	Material Transfer Agreement (MTA) for garden establishment to take up Syngonium (05 Nos.), Green Cyprus (05 Nos.), Schffelera (02 Nos.), Rose (05 Nos.), Spider Lily (02 Nos.) and Pencil Pine (02 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School, Bandla, Palampur, Kangra H.P.	16.01.2023
251.	Material Transfer Agreement (MTA) for garden establishment to take up Hydrangea (05 Nos.), Syngonium (05 Nos.), Green Cyprus (05 Nos.), Araucaria (01 Nos.), Schffelera (02 Nos.), Rose (05 Nos.), Spider Lily (02 Nos.) and Pencil Pine (02 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Senior Secondary School, Bandla, Palampur, Kangra H.P.	16.01.2023

S. No.	Title of agreement	Name of party	Date of signing
252.	Material Transfer Agreement (MTA) for garden establishment to take up Hydrangea (05 Nos.), Syngonium (03 Nos.), Green Cyprus (05 Nos.), Golden Cyprus (01 Nos.), Araucaria (02 Nos.), Schffelera (02 Nos.), Rose (01 Nos.), Spider Lily (02 Nos.), Pencil Pine (02 Nos.) Cycas (02 Nos.), Bougainvillea (02 Nos.) and Agave (02 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Middle School, Lohna, Palampur, Kangra H.P.	16.01.2023
253.	Material Transfer Agreement (MTA) for garden establishment to take up Hydrangea (05 Nos.), Syngonium (05 Nos.), Green Cyprus (05 Nos.), Golden Cyprus (02 Nos.), Araucaria (02 Nos.), Schffelera (02 Nos.), Rose (05 Nos.), Spider Lily (02 Nos.) and Pencil Pine (02 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School, Lohna, Kangra H.P.	16.01.2023
254.	Material Transfer Agreement (MTA) for garden establishment to take up Nerium (05 Nos.), Thuja (05 Nos.), Pencil Pine (04 Nos.), Ficus (05 Nos.), Bougainvillia (05 Nos.), Dracena (05 Nos.) and Roses (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Senior Secondary School Purba, Distt. Kangra, H.P.	16.01.2023
255.	Material Transfer Agreement (MTA) for garden establishment to take up Nerium (05 Nos.), Thuja (05 Nos.), Pencil Pine (04 Nos.), Ficus (05 Nos.), Bougainvillia (05 Nos.), Dracena (05 Nos.) and Roses (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Senior Secondary School Daroh, Distt. Kangra, H.P.	16.01.2023
256.	Material Transfer Agreement (MTA) for garden establishment to take up Nerium (05 Nos.), Thuja (05 Nos.), Pencil Pine (04 Nos.), Ficus (05 Nos.), Bougainvillia (05 Nos.), Dracena (05 Nos.) and Roses (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Senior Secondary School Marhoon, Distt. Kangra, H.P.	16.01.2023
257.	Material Transfer Agreement (MTA) for garden establishment to take up Nerium (05 Nos.), Thuja (05 Nos.), Pencil Pine (04 Nos.), Ficus (05 Nos.), Bougainvillia (05 Nos.), Dracena (05 Nos.) and Roses (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School Balota, Distt. Kangra, H.P.	16.01.2023
258.	Material Transfer Agreement (MTA) for garden establishment to take up Nerium (05 Nos.), Thuja (05 Nos.), Pencil Pine (04 Nos.), Ficus (05 Nos.), Bougainvillia (05 Nos.), Dracena (05 Nos.) and Roses (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School Bhatillu, Distt. Kangra, H.P.	16.01.2023

S. No.	Title of agreement	Name of party	Date of signing
259.	Material Transfer Agreement (MTA) for garden establishment to take up Nerium (05 Nos.), Thuja (05 Nos.), Pencil Pine (04 Nos.), Ficus (05 Nos.), Bougainvillia (05 Nos.), Dracena (05 Nos.) and Roses (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Middle School Bhatillu, Distt. Kangra, H.P.	16.01.2023
260.	Material Transfer Agreement (MTA) for taking up one lakh lemongrass slips under "CSIR Aroma Mission".	Mani Trust, Mani Bhawan, Relli Road, Kalimpong West Bengal – 734 301	18.01.2023
261.	Material Transfer Agreement (MTA) to take up Scented geranium (5000 nos.) and 50 kg seed of wild marigold FOC under "CSIR-Aroma mission-II".	Himalayan Phytochemical & Growers Association, Baggi, Sundar Nagar (H.P.)	18.01.2023
262.	Material Transfer Agreement (MTA) to take up aromatic Marigold Variety Him Swarnima (8 kg seed) and rooted plants of scented geranium (500 nos.) under "CSIR Aroma Mission phase–II".	Sh. Sanjeev Mohil, V.P.O. Chalana via Nahan, Tehsil Dadahu, Distt. Sirmour, (H.P.)	18.01.2023
263.	Material Transfer Agreement (MTA) to take up 2,500 plants of Lavender.	Devanya Hotel and Resorts Pvt. Ltd. Nainital, Uttarakhand	18.01.2023
264.	Material Transfer Agreement (MTA) to takeup 1 kg seed of Aromatic marigold variety Him Swarnima from CSIR-IHBT under CSIR- Aroma Mission Phase-II.	Aatmiya Herbal Industries LLP, Siwan, Bihar	18.01.2023
265.	Material Transfer Agreement (MTA) to take up 500 g seed of German Chamomile from CSIR-IHBT under CSIR- Aroma Mission Phase-II.	Sh. Pritam Chand Tehsil Khundian/ Gram panchayat Majhin, Dhatehr Kangra (H.P.)	18.01.2023
266.	Material Transfer Agreement (MTA) for garden establishment to take up Syngonium red (10 Nos.), Syngonium green (05 Nos.), Money plant (05 Nos.), Hibiscus (05 Nos.), *Tabernaemontana divaricate* (05 Nos.), Rose (05 Nos.), Thuja (02 Nos.), Green Cypress (05 Nos.), Annual Chrysanthemums (25 Nos.) and Calendula (20 Nos.) plants free of cost under "CSIR Floriculture Mission".	GPS, Ladoh, Panchrukhi, Distt. Kangra, H.P.	01.02.2023
267.	Material Transfer Agreement (MTA) for garden establishment to take up Golden cypress (02 Nos.), Araucaria (02 Nos.), Areca palm (02 Nos.), Bougainvillea (02 Nos.), Rhoeo (10 Nos.), Schefflera (10 Nos.), Rose (10 Nos.) and Hibiscus (05 Nos.) plants free of cost under "CSIR Floriculture Mission".	GPS, Dattal, Panchrukhi, Distt. Kangra, H.P.	01.02.2023
268.	Material Transfer Agreement (MTA) for garden establishment to take up Hibiscus (05 Nos.), Rose (05 Nos.), Annual Chrysanthemums (10 Nos.), Calendula (20 Nos.), *Hamelia patens* (05 Nos.) and Bougainvillea (02 Nos.) plants free of cost under "CSIR Floriculture Mission".	GPS, Tatehal, Distt. Kangra, H.P.	01.02.2023

S. No.	Title of agreement	Name of party	Date of signing
269.	Material Transfer Agreement (MTA) for garden establishment agrees to take up Hibiscus (05 Nos.), Rose (05 Nos.), Annual Chrysanthemums (10 Nos.), Calendula (20 Nos.), *Hamelia patens* (05 Nos.) and Bougainvillea (02 Nos.) plants free of cost under "CSIR Floriculture Mission".	GPS, Khungnoo, Distt. Kangra, H.P.	01.02.2023
270.	Material Transfer Agreement (MTA) for garden establishmentagrees to take up Bougainvillea (05 Nos.), Areca palm (02 Nos.), Rose (10 Nos.), Annual Chrysanthemums (20 Nos.), Calendula (10 Nos.), Thuja (10 Nos.) Nerium (10 Nos.) Green cypress (05 Nos.) and Acalypha (05 Nos.) plants free of cost under "CSIR Floriculture Mission".	GPS, Pahra, Distt. Kangra, H.P.	01.02.2023
271.	Material Transfer Agreement (MTA) for garden establishment to take up Annual Chrysanthemums (20 Nos.), Calendula (10 Nos.), Ice Plant (05 Nos.), Tuberose bulb (50 Nos.) Gladiolus corms (20 Nos.) Syngonium (10 Nos.), Money plant (10 Nos.), Rhoeo (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	GPS, Rajpur, Distt. Kangra, H.P.	01.02.2023
272.	Material Transfer Agreement (MTA) for garden establishment to take up Annual Chrysanthemums (20 Nos.), Calendula (10 Nos.), Ice Plant (05 Nos.), Tuberose bulb (50 Nos.) Gladiolus corms (20 Nos.) Syngonium (10 Nos.), Money plant (10 Nos.), Rhoeo (10 Nos.), Ticoma (05 Nos.), Spider lily (05 Nos.) and Plumeria (05 Nos.) plants free of cost under "CSIR Floriculture Mission".	GPS, Banuri, Distt. Kangra H.P.	01.02.2023
273.	Material Transfer Agreement (MTA) signed to evaluate performance of stevia at West Bengal.	Dr. Abhijit Bandopadhyay, UGC, Centre for Advanced Studies Department of Botany,University of Burdwan, West Bengal	02.02.2023
274.	Material Transfer Agreement (MTA) signedfor taking slips of lemongrass, seeds of wild marigold and seeds of palmorosa.	Dr. Nitin Verma, Professor and Principal, School of Pharmacy, Chitkara University (H.P.)	06.02.2023
275.	Material Transfer Agreement (MTA) for garden establishment agrees to take up Rohio (60 Nos.), Syngonium (white) (54 Nos.), Syngonium (pink) (54 Nos.), Money Plant (Green) (54 Nos.), Money Plant (golden) (24 Nos.), Money Plant (variegated) (12 Nos.), Asparagus (20 Nos.), Tradenscatia (56 Nos.), Spider Plant (44 Nos.) Panels (126 Nos.) and Pots (378 Nos.) free of cost under "CSIR Floriculture Mission".	Sub Divisional Magistrate Office, Bhoranj, Hamirpur, H.P.	07.02.2023

S. No.	Title of agreement	Name of party	Date of signing
276.	Material Transfer Agreement (MTA) for garden establishment to take up Bottle Palm (03 Nos.), Table Palm (03 Nos.), Areca Palm (04 Nos.), Bleeding Heart (02 Nos.), Rangoon Creeper (05 Nos.), Ticoma (05 Nos.), Jatropha (09 Nos.), Hydrangea (10 Nos.), Bougainvillea (06 Nos.), Loose Rose (06 Nos.), Pendenance (10 Nos.), Gladiolus corms (2000 Nos.) free of cost under "CSIR Floriculture Mission".	Government High School, Gullela Block Bhoranj, Hamirpur, H. P.	07.02.2023
277.	Material Transfer Agreement (MTA) for garden establishment to take up Cycas (02 Nos.), Golden Cypress (01 No.), Green Cypress (10 Nos.), Duranta (200 Nos.), Bleeding Heart (04 Nos.), Boxwood (50 Nos.), Roses (40 Nos.), Nerium (05 Nos.), Ophipogon (50 Nos.), Gladiolus (250 Nos.), Madhumalti (20 Nos.), *Tabernaemontana divaricata* (05 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Middle School, Amned, Block Bhoranj, Hamirpur, H. P.	07.02.2023
278.	Material Transfer Agreement (MTA) for garden establishment to take up Boxwood (10 Nos.), Araucaria (2 Nos.), Syngonium (15 Nos.) Thuja (5 Nos.), Rohio (10 Nos.), Golden Cypress (2 Nos.), Hydrangea (15 Nos.), Asparagus (15 Nos.), Green Cypress (5 Nos.), *Combretum indicum* (3 Nos.), Money plant (5 Nos.), Schefflera (2 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School, Gullela, Dist. Solan H.P.	07.02.2023
279.	Material Transfer Agreement (MTA) for garden establishment to take up *Jasminum humile* (10 Nos.), Curtain creeper (10 Nos.), Table Palm (02 Nos.), Hibiscus (05 Nos.), Bougainvillea (02 Nos.), Loose Roses (25 Nos.), Draceana (10 Nos.), Rohio (20 Nos.), Ophipogon (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School, Amned, Block Bhoranj, Hamirpur, H. P.	07.02.2023
280.	Material Transfer Agreement (MTA) for garden establishment to take up *Hamelia patens* (40 Nos.), Areca Palm (05 Nos.), Pendenance (20 Nos.), Duranta (200 Nos.), Gladioulus corms (500 Nos.), Aralia (40 Nos.), Loose Rose (50 Nos.), Bougainvillea (15 Nos.), Golden cypress (01 No.), Thuja (03 Nos.), Spider plant (30 Nos.), Asparagus (45 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School, Bhoranj, Block Bhoranj, Hamirpur, H. P.	07.02.2023
281.	Material Transfer Agreement (MTA) for garden establishment to take up Boxwood (20 Nos.), Ophiopogon (20 Nos.), Spider Plant (20 Nos.), Eranthemum (10 Nos.), Agev (02 Nos.), Cycas (02 Nos.), Duranta (20 Nos.), Topiary (01 No.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School, Bumana, Block Bhoranj, Hamirpur, H. P.	07.02.2023

S. No.	Title of agreement	Name of party	Date of signing
282.	Material Transfer Agreement (MTA) for garden establishment to take up Money Plant (10 Nos.), Money Plant Varieagated (10 Nos.), Money Plant Golden (10 Nos.), Loose Rose (25 Nos.), Ticoma (10 Nos.), Rangoon Creeper (05 Nos.), Ficus Topiary (02 Nos.), Foxtail Palm (04 Nos.), Boxwood (25 Nos.), Green Cypress (08 Nos.), *Ficus benzamina* (05 Nos.), Red Draceana (05 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School, Didwin Tikkar Block Bhoranj, Hamirpur, H. P.	07.02.2023
283.	Material Transfer Agreement (MTA) for garden establishment to take up Foxtail Palm (20 Nos.), Royal Palm (10 Nos.), Golden Cypress (01 Nos.), Spider Plant (30 Nos.), Loose Roses (10 Nos.), Madhumalti (05 Nos.), Hibiscus (02 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School, Samrala, Block Bhoranj, Hamirpur, H. P	07.02.2023
284.	Material Transfer Agreement (MTA) for garden establishment to take up Topiary (02 Nos.), Bleeding Heart (05 Nos.), *Ficus Benjamina* (05 Nos.), Golden Cypress (01 No.), Madhumalti (05 Nos.), *Hamelia Patens* (05 Nos.), Rohio (50 Nos.), Spider Plant (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School, Tal, Block Bhoranj, Hamirpur, H. P.	07.02.2023
285.	Material Transfer Agreement (MTA) for garden establishment to take up *Ficus Benjamina* (06 Nos.), Dracaena (red Spikes) (50 Nos.), Syngonium red (50 Nos.), Syngonium white (50 Nos.), Hibiscus (05 Nos.), Araucaria (01 No.), Plumeria (04 Nos.), Gladiolous (1000 Nos.), Loose Rose (25 Nos.), Agev (01 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Primary School, Thathwani, Block Bhoranj, Hamirpur, H. P.	07.02.2023
286.	Material Transfer Agreement (MTA) for garden establishment to take up Dracaena (10 Nos.), Araucaria (3 Nos.), Green Cypress (10 Nos.), Hibiscus (10 Nos.), Areca palm (10 Nos.), Table palm (10 Nos.), Cycas (1 No.), Bottle palm (2 Nos.), Raphis palm (2 Nos.), Golden Cypress (2 Nos.), Bougainvillea (10 Nos.), Rangoon creeper (10 Nos.), Thuja (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government High School, Ranjitgarh, Mukatsar, Punjab	07.02.2023
287.	Material Transfer Agreement (MTA) for garden establishment to take up Dracaena (10 Nos.), Araucaria (3 Nos.), Green Cypress (10 Nos.), Hibiscus (10 Nos.), Areca palm (10 Nos.), Table palm (10 Nos.), Cycas (1 No.), Bottle palm (2 Nos.), Raphis palm (2 Nos.), Golden Cypress (2 Nos.), Bougainvillea (10 Nos.), Rangoon creeper (10 Nos.), Thuja (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government High School, Ghagga, Mukatsar, Punjab	07.02.2023

S. No.	Title of agreement	Name of party	Date of signing
288.	Material Transfer Agreement (MTA) for garden establishment to take up Dracaena (10 Nos.), Araucaria (3 Nos.), Green Cypress (10 Nos.), Hibiscus (10 Nos.), Areca palm (10 Nos.), Table palm (10 Nos.), Cycas (1 No.), Bottle palm (2 Nos.), Raphis palm (2 Nos.), Golden Cypress (2 Nos.), Bougainvillea (10 Nos.), Rangoon creeper (10 Nos.), Thuja (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government Senior Secondary School, Kotkapura, Mukatsar, Punjab	07.02.2023
289.	Material Transfer Agreement (MTA) for garden establishment to take up Dracaena (10 Nos.), Araucaria (3 Nos.), Green Cypress (10 Nos.), Hibiscus (10 Nos.), Areca palm (10 Nos.), Table palm (10 Nos.), Cycas (1 No.), Bottle palm (2 Nos.), Raphis palm (2 Nos.), Golden Cypress (2 Nos.), Bougainvillea (10 Nos.), Rangoon creeper (10 Nos.), Thuja (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government High School, Khunde Halal, Mukatsar, Punjab	07.02.2023
290.	Material Transfer Agreement (MTA) for garden establishment to take up Dracaena (10 Nos.), Araucaria (3 Nos.), Green Cypress (10 Nos.), Hibiscus (10 Nos.), Areca palm (10 Nos.), Table palm (10 Nos.), Cycas (1 No.), Bottle palm (2 Nos.), Raphis palm (2 Nos.), Golden Cypress (2 Nos.), Bougainvillea (10 Nos.), Rangoon creeper (10 Nos.), Thuja (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government High School, Hariewala, Mukatsar, Punjab	07.02.2023
291.	Material Transfer Agreement (MTA) for garden establishment to take up Royal Palm (05 Nos.), Foxtail Palm (05 Nos.), Washingtonia Palm (03 Nos.), Thuja (10 Nos.), Roses (20 Nos.), Asparagus (30 Nos.), Eranthemum (20 Nos.), Dracaena red ruby (20 Nos.) and *Tabernaemontana divaricate* (10 Nos.) plants free of cost under "CSIR Floriculture Mission".	Government High School, Kakral Kalan, Ludhiana, Punjab	07.02.2023
292.	Material Transfer Agreement (MTA) for garden establishment to take up Royal Palm (05 Nos.), Table Palm (05 Nos.), Foxtail Palm (05 Nos.), Washingtonia Palm (03 Nos.), Green cypress (10 Nos.), Roses (20 Nos.), Asparagus (30 Nos.), Eranthemum (20 Nos.), Dracaena red ruby (20 Nos.) and *Tabernaemontana divaricate* (10 Nos.) plants on Free of cost (FOC) basis under "CSIR-Floriculture Mission".	Government Primary School, Nanowal Kalan, District Fatehgarh Sahib, Punjab	07.02.2023
293.	Material Transfer Agreement (MTA) signed for producing planting material of aromatic crops and providing to farmers under CSIR Aroma Mission Phase-II.	Associate Director (R&E), Regional Horticulture Research Training Station, (RHRTS) Jachh, Tehsil Nurpur Distt. Kangra (H.P.)	14.02.2023

S. No.	Title of agreement	Name of party	Date of signing
294.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (2,000 Nos.) on subsidized price (10% of actual price) under "CSIR-Floriculture Mission".	Mr. Raj Kumar, s/o Duni chand, Tehsil Shimla, Deothi (250), Shimla H.P.	22.02.2023
295.	Material Transfer Agreement (MTA) agrees to take up carnation rooted cuttings (2,000 Nos.) on subsidized price (10% of actual price) under "CSIR-Floriculture Mission".	Mr. Sanjay Thakur, c/o Lekh Ram Thakur, Shilru Sapli (311) Shimla H.P.	22.02.2023
296.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (2,000 Nos.) on subsidized price (10% of actual price) under "CSIR-Floriculture Mission".	Mr. Bodh Raj Sharma, s/o Dharam Dutt Sharma, Tehsil Shimla, Playana, Shimla H.P.	22.02.2023
297.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (2,000 Nos.) on subsidized price (10% of actual price) under "CSIR-Floriculture Mission".	Mr. Narinder, s/o Tulsi Ram, Post Office Thaila, The Shimla, Nakhlashi, Shimla, H.P.	22.02.2023
298.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (2,000 Nos.) on subsidized price (10% of actual price) under "CSIR-Floriculture Mission".	Mr. Dharam Singh, s/o Niram singh, Post office Shimla, H.P.	22.02.2023
299.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (2,000 Nos.) and gladiolus corms (50,000 Nos.) on subsidized price (10% of actual price) under "CSIR-Floriculture Mission".	Mr. Suresh Kumar, s/o Budhi Ram, Tehsil Sunni, Ramahan (89) Gumma, Shimla, H.P.	22.02.2023
300.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (2,000 Nos.) on subsidized price (10% of actual price) under "CSIR-Floriculture Mission".	Mr. Tara Chand, s/o Bhagat ram, Village Kanola, Post office Mashobra, Tehsil Shimla, Mashobra (b) (246) Shimla, H.P.	22.02.2023
301.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (2,000 Nos.) on subsidized price (10% of actual price) under "CSIR-Floriculture Mission".	Mr. Hem Raj Sharma, s/o Suraj Dutt sharma, Tehsil Shimla, Village Shalli, Mukoti (237), Shimla, H.P.	22.02.2023
302.	Material Transfer Agreement (MTA) on subsidized price (10% of actual price) under "CSIR-Floriculture Mission".	Mr. Amar singh, s/o Mast Ram, Shilru Sapoli (311), Mashobra, Shimla, H.P.	22.02.2023
303.	Material Transfer Agreement (MTA) to take up carnation rooted cuttings (2,000 Nos.) on subsidized price (10% of actual price) under "CSIR-Floriculture Mission".	Mr. Bhagat Ram, s/o Late Tulsi Ram, Village Nakhlashi Post Office Thaila, Shimla, Mashobra (b) (246), Shimla, H.P.	22.02.2023
304.	Material Transfer Agreement (MTA) to take up Araucaria (01 Nos.), Bougainvillea (05 Nos.), Bromelia (05 Nos.), Dracaena (05 Nos.), Ficus (10 Nos.), Gladiolus (10 Nos.), Hibiscus (02 Nos.), Maranta (03 Nos.), Nerium (10 Nos.), Pencil Pine (02 Nos.), Schefflera (02 Nos.), Spider Lily (03 Nos.), Spider Plant (04 Nos.), Thuja (03 Nos.) plants on Free of cost (FOC) basis under "CSIR-Floriculture Mission".	Government Senior Secondary School, Charri, Dharamshala, (H.P.)	01.03.2023

S. No.	Title of agreement	Name of party	Date of signing
305.	Material Transfer Agreement (MTA) to take up Araucaria (01 Nos.), Bougainvillea (05 Nos.), Bromelia (05 Nos.), Dracaena (05 Nos.), Ficus (10 Nos.), Gladiolus (10 Nos.), Hibiscus (02 Nos.), Maranta (03 Nos.), Nerium (10 Nos.), Pencil Pine (02 Nos.), Schefflera (02 Nos.), Spider Lily (03 Nos.), Spider Plant (04 Nos.), Thuja (03 Nos.) plants on Free of cost (FOC) basis under "CSIR-Floriculture Mission".	Government Senior Secondary School, Gharoh, Dharamshala, (H.P.)	01.03.2023
306.	Material Transfer Agreement (MTA) to take up Araucaria (01 Nos.), Bougainvillea (05 Nos.), Bromelia (05 Nos.), Dracaena (05 Nos.), Ficus (10 Nos.), Gladiolus (10 Nos.), Hibiscus (02 Nos.), Maranta (03 Nos.), Nerium (10 Nos.), Pencil Pine (02 Nos.), Schefflera (02 Nos.), Spider Lily (03 Nos.), Spider Plant (04 Nos.), Thuja (03 Nos.) plants on Free of cost (FOC) basis under "CSIR-Floriculture Mission".	Government Middle School, Lanjhani, Dharamshala, (H.P.)	01.03.2023
307.	Material Transfer Agreement (MTA) to take up Araucaria (01 Nos.), Bougainvillea (05 Nos.), Bromelia (05 Nos.), Dracaena (05 Nos.), Ficus (10 Nos.), Gladiolus (10 Nos.), Hibiscus (02 Nos.), Maranta (03 Nos.), Nerium (10 Nos.), Pencil Pine (02 Nos.), Schefflera (02 Nos.), Spider Lily (03 Nos.), Spider Plant (04 Nos.), Thuja (03 Nos.) plants on Free of cost (FOC) basis under "CSIR-Floriculture Mission".	Government Senior Secondary School, Kaliara, Dharamshala, Himachal Pradesh	01.03.2023
308.	Material Transfer Agreement (MTA) for taking up 60000 rooted carnation plants.	Dhauladhari Krishak Utpadak Evum Marketing Cooperative Society Limited, VPO Chakmoh Tehsil Dhatwal District Hamirpur (H.P.)	27.03.2023
309.	Material Transfer Agreement (MTA) to take up aromatic marigold seeds and palmarosa seeds	Sanjeev Mohil, VPO Chalana, via Nahan, Tehsil Dadahu, Distt. Sirmour, HP - 173001	28.03.2023
310.	Material Transfer Agreement (MTA) to take up aromatic marigold seeds	Vishnu Dev Mishra, H no. 1146/5, Mohalla Amarpur, Behind Old co- operative Bank,P.O Nahan, Tehsil Nahan, Sirmour, HP-173001	28.03.2023
311.	Material Transfer Agreement (MTA) to take up aromatic marigold seeds	Sandeep Thakur, Village Satna, P O. Jamta , Tehsil Nahan, Distt. Sirmour, H P-173001	28.03.2023
312.	Material Transfer Agreement (MTA) to take up aromatic marigold seeds	Lalit Mohan, Village Burman, P.O. Jamta, tehsil Nahan, Distt. Sirmour, H.P. -173001	28.03.2023

S. No.	Title of agreement	Name of party	Date of signing
	BIOTECHNOLOGY		
1.	Material Transfer Agreement (MTA) to take up planting material of apple raised through plant tissue culture in flask	M/s Sharma Biotech, V.P.O Samoh District Bilaspur Himachal – 174031	02.07.2022
	CHEMICAL TECHNOLOGY		
1.	Material Transfer Agreement (MTA) for resorcinol derivatives for evaluation and testing purposes	Colgate-Palmolive Company, USA	14.10.2022
	MISCELLANEOUS MOUs		
	AGROTECHNOLOGY		
1.	MoU to install cold storage unit free of cost under CSIR-Floriculture Mission.	Friends Farmer Welfare Club VPO Nanowal, Tehsil Khamano, District Fatehgarh Sahib Punjab	06.04.2022
2.	MoU to install cold storage unit free of cost under CSIR-Floriculture Mission.	Flower Growers Social Welfare Trust Nayagaon Chandan Singh, Kaladhungi, Kaladhungi, Kamola, Nainital, Uttarakhand	06.04.2022
3.	MoU for growth of agriculture in high hills of H.P. and J&K.	State Bank of India, Cama Road, Mumbai and North region office at Sector 17 A Chandigarh	09.05.2022
4.	MoU for creation of a framework for collaboration between IBSD and CSIR-IHBT.	IBSD, Imphal, Manipur	11.05.2022
5.	MoU to join hands for strategic partnership for livelihood promotion and rural development.	Jaivik Foundation, E-700, Near Chhajju Gate, Sanjay Gandhi Marg, Delhi	24.05.2022
6.	MoU to undertake joint collaboration in the field of essential oil.	M/s Appleway International, Dist. Solan, Himachal Pradesh – 173 220	27.05.2022
7.	MoU to install cold storage unit free of cost under CSIR-Floriculture Mission.	The Bagsiad Farmer Development Producers cum sale Cooperative Society Ltd., P.O. – Bagsiad, Tehsil – Thunag, Mandi H.P.	02.06.2022
8.	MoU for the purpose of increasing farm income, livelihood promotion and rural development in Himachal Pradesh.	Directorate of Horticulture, Government of Himachal Pradesh Navbahar, Shimla	21.09.2022
9.	MoU for taking up damask rose, rosemary, geranium, ginkgo bioloba, oregano and lemaon balm.	Er. Karamjit Singh 405, Sector 71, Mohali(Pb.)	23.11.2022
10.	MoU to establishment of cold storage unit. free of cost under "CSIR Floriculture Mission".	Mani Trust, Mani Bhawan, Relli Road, Kalimpong, West Bengal	07.02.2023
11.	MoU signed towards the major challenges faced by Ladakh region are: (i) Lack of storage facilities for agri-horti produce (ii) Logistical challenges(iii) Limited industrial access and lack of processing facilities, (iv) Lack of exposure to modern packaging technology(v) Limited exposure of farmers to advance post-harvesting technologies and (vi) High dependence on agriculture as the source of livelihood.	Directorate of Industries & Commerce, UT Ladakh.	15.02.2023

S. No.	Title of agreement	Name of party	Date of signing
12.	MoU signed between CSIR-IHBT and, a flagship programme of the Ministry of Rural Development, Govt. of India, to discover, innovate, develop and disseminate the processes, products and technologies from Himalayan bioresources for society, industry, environment and academia.	H.P. State Rural Livelihood Mission, Rural Development Department, HP Shimla under Deendayal Antyodaya Yojana-National Rural Livelihood Mission (DAY-NRLM)	17.02.2023
13.	MoU signed on Technologies and Entrepreneurship Development.	Mosachi Holdings & Group Companies, Ahmedabad	21.02.2023
14.	MoU to install distillation unit (under CSIR-Aroma Mission-II).	Shivalik Medicinal and Aromatic Plants Cultivation Society Chauki Maniar, Una (H.P.)	27.03.2023
	CHEMICAL TECHNOLOGY		
15.	MoU for development of new drugs for the treatment of neglected tropical and viral diseases with Drugs for Neglected Diseases initiative (DNDi) 15, chemin Camille-Vidart, 1202, Geneva, Switzerland.	Drugs for Neglected Diseases initiative (DNDi), Switzerland	08.04.2022
	ACADEMICS		
16.	MoU for creation of a framework for collaboration between IBSD and CSIR-IHBT.	The Institute of Bioresources and Sustainable Development, Imphal, Manipur 795001	11.05.2022
17.	MoU for collaborative research (Biotechnology)	Lovely Professional University, Jalandhar	13.06.2022
18.	MoU for collaborative research.	Sri Sai University, Palampur H.P.	24.06.2022
19.	MoU for a cooperative arrangement towards - strengthening Indian higher education and research through mutual resource sharing	Central University of Haryana, Vice-chancellor, Mahendragarh, Haryana- 123 031	02.07.2022
20.	Development of botanical formulation from plant extracts and seed oil of *Triadica sebifera (L.)* Small for the control of aphid, Aphis craccivora Koch Centre for Cellular and Molecular Platforms (C-CAMP)	Centre for Cellular and Molecular Platforms, NCBS-TIFR Campus, GKVK Post, Bellary Road, Bangalore-560065, India	15.07.2022
21.	MoU for strengthening Indian higher education and research through mutual resource sharing.	Central University of Punjab, Registrar, V.P.O Ghudda, Bhatinda, Punjab 151401	20.07.2022
22.	MoU for collaborative and joint research work in the various areas of mutual interest.	Central University of Himachal Pradesh, Dharamshala, District Kangra (Himachal Pradesh)	05.08.2022
23.	MoU to join hands for the cause of promotion of quality research and high end science.	Sardar Patel University, Mandi (Himachal Pradesh)- 175 001	05.09.2022
24.	MoU for collaborative research and academic activities.	Government Post Graduate College, Ambala Cantt (Haryana)	25.10.2022
25.	MoU for collaborative research and academic activities.	Graphic Era (Deemed to be) University, Dehradun- 248002, Uttarakhand.	25.10.2022
26.	MoU for close cooperation in research and academic activities.	Lovely Professional University, Jallandhar	17.12.2022

S. No.	Title of agreement	Name of party	Date of signing
	AGREEMENTS WITH INCUBATEES / START-UPS		
	BIOTECHNOLOGY		
1.	Facility use agreement for availing Incubation facility for R&D	Rna Vaxbio Private Limited, Anand Cinema Complex, The Mall, Solan Himachal Pradesh	02.07.2022
2.	Agreement under “CM Startup Scheme” for incubation facility for Hydroponic farming of *Bacopa monnieri* and *Rauvolfia serpentine*.	Mr. Ranjiv Singh VPO Raja Ka Bagh, Tehsil Nurpur, Distt. Kangra, H.P.	17.08.2022
3.	Agreement under “CM Startup Scheme” for incubation facility for Hydroponic production of high-value vegetables (Kale, cherry tomato and lettuce etc.).	Mr. Suveer Singh, having residential address at H. No. 102, Block No. 1, Sanyard, Tehsil Sadar Mandi, Distt. Mandi, H.P.	22.08.2022
4.	Agreement under “CM Startup Scheme” for incubation facility for Hydroponic cultivation of *Nardostachys jatamansi*.	Ms. Shikha Kalsi Village-Bani, Post office-Bani, Tah. Barsar, Distt. Hamirpur, H.P.	31.08.2022
5.	Agreement under Himachal Pradesh regarding ‘Chief Minister Startup Scheme’ 175019 for Development of Plant based digestive stimulant for human gut health.	Ms. Yamini Sharma, 372/11 V.P.O Purana Bazar Teh Sundernagar District Mandi H.P.	15.09.2022
6.	Agreement under Himachal Pradesh regarding ‘Chief Minister Startup Scheme’ 175019 for a nutritive, tasty and healthy herbal and nutraceuticals fortified bakery products (cakes and bars).	Ms. Mona Singh, Cofounder of Yuktika Biotech and Nutraceuticals Pvt. Ltd., Village Bharmat, Tehsil Palampur.	27.09.2022
	AGROTECHNOLOGY		
1.	Agreement under “CM Startup Scheme” for incubation facility for Value addition of flowers through dehydration technology.	Ms. Seema Kumari VPO Banuri, Tehsil Palampur, Distt. Kangra.	31.08.2022

MISSION MODE PROJECTS

CSIR AROMA MISSION

CSIR-IHBT interventions under CSIR-Aroma Mission

During 2022-23, the area under cultivation of aromatic crops was extended to 3000 ha in the CSIR-Aroma Mission program, seventeen additional distillation units were installed (overall 61 units) at farmers' fields, empowering farmer groups in production of essential oil from their produce of aromatic crops. Nearly 8.0 tonnes of high grade aromatic marigold (Tagetes) oil was produced in the state of Himachal Pradesh leading to revenue generation of Rs. 11.2 crores and benefitting 2000 farmers. CSIR-IHBT endeavours led to area extension of aromatic crops in eleven states and two union territories. During the period, 3121 farmers,unemployedyouth,entrepreneurs were involved in cultivation, processing and value addition of aromatic crops. Overall, seven new varieties of aromatic crops of aromatic marigold, Indian valerian, palmarosa, scented geranium, rosemary, lavender and clary sage were developed while thirteen agrotechnologies for cultivation of aromatic crops were also standardized. The revenue generation through sale of essential oils in 2022-23 was 19.86 crores.

➢ **Generation of quality planting material**

Quality planting material of targeted aromatic crops was generated within the institute and supplied to the farmers to bring the degraded and waste land under aromatic crops cultivation. Given below is the complete detail of quantities of the planting material of the target aromatic crops generated and supplied during the year (Table 1)

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

Crops	Planting material distributed
Aromatic marigold	412 kg seeds
Damask rose	5,500 plants
Lemongrass	9,62,000 slips
Rosemary	28,000 plants
Ocimum	4 kg seeds
Geranium	40,000 plants
Chamomile	50 kg seeds
Clary sage	3 kg seeds
Artemisia maritima	27 kg seeds
Lavender	18,000 plants

➢ **Training and awareness programmes for skill development**

Twelve awareness cum training programs on cultivation and process technologies of aromatic crops were conducted during April, 2022 to March, 2023 and 527 rural men women farmers were trained (Table 2). Practical exposure on field preparation for nursery beds, plantation of crops, harvesting of crops at proper stage to obtain higher essential oil content and composition, essential oil extraction in Clevenger apparatus, mini distillation unit and pilot plant was imparted. Under this program the farmers were inculcated for the cultivation of aromatic crops namely damask rose, aromatic marigold, chamomile, lavender, scented geranium, lemongrass, tulsi and rosemary.

Table 2

S. No.	State	District	Program Location	Program Date	Men	Women	Total
1	H. P.	Kangra	Palampur	05/07/2022	48	02	50
2	H.P.	Kangra	Dharamshala	13/07/2022	03	48	51
3	H.P.	Kangra	Palampur	14/07/2022	03	03	06
4	H.P.	Kangra	Palampur	22/07/2022	00	02	02
5	H.P.	Mandi	Dhwali	23/07/2022	41	49	90
6	H.P.	Kangra	Palampur	26/07/2022	15	00	15
7	W. B.	Kalimpong	Kalimpong	23/08/2022	60	90	150
8	H.P.	Kangra	Palampur	24/08/2022	07	08	15
9	Sikkim	Namchi and Soreng	Sumbhuk	24/08/2022	60	40	100
10	H.P	Kangra	Palampur	30/08/2022	08	22	30
11	H.P	Kangra	Palampur	19/10/2022	08	00	08
12	U.K.	Champawat	Saniya and Mara	09/11/2022	03	07	10

Awareness cum training program on cultivation of aromatic plants at Dhwali, Kangra, H.P.

Awareness cum training program on cultivation of aromatic crops at Dharamshala, Kangra

Training program on aromatic plant cultivation at CSIR-IHBT farm

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

An awareness cum training program on aromatic plants cultivation at village Kareri, Distt Kangra, HP.

Training program on aromatic plant cultivation at CSIR-IHBT farm

An awareness cum training program on aromatic plants cultivation at Kalimpong, West Bengal

An awareness cum training program on aromatic plants cultivation at Sumbhuk, Sikkim

Distribution and plantation of quality planting material of lemongrass at Talajagar, Odisha

Distribution and plantation of quality planting material of aromatic marigold at Kangpokpi, Manipur

Technical support to the farmers of Distt. Kangra, HP at CSIR-IHBT facility for essential oil distillation

Technical support to the farmers of Distt. Kangra, HP at farmers' field for essential oil distillation using mobile distillation unit

Fig. 1 Glimpse of awareness cum training programs on cultivation of aromatic plants, distribution of quality planting material to farmers and technical support to the farmers for essential oil distillation.

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. S G E 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.

Area extension and generation of quality planting material

During 2022-23, 249.90 ha area were brought under the floriculture crops. Area covered under different crops were Marigold (206 ha), Gladiolus (8.08 ha), Chrysanthemum (12.84 ha), Gerbera (0.31 ha), Carnation (1.07 ha), Lilium (1.47 ha), Tuberose (1.09ha), Rose loose (3.53 ha) and Tulip (1.27 ha). Bringing a large area under floriculture requires propagules, hence the Institute generated planting material for the same. Under CSIR-Floriculture Mission, around 55.8 lakh quality planting material of floricultural crops such as Marigold (24,16,809 seedlings), Gladiolus (15,96,350 bulbs), Chrysanthemum 11,55,165 rooted cuttings), Gerbera (27,500 plants), Carnation (21,400 plants), Lilium (2,94,200 bulbs), Tuberose (1,08,000 bulbs), Cut-rose (36,850 cuttings) Loose rose (52,930 cuttings), Cymbidium orchids (50,806 bulbs) have been distributed to the farmers of Himachal Pradesh, Haryana, Punjab, Uttrakhand and Leh-Ladhakh.

Distribution of planting materials to farmers

Gladiolus corms, Nainital, UK

Lilium bulbs, Nainital, UK

Marigold seedlings Mandi Dabwali, Haryana

Training and awareness programmes

Twenty-eight awareness cum training programmes on cultivation and value addition technologies of floricultural crops including dehydration technology of flowers were organized. Training program for making incense sticks, dhoop cones, and Agarbattis from flower, training cum distribution programme of bee hive boxes with honeybee (Apis mellifera) colonies were conducted from April 2022 to March 2023 and more than 700 unemployed youth, rural women (self-help groups) and farmers (clusters) were trained.

A training program for making 'Incensesticks, Dhoopcones, and Agarbattis from flower waste' was organized on 22.07.22 for a self-help group 'Jagriti' at village Malghotta, Kharanal, Baijnath under the Floriculture Mission

Five days awareness cum training programme on cultivation, processing and marketing of floriculture crops under CSIR floriculture mission was organized on 25.07.2022-29.07.2022

Integration of Apiculture in Floriculture

Various apiculture clusters targeting existing fruit orchards and new nectar yielding floral crop fields were established including eleven bee keeping clusters (20 farmers/clusters in 10 clusters and 10 farmers in one cluster) in Himachal Pradesh and Uttarakhand. Two thousand and one hundred (2100 No.) bee hive boxes with colonies and 210 beekeeping kits (Bee veil, Bee smoker, Hive tool, uncapping knife) were distributed to the farmers. Eleven honey extractors are distributed in 11bee keeping clusters. The crops targeted in different bee keeping clusters are marigold, rose, litchi, apple, mango, guava, citrus, pear, peach, papaya, mulberry etc.

Urban Floriculture and Vertical Gardens

Established twelve vertical gardens in different state government offices and public such as Dharmashala airports, Kullu bhuntar airport, AIIMS, Bilaspur etc. About 206 gardens have been established in the various schools, colleges and public institutions across Himachal Pradesh, Punjab, Haryana and Uttrakhand.

Garden establishment at Govt. Girls Senior secondary School, Nadaun

Establishment of Tulip Garden in Palampur (Tourist attraction)

Himachal's first 'Tulip Garden' was established at CSIR-IHBT, Palampur. Around 10,000 nos. of students, tourists, researchers, farmers and public visited Tulip Garden this year.

Hon'ble Chief Minister of Himachal Pradesh, Shri Sukhwinder Singh Sukhu, visited Tulip garden, CSIR-IHBT on 8th March, 2023 and interacted with scientists of the institute and appreciated the same. He also discussed regarding expansion of tulip cultivation and bulb production in suitable areas of the state

Cold storage facility

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

Value added products developed at CSIR-IHBT

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

CSIR MISSION ON IMMUNOMODULATORY FUNCTION OF NUTRITIONALS AND NUTRACEUTICALS FOR HEALTH AND WELLNESS

In the CSIR Mission on Nutraceuticals and Nutritionals some of the commercializable nutraceuticals were developed and leads were in place, ready to be taken forward. With this backdrop, brainstorming among experts was conducted for new ideas and inputs that were fine-tuned and taken forward as a new Mission focusing on Wellness and Immunity.

Objectives

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

Expected deliverables

- 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

Theme-wise progress under different work-packages

Theme 1. Polyherbal-based Immuno-modulatory Products

(a) *Adhatoda vasica* and *Vitex negundo* based immunity boosting formulation

  - Assessed the influence of *Vitex negundo* and *Adhatoda vasica* on LPS-induced mice model individually as well as in combination. After completion of the live phase, organs were collected and cytokines milieu was measured. It was observed that *Vitex negundo* and *Adhatoda vasica* combination modulated the ratio of pro-inflammatory/ anti-inflammatory cytokines, which are considered as a cornerstone in the pathology of inflammatory disorders.
  - Standardization of *Vitex negundo* and *Adhatoda extracts* extract was done for product formulation. *In vitro*, investigation was carried out for individual extracts and their combinations.
  - *In vivo* study for checking the effect of the formulation in animal models was also performed.

Theme 2. Plant Extractives for Organ Health

a) Development of polyherbal nutraceutical formulation for kidney health (plants: polyherbal (*Hippophae rhamnoides*, *Picrorhiza kurroa* and *Tinospora cordifolia*)

  - A prototype of the formulation was developed. The initial dose and ratio of the above extracts were decided according to literature and in-vitro studies.
  - All the ingredients of the formulation were selected as per the FSSAI guidelines
  - The developed formulation was chemically characterized using UPLC, and the marker compound was quantified.
  - Three months of real-time stability studies of the formulation were done.
  - The efficacy of the developed product was tested in the LPS and hyperglycemia-induced kidney damage model.
  - An acute oral toxicity study of the developed product was done as per OECD guidelines.

Theme 3. Combination of Regional Teas for Boosting Immunity

a) Indigenous synergism from regional tea varieties for immunomodulation

- Development of tea products and all the related studies under specific objectives of the project have been completed and I found no offshoot or lead now to formulate it in the form of project and take it further in the next mission for this particular work package.

Theme 4. Combination of Spice Extractives for Boosting Immunity

a) Developing immunomodulatory products based on *Carum carvi* & *Bunium persicum*

- Screened *Carum carvi* & *Bunium persicum* (local spices of the Himalayan region) to develop immunomodulatory products based on a history of their traditional use
- Based on the quantification of polyphenols, the hydro-alcoholic extracts were found to be the best for both species (*Carum carvi* & *Bunium persicum*).
- Increased production of IFN-γ after treatment with extracts implied their role in antiviral efficacy, and increased production of IL-1β signified regulatory effects on cytokines milieu. Further, the extracts showed modulatory attributes for Th2 cytokines IL4 and IL13 production and thus had immunomodulatory effects.
- With the validation of the immunomodulatory properties of the species (*Carum carvi* & *Bunium persicum*), nutritional products nutritional products, namely spread and drops, were formulated.

Theme 5. Digital Data Portal of Fruits from India with Immune Boosting Capacity (Epidemiological and Scientific Evidence Based) Ultimately A Monograph

- Over 70 fruits documented in the digital portal having immunomodulation activities grown in India

Theme 6. Digital Data Portal of Fruits from India with Immune Boosting Capacity (Epidemiological and Scientific Evidence Based) Ultimately A Monograph

- The epidemiological and clinical trial-based evidence for immunomodulation activities is documented in a digital portal for more than 50 vegetables (including native) grown in India. It includes immunity-boosting phytochemicals present in vegetables and respective immunomodulatory markers regulated by them.

Theme 7. Human Intervention Trials

- Scientifically validated nutraceuticals with Human Intervention data developed for
  - i. Vitamin D_2 deficiency,
  - ii. Cartilage health,
  - iii. Cardiac health,
  - iv. Neurodegeneration

STATE GOVERNMENT SPONSORED PROJECT

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

Principal Investigator: Dr Rakesh Kumar

Co Principal Investigator: Dr Rohit Joshi

Research Team: Dr Kiran Devi, Dr Robin Joshi, Ms Neha Chaudhary and Ms Tanya Bhangalia

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 nearly 13.2 tonnes per year. Year on year, the import of Saffron in India grew by 88.53% from 2014 to 2018. A major constraint in large-scale cultivation of saffron is the scarcity of disease-free planting material; considering the constraints, CSIR-IHBT developed a tissue culture protocol for the production of disease-free corms. The institute's efforts in promoting the cultivation of saffron in the state to enhance the livelihood of farming communities have been widely acclaimed at the state level. 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 the Department of Agriculture, HP, for saffron corm production and the establishment of a seed production chain for the cultivation of heeng at a commercial scale within the state with following objectives. The progress made under this project during April 1, 2022 to March 31, 2023 has been summarized hereunder.

During this year, quality planting material (3724 kg corms plus 50,000 corms developed through tissue culture) were supplied to the agriculture department for distribution among the farmers of 6 districts, *viz.*, Mandi, Chamba, Kullu, Kinnaur, Kangra, and Lahaul & Spiti (Table 1). A total of 1.5 ha area have been covered during this year under saffron cultivation at the villages under the above mentioned districts. Time to time monitoring of the crop at different growth stages is being done by the agricultural officers of department of agriculture along with CSIR-IHBT team.

Table 1 Detail of saffron corms (seed) distribution to Agriculture Department, Govt. of HP during 2022-23 under the saffron project

S. No	Districts	Planting material (kg)	Date
1	Kinnaur	1000	12.09.2022
2	Chamba	1000	12.09.2022
3	Lahaul & Spiti	200	15.09.2022
4	Kullu	760	27.09.2022
5	Kangra	150	27.09.2022
6	Mandi	614	03.10.2022
	Total	**3724**	
	Kangra	50000 nos (Tissue culture raised corms)	10.10.2022

Fig. 1 Saffron corm Plantation and flowering at different districts.

On farm training of progressive farmers

Training cum capacity building programs for the progressive farmers of district Kangra, Kinnaur, Kullu, Mandi and

Lahaul & Spiti was conducted by team CSIR IHBT along with Department of Agriculture, H.P. Government.

Table 2 Detail of training cum capacity building programs for the progressive farmers

Sr. No.	Date	Village	Districts	Farmers
1	12-05-2022	Bada Gran	Kangra	55
2	05-08-2022	Gondhla	Lahual & Spiti	52
3	19.09.2022	Ribling	Lahual & Spiti	48
4	28.09.2022	Multhan	Kangra	24
5	14.03.2023	Nirmand	Kullu	55
6	15.03.2023	Sangla,	Kinnaur	63
7	16.03.2023	Kalpa,	Kinnaur	21
8	17.03.2023	Thunag	Mandi	10
9	27.03.2023	Nalhota	Kangra	44
			Total	**372**

Nalhota, Kangra

Kuppa, Sangla

Bada Gran, Kangra

Kilba, Kinnaur

Gondhla, Lahaul & Spiti

Rakhchui, Mandi

Ribling, Lahaul & Spiti

Nalhota, Kangra

Fig. 2 Training cum capacity building programs conducted for the progressive farmers of different districts of HP.

Corm storage and distribution

Corms storage and package

Transportation

Distribution of Corms

Fig. 3 Production and distribution of saffron corms to different districts of HP.

Capacity building of agriculture officers and farmers.

A five-day capacity building program of the agriculture officers of the Department of Agriculture, Himachal Pradesh, on production technology of saffron and heeng was held from September 06-10, 2022, at CSIR-IHBT Palampur. Twelve agriculture officers, including agriculture development officers, and

Agriculture Extension Officers from six districts *viz.*, Chamba, Kangra, Kinnaur, Kullu, Lahaul & Spiti, and Mandi, participated in the program. In this program, the emphasis was given on agro techniques right from sowing, site selection, soil sampling, plantation, plantation techniques, nutrient management, weed management, insect pest management, harvesting, storage, packaging, and post-harvest management of saffron and heeng along with tissue culture techniques by the faculty members of IHBT. The activities of the five day capacity building program are shown in **Fig. 4**.

Fig. 4 Capacity building of agriculture officers at CSIR-IHBT for saffron farming (6-10 September, 2022).

INTRODUCTION OF APPLE CROPS IN NORTH-EASTERN PROJECT IN COLLABORATION WITH NERCORMP

PROMOTION OF LOW CHILLING VARIETIES OF APPLE IN NORTH-EASTERN STATES

Project Investigation: Dr Rakesh Kumar

Research Group: Dr Vipin Hallan and Dr Kiran Singh Saini

Apple (*Malus x domestica* Borkh.) is a deciduous tree native to western Asia and extensively cultivated worldwide. It thrives in temperate zones, where most commercially grown varieties thrive with the necessary chilling temperature. Low chilling varieties, requiring 250-300 hours of chilling, presenting a viable option for extra income to farmers in Manipur and Mizoram. These regions possess favorable agroclimatic conditions, offering an opportunity to reduce carbon emissions associated with apple supply from North India to Manipur and Mizoram. CSIR-IHBT carrying out two DBT funded projects entitled **"**Surveillance, multiplex virus diagnostics, raising quality rootstocks for promotion of low chilling varieties of apple (*Malus domestica* Borkh.) in Manipur to improve the livelihood of local farmers**"** and **"**Inter-institutional program support on the development and sustainable utilization of bio-resources of Mizoram [Sub project 3: Introduction of low chilling varieties of apple *(Malus domestica L.*) in Mizoram to improve the livelihood of tribal farmers**".** This year, as part of our projects aimed at promoting apple cultivation in North East India, CSIR-IHBT successfully supplied 12,800 rooted plants of two low-chilling varieties to Manipur and Mizoram. Suitable sites for cultivating low chilling varieties of apple were carefully chosen in five districts of Manipur, namely Senapati, Bishnupur, Imphal East, Ukhrul, and Imphal West. A total of 6,400 rooted plants of two low-chilling apple varieties, Anna and Dorsett Golden, were then planted in these selected locations. In Mizoram, capacity building programs were organized to support the cultivation of low chilling varieties of apple in various villages including Aizawl, Thenzawl, Ailawng, and Hmuifang. As part of this initiative, 6,400 rooted plants of apple were provided to farmers in Mizoram, aiding them in their apple cultivation endeavors.The virus free root stocks (MM 793, MM111, MM106, and M7) were raised through tissue culture technique and then grafted with Anna (400 h) and Dorsett Golden (350 h). The comprehensive detail of low chilling varieties of apple is given in Table 1. Glimpses of the project activities are shown in **Fig. 1**.

Table 1 Detail of low chilling varieties of apple supplied to Manipur and Mizoram states

Variety Name	Root Stock	Total Plants	State
Anna	MM111	700	
Dorsett Golden	MM111	700	
Anna	M793	800	
Dorsett Golden	M793	700	Manipur
Anna	M7	900	
Dorsett Golden	M7	1100	
Anna	MM106	800	
Dorsett Golden	MM106	700	
Anna	MM111	800	
Anna	M7	600	
Anna	MM106	900	
Anna	M793	900	
Dorsett Golden	MM111	700	Mizoram
Dorsett Golden	M7	700	
Dorsett Golden	MM106	900	
Dorsett Golden	M793	900	
Grand Total		**12800**	

Apple plants ready for supply

Supply of low chilling varieties of apple to Manipur

Distribution of low chilling apple plants to the farmers of Manipur

Distribution of low chilling apple plants to the farmers of Mizoram

Assistance for apple planting at farmer's field in Manipur

Inspection of apple plantation at farmer's field in Mizoram

Awareness of apple cultivation in Imphal (Manipur), during one week one lab program

Interaction with the scientists of MISTIC, Aizawl, Mizoram

Capacity building programme at Ailawng village (Mizoram)

Capacity building programme at Hmuifang village (Mizoram)

Fig. 1 Glimpses of project activities in Manipur and Mizoram.

PROJECT FROM SCHEME OF FUND FOR REGENERATION OF TRADITIONAL INDUSTRIES (SFURTI) CLUSTERS UNDER THE MoMSME

SCHEME OF FUND FOR REGENERATION OF TRADITIONAL INDUSTRIES (SFURTI) CLUSTERS UNDER THE MoMSME

Principal Investigators: Dr. Rakshak Kumar

CSIR-IHBT Palampur has been designated as the technical agency, for two nodal agencies *viz*. Khadi and Village Industries Commission (KVIC), Mumbai and the Foundation of MSME Clusters (FMC), New Delhi for cluster development under the SFURTI Scheme. Under the scheme, scientifically validated technologies developed at CSIR-IHBT, Palampur, such as "Vitamin D_2 enriched *shiitake* mushroom production and processing," "Efficient bacterial formulations for enriched compost in cold hilly region," are being implemented in the five clusters in rural areas of Sikkim and Himachal Pradesh. The clusters are aspiring to provide employment to 1150 beneficiaries. A new clusters at Chumoukedima, Nagaland has been sanctioned this year and another cluster at Chamba, Himachal Pradesh is under consideration at Ministry level. The current status of the functional clusters are as follows:

Enriched composting/ vermi-composting clusters

The two vermicomposting clusters Moonew Tareybhir **(Fig. 1a)** and Triloki enriched composting/ vermicomposting cluster **(Fig. 1b)** got functional on 31st March 2022. As planned, tool kits have been distributed among artisans, and vermicomposting sheds were also built at the artisans' sites. The awareness cum technical trainings are undergoing in accordance with the detailed proposal report (DPR). Both clusters have begun the production of targeted products and have started commercializing. In Moonew Tareybhir cluster, the turnover for 2021-2022 was recorded as Rs 42 lakhs. In the current year, more than 100 tonnes of vermicompost has been produced, and sold to both government as well as private stakeholders **(Fig. 2a)**. In Triloki cluster, the sale has begun in the 2021-2022 year and so far 50 tons of vermicompost has been sold to government sector **(Fig. 2b)**. Both the common facility centres (CFCs) are equipped with advanced instruments and artisans have received technical training to help them enhance their skills and produce high-quality products. Furthermore, for both clusters, an e-commerce platform has been created for online marketing and sales (https://moonewvermikala.com/; https://trilokivermi.com/).

Shiitake and other food processing clusters

In the three sanctioned *Shiitake* clusters **(Fig. 3)**, the construction of CFCs at West Sikkim, Sumbuk and Norbu Choeling *Shiitake* and other food processing Clusters have been completed. In both West Sikkim and Sumbuk clusters, the machinery has been delivered, and three-phase electricity line has been resumed and production has begun at full pace. The trial run for *shiitake* mushroom production has begun in both the cluster and it is expected that by August 2023, the commercialization of the products from the cluster will begin. Soft intervention activities of the clusters, such as awareness and technical training programmes for the artisans are undergoing as planned in the project proposal. The trial run of *shiitake* mushroom product at Norbu Choeling Cluster should begin by December 2023 as 90% of the CFCs are completed and we are waiting for three-phase electricity connection.

Fig 1. Visual representation of Common Facility Centres (CFCs) of Moonew Tareybhir (a) and Triloki enriched composting/ Vermicomposting clusters (b).

Fig. 2 Supply of product from the Moonew Tareybhir enriched vermicomposting cluster.

(a) Mother CFC, West Sikkim Cluster (b) Mother CFC, Sumbuk Cluster (c) Mother CFC, Norbu Cluster

Fig. 3 Current status of Common facility centres (CFCs) West Sikkim *Shiitake* Cluster (ready to be functional(a); Sumbuk *Shiitake* Cluster (ready to be functional (b); Norbu Choeling *Shiitake* cluster (under progress) (c).

AGROTECHNOLOGY DIVISION

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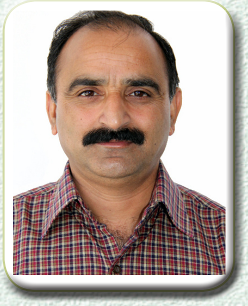


Tea Science

Tea is a popular and high-demanded beverage around the world. As traditional way of tea harvesting by hand is labour-intensive, mechanical harvesting using tea-plucking machines has been widely adopted by many countries. Mechanical tea harvesting using machines is highly efficient, but these harvested tea leaves are always low quality because they contain a mixture of old leaves. To address this problem, a study was carried out in collaboration with CSIR-CMERI for the development of an Artificial Intelligence (AI) model for the segregation of tea leaves.

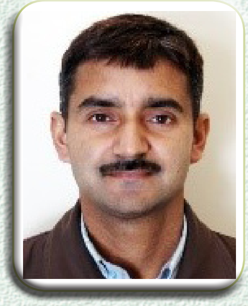
Fig. 1 Tea data set collection for the development of model.

The training and testing datasets for the model were generated for the freshly collected tea leaves consisting of one bud with one leaf, one bud with two leaves, one bud with three leaves, one bud with four leaves, one bud with five leaves, waste leaves and twigs. Firstly, the fresh weight of these tea leaves samples were noted down in the data book using weighing balance. After that pictures of these leaves were captured using a DSLR camera mounted on the tripod stand in control conditions (dark room) **(Fig. 1)**.

Fig. 2 One bud with one leaf, one bud with two leaves, one bud with three leaves, one bud with four leaves, and waste leaves (from left to right).

In doing so, 2600 pictures of the above categories of tea leaves representing 56 **(Fig. 2)** samples collected at different times from the tea garden were acquired along with their fresh (composite & individual) and dry weights. These data were used for the development of the model, which is being updated with more datasets and needs to be integrated with the electro-mechanical system.

Research group: Amit Kumar, VS Dhadwal and Baldev Singh.



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Plant Breeding

The present research work is focused on breeding efforts for the improvement of floriculture and medicinal plants for the development of new varieties under the CSIR-Floriculture mission and the Niche Creating Project, respectively.

Evaluation of Lilium hybrid in multi-location trials

Hybridization was done among asiatic lily cultivars London (yellow) and Machete (red) to generate new flower colour and flower shape variations in lilium. Among 71 hybrids developed through this particular cross, CSIR-IHBT-LH-3-4 was selected for large size, attractive color and better vigor compared to the parental lines **(Fig. 1)**. Clonal propagation of CSIR-IHBT-LH-3-4 is being done through scales and bulbs for the multiplication of the plants. The selection CSIR-IHBT-LH-3-4 was characterized morphologically and evaluated for the field performance at four locations along with parents. Plantation was done in Randomized Block Design with ten plants per genotype replicated three times. Data recording was done on five plants per replication for plant height (cm), flower diameter (cm), and number of flowers per flowering shoot at four locations in 2022-23 (Table 1). CSIR-IHBT-LH-3-4 performed consistently at all the locations.

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

Evaluation of *Picrorhiza kurroa* breeding lines in multi-location trials

Six clonal lines of *Picrorhiza kurroa* were evaluated for fresh stolon biomass yield at four locations in mid and high altitude regions over a period of two years (2021-22 & 2022-23). The population mean of the lines was used as a control. Experiments were laid out in Randomized Block Design with thirty plants per clonal line in the plot and replicated four times. Data recording was done on competitive plants for fresh stolon biomass (g). Based on the mean performance, CSIR-IHBT-PK-03 was significantly superior to check with respect to dry root biomass (Table 1). On the basis of comparison over locations, the best performance of

Table 1 Mean variations for stolon biomass in *Picrorhiza kurroa* lines over different locations

S. No.	Plant No.	Stolon biomass (g/plant)			
		Ribling	Shansha	Salgran	Palampur
1.	CSIR-IHBT-PK-01	7.00	5.46	5.30	4.77
2.	CSIR-IHBT-PK-02	7.12	5.6	5.08	4.78
3.	CSIR-IHBT-PK-03	9.01*	6.51*	5.49*	5.06*
4.	CSIR-IHBT-PK-04	6.52	5.86	5.34	4.71
5.	CSIR-IHBT- PK-05	6.84	6.15	4.90	4.78
6.	CSIR-IHBT- PK-06	6.38	5.28	4.81	4.70
	Mean (µ)	7.15	5.81	5.15	4.80
	S. E. (d)	0.58	0.31	0.12	0.07
	C. D.	1.20	0.64	0.25	0.16

*Significant at P=0.05

Picrorhiza kurroa was obtained at Ribling followed by Shansha, while production in stolon biomass declined at Salgran and Palampur conditions.

Evaluation of *Inula racemosa* breeding lines in multi-location trials

Ten lines of *Inula racemosa* were evaluated for dry root biomass yield at four locations in mid- and high-altitude regions over a period of two years. The population mean of the lines was used as a control. Experiments were laid out in Randomized Block Design with thirty plants per breeding line in the plot and replicated three times. Data recording was done on a plant basis per replication for dry root biomass (g). Based on the mean performance, CSIR-IHBT-IR-09 was significantly superior to check with respect to dry root biomass (Table 2). On the basis of comparison over locations, the best performance of *Inula racemosa* with respect to dry root biomass was obtained at Shansha followed by Ribling, while production in root biomass declined at Janjheli and Palampur conditions.

Table 3 Mean variations for root biomass in *Inula racemosa* lines over different locations

S. No.	Plant No.	Root biomass (g/plant)			
		Ribling	Shansha	Janjheli	Palampur
1.	CSIR-IHBT-IR-01	515.3	427.3	267.7	145.3
2.	CSIR-IHBT- IR -02	639.3	685.0	331.3	250.3
3.	CSIR-IHBT- IR -03	608.3	615.3	314.3	200.7
4.	CSIR-IHBT- IR -04	561.7	448.3	241.3	115.7
5.	CSIR-IHBT- IR -05	391.7	418.0	307.7	115.7
6.	CSIR-IHBT- IR -06	490.7	233.0	227.0	199.3
7.	CSIR-IHBT- IR -07	625.7	643.3	312.7	211.7
8.	CSIR-IHBT- IR -08	412.3	205.3	223.7	194.7
9.	CSIR-IHBT- IR -09	745.7*	821.0*	355.0*	265.0*
10.	CSIR-IHBT- IR -10	640.7	757.7	322.0	225.0
	Mean (μ)	563.13	525.43	290.26	192.33
	S. E. (d)	4.10	3.93	4.16	4.26
	C. D.	8.73	8.38	8.87	9.07

*Significant at P=0.05

Research group: Ajay Kumar, Rahul Dev Gautam, Romika Thakur and Manish Kumar.

Relevant Publications:

- Journal of Applied Research on Medicinal and Aromatic Plants. 2022, 100421.
- Industrial Crops & Products. 2022, 116145.
- Plants. 2022, 11(29).

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Agrotechnology Division

Our group is developing agro technologies and is involved in the generation of quality planting material for aromatic, medicinal, and industrial crops *viz.*, *Rosa damascena*, *Tagetes minuta, Cymbopogon* spp., *Crocus sativus, Ocimum spp., Pelargonium graveolens*, and *Hypericum perforatum*, etc. We are also involved in providing technical and hand-holding support to farmers for saffron production in non-traditional areas and promoting low-chilling apple plantations in the North Eastern Region of India.

Influence of seaweed and corm size on corm yield of saffron under the western Himalayas

Saffron (*Crocus sativus* L.), a low-volume high-value crop is obtained from the dried stigmas of its flowers and belongs to the family Iridaceae. A field experiment was conducted to study the effect of seaweed (SW1: *Solieria chordalis* and SW2: *Gracileria edulis*) and corm size on the growth and yield of saffron corms during 2022 **(Fig. 1)**. The analyzed results revealed that significantly higher plant height, leaf length and number of leaves at 60 and 90 DAP (days after planting) were recorded by the application of SW1 (*Solieria chordalis* @ 2.5%). However, physiological parameters and the number of daughter corms per plant were higher in SW2 (*Gracileria edulis* @ 2.5%). Growth parameters showed higher in higher corm size (>14g).

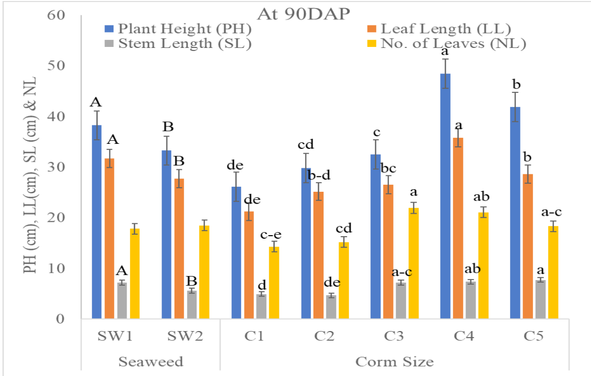

Fig. 1 Experimental view and Effect of seaweed extract and corm size on growth parameters of saffron.

Interactive effect of biostimulant and inorganic fertilizer on growth and yield of German chamomile (*Matricaria chamomilla* L.)

German chamomile (*M. chamomilla*) is an annual star herb due to its medicinal and aromatic properties. Both the flower heads and blue essential oils of German chamomile possess several pharmacological properties. A field experiment was conducted to study the effect of biostimulant [seaweed extract and plant growth promoting rhizobacteria (PGPR)] and inorganic fertilizer [NPK recommended dose (RD)] on growth, yield and essential oil composition of German chamomile during 2022 **(Fig. 2)**. The analyzed results revealed that essential oil content percentage was recorded significantly higher with the application of PGPR with 150% of RD dose of NPK compared to other treatments.

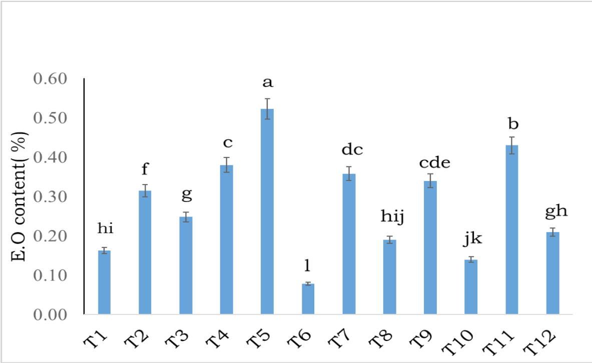

Fig. 2 Experimental field view and effect of PGPR, Seaweed and inorganic fertilizer on essential oil content (EO) of German chamomile.

Biostimulant effect on the growth, yield and quality of shyama tulsi (*Ocimum tenuiflorum* L.)

Ocimum tenuiflorum L., (family Lamiaceae) is an aromatic perennial plant commonly known as holy basil or tulsi. Essential oils produced from these plants could be active ingredients in medicines, cosmetic, food, and agriculture applications. The experiment was conducted in 2022 to study the effect of different seaweed (SW) concentrations and their application methods on crop growth and yield **(Fig. 3)**. The analyzed results revealed that EO content was significantly higher in C2 (5 mL of SW) compared to other concentration but remained at par with C1 (2.5 mL of SW). In the case of the application method, drenching (M1) was significantly superior to foliar spray (M2).

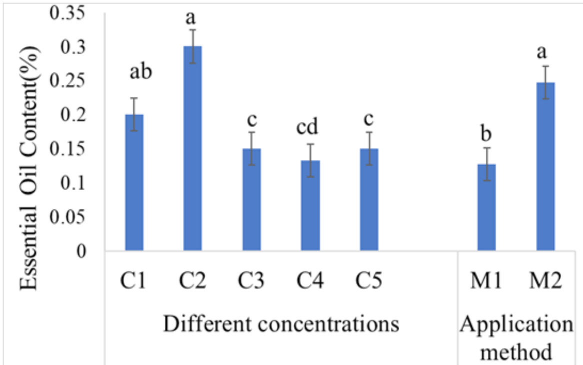

Fig. 3 Effect of seaweed extract on essential oil content of tulsi.

Research group: Swati Walia, Shalika Rathore, Yograj Negi, Praveen Thakur, Surbhi Sharma, Neha Chaudhary, Ayush Paul, Sumedha Thakur, Tanya Bhangalia, Vijay Prakash Dhyani, Monika Rana, Saizal Jamwal, Meghna Thakur and Kanchan Kundlas.

Relevant Publications:

- Frontiers in Plant Science. 2023, 14:1097682.
- Frontiers in Plant Science. 2022, 13:917388.
- Frontiers in Plant Science. 2022, 13:976295

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Medicinal and aromatic plants (MAPs) accumulate phytochemicals and volatile compounds which are used as raw materials in the pharmaceutical, cosmetic, and food industries. At present there is a huge demand for MAPs globally as well as domestically, which cannot be met by wild collection. The primary target of our research group is the development of agronomic practices.

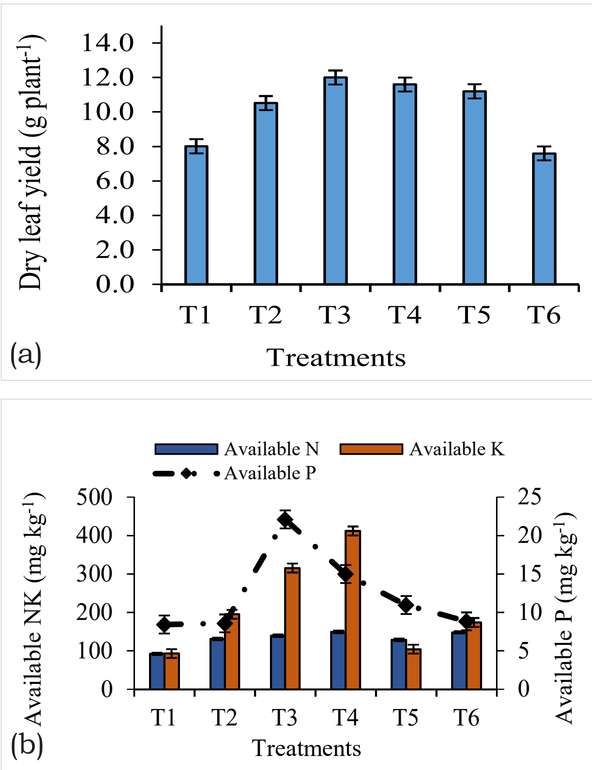

Fig. 1 Effect of different concentrations of seaweed extract on dry leaf yield of *Stevia rebaudiana* (a) and soil available nutrients under different concentrations of seaweed treatments (b).

A pot experiment was conducted to understand the effect of seaweed on the growth and secondary metabolite yield of *Stevia rebaudiana* and nutrient availability in the soil. The drenching of ICSP seaweed extract @ 0.75% in combination with 50% of recommended NPK (T3) produced the highest dry leaf yield which was 49.18% and 14.17% higher as compared with control (T1) and 100% recommended NPK dose (T2), respectively **(Fig.1a)**. The results of soil nutrients show that available nitrogen and potassium was observed maximum in plants drenched with 0.75% seaweed extract supplemented by 50% recommended NPK (T3). While available phosphorus was recorded highest in plants treated by drenching 2.5% ICSP supplemented with 50% recommended NPK (T4) **(Fig. 1b)**.

Foliar applications of different plant growth regulators and low concentrations of herbicides have been found to increase growth and yield in different plants.

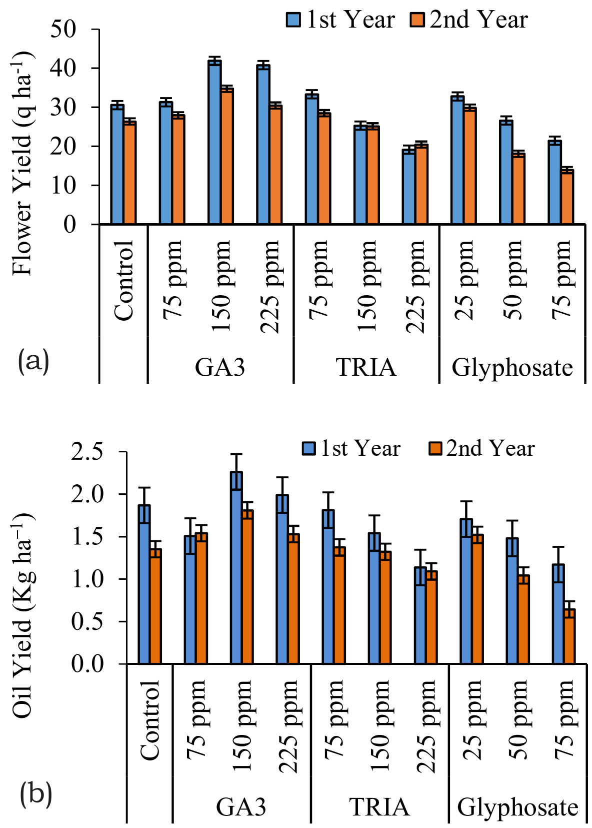

Fig. 2 Effect of plant growth regulators on (a) flower yield (q ha^{-1}) and (b) oil yield (kg ha^{-1}) of *Rosa damascena* (GA_3=Gibberellic acid, TRIA=Triacontanol).

The experiment was conducted to understand the effect of growth regulators on the yield and quality of essential oil of damask rose (*Rosa damascena*). The results revealed that flower yield ranged from 13.93 to 41.90 q ha^{-1}, and oil content varied from 0.046–0.061% with the applications of growth regulators and herbicides. Flower number (No. bush^{-1}) and flower yield (q ha^{-1}) were significantly ($P \leq 0.05$) increased by the foliar application of GA_3 over control and other treatments during both years.

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

Fig. 3 Monk fruit flowering in a progressive farmer's field at Piplaage, Kullu, Himachal Pradesh during September 2022.

Mass multiplication and maintenance of the quality planting materials

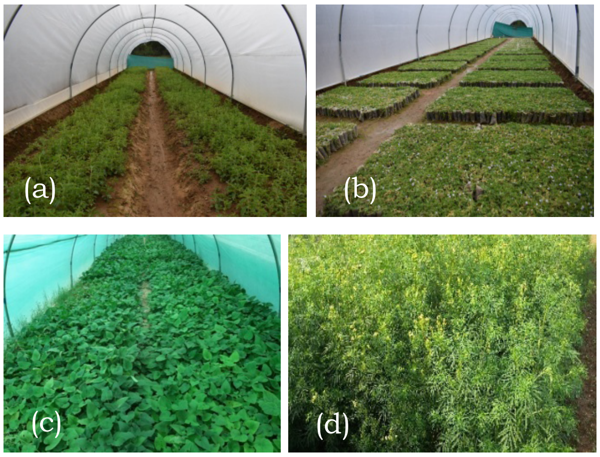

Fig. 4 *Stevia rebaudiana* (A), *Bacopa monnieri* (B), *Valeriana jatamansi* (C) nursery raised at CSIR-IHBT and field view of *Tagetes minuta* seed production unit (D).

Extension Activities/ Rural Development:

About 250 acres of land have been brought under stevia, valeriana, mentha and others medicinal and aromatic crops cultivation in different parts of the country. Besides, large numbers of quality planting materials of stevia (~1.5 lakh plant) *Valeriana jatamansi*, Tagetes, and Mentha (2130 kg suckers and 5030 no. of suckers), and other MAPs have been provided at free of cost to support the farmers under CSIR – Aroma Mission (Phase-II) and other projects funded by DST, Govt. of India, National Medicinal Plant Board (NMPB), Ministry of AYUSH.

Research group: Ramdeen Prasad, Ramjeelal Meena, Mitali Mahajan, Shivani, Babit Kumar Thakur, Aditi Sharma, Anju Krishnan, Naveen, Anjali Thakur, Banish Guleria and Jai Prakash Yadav.

Relevant Publications:

- Molecules. 2022, 27:2387.
- Frontiers in Plant Science. 2022, 13:896237.
- Agricultural Water Management. 2022, 264(30): 107511.

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Entomology and Pest Management

Coordinator-JIGYASA; Skill Development Programme; Trainings and Research Internship; Students' Visit.

Development of Biopesticides

In the direction of developing biopesticides, plant extracts, essential oils, and their fractions were evaluated to identify leads.

Medicinal Mushrooms

Deposited *Ophiocordyceps* and *Morchella* specimens collected from Himachal Pradesh at Central National Herbarium, Howrah, Kolkata, India.

Identified and cultured fungus, *Tolypocladium* sp. of economic importance.

Advisory Services

Services rendered to tea planters, aromatic crops growers, flower growers, and farmers for timely and sustainable management of insect and mite pests of crops through online/ offline mode.

JIGYASA Programme

Coordinated "JIGYASA 2.0 Virtual Laboratory Program"-a student-scientist connect programme at CSIR-IHBT under Scientific Social Responsibility (SSR) activity of Scientific Community and Institutions. During 2022-23, a total of 6083 school students and their teachers from JNVs, Govt. and Public Schools participated in different activities conducted throughout the year. Besides, coordinated for making of a short film on "R&D activities of CSIR-IHBT"

Adoption of Atal Tinkering Lab Schools (ATLs)

Coordinated activities with CSIR-HQs & Niti Aayog for the adoption of 5 additional ATLs than already adopted 10 ATLs schools of HP for their smooth functioning.

Apart from school students, coordinated the educational visits of 1519 students and teachers from different Universities, Institutes, and Colleges of 8 states and UTs.

Skill Development Programmes

Coordinated CSIR-Integrated Skill Initiative and Skill programmes of the Institute. After registering CSIR-IHBT, as a "Training Provider" (TP) and Training Center (TC) at National Skill Development Council (NSDC),

One job role "Plant Tissue Culture Technician-AGR/Q8101 (2.0)" of CSIR-IHBT is approved under the Agriculture Sector and accredited by SSC at Skill India Portal, under the CSIR-Integrated Skill Initiative Programme.

Training/ Internship of students

Coordinated training/ internship activities of 250 UG/ PG/ Ph.D. students from different educational and research institutes of Pan India (12 different states and 03 UTs). Out of these, 175 students completed their training programme and 75 ongoing.

Skill Vigyan Programme of DBT-HIMCOSTE

During this year, two LSSSDC-approved courses *viz*. Quality Control Biologist and Lab Technician/ Assistant of three-month duration were successfully conducted.

Restructured National Bamboo Mission (R-NBM)

Coordinated ongoing activities of **(**R-NBM) at CSIR-IHBT to generate and supply quality planting material to different stakeholders. During this year, Institute has supplied more than 4,000 plants to different stakeholders.

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

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Development of improved varieties

Our group is developing improved varieties of medicinal, aromatic, floriculture and commercially important plants and also involved in the generation of quality planting material of *Ferula assa-foetida*. We are also involved in providing technical and hand-holding support to the farmers for *Heeng* cultivation in the cold desert regions of the Indian Himalayas.

Distribution and cultivation of *Heeng* [*F. assa-foetida* L.]

Ferula assa-foetida L. (*Heeng*) is one of the top spice and medicinal plants traded in India. Raw asafoetida (*Heeng*) is extracted from the fleshy roots of *Ferula assa-foetida* as an oleo-gum resin. Recognizing its importance, the institute introduced *Heeng* seeds for the first time in India to reduce the import of raw asafoetida and to enhance the livelihood of the farmers in the cold desert region. The institute focused on the generation and distribution of quality planting material to the farmers. A total of 14,536 plants were distributed to the farmers of Himachal Pradesh, Uttarakhand, Ladakh, and J&K during 2022-2023 **(Fig. 1)**. So far, the institute has distributed 47,052 plants to the farmers covering an area of 7.06 ha under *Heeng* cultivation.

3rd capacity building program was organized for the Agriculture officers of Department of Agriculture, HP, on *Heeng* and *Saffron* cultivation during 06-10 September 2022 **(Fig. 2)**. This training covered the aspects of *Heeng* seed stratification, seed germination, nursery raising, soil and climatic requirements, site selection, and agrotechnology of *Heeng*. In this capacity building program, 14 Agriculture officers from different districts of Himachal Pradesh actively participated. The institute also organized awareness cum training programmes for farmers on *Heeng* cultivation. During the year 2022-2023, Twenty-one on-farm training programs were also conducted on *Heeng* cultivation in which 402 progressive farmers were trained. So far, 56 on-farm training programmes have been organized for the farmers of which 1,058 farmers have been trained in *Heeng* cultivation.

Fig. 1 Supply of *Heeng* plants to the farmers of HP.

Fig. 2 3rd capacity building programme organized at CSIR-IHBT, Palampur during 06-10 Sept, 2022.

Genome size estimation of *F. assa-foetida* L. (*Heeng*)

Ferula assa-foetida is not well-explored crop for its genomic studies. Flow cytometry is used for the estimation of the genome size. For standardization of protocol for estimation of the genome size of *Ferula assa-foetida* L. (*Heeng*), four common lysis buffers such as Galbraith buffer, Woody plant buffer, Tris.$MgCl_2$ buffer, Otto's Buffer-I and Otto's buffer-II along with their modifications were used to isolate the intact nuclei from *Heeng* leaves. *Pisum sativum* L. 'Ctirad' (2C = 9.09pg) provided by the Institute of Experimental Botany, Olomouc, Czech Republic was used as the internal reference standard. The estimated genome size of *Ferula assa-foetida* L. (*Heeng*) ranged from 4.33pg to 4.84pg **(Fig. 3)**.

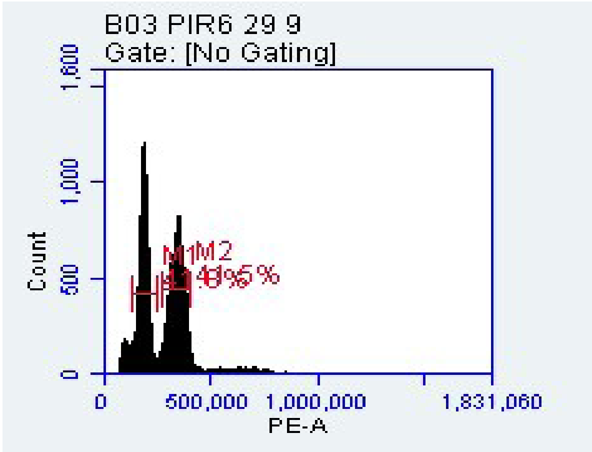

Fig. 3 Histogram of *Heeng* (Peak 2) with internal reference standard of *Pisum sativum.*

Relevant Publications:

- Food Research International. 2023, 164: 112434.
- Journal of Applied Research on Medicinal and Aromatic Plants. 2022, 31: 100421.
- Industrial Crops and Products. 2023, 193: 116145.

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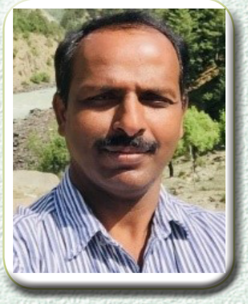
Entomology and Pest Management



Pest management, Biopesticides, Botanicals, Entomopathogenic fungi and Apiculture

Pests play a major role in reducing the economic yield if control measures are initiated timely based on the economic threshold level (ETL). Indiscriminate and repeated use of synthetic pesticides for the control of pests led to development of resistance, along with harmful effect to natural enemies of pests, consumer's health, and the environment. Due to awareness about the ill effect of pesticides on health and the environment, bio-pesticides gaining importance for the control of pests globally. Therefore, it is necessary to identify alternatives to synthetic pesticides. Hence our group is working on screening plant extracts, fractions, essential oils and isolated molecules for insecticidal activities against *Plutella xylostella*, *Aphis craccivora*, *Planococcus liacinus*, *Tetranychus urticae* and stored grain pests (pulse beetle, rust red flour beetle) for identification of lead (s) for biopesticide formulation. Our group is also working on isolation, characterization of native strain (s) of entomopathogenic fungi from insect cadavers'/soil, and its evaluation against target pests. In addition, we also working on the integration of apiculture in aromatic, medicinal, floricultural, and fruit crops for pollination, higher yield, and honey production for enhancement of the livelihood of farmers.

Characterization of *Triadica sebifera* extracts, antifeedant activities of extracts, fractions, seed oil and isolated compounds against *Plutella xylostella* and their effect on detoxification enzymes

P. xylostella is one of the major pests of cruciferous crops globally. The combination of seed oil with bark extract of *T. sebifera* showed higher deterrence (DC_{50}=317.10 mg/L) against larvae which may be due to the presence of shikimic acid, xanthoxylin, quercetin, kaempferol, methyl gallate, and stigmasterol metabolites identified in leaf and bark extracts by UHPLC-QTOF-IMS analysis. Among compounds, gallic acid showed higher deterrence (67.5%). *n*-butanol fraction of bark was more repellent (RC_5 = 414.6 mg/L). The seed oil with leaf extract (1:1 ratio) alone with choice and seed oil with leaf and bark extract without choice showed synergistic interaction. The ethanolic extract of leaf, bark, and seed oil inhibited Glutathione-S-Transferase (GST) and acetylcholine esterase (AChE) in *P. xylostella.*

Insecticidal potential of extracts, fractions, and molecules of *Aconitum heterophyllum* against aphid *Aphis craccivora* (Hemiptera: Aphididae)

A. craccivora is the major sap-sucking pest of leguminous crops and a vector of plant viruses. In the current study toxicity of extract, fractions, and isolated compounds of *A. heterophyllum* was evaluated against *A. craccivora.* Ethanolic (LC=2837.17 mg/L) and aqueous methanolic extracts (LC_{50}=2971.59 mg/L) were effective against *A. craccivora*. Among fractions, *n*-butanol fraction of aqueous methanolic extract (LC_{50} =986.96 mg/L) was found most effective, followed by ethyl acetate fraction of ethanolic extract (LC_{50} =1037.52 mg/L) and *n*-hexane fraction of both extracts (LC_{50} =1113.85 to 1233.11 mg/L). Among pure molecules, aconitic acid was found most effective (LC_{50} = 1313.19 mg L^{-1}) and was at par with azadirachtin 0.15% EC. The methanolic extract showed significant inhibition of GST in *A. craccivora.*

Toxicity and synergistic activity of compounds from essential oils and their effect on detoxification enzymes against *Planococcus lilacinus*

P. lilacinus is a primary sap sucking pest of fruit, plantation and ornamental plants. The pure compounds L-limonene, *β*-myrcene and ocimene showed promising toxicity (each at LD_{50}=0.37 μg/insect) to crawlers. The binary mixtures of geraniol + L-menthol, and L-limonene + geraniol exhibited synergistic effects (each at LD_{50}=0.03 μg/insect). Ocimene and *β*-myrcene inhibited the AChE and GST in *P. lilacinus*. These enzymes are the target sites for action in mealybug.

Insecticidal and detoxification enzyme inhibition activities of essential oils for the control of pulse beetle, *Callosobruchus maculatus* and *Callosobruchus chinensis* (L.) (Coleoptera: Bruchidae).

Pulse beetle is the secondary pests of pulses affecting quality and marketability. Among different essential oils (EOs) screened; *Acorus calamus* showed promising fumigant toxicity to both species (LC_{50}=1357-1379 μl/L). Binary mixture of *A. calamus* + *Lavandula angustifolia* also effective (LC_{50}= 92.18-108.6 μl/L). The activity may be due to the presence of cis-asarone, 1,8-cineole etc. All the combinations of EOs showed synergistic activity. *A. calamus* and *L. angustifolia* oil significantly inhibited the AChE and GST in pulse beetle.

Diversity, abundance and impact of insect visitors in *Litchi chinensis* production

The present study was conducted in Litchi orchards to study the diversity and abundance of insect visitors, the impact of pollination on quantitative parameters, and different modes of pollination. In natural pollination, the abundance of insect visitors of Hymenoptera was more during morning and evening (44.89-50.25%) as compared to Lepidoptera. The natural pollination with one *Apis mellifera* colony showed a higher abundance of insect visitors of Hymenoptera (50.5-57.31%) compared to Lepidoptera and Diptera. The fruit size, seed size, peel weight, juice pH, pulp weight, moisture, and total soluble solids were higher in natural pollination with *A. mellifera*. The percent fruit set and fruit weight (g) were significantly higher in natural pollination with *A. mellifera* (23.2% and 1.60 g, respectively). There was no fruit set observed in bagged panicles with nylon mesh.

Integration of apiculture in aromatic, medicinal, floricultural and fruit crops

Under CSIR Aroma and Floriculture Mission, 18 beekeeping clusters were established in Himachal Pradesh and Uttrakhand for pollination, better fruit set, higher yield, and honey production for enhancement of the livelihood of farmers. Beehive boxes (3500 no.), bee colonies (3500 no.), and 350 beekeeping kits (bee veil, bee smoker, hive tool, uncapping knife one each/farmer and one honey extractor/cluster). The crops targeted in beekeeping clusters are marigold, rose, wild marigold, salvia, jatamansi, geranium, rosemary, lavender etc., with an area of 296.71 ha. About 18.016 tons of honey and 0.163 tons of bee wax was produced. About 28 training cum awareness programs on apiculture was organized covering 350 farmers.

Research group: Urvashi, Sandeep Kumar, Sheetal Bali, Nandita Chauhan, Pooja Kumari, Shagun Rana, Himanshi Gupta, Deeksha, Dipali Chowdhury, Charles Arokiyaraj, Kangkanjyoti Bhattacharyya and Neeraj Kumar.

Relevant Publications:

- Frontiers in Plant Science. 2022, DOI-0.3389/fpls.2022.1016737.
- Pest Management Science. 2022, DOI-10.1002/ps.7324.
- Molecules. 2022, 27, 1967. DOI-10.3390/molecules2706196.

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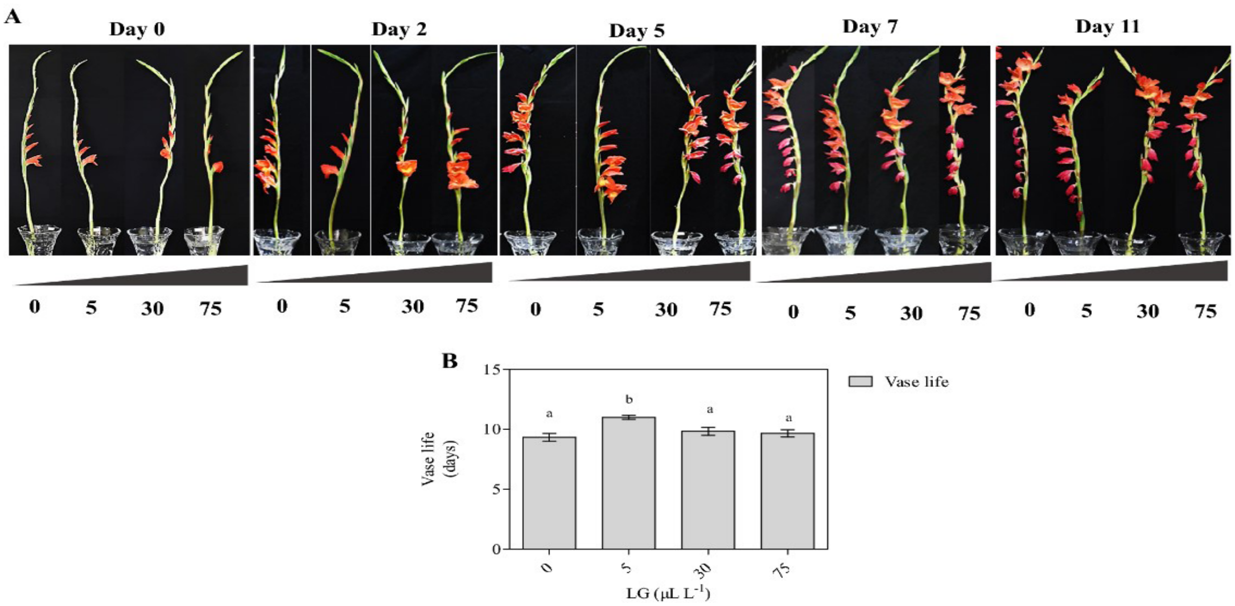
Development of Agrotechnology

Our group is developing agro technologies including pre- / post-harvest technologies for ornamental crops like gladiolus, bird of paradise, gerbera as well as *in vitro* propagation protocol for commercially important cut flowers like Iris and wild ornamentals like *Tulipa clusiana* and *Incarvillale emodi* for the generation of quality planting material. We are also involved in providing planting material related to various floriculture crops like gerbera, chrysanthemum, marigold, gypsophilla, carnation, etc. to farmers. We are also providing as technical and handholding to farmers for the promotion of cultivation and production of floriculture crop production in various regions of India. We are also developing agro technologies for tulip bulb production in Himachal Pradesh to make India self-reliant in tulip bulb production.

Improvement of post-harvest life of Gladiolus by using Lemon grass oil as an eco-friendly agent

Gladiolus (*Gladiolus grandiflorus* Andrews) is a high-valued bulbous cut flower. However, the shorter postharvest life of the gladiolus, limits its marketing and commercial value. The effect of lemongrass (LG) essential oil as an antimicrobial agent was studied towards increasing the vase life of gladiolus. The analyzed results revealed that as compared to control (distilled water), treatment with a lower concentration of 5 $\mu L\ L^{-1}$ LG essential oil prolonged the vase life of gladiolus up to 11 days (d) Fig. 1. Scanning Electron Microscope (SEM) observation indicated that the sample treated with 5 $\mu L\ L^{-1}$ LG essential oil showed intact vasculature, suggesting reduced microbial blockage at the stem end which was further corroborated by microbial count. Moreover, transcripts levels of genes associated with senescence viz., *GgCyP1* and *GgERS1a* were downregulated, while expression of *GDAD1* and antioxidant genes such as *GgP5C5*, *GgPOD 1*, *GgMnSOD*, and *GgCAT1* were upregulated in LG treated cut spikes as compared to control.



Representative photographs of vase performance (**A**), vase life (**B**) of gladiolus in untreated (control) and LG essential oil treated spikes.

Improvement of postharvest life of cut flower bird of paradise (BDP)

To improve the postharvest longevity and increase the marketability of the bird of paradise (*Strelitzia reginae* L.), the relative efficacy of two different biologically synthesized nanoparticles (NPs) was evaluated. The novel proprietary stimulants were graphene oxide (GO) and silver nanoparticles (SNPs). Among all the applied treatments, the synergistic effect of GO + SNPs at 1 μL L^{-1} vase solution significantly (p =0.05) prolongs the post-harvest life of cut flowers of BOP. Increased vase life over the deionized water (DI) control was associated with better maintenance of relative water uptake, relative fresh weight, suppressed microbial density at stem-end and delay of stem blockage, reduced electrolyte leakage, malondialdehyde (MDA), SOD, and POD activity. In contrast to the control, the administration of NPs gave better results for all analyzed parameters. Application of biologically synthesized NPs in combination (GO + SNPs at 1 μL L^{-1}) extended the vase life of cut flowers by 6 days compared with control flowers, and overall, showed better results than the control **(Fig. 2)**. The findings of the studies revealed that the standardized NPs could have more potential in prolonging the postharvest life of cut flowers in BOP.

Optimization of *in vitro* propagation protocol in an ornamentally important crop *Iris x hollandica* Tub. cv. professor Blaauw

An efficient *in vitro* propagation system has been developed for *Iris × hollandica* Tub. cv. Professor Blaauw (Dutch iris) using meta-Topolin (mT) for the first time. Effect of various concentrations of BAP, Kn, and mT (0, 0.5, 1.0, 1.5, and 2 mg L−1) along with varying photoperiods (16 h light and dark incubation for 1, 2, 3, and 4 weeks) on *in vitro* shoot induction from the twin scale explants was studied. Of the cytokinins tested, different doses of mT has resulted in better shoot induction response from twin scale explants than BAP and Kn. The efficacy of BAP and mT alone or in combination with auxins for *in vitro* shoot multiplication was also compared (Fig. 3). The synergistic effect of cytokinin-auxin in multiplication medium comprising MS + 1.0 mg L^{-1} mT + 0.25 mg L^{-1} NAA resulted in a considerably higher number of shoots (17.53) with mean shoot length (7.06 cm)

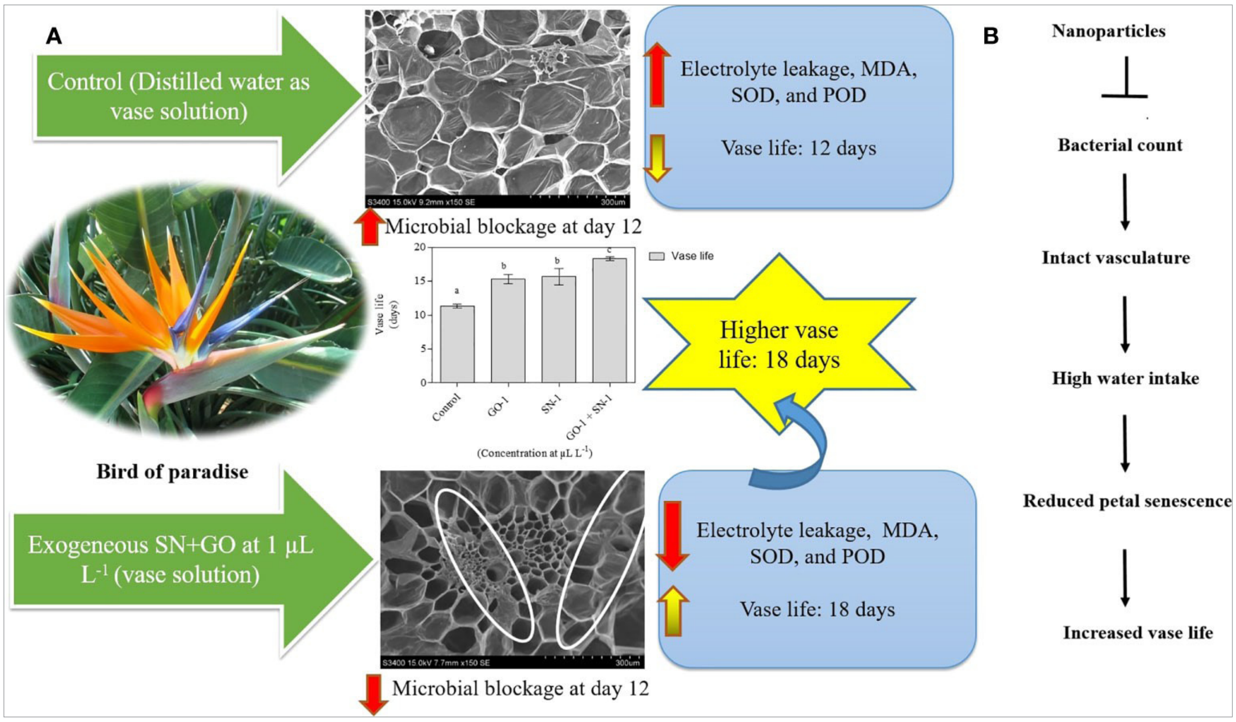


Fig. 2 Synergistic effect of graphene oxide and silver nanoparticles as biostimulant improves the postharvest life of cut flower bird of paradise (*Strelitzia reginae* L.).

and the maximum number of bulblets (2.74). The positive effect of increased sucrose concentration (90 g L^{-1}) alone or with paclobutrazol (5 mg L^{-1}) on in vitro bulblet formation and bulblet size was observed respectively. The superiority of mT over BAP was also found during *in vitro* rhizogenesis. Shoots raised on the mT medium were healthy and long enough, thus showed better rooting response (63.83%) on ½ MS medium + 0.5 mg L^{-1} IAA after 4 weeks of incubation. About 89.16% survival rate was recorded for *in vitro* raised plantlets under *ex vitro* conditions. Analysis of clonal fidelity of thirteen *in vitro* regenerated plants was done using SCoT markers. Out of 36 primers, 13 primers showed clearly scorable monomorphic bands, thus displaying genetic uniformity among in vitro regenerated plantlets. This mT-mediated protocol can be routinely used for the rapid large-scale production of this valuable floriculture crop.

Research group: Vipasha Verma, Meenakshi Thakur, Raghawendra Kumar, Mahinder Partap, Ankush Bajad, Anjali Chandel, Ujala Kashyap, Priti, Gurpreet Singh, Diksha Sharma, Jyoti, Akhil Sharma, Mohar Singh, Nikhat Sharma, Ruchika Dogra, Neha, Shelly, Saurabh and Navdeep.

Relevant Publications:

- Science Reporter. 2023, 13:2630.
- Frontiers in Plant Science. 2022, 13:3617.
- Plant Cell, Tissue & Organ Culture. 2022, 151: 695.

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Plant Biology

Assessment of genetic diversity *in Colchicum luteum* using ISSR markers

Out of 70 UBC primers screened for *C. luteum*, 10 were selected based on the number of ISSR markers generated after PCR amplification. The 10 primers were then used on all 27 individuals of *C. luteum* to assess genetic variability among and within populations. **Fig. 1** shows the results of 2 UBC primers i.e., UBC811 and UBC825. The results suggest that individuals of *C. luteum* from Triloknath population (T1-T5) display higher levels of genetic variation, even within the population, as compared to the other 2 populations (Ruding Lahaul and Kukumseri). The Triloknath population may be considered for conservation.

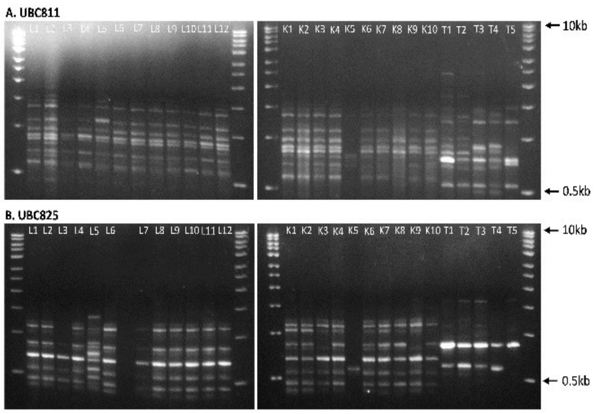

Fig. 1 ISSR markers generated for 27 individuals of 3 populations of *C. luteum* using UBC811 (A) and UBC825 (B) primers.

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

Analysis of the transcriptome data of the highly specialized *N. khasiana* leaf revealed transcripts showing homology to genes of microbial origin (Dkhar et al., 2020). Some of these transcripts matched genes that code for acid phosphatase, acid protease, and peptidase. Is it likely then that does microbes associated with *N. khasiana* play a role in phosphate acquisition? To address this, we have isolated and identified about 100 bacterial and fungal endophytes from the different plant parts of the *N. khasiana* plant, including seeds **(Fig. 2a)**. Using confocal microscopy, we are able to detect their presence in the lid of the *N. khasiana* pitcher **(Fig. 2b)**.

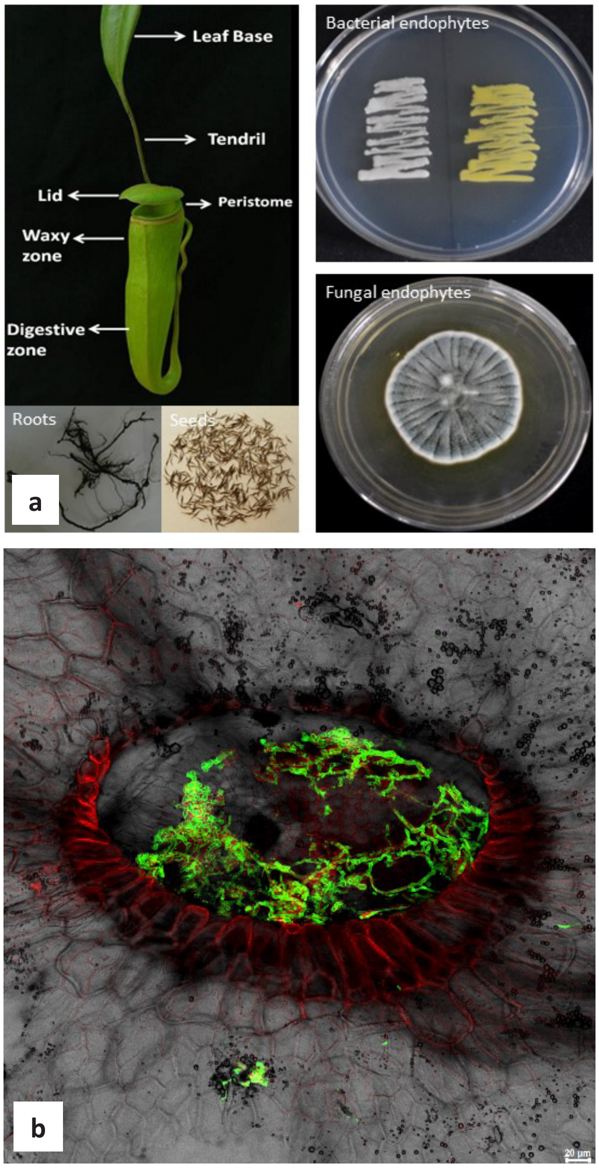

Fig. 2 Endophytes of *N. khasiana*. a, selected bacterial and fungal endophytes isolated from the *N. khasiana* leaf, including roots and seeds. b, detection of fungal endophytes in the lid of *N. khasiana* pitcher.

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

Nepenthes khasiana employs a wide range of proteins for prey digestion and plant defence (Dkhar et al., 2020). We used the assembled transcript data of Dkhar et al. (2020) to amplify, clone and express some of these proteins. Using a suitable expression vector, we were able to heterologously express defensin in *E. coli* upon induction with 1 mM IPTG at 37°C **(Fig. 3)**.

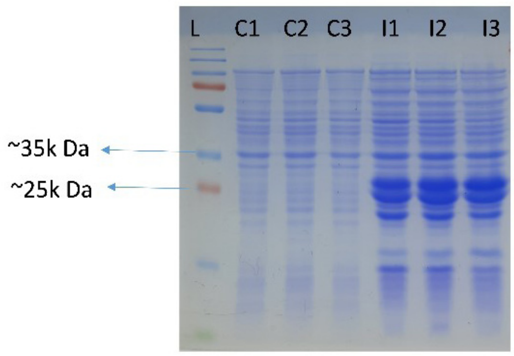

Fig. 3 Image showing result of 1-D SDS PAGE (15%) electrophoresis for induction of defensin from *N. khasiana*.

In vitro propagation of *Glycyrrhiza glabra* (Mulethi)

Direct regeneration of *G. glabra* is achieved using nodal explant. Nodal explants were sterilized under running tap water for 30 min, treated with Tween-20 and 0.2% Bavistin for 20 and 30 min, respectively. Under aseptic conditions, the nodal explants were treated with 1% sodium hypochlorite and 0.05% $HgCl_2$ and rinsed thoroughly using autoclaved distilled water. The explants were dried and inoculated on full-strength MS salt containing 3% sucrose, 0.8% Agar, 1X vitamins, and 1.5mg/L BAP **(Fig. 4a)**. Cultures were maintained at 25±1°C temperature, 60% humidity with 16/8 hr light/ dark period. Shoots were induced 8 days after inoculation **(Fig. 4b)**. Multiple shoots were observed after 24 days of inoculation **(Fig. 4c)**.

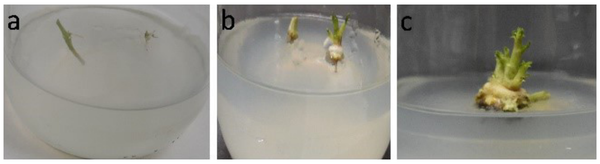

Fig. 4 Multiple shoot induction in *Glycyrrhiza glabra* (Mulethi).

A note on the identity of the Spikenard (*Nardostachys jatamansi*, Caprifoliaceae) based on DNA sequence data

Spikenard is a common name for the Himalayan medicinal herb *Nardostachys jatamansi*. It is a small perennial rhizomatous herb that is restricted in geographic distribution to specialized habitats in high altitudes of the Alpine Himalayas encompassing India, Nepal and China, between 3000-5000 masl. It is known as 'Jatamansi' in India and Nepal, and 'Gansong' in China. Our analysis of the DNA sequence data of the *rbc*L and *mat*K genes revealed that representatives of the genus *Nardostachys*, including *N. grandiflora*, belong to the same species **(Fig. 5)**.

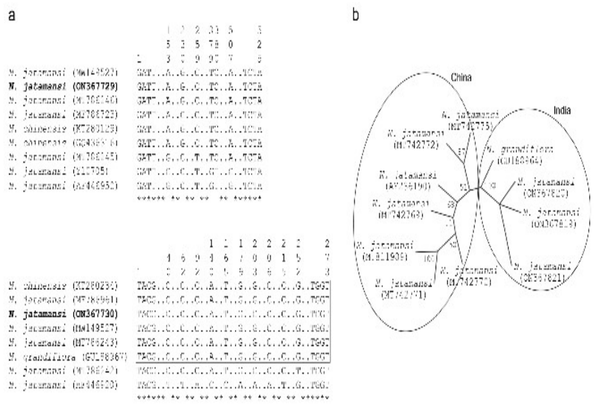

Fig. 5 Sequence alignment data matrixes and unrooted MP tree. a, portions of the alignment matrixes of the *rbcL* (top panel) and *matK* (bottom panel) genes showing the variable nucleotide sites. b, unrooted MP tree of the ITS region demonstrating the genetic relatedness among the representatives of the genus *Nardostachys* included in the present study. Numbers on node denote bootstrap values.

Research group: Kiran Dhiman, Manisha Devi, Yogesh Kandpal, Renu and Tanvi Sharma.

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Plant Breeding

Our group is working on genetic improvement and varietal development of medicinal, aromatic, and other commercially important plants ie., German chamomile (*Matricaria recutita* L.), lavender (*Lavandula angustifolia*), true cinnamon (*Cinnamomum verum*) and heeng (*Ferula assa-foetida*). We are also involved in the introduction of mulethi (*Glycyrrhiza glabra*); and the revival of traditional plants like amaranth, quinoa (*Chenopodium quinoa*), and small millets in Himachal Pradesh.

G×E interaction and genotypic stability in German chamomile

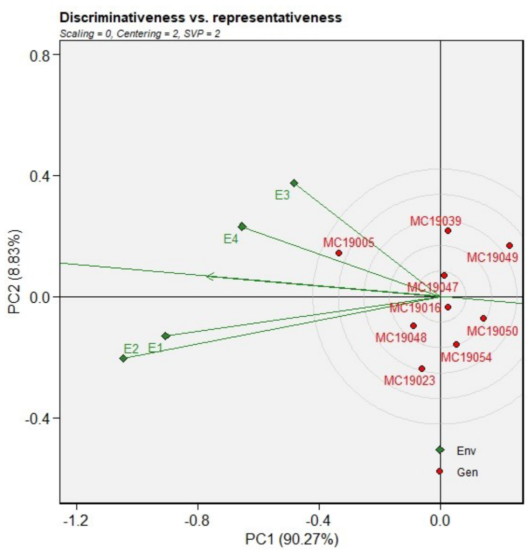

Fig. 1 GGE biplot represents genotype vs environment interaction for fresh flower yield in German chamomile.

German chamomile is a highly valuable medicinal and aromatic herb lacking superior and stable varieties for varied environments in the western Himalayas. The study was conducted to estimate genotypic effects and their interaction with the environment under various conditions of Himachal Pradesh. The experiments were laid out at four different locations with nine selected genotypes. The first two principal components (PC1 and PC2) of the GGE biplot contributed 99.14% of the total variability (contributed 90.27% and 8.87% individually) **(Fig. 1)**. MC19005 was the best stable performer over all the test environments. All four environments behaved like a Mega-environment.

Molecular characterization of superior selections of lavender

Lavender (*Lavandula angustifolia*) is grown all over the world for its essential oil, which is used in fragrances, cosmetic items, antiseptics, pharmaceutical preparations, aroma therapy, and alternative medicine. The present experiment was conducted to characterize a set of eight superior selections at molecular level with 18 simple sequence repeat markers (SSRs). A total of 74 alleles with an average of 4.11 alleles per locus were amplified over all the genotypes. The expected major alleles frequency ranged from 0.25 to 0.88 (with an average of 0.47), gene diversity ranged from 0.22 to 0.81 (with an average of 0.64), and polymorphic information content ranged from 0.19 to 0.79 (with an average of 0.59) (Table 1). The studied markers have a promising amount of polymorphism that can be transformed into genetic markers specific to cultivars.

Table 1 Allelic richness, polymorphic information content and gene diversity at 18 SSR loci over 8 selections of lavender

SSR Loci	Allele size (bp)	Major allele frequency	Total number of alleles	Polymorphic information content	Gene diversity
Laf6	235-250	0.38	5	0.71	0.75
Laf1	282-288	0.50	3	0.51	0.59
Laf16	162-168	0.88	2	0.19	0.22

SSR Loci	Allele size (bp)	Major allele frequency	Total number of alleles	Polymorphic information content	Gene diversity
Laf15	163-172	0.25	4	0.70	0.75
Laf11	176-198	0.38	6	0.75	0.78
Laf13	190-200	0.63	4	0.52	0.56
Laf 19	162-186	0.38	6	0.75	0.78
Lal4	189-195	0.63	3	0.47	0.53
Lal9	153-175	0.25	6	0.79	0.81
Lint10	135-189	0.38	4	0.67	0.72
Laf2	247-279	0.25	6	0.79	0.81
Laf8	243-251	0.75	2	0.30	0.38
Laf9	147-161	0.25	5	0.75	0.78
Laf10	210-218	0.75	3	0.37	0.41
Laf14	130-132	0.63	3	0.47	0.53
Lint4	178-200	0.38	5	0.71	0.75
Lint5	174-196	0.50	3	0.51	0.59
Lint6	149-252	0.38	4	0.67	0.72
Mean		0.47	4.11	0.59	0.64

Potential variability in cinnamon germplasm

Cinnamon (Dalchini) is the peeled bark rolled in quills, has sweet spicy aroma, and is derived from an evergreen bushy tree *Cinnamomum verum*. Realizing the large import (~ 45,000 tonnes annually) of cinnamon in the country and that the major one imported in India is deleterious *C. cassia*, it was envisioned to expend organized cultivation of *C. verum* in non-traditional areas. A set of 153 diverse seedlings (obtained from ICAR-IISR, Kerala) are being evaluated in Palampur (HP) with three checks (*Nithyasree*, *Konkan Tej* and Local1) in an augmented design. Six morphological parameters were observed after the rainy season in the year 2022 to check the initial growth of newly introduced germplasm of cinnamon in its non-traditional areas of Himachal Pradesh. The superior genotypes (CV4, CV33, CV77, CV89, CV107, CV136, CV 154, and CV168) should be focused for future breeding programs and for local adaptations in Himachal Pradesh aiming its large scale cultivation.

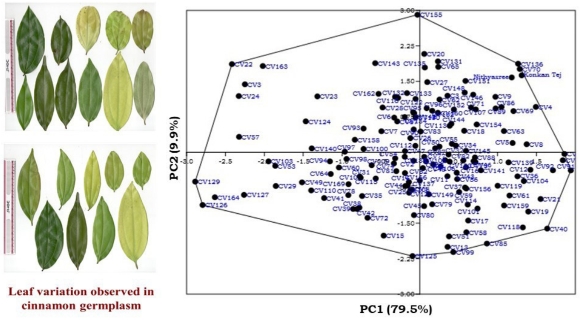

Fig. 2 Early morphological variation among cinnamon germplasm evaluated at Palampur.

Collection and multiplication of small millets

A total of 239 diverse accessions of small millets including finger millet, foxtail millet, kodo millet, proso millet, little millet, and barnyard millet were obtained from the international gene bank at ICRISAT, Patancheru and being multiplied for their further evaluation aiming revival of millets in Himachal Pradesh.

Research group: Navjot Kaur, Asmita Saini, Pratibha Pandey and Hari Sharan.

Relevant Publications:

- Industrial Crops and Products. 2023, 193: 116145.
- Scientific Reports. 2022,12: 15285.
- Journal of Applied Research on Medicinal and Aromatic Plants. 2022, 31.

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Floriculture

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

Effect of drying techniques on phytochemical contents and biological activities of marigold genotypes

Marigold (*Tagetes erecta* L.) flower has long been used as a food colorant and ingredient in human food and animal feed. Drying is one of the most important processes for producing marigold powder. Therefore, the effects of different drying techniques, namely freeze drying, oven drying, and shade drying, on the color, phenolic compounds, and antioxidant activity of marigold flowers were evaluated. The results indicate that color changes were less for freeze-dried marigold than after oven-dried and shade-drying. Different drying methods resulted in changes in the content of individual bioactive compounds. Freeze-dried flowers gave the highest phenolic content (73.15 mg/g) in aqueous extract in Tennis Ball (TB) variety of marigold. However, in oven-dried conditions, flavonoids showed the highest value (47.91 mg/g) in Arka Pari (AP) marigold. Antioxidant activity was good in both oven drying as well as freeze drying conditions i.e., the highest DPPH free radical scavenging activity of IC_{50} value (149.00 µg/ml) in Pusa Basanti Gainda (PBG) of oven drying and ABTS (304.63 µg/ml) in Arka Pari (AP) of freeze drying. Whereas, ferric reducing antioxidant power assay (FRAP) exhibited maximum value in freeze drying (14.52 µg/mL) in the Pusa Narangi Gainda (PNG) variety of marigold. These results demonstrate that freeze-drying and oven-drying should be considered a suitable drying method for marigold with respect to preserving their color, antioxidant properties, and bioactive compounds and provided useful information for the industrial production of marigold powder.

Nutritional profile of Edible flowers

Edible flowers have great nutraceutical value. It's a new research area where we can focus on region-specific, traditionally consumed, health-beneficial edible flowers. In India, edible flowers are the least explored aspects. There are several reports justifying that people started eating edible flowers centuries ago, but there is very little research work on complete nutritional characterization, biologically active compounds, and health benefits of edible flowers. So, our sole purpose of this project is to characterize the nutritional and phytochemical composition of some cultivated and wild edible flowers across Himachal and other parts of India. In this study, we have used *Bauhinia variegate* (Kachnar), *Tropaeolum majus* (Nasturtium), *Tagetes erecta* var. Pusa Basanti Gainda (Yellow marigold), *Matricaria chamomile* (Chamomile). The moisture content of the flowers ranged between 77% and 86% with the highest moisture content observed for Nasturtium. The total nutrient content, specifically crude protein, starch, and total sugars was highest in Kachnar. Yellow Marigold and Chamomile contained the highest fat content. The vitamin C content was highest in Chamomile by Nasturtium. The ash content of the flowers ranged from 4.5% to 6.75%. Kachnar and chamomile contain higher water-soluble proteins. Further, flowers' mineral profiling showed the highest magnesium content in Yellow Marigold while potassium and phosphorus contents were highest in Nasturtium. The fatty acid composition of flowers was estimated using GC-MS and it was found that Palmitic (C-16:0), linoleic (LA, C-18:2, n-6), and alpha-linolenic acid (ALA, C-18:3, n-3), were the predominant fatty acids.

Effect of pre-treatments on nutritional and phytochemical characteristics of Calendula

Calendula officinalis L. (pot marigold) of the Asteraceae family, is an annual ornamental plant with yellow to orange flowers, mostly grown as an ornamental and medicinal plant. Since it comprises nutritional and phytochemical properties so it has been approved for food use and emerge in the food and drug administration (FDA) list of generally recognized safe substances; thus, making it edible in nature. Keeping the importance of this plant in mind, an experiment was conducted to investigate the effect of different concentrations of potassium nitrate on the nutritional and physiochemical properties. Treatments consisted of four different concentrations viz., (0 mg/L as the control; 100 mg/L as T2; 200 mg/L as T3; 250 mg/L as T4) in five replications. The result signifies that different concentrations of KNO_3 have a considerable effect on the different parameters of calendula. The best foliar effect of KNO_3 on factors such as total soluble protein, carbohydrates, reducing sugars, total phenolic, and flavonoids was observed on T4 However, for crude protein and carotenoid content, the highest measured value was found to be in T3 treatment (200 mg/L). Therefore, with the rising demand for calendula, it has been recommended to apply KNO_3 at 250 mg/L to enhance the phytochemical status of the plant.

Relevant Publications:

- Antioxidants. 11(10): p.2032.
- Food Research International. 111977.
- Journal of Plant Nutrition. 1-16.

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Agronomy

Our research group is focused on the development of agro-technologies of *Salvia sclarea, Saussurea costus, Inula racemosa, Curcuma caesia, Ferula assa-foetida, Dracocephalum heterophyllum* and *Cinnamomum verum*. We are also involved in the introduction and extension of Dalchini (*Cinnamomum verum*) and Heeng (*Ferula assa-foetida*) in the non-traditional areas of Himachal Pradesh.

Effect of mulch and nitrogen levels on fresh inflorescence yield and essential oil content of *Salvia sclarea*

Ten treatment combinations comprising two mulch treatments (M_1= no-mulch and M_2= mulch) and five levels of N {N_1= control, N_2= 100% recommended dose of fertilizer (RDF), N_3= 25% N through RDF + 75% N through FYM, N_4= 50% N through RDF + 50% N through FYM and N_5= 75% N through RDF + 25% N through FYM} were evaluated in factorial randomized block design. The results revealed that the application of mulch produced significantly ($p \leq 0.05$) higher fresh inflorescence yield compared to the no-mulch during both years **(Fig. 1)**. In the case of N levels, the application of 100% RDF and; 75% N through RDF + 25% N through FYM registered higher fresh inflorescence and essential oil content during 2020-21 and 2021-22, respectively. The results of this study suggested that a higher yield and quality of essential oil of *S. sclarea* can be achieved with 75% of N through RDF and 25% of N through FYM in combination with mulch application.

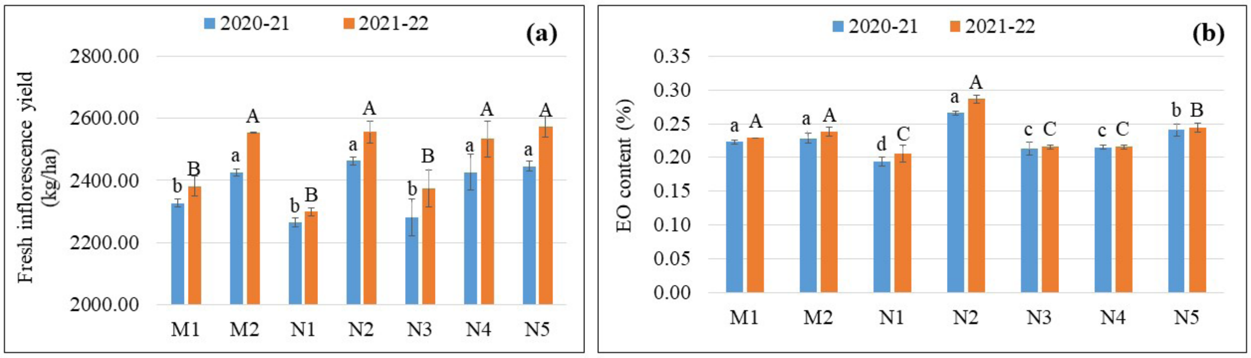


Fig. 1 Effect of mulch and nitrogen levels (a) on fresh inflorescence yield (b) on essential oil content of *Salvia sclarea*.

Effect of fertilizer levels on essential oil yield and marker compound of *Saussurea costus*

A field experiment comprised three levels of nitrogen (60, 90, and 120 kg/ha), three levels of phosphorus (20, 40, 60 kg/ha), and two levels of potassium (20 and 40 kg/ha) was conducted in factorial randomized block design. Under N levels, highest essential oil yield was registered with N_{120}, which was at par with N_{90} **(Fig. 2)**. Similarly, highest essential oil yield was found in P_{60}, which showed non-significant variations with P_{40}. Irrespective of applying N and P, varying levels of K fertilizer also significantly influenced the essential oil yield, and the maximum essential oil yield was recorded with K_{40}, which showed significant variations with K_{20}. The heat map analysis indicated that the accumulation pattern of the chemical compound was not constant over the treatment combination **(Fig. 3)**. The clustering showed that $N_{90}P_{20}K_{20}$ recorded a higher concentration of 14-hydroxy-*a*-muurolene, spathulenol, and dihydro-*a*-ionone. However, the concentration of ar-curcumene and γ-costol were higher under $N_{90}P_{60}K_{20}$. Similarly, application of $N_{120}P_{20}K_{40}$ resulted in a higher concentration of α-selinene, *β*-elemene and *α*-costol while, linoleic acid was recorded higher under $N_{120}P_{40}K_{40}$.

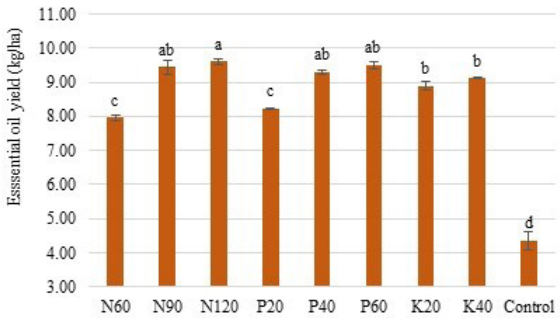


Fig. 2 Effect of fertilizer levels on essential oil yield of *Saussurea costus.*

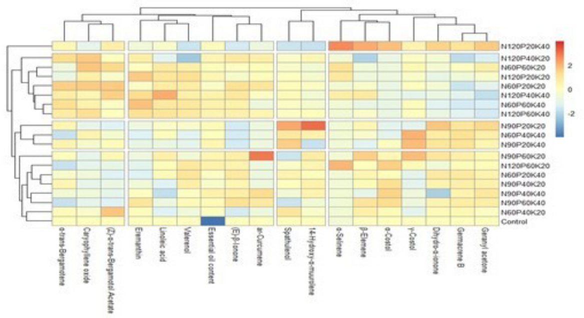


Fig. 3 Heat map of essential oil content and chemical compounds identified in the costus oil in response to different NPK treatment combinations.

Agro-technologies for of small millets

Agro-technologies of small millets including finger millet, foxtail millet, kodo millet, proso millet, little millet and barnyard millet obtained from ICRISAT, Patancheru, Hyderabad are being developed for suitable time of planting under Palampur conditions for revival of traditional crops in Himachal Pradesh.

Extension activities

Area expansion under *Dalchini* (*Cinnamomum verum*) in Himachal Pradesh

Started organized cultivation of true cinnamon (*Cinnamomum verum*) in Himachal Pradesh by distributing 10,000 plants to the farmers in 37 locations of Distt. Kangra, Hamirpur, Bilaspur, Una and Sirmaur to cover an area of 9.0 ha. Thirteen training programs (09 on-campus and 04 on-farm) were conducted under cinnamon cultivation and trained 285 farmers including Officers of State Departments.

Fig. 4 Distributing planting material of cinnamon for plantation in Kangra, Hamirpur, Bilaspur, Una and Sirmaur, H.P.

Himachal Pradesh State Rural Livelihood Mission

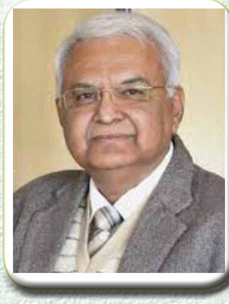
Co-ordinated twelve training programs (two days) on "*Agro-Ecological Practices of Farming and Successful Income Generation Model*" to Farm Livelihood Community Resource Persons (Krishi and Pashu Sakhi) and Mahila Kisan under Deendayal Antyodaya Yojana - National Rural Livelihood Mission (DAY-NRLM) at CSIR-IHBT, Palampur. In these training programs, 306 women farmers and 41 officers of Himachal Pradesh State Rural Livelihood Mission (HPSRLM), Rural Development Department, H.P. from twelve Distt. of Himachal Pradesh participated.

Research group: Diksha Dhiman, Sakshi Vishvamitera and Sidharth Baghla.

Relevant Publications:

- Journal of Applied Research on Medicinal and Aromatic Plants. 31: 100421.
- Scientific Reports. 12: 15285. doi:10.1038/s41598-022-19628-0.
- Biofortification in Cereals Progress and Prospects (Ed. Deshmukh R, Nadaf A, Ansari WA, Singh K and Sonah H, Springer Nature).

BIOTECHNOLOGY DIVISION



Sanjay Kumar, Director (till 28.02.2023)
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Plant Adaptation and Secondary Metabolism

In the past few decades, a steady inclination towards herbal phytomedicines has been observed within large sections of world populations, primarily due to the magnified risk imposed by the adverse side effects of allopathic medicines. Amongst the various medicinal herbs that constitute the backbone of herbal medicines in India, *M. acuminata* forms an important candidate taxa (Bhattacharyya et al., 2022 a, b). Our research group initiated TCL-derived *in vitro* cultures of *M. acuminata t*- and maintained in Murashige and Skoog (MS) medium supplemented with 1.5 mg/l *meta*-topolin (*m*T), 5.0 mg/l chitosan, 1.5 mg/l indole-3- butyric acid (IBA) and 5.0 mg/l phloroglucinol (PG). The phytoactive potentials were evaluated using UPLC and the expression patterns of various secondary metabolite biosynthesis genes were studied in various tissue parts and correlated with metabolite yield (Bhattacharyya et al., 2022a).

Furthermore, in order to understand the molecular basis of alternative in vitro systems for therapeutic bioprospection and sustainable utilization of *M. acuminata*, next generation sequencing (NGS) assisted transcriptome profiling of leaf and pseudobulb tissues were performed (Bhattacharyya et al.,2022b). Data suggested that leaf tissues rather than pseudobulb can be used as an alternate source of bioactive metabolites thereby shifting the need of harvesting the pseudobulb (Bhattacharyya et al., 2022 b). In order to ascertain the clonal fidelity of the long term - propagated *in vitro* lines of *M. acuminata*, genetic homogeneity and antimicrobial activity were assessed. The plants were found to exhibit 94% clonal fidelity in comparison to their mother plant and exhibited potent antibacterial activity (Bhattacharyya et al., 2023). The present approach can serve as a model approach for sustainable utilization of endangered orchid species of high industrial demand, strengthening the utility of chitosan as growth promoter in orchid micropropagation.

We also studied microbial diversity associated with *Arnebia euchorma* to investigate their crucial role in plant fitness and secondary metabolite biosyntehsis. A leaf endophyte, *Sphingomonas faeni* strain ALB2, was isolated and its genome was sequenced on the Illumina NovaSeq 6000 platform. The draft genome sequence of the bacterium comprised 4,720,245 bp and contained 4,233 protein-coding genes, with a GC content of 65.66% (Bhardwaj et al., 2022).

Relevant Publications:

- South African Journal of Botany. 155: 372-382.
- Plant Cell, Tissue & Organ Culture. https://doi.org/10.1007/s11240-022-02369-3.
- Frontiers in Plant Science. 13: 954467.

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Biofertilizer and R&D Management

Over the years CSIR-IHBT has isolated microbes from rugged regions of high altitudes and has built a rich repository of microbes with excellent plant growth promoting (PGPRs) attributes and highly tolerant to stresses including heavy metal toxicity. Leads are available wherein preliminary results showed that some PGPRs i.e. IHBT-FS2, IHBT-F4, IHBT-A2-3, IHBT-A6, IHBT-E2-2, IHBT-B2-1, IHBT-B3, IHBT-B4-3, IHBT-E6-3 and IHBT-G4 are highly resistant to lead, chromium, arsenic and cadmium heavy metal **(Fig. 1)**. Out of these isolates, it has been observed that IHBT- FS2 strain tolerates 15mM lead acetate, 30mM chromium (III) chloride hexahydrate, 100mM sodium arsenate and 10mM cadmium chloride anhydrous heavy metal stress as compared to other microbial strains **(Fig. 2)**. Furthermore, the selected strain also maintained its plant growth promoting traits such as siderophore production, phosphate solubilization and indole-3-acetic acid (IAA) production under stressed conditions. Interestingly, results showed that IHBT-FS2 strain have good bioremediation property, and positively influences the plant growth under heavy metal stress environment.

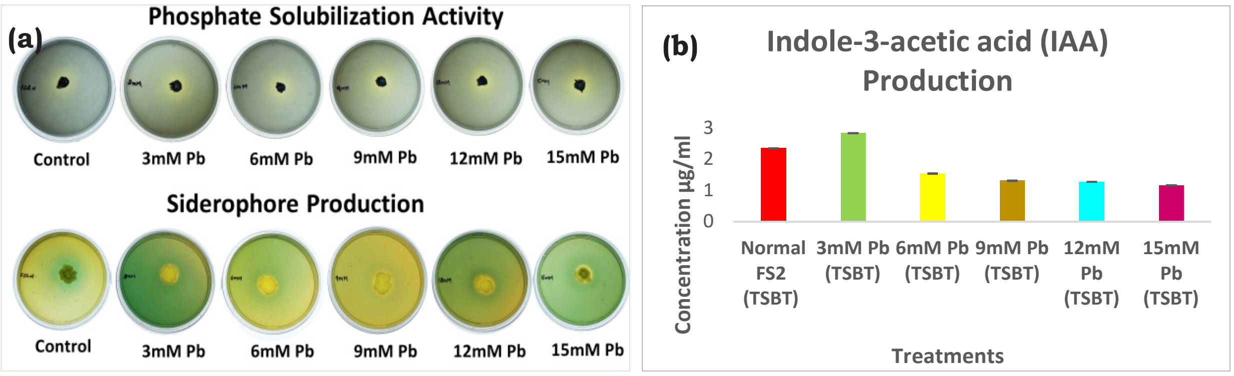


Fig. 1 (a), (b) Evaluation of Plant growth promoting attributes (phosphate solubilization, siderophore and IAA production) of IHBT-FS2 strain under different concentrations (3mM, 6mM, 9mM, 12mM and 15mM) of lead acetate.

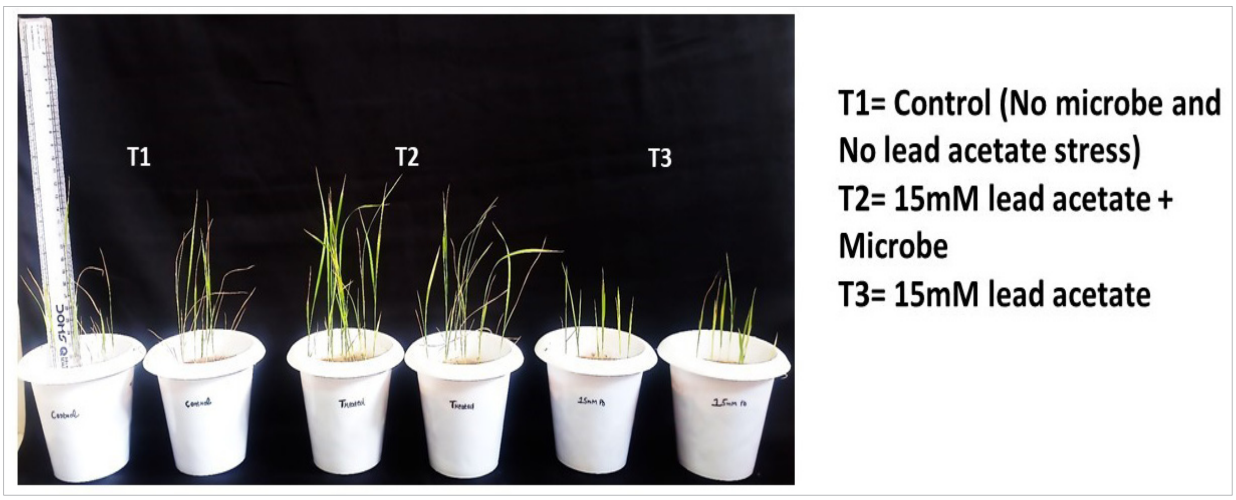


Fig. 2 Evaluation of soil remediation efficiency of lead acetate tolerant microbial strain.

Under the project entitled "Breaking the Barrier of saffron cultivation through technological intervention for enhancing production and Livelihood of Farmers in Kashmir and Non- Traditional Areas" a total of 60 bacterial strains were isolated from the saffron rhizosphere field in Patti village Palampur Himachal Pradesh (HP) and screened for PGP attributes i.e phosphate and potassium solubilization, siderophore production, Indoleacetic acid (IAA) synthesis, and Nitrogen fixation. 86% isolated bacterial population had multiple plant growth-promoting attributes and only 14% isolated bacterial population had no PGP activity. Based on PGP traits four bacterial strains were selected for further study, the thermotolerance potential of four PGPRs were assessed and their PGP traits were analyzed under different temperature regimes (4°C and15°C). During screening, PGPR FS2 exhibited the best thermotolerance potential under wide temperature regimes **(Fig. 3)**. Further, application of PGPR FS2 significantly improved growth of wheat seedling at a low temperature of 10°C). The shoots length increased by 1.8t, roots length 1.5t, and the total number of roots 1.6t as compared to the control treatment, hence PGPR FS2 could be a promising bioistimulant for hilly agriculture system.

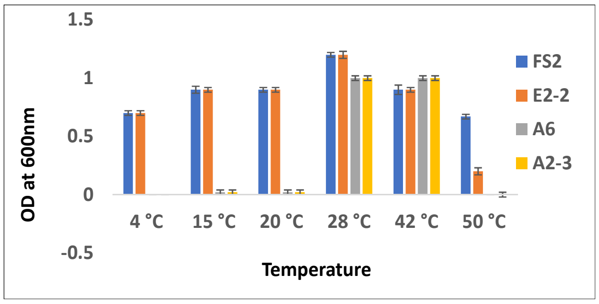


Fig. 3 Thermotolerant potential of selected PGPRs.

The efforts were made towards increasing the corm size of saffron through tissue culture by modulating the carbon source, growth retardants and plant growth regulators. After transferring multiple shoots in the modified medium, bigger sized corms were observed with well-developed tunics and root biomass. The average corm weight was 3 gm (T1) as compared to 0.39 gm in control (T2) **(Fig. 4)**.

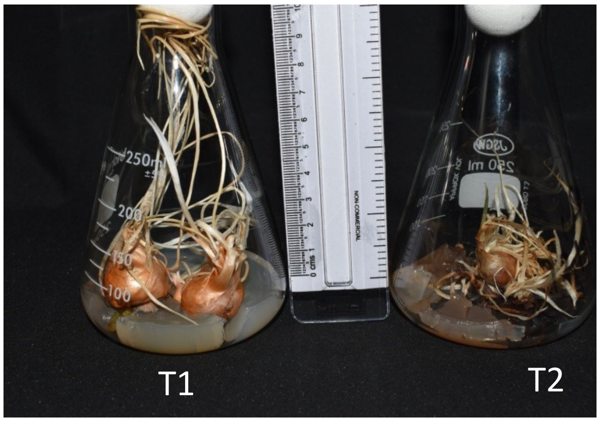
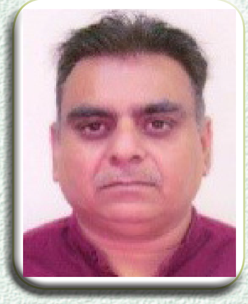


Fig. 4 *In vitro* raised corms.

Research group: Nilofer Ali, Sukrit Saklani, Priya Kaushal, Raveena Saini, Gudiya, Komal, Kanupriya and Saloni.

Relevant Publications:

- Frontiers in Plant Science. 2023, 1141538.
- Microbiological Research. 2023, 270:127317.
- Frontiers in Plant Science. 2023, 1041413.



Vipin Hallan, Chief Scientist

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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.

Homeobox 27, a Homeodomain Transcription Factor, Confers Tolerances to CMV by Associating with Cucumber Mosaic Virus 2b Protein

Transcription factors (TFs) play an important role in plant development; however, their role during viral infection largely remains unknown. The present study was designed to uncover the role transcription factors play in Cucumber mosaic virus (CMV) infection. During the screening of an *Arabidopsis thaliana* (Col-0) transcription factor library, using the CMV 2b protein as bait in the yeast two-hybrid system, the 2b protein interacted with Homeobox protein 27 (HB27). HB27 belongs to the zinc finger homeodomain family and is known to have a regulatory role in flower development, and responses to biotic and abiotic stress. The interaction between CMV 2b and HB27 proteins was further validated using in planta (bimolecular fluorescence complementation assay) and in vitro far-Western blotting (FWB) methods. In the bimolecular fluorescence complementation assay, these proteins reconstituted YFP fluorescence in the nucleus and the cytoplasmic region as small fluorescent dots. In FWB, positive interaction was detected using bait anti-MYC antibody on the target HB27-HA protein. During CMV infection, upregulation (~3-fold) of the HB27 transcript was observed at 14 days post-infection (dpi) in *A. thaliana* plants, and expression declined to the same as healthy plants at 21 dpi. To understand the role of the HB27 protein during CMV infection, virus accumulation was determined in HB27-overexpressing (HB27 OE) and knockout mutants. In HB27-overexpressing lines, infected plants developed mild symptoms, accumulating a lower virus titer at 21 dpi compared to wild-type plants. Additionally, knockout HB27 mutants had more severe symptoms and a higher viral accumulation than wild-type plants. These results indicate that HB27 plays an important role in the regulation of plant defense against plant virus infection **(Fig. 1)**.

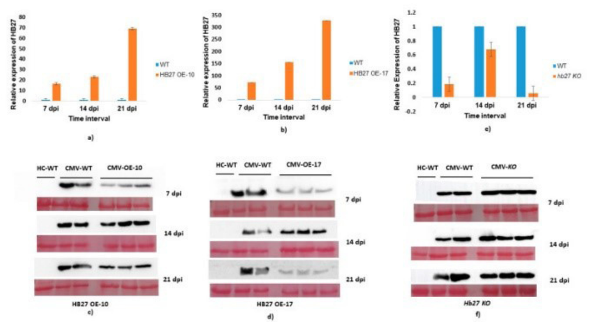

Fig. 1 Determination of effects of HB27 overexpression and knockout on CMV. The transcript levels of HB27 were calculated in CMV-infected plants compared to healthy plants at 7, 14 and 21 dpi. The relative expression was estimated using the 2−ΔΔCt method after the expression levels were normalized by 18S (a,b,e). CMV accumulation in overexpression and knockout was determined by Western blotting using coat protein-specific antiserum (c,d,f).

Geminivirus-derived vectors as tools for functional genomics

A persistent issue in the agricultural sector worldwide is the intensive damage caused to crops by the geminivirus family of viruses. The diverse types of viruses, rapid virus evolution rate, and broad host range make this group of viruses one of the most devastating in nature, leading to millions of dollars' worth of crop damage. Geminiviruses have a small genome and can be either monopartite or bipartite, with or without satellites. Their ability to independently replicate within the plant without integration into the host genome and the relatively easy handling make them excellent candidates for plant bioengineering. This aspect is of great importance as geminiviruses can act as natural nanoparticles in plants which can be utilized for a plethora of functions ranging from vaccine development systems to geminivirus-induced gene silencing (GIGS), through deconstructed viral vectors. Thus, the investigation of these plant viruses is pertinent to understanding their crucial roles in nature and subsequently utilizing them as beneficial tools in functional genomics. This review, therefore, highlights some of the characteristics of these viruses that can be deemed significant and the subsequent successful case studies for exploitation of these potentially significant pathogens for role mining in functional biology **(Fig. 2)**.

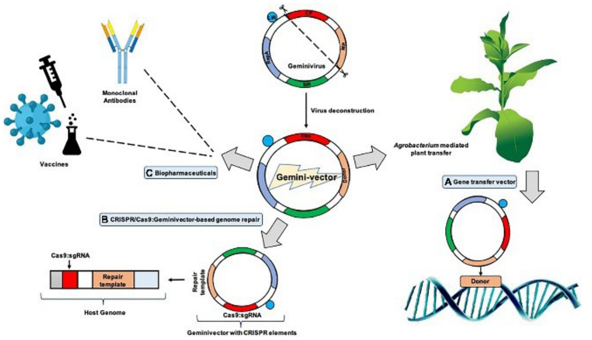

Fig. 2 Geminiviral vectors and their functional relevance. Virulence factors like the viral movement protein (MP) and coat protein (CP) are detached to be replaced with the donor DNA and specific nucleases which give rise to "geminivectors." These vectors have multidirectional functionalities in which they primarily act as (A) gene transfer vectors, where vectors are used for the transient expression of genes of interest, production of specific proteins, and participation and annotation of unknown gene characteristics, among others; (B) CRISPR/Cas9-based genome repair: where they are used for template repair in the host genome, while also essentially participating in genome editing; and (C) biopharmaceuticals: where production of important vaccines has been successfully conducted using geminivectors. Monoclonal antibodies have been prepared for the deadly *Ebola virus*, and antigen production for hepatitis B and HIV has been successful.

NF-YB family transcription factors in Arabidopsis: Structure, phylogeny, and expression analysis in biotic and abiotic stresses

Nuclear factor-Y (NF-Y) transcription factors (TFs) are conserved heterotrimeric complexes present and widespread across eukaryotes. Three main subunits make up the structural and functional aspect of the NF-Y TFs: NF-YA, NF-YB and NF-YC, which bind to the conserved CCAAT- box of the promoter region of specific genes, while also interacting with each other, thereby forming myriad combinations. The NF-YBs are expressed differentially in various tissues and plant development stages, likely impacting many of the cellular processes constitutively and under stress conditions. In this study, ten members of NF-YB family from *Arabidopsis thaliana* were identified and expression profiles were mined from microarray data under different biotic and abiotic conditions, revealing key insights into the involvement of this class of proteins in the cellular and biological processes in *Arabidopsis*. Analysis of *cis*-acting regulatory elements (CAREs) indicated the presence of abiotic and biotic stress-related transcription factor binding sites (TFBs), shedding light on the multifaceted roles of these TFs. Microarray data analysis inferred distinct patterns of expression in various tissues under differing treatments such as drought, cold and heat stress as well as bacterial, fungal, and viral stress, indicating their likelihood of having an expansive range of regulatory functions under native and stressed conditions; while quantitative real-time PCR (qRT-PCR) based expression analysis revealed that these TFs get real-time-modulated in a stress dependent manner. This study, overall, provides an understanding of the AtNF-YB family of TFs in their regulation and participation in various morphogenetic and defense-related pathways and can provide insights for development of transgenic plants for trait dependent studies.

Research group: Surender Kumar, Rahul Mohan Singh, Pooja Bhardwaj, Usha Rattan, Bipasha Bhattacharjee, Kamini Kapoor, Preshika, Savita Choudhary, Anish Tamang, Govind Rai, Abhisha Roy, Parmeet Kaur and Priyaluxmi.

Relevant Publications:

- Frontiers in Microbiology. 2023, 17(13): 1067427.
- Pathogens. 2022, 11(7): 788.
- Frontiers in Microbiology. 2022, 1(13): 799345.

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Molecular Genetics and Genomics Lab

The current efforts of my group to utilize 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 Fundamental Basic Research (FBR), CSIR Aroma Mission, and various projects sponsored by DBT. In continuation of the previous reports, the group made following significant achievements during the period under report.

Transcriptional dissection of spatial molecular interplay underlying Alantolactone and Inulin biosynthesis in *Inula racemosa* Hook f.

The *Inula racemosa* Hook. f. (Pushkarmula; family: Asteraceae), is a high-altitude perennial herb having natural habitat in cold arid western alpine region of Himalayas (2700-3500 m). As per Sanskrit text on Indian traditional medicine "Charaka Saṃhitā", the plant was characterized as sweet variety of "Kustha" and cited as best medicament of pleurisy with "Śvāsahara" (anti-asthmatic) and 'Hikkānigrahaṇa' (stops hiccups) activities. The root of Pushkarmula were used by ancient mankind for treatment of cardiovascular, liver diseases and respiratory tract disorders in east Asia and Europe.

Despite the increasing ethnopharmacological importance, except limited chemical information, the transcriptomics or genomic efforts have not been carried out yet. Earlier chemical studies identified presence of several phytopharmaceutical constituents, like flavanol glycosides, sesquiterpenoids and sesquiterpenes lactones (SLs:

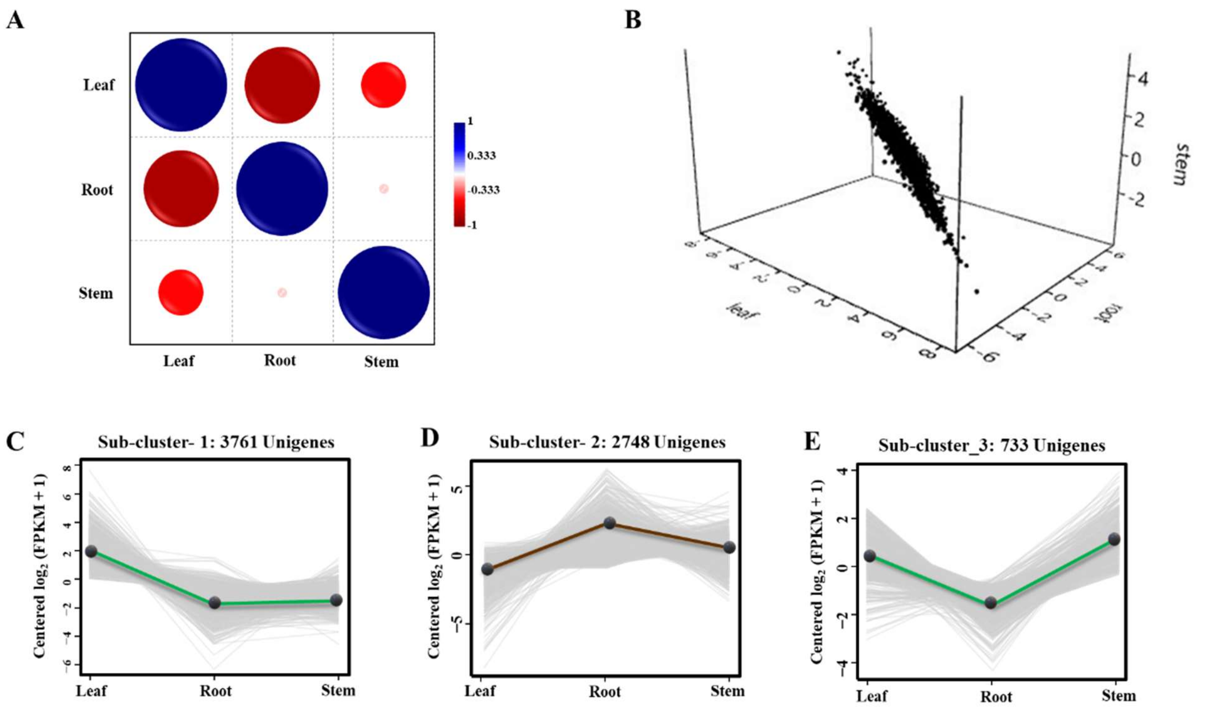


Fig. 1 Organ-specific expression analysis of three tissues *viz.* leaf, root, and stem of *I. racemosa.* (A) Pearson's correlation among leaf, stem, and root tissue. (B) Bubble plot representing normalized tissue specific gene expression. (C-E) Gene expression sub-clustering of significantly expressed unigenes based on median FPKM values.

sesquiterpenes with lactone ring) in the roots of *Inula racemosa.* During this year, efforts were made to unveil global transcriptional atlas underlying organ-specific specialized metabolites biosynthesis by integrating RNA-Seq analysis of 433 million sequenced reads with the phytochemical analysis of leaf, stem, and root tissues. Overall, 7242 of 83772 assembled non-redundant unigenes were identified exhibiting spatial expression in leaf (3761), root (2748) and stem (733) **(Fig. 1)**.

Overall, 7242 of 83772 assembled non-redundant unigenes were identified exhibiting spatial expression in leaf (3761), root (2748) and stem (733). Subsequently, integration of predicted transcriptional interactome network of 2541 unigenes (71841 edges) with Gene ontology and KEGG pathway enrichment analysis revealed isoprenoid, terpenoid, diterpenoid and gibberellin biosynthesis with antimicrobial activities in root tissue. Interestingly, the root-specific expression of germacrene mediated alantolactones biosynthesis (GAS, GAO, G8H; IPP: DMAP & KAO) and anti-microbial activities (BZR1, DEFL, LTP) well sup-ported with both quantitative expression profiling and phytochemical accumulation of alanto-lactonesand iso-alantolactones, which suggests "roots" as site of alantolactones biosynthesis. A significant interactions of leaf-specific carbohydrate me-tabolism with root-specific inulin biosynthesis indicates source (leaf) to sink (root) regulation of inulin **(Fig. 2)**.

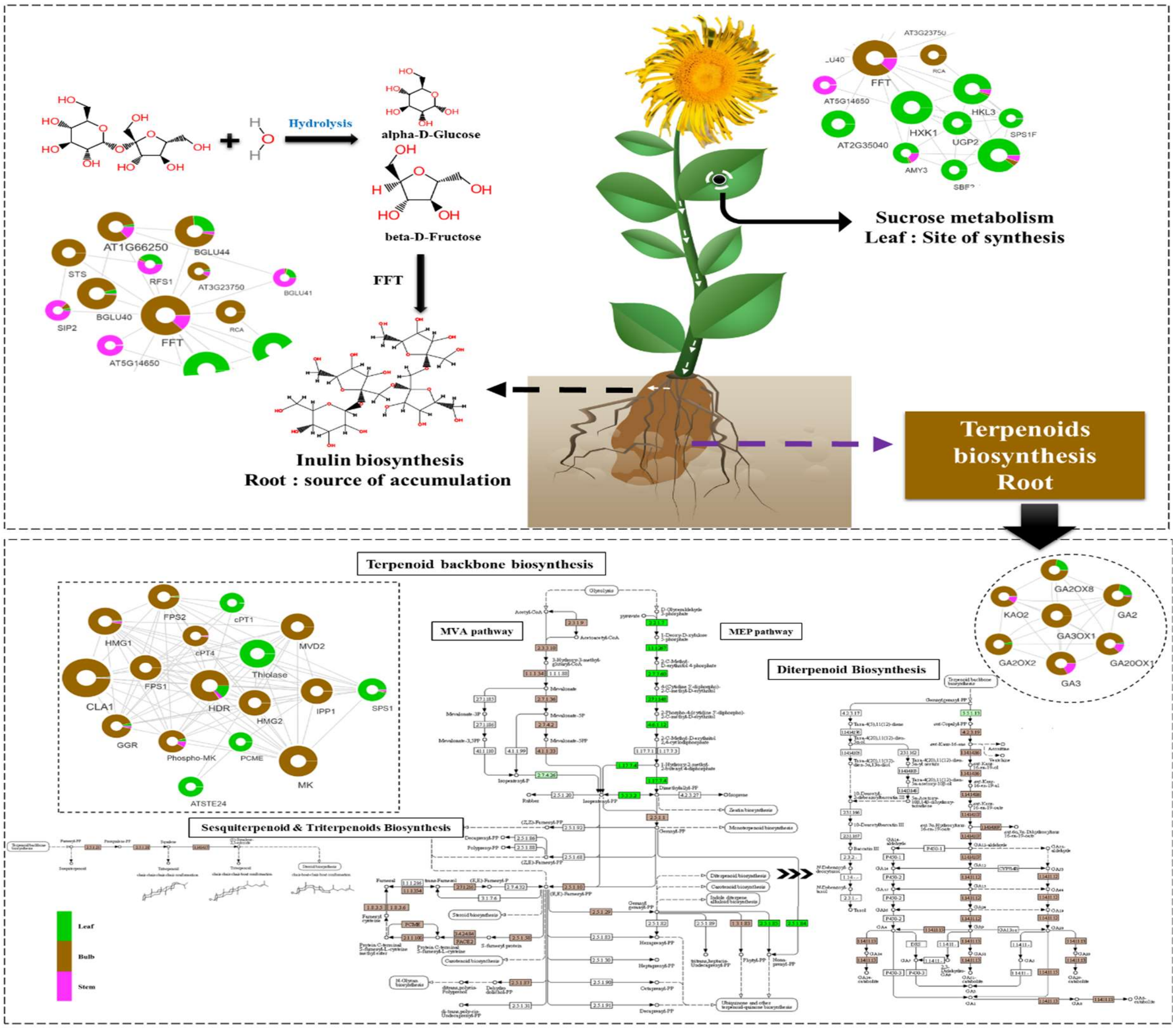


Fig. 2 Global transcriptional dynamics of spatial expression of terpenoids and inulin biosynthesis in *I. racemosa*.

Our findings comprehensively demonstrate the source-sink transcriptional regulation of alantolactones and inulin biosynthesis, which can be further extended for upscaling the special-ized metabolites. Nevertheless, creation of functionally relevant molecular markers will expe-dite the breeding strategies for genetic improvement of *I racemosa.* **(Seth et al. Int. J. Mol. Sci. 2022, 23, 11213. https://doi.org/10.3390/ijms231911213).**

Transcriptional genomic resource revealed molecular insights specialized metabolism in endangered *Angelica glauca* Edgew

The Indian Himalayan Region (IHR) is an important biodiversity hotspot with an abundance of 1,748 Medicinal and Aromatic Plant species (MAPs) having significant utility in Indian traditional medicines. *Angelica glauca* Edgew (syn Angelica nuristanica; family: Apiaceae; common name "Chora" "Gandhrayan" and "Smooth angelica"), is an important medicinal and aromatic herb endemic to IHR. It is an endangered medicinal & aromatic herb is rich source of numerous industrially important bioactive metabolites including terpenoids, phenolics and phthalides. Nevertheless, genomic interventions for sustainable utilization and restoration of its genetic resources are greatly offset due to the scarcity of genomic resources and key regulators of underlying specialized metabolism.

To unravel the global atlas of specialized metabolism, the first spatial transcriptome sequencing of leaf, stem and root generated 109 million high quality paired end reads, assembled *de novo* into 81,162 unigenes exhibiting 61.53% significant homology with six public protein databases. The organ-specific clustering grouped 1136 differentially expressed unigenes into four sub-clusters differentially enriched in leaf, stem and root tissue **(Fig. 3)**.

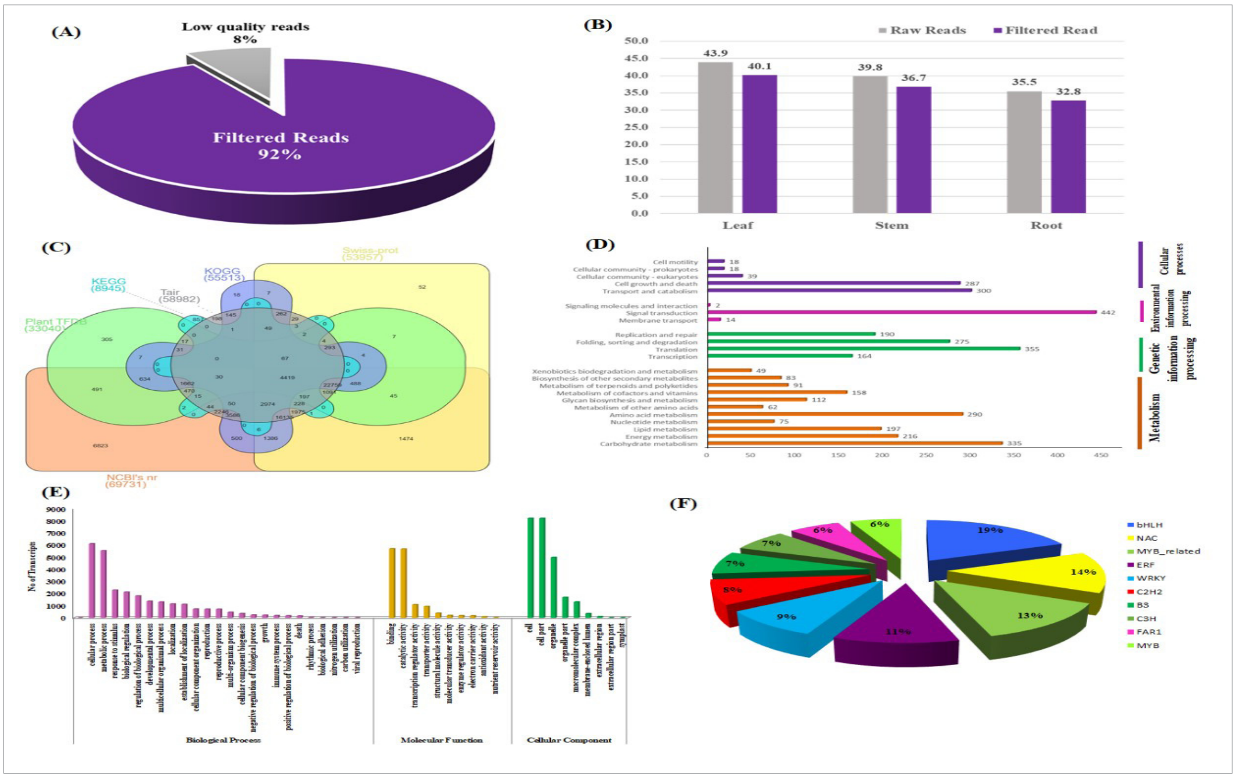
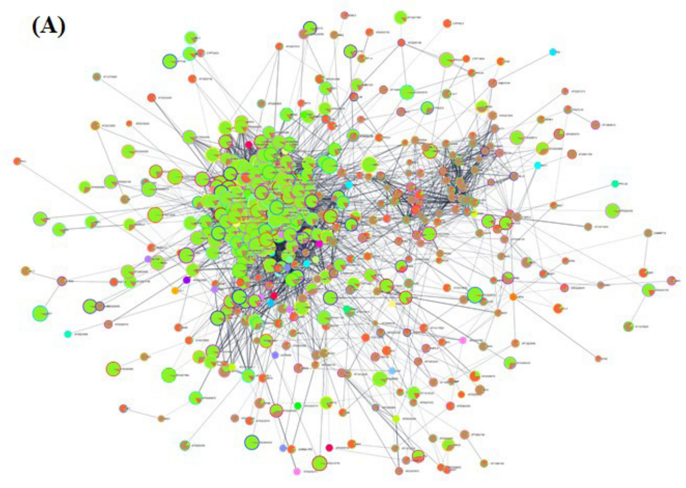


Fig. 3 (A) Quality filtering of sequenced reads. (B) High quality filtered reads in Leaf, Stem and Root tissue. (C) Venn diagram representing the functional annotation of transcripts with six public databases. (D) KEGG annotation grouped transcripts into four main categories: Metabolism, Genetic information processing, Environmental information pro-cessing, and Cellular processes.

The prediction of transcriptional interactome network by integrating enriched gene ontology (GO) and KEGG metabolic pathways identified key regulatory unigenes corresponding to terpenoids, flavonoids and carotenoids biosynthesis in leaf, followed by stem and root tissues, respectively **(Fig. 4)**.



(B)

No. of Nodes	651
Edges	24017
Avg. no. of neighbors	73.785
Clustering coeff.	0.475
Enrichment Avg. Degree	67.27
Enrichment Clustering coeff	0.506
Enrichment Edges	24017
Enrichment Expected Edges	4918
Network Enrichment	1.00E-16

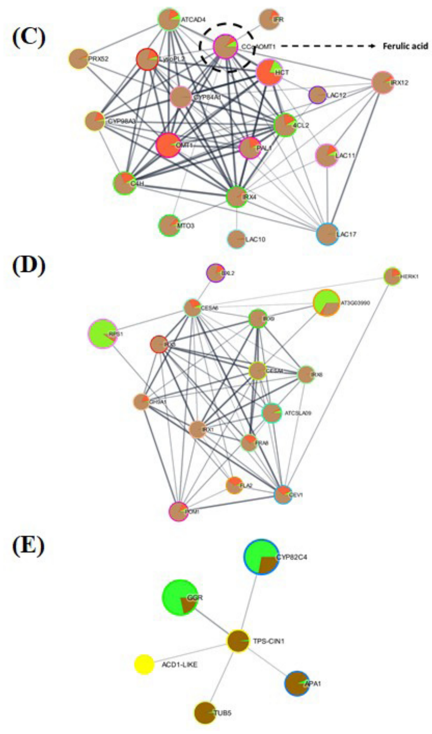


Fig. 4 (A) Predicted spatial transcriptional interactome of Angelica glauca. (B) Network statistics of the interactome build. (C) Enriched network of Ferulic acid pathway. (D & E) Terpenoids biosynthesis, green color represents significant enrichment in the leaf tissue, orange in stem and brown in the root tissue.

Furthermore, stem and root specific significant enrichment of Phenylalanine ammonia lyase (PAL), Cinnamate-4-hydroxylase (C4H) and Caffeic acid 3-O-methyltransferase (COMT) indicate phenylalanine mediated ferulic acid biosynthesis in the stem and root. However, root- specific expression of NADPH-dependent alkenal/one oxidoreductase (NADPH-AOR), S-adenosyl-L-methionine-dependent Methyltransferases (SDM), Polyketide cyclase (PKC) and CYP72A15 suggests "root" as a primary site of phthalide biosynthesis. Additionally, GC-MS and UPLC analysis corresponded with organ-specific gene expression with higher content of limonene and phthalide compounds in roots, while higher accumulation of ferulic acid in the stem followed by root and leaf tissue. The first comprehensive genomic resource with an array of candidate genes of key metabolic pathways can be potentially utilized for targeted upscaling of aromatic and pharmaceutically important bioactive metabolites. This will also expedite genomic-assisted conservation and breeding strategies for the revival of endangered *A. glauca*. **(A. Devi et al. Int. J. Mol. Sci. 2022, 23(19), 11064; https://doi.org/10.3390/ijms231911064).**

Research group: Romit Seth, Vishal Sharma, Sapna Thakur, Aasim Majeed, M. Saba Rahim, Poonam Pal, Balraj Sharma, Mamta Masand, Ashlesha Holkar, Shikha Sharma, Amna Devi, Vishal Bhatt, Subhankar, Palak Sharma, Shivani Sandal, Sangeeta Kumari and Avantika.

Relevant Publications:

- International Journal of Molecular Sciences. 2022, 23, 11213.
- International Journal of Molecular Sciences. 2022, 23(19), 11064.

Ravi Shankar, Principal Scientist
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Biotechnology (Bioinformatics)

We work in high-throughput computational biology where prime research areas have been providing solutions for NGS at various levels, Computational Genomics and regulomics, high-performance computing, and Machine & Deep Learning solutions. The current year saw the following major research works, which culminated in publications.

Only ~3-5% of the genome result in protein coding genes. The majority of the genome is non-coding; however, that does not mean inertness. In fact, they are much more important components of the genome than the genes themselves, as they determine the dynamics of a species, a tissue type, and the living systems behavior. They are king-makers of genome and one such component is long non-coding RNAs. Recently, their role in the system came to the surface, which ranged from determining promoter strength and transcription to the formation of epigenetic control switches of genome, to regulatory RNAs formation, to becoming a warehouse of cells and chaperons.

Compared to plants, in humans, many lncRNAs have been identified. Plant biology has lagged tremendously in acknowledging lncRNAs importance. Unlike humans, plants have much bigger and highly complex genomes. Add to this the fact that lncRNAs vary a lot across the species. Thus, identifying them through any homology-based approaches fails. Features recognized for one species does not work for another one. Interestingly, in the wake of RNA-seq based studies in plants, this almost complete lack of awareness about lncRNAs is so evident that a vast amount of them are wrongly annotated as protein coding genes instead of lncRNAs. At the same time their genomic lncRNA annotation remains illusive.

To ends all misadventures in plant genomics, we developed DeepPlnc software which breached the accuracy level of 98% while being tested across a considerable volume of different datasets, a rare score ever achieved by any existing software. We have implemented a bi-model CNN based Deep Learner, which where alogn with the sequence the structural information of the RNA was also learned, and both were seen in the context of each other. Also, it was found that the best identification peaks for lncRNAs are determined by local information within the range of 400 bases. DeepPlnc is freely available as a web-server as well as stand-alone software at our lab's web page and GitHub **(Fig. 1)**.

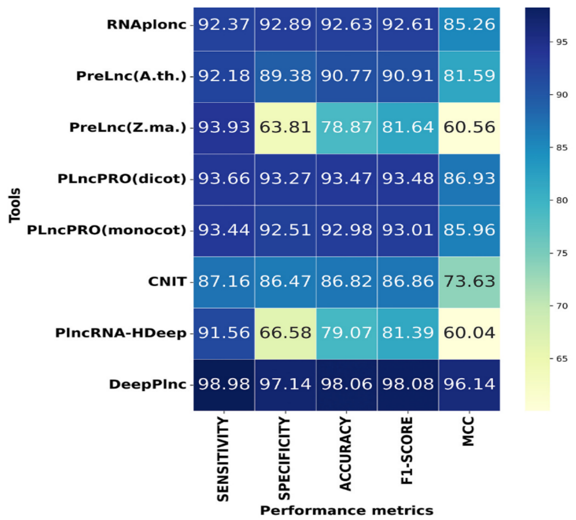


Fig. 1 DeepPlnc outperforms all the state-of-art existing software to detect lncRNAs, by huge margin.

Also, unlike the existing pool of software, DeepPlnc can perform with equal accuracy even across incomplete sequences. This means that one can use it for practical application of genomic annotation and can use it to annotate *de novo* assembled transcriptomes. We demonstrated the impact of DeepPlnc on the correct annotation of transcriptomes by applying it to annotate the recently published transcriptome of Rheum austral **(Fig. 2)**. As can be understood from this figure alone, without using DeepPlnc, how much wrong a transcriptome study could go ?

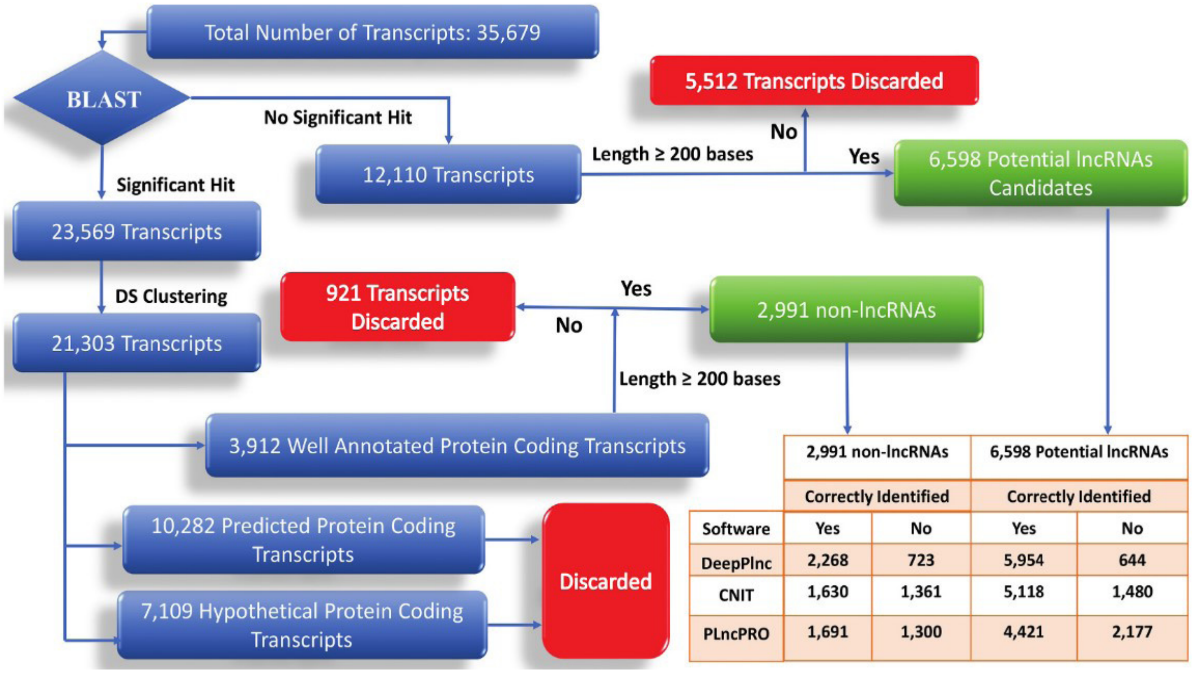


Fig. 2 Run of DeepPlnc across recently published Rheum australe transcriptome. A large number of the annotated transcriptome were found actually belonging to lncRNAs, which are otherwise wrongly annotated as protein coding genes in the currently prevailing RNA-seq analysis culture.

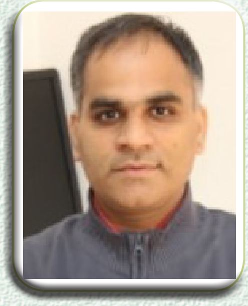
Besides the work on the development of DeepPlnc software, our lab also carried out two different RNA-seq based studies. The first one was carried out to understand cold acclimation in high-altitude plant Rhododendron in a time-series manner. The study revealed various facets of climate adaptation in high-altitude plants.

The second RNA-seq based transcriptome study was carried out to reveal the various secondary metabolite biosynthetic pathways in a prized endangered orchid, *Malaxis acuminata*. This species is on the verge of extinction due to the high demand for its pseudobulbs. Pseudobulbs are the source of β-sitosterol and eugenol having great medicinal importance. Beside pseudobulbs, leaves of this plant can also be site for β-sitosterol and eugenol biosynthesis.

Research group: Ritu, Jyoti, Sagar Gupta, Veerbhan Kesarwani, Umesh Bhati, Amit and Manjeet.

Relevant Publications:

- Frontiers in Plant Science. 2022, 13: 954467
- Scientific Reports. 2022, 12: 15553.
- Genomics. 2022, 114 (5) 110443.



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Biotechnology (Bioinformatics)

Our group focuses on positioning of Himalayan bioactive molecules against a diverse target space through advanced biophysical methods. Moreover, we also explore the conformational space of host-guest inclusion complexes to improve the hydrosolubility and stability of poorly soluble bioactive molecules. Following are some of the exciting results obtained during this academic year.

Restoring structural alterations and aggregate inhibition caused by V30M mutation in transthyretin protein

Transthyretin (TTR) is a tetrameric protein found in human plasma and cerebrospinal fluid that functions as a transporter of thyroxine (T4) and retinol. Substitution of valine to methionine at position 30 (V30M) is the most common mutation that destabilizes the tetramer structure of TTR protein resulting in a fatal neuropathy known as TTR amyloidosis. The V30M TTR-induced neuropathy can be inhibited through the stabilization of the TTR tetramer by binding small molecules. We accessed the potential of in-house synthesized quinoline molecules to stabilize the V30M TTR structure and analyzed the impact of protein-ligand interactions through molecular docking, molecular dynamics (MD) simulations, steered MD, and umbrella sampling simulations. This study revealed that the binding of quinoline molecules reverted the structural changes including the residual flexibility, changes in secondary structural elements, and also restored the alterations in the electrostatic surface potential induced by the V30M mutation. Further, the topmost 4G and 4R molecules were compared with an FDA-approved drug (Tafamidis) and a reference quinoline molecule 14C. Here, we suggest that the quinoline molecules could revert the structural changes, cease tetramer dissociation, prevent abnormal oligomerization and therefore could be developed as an effective therapeutics against TTR amyloidosis.

Integrating microsecond timescale classical and biased MD simulations to target BRD4-BD1

We combined inherently different computational analyses derived from multi-scale conventional, steered and umbrella sampling simulations to identify potential drug candidates for the first bromodomain of the human bromodomain containing protein 4 (BRD4- BD1). The BRD4-BD1 protein is a recognized therapeutic target for various diseases including cancer, neurological disorders, inflammation, and obesity. The in-house synthesized benzosuberene-sulfone (BSS) molecules were assessed for their potential to act as inhibitors against the BRD4-BD1 protein. We compared the molecular interactions and docking scores of BSS analogs with six different co-crystal inhibitors of the BRD4-BD1 protein **(Fig. 1)**.

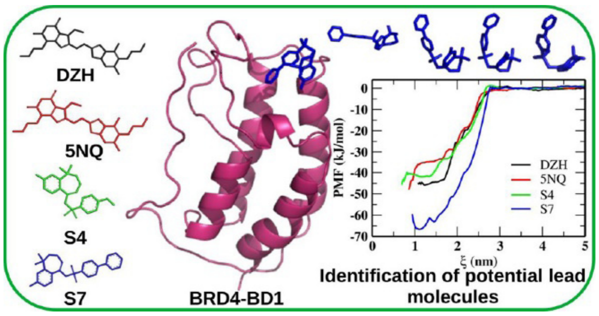

Fig. 1 The overall workflow of the study is to identify potential inhibitors for BRD4-BD1.

Further, the end-state Molecular Mechanics Poisson-Boltzmann Surface Area (MM/PBSA) approach estimated the thermodynamic free energy of binding for each complex. Our results show the potential of organosulfur molecules to be developed as inhibitors of the BRD4-BD1 protein and endorse their evaluation by suitable *in-vitro* and *in-vivo* studies.

Revealing the dynamics of host-guest inclusion complexes

The low hydro-solubility of Formononetin (FMN) has limited its prospective use in the cosmetic, neutraceutical and pharmaceutical industries. Cyclodextrins (CDs), especially β-CD and its derivatives have emerged as promising agents to improve the water solubility of poorly hydrosoluble compounds by forming inclusion complexes. We employed multiscale (1000 ns) explicit solvent and umbrella sampling molecular dynamics (MD) simulations to study the interactions and thermodynamic parameters of inclusion complex formation between FMN and the five most commonly used β-CD derivatives **(Fig. 2)**. The binding conformation with the benzopyrone ring of FMN inside the central cavity of β-CD derivatives was more frequent than the phenyl group occupying the hydrophobic cavity. Various non-bonded contacts including hydrogen bonds, pi-lone pair, pi-sigma, and pi-alkyl interactions supported these interactions. FMN showed favorable end-state MD-driven thermodynamic binding free energies with all the selected β-CD derivatives except succinyl-β-CD (S-β-CD). Furthermore, umbrella sampling simulations were used to investigate the interactions and thermodynamic parameters of the host-guest inclusion complexes. The SBE-β-CD/FMN inclusion complex showed the lowest binding energy signifying the highest affinity among all the selected host-guest inclusion complexes. Our study could be used as a standard for analyzing and comparing the ability of different β-CD derivatives to enhance the hydro-solubility of poorly soluble molecules.

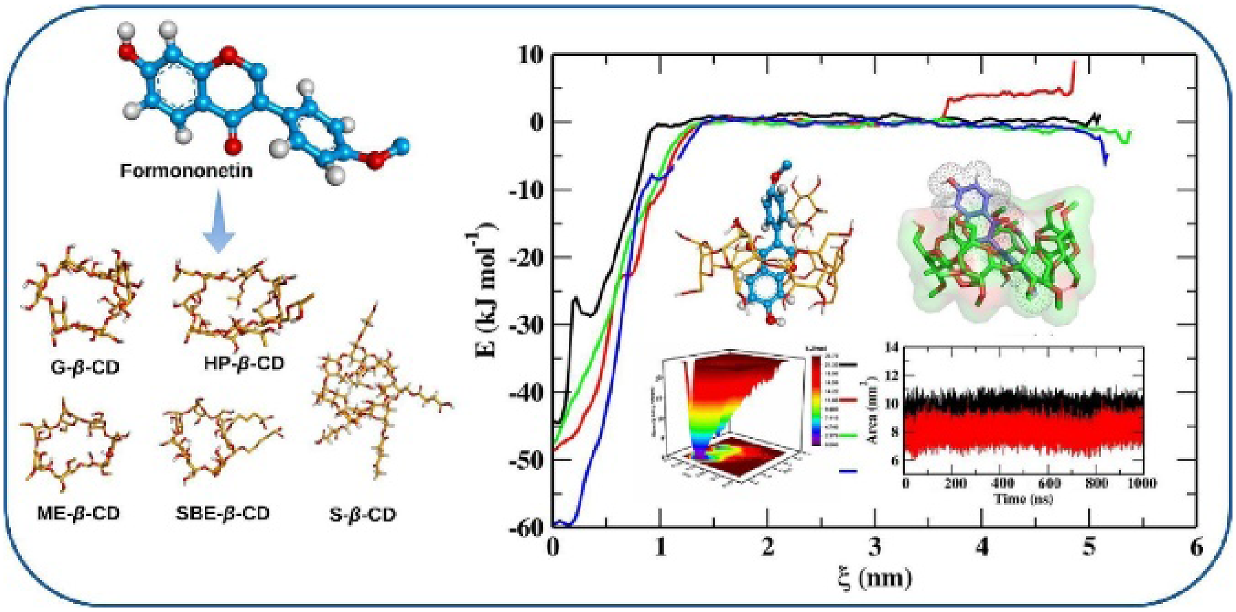

Fig. 2 Strategy to identify best host molecule for improving hydrosolubility of FMN.

Research group: Ashish Gupta, Vijay Kumar Bhardwaj, Ankita Dhiman, Rahul Singh, Bhanu Sharma and Pramod Kumar.

Relevant Publications:

- International Journal of Biological Macromolecules. 2023, 231: 123318.
- Chaos, Solitons & Fractals. 2023, 167:113061.
- Carbohydrate Polymers. 2023, 310: 120729.

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Molecular Microbiology

Our research group is focused on functional genomics of high-altitude microbes with a major focus on extremozymes of industrial relevance. We also study the adaptation of microbes to extreme Himalayan niches. Particularly, we are targeting enzymes/biomolecules from the bacteria of high altitude regions for Biofuels (Cellulase, hemicellulase, laccase etc.), therapeutics (anti-cancerous), and PHA-based bioplastics. Some of the interesting leads we obtained during the period are as mentioned below.

Identification and characterization of lignocellulolytic enzymes:

To produce bioenergy from sustainable bioresources such as lignocellulose biomass is important to boost the bioeconomy. Therefore, efforts are being made in our lab to identify the unique microbes and characterize enzymes for commercial applications. In continuation of our earlier efforts, here we reported xylanase, which has multiple applications in the food, pharmaceuticals, bio-bleaching, and textiles industries. The study explored a putative novel bacterium *Paenibacillus* sp. PCH8 shows xylanolytic activity from Himalayan glacial soil. Genome sequencing and analysis revealed multiple genes encoding xylanases, cellulases, and other lignocellulolytic enzymes. The bacterium showed xylanolytic activity in wide pH (4.0 – 12.0) and temperature (4 to 90 °C). Multi-substrate enzymatic activity **(Fig. 1)** (IU/mg) was observed for beechwood (21.42), oat spelt xylan (19.8), CMC (5.17), avicel (7.7), and starch (1.62) in protein fraction. The hydrolysis of xylan led to the formation of xylose, xylobiose, xylotriose, and xylotetraose upon analysis by LC-MS. In addition, xylooligosaccharides (XOS) containing hydrolysate enhanced the growth of probiotic microbes, suggesting prebiotic potential. Thus, the study provides a new source of xylanases from *Paenibacillus* sp. PCH8, with potential applications in lignocellulosic biomass hydrolysis and XOS production.

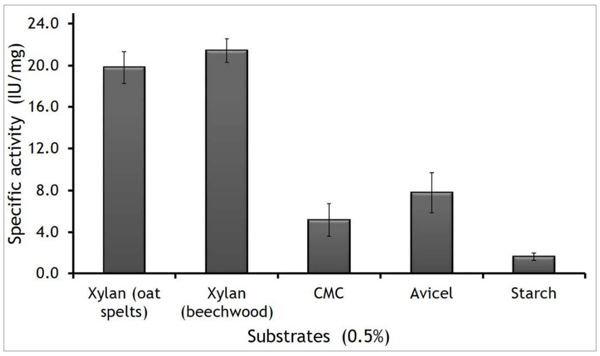

Fig. 1 The multi-substrate activity of partially purified Xylanase enzyme fraction on diverse polysaccharides.

Microbial adaptation to high-altitude environments: Bacterial adaption to the multiple stressed environments of high-altitude niches in the Himalayas is intriguing and is of considerable interest to biotechnologists. Previously, we studied the culturable and unculturable metagenome microbial diversity from glacial and kettle lakes in the Western Himalayas. In this study, we explored the adaptive strategies of a unique Himalayan eurypsychrophile lodobacter sp. PCH194, which can synthesize polyhydroxybutyrate (PHB) and violacein pigment. Whole-genome sequencing and analysis of *Iodobacter* sp. PCH194 (4.58 Mb chromosome and three plasmids) revealed genetic traits associated with adaptive strategies for cold/freeze, nutritional fluctuation, defense against UV, acidic pH, and the kettle lake's competitive environment. Differential proteome analysis suggested the adaptive role of chaperones, ribonucleases, secretion systems, and antifreeze proteins under cold stress. Antifreeze activity inhibiting the ice recrystallization at -9°C demonstrated the bacterium's survival at subzero temperature.

The bacterium stores carbon in the form of PHB under stress conditions responding to nutritional fluctuations. However, violacein pigment protects the cells from UV radiation. Concisely, genomic, proteomic, and physiological studies revealed the multiple adaptive strategies **(Fig. 2)** of Himalayan *Iodobacter* to survive the high-altitude stresses.

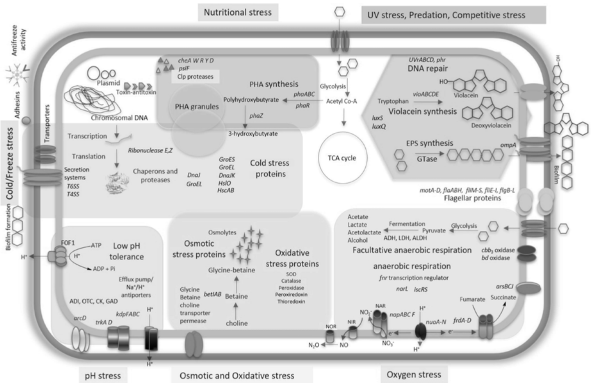

Fig. 2 The model of *Iodobacter* sp. PCH194 adaptive strategies. The model is based on genomic, proteomic, and physiological data showing multiple strategies of *Iodobacter* sp. PCH194 to adapt to the predominantly frozen kettle lake environment in the high-altitude Himalayas.

L-asparaginase for therapeutic and acrylamide mitigation in foods:

L-Asparaginase (L-ASNase) is a key enzyme used to treat acute lymphoblastic leukemia, a childhood blood cancer, and in the mitigation of acrylamide in foods. Here, we have done comprehensive and comparative analysis of L-asparaginases from different bacterial species with diverse activities. Through bioinformatics approach and experimental validation, we tried to understand the molecular basis for high affinity for its substrates such L-asparagine and L-glutamine. We have identified critical aa residues responsible for dual activities. Also, a stable and robust L-asparaginase from *Pseudomonas* sp. PCH199, with a high affinity for L-asparagine, was cloned and expressed in *Escherichia coli* **(Fig. 3A)**. The enzyme has shown stability in the presence of most metal ions and protein-modifying agents. Pg-ASNase II was cytotoxic towards the MCF-7 cell line (breast cancer) with an estimated IC_{50} value of 0.169 U/mL in 24 h. Further, Pg-ASNase II treatment led to a 70% acrylamide reduction in baked foods. These findings suggest the potential of Pg-ASNase II in therapeutics and the food industry.

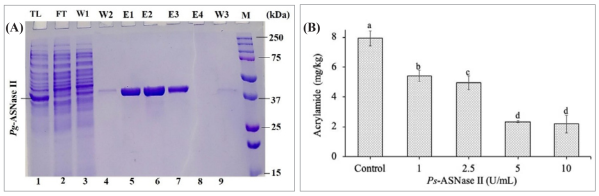

Fig. 3 (A) Polyacrylamide gel electrophoresis of recombinant His-tagged Pg-ASNase II. (B) Acrylamide formation in fried control (untreated) chips and its reduction in treated potato chips to enzyme dosages (1, 2.5, 5, and 10 U/mL).

Acrylamide has received worldwide attention due to its existence in commonly consumed foods. L-asparaginase reduces acrylamide formation in foods by hydrolyzing available L-asparagine. Herein, we also evaluated L-asparaginase for acrylamide reduction in food samples. The enzyme was active at a wide pH range (5.0–11.0) and temperature (10–80 ◦C) with optimum activity at 45 ◦C in 50 mM Tris-HCl (pH 8.5) after 10 min. The enzyme was stable and efficient retained 62 % residual activity after 60 days of storage at 4 ◦C. The Ps-ASNase II enzyme (5 U/mL) treatment of raw potato chips resulted in 90 % asparagine hydrolysis exhibiting high efficiency. Ps-ASNase II (5 U/mL) treated potato chips significantly reduced acrylamide content by 73 % at 37 ◦C within 24 min compared to untreated controls **(Fig. 3B)**. Collectively, these findings verified Ps-ASNase's effectiveness and capability to lower acrylamide formation in fried potato chips without altering the food product's nutritional profile. Therefore, the enzyme has the potential for use in mitigating acrylamide in food products, besides having therapeutic applications.

Research group: Shubham Thakur, Palak, Tamanna, Subhash Thakur, Matruprasad Mohanty, Vijeta Patial, Meenakshi, Shamli and Ambika.

Relevant Publications:

- Frontiers in Microbiology. 13: 1058249.
- Carbohydrate Polymer Technologies and Applications. 3: 100215.
- Food Research International. 162: 111936. https://doi.org/10.1016/j.foodres.2022.111936.

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Chemical Nanotechnology, Nanobiology and Biomaterials

In our effort to develop nanomaterials based solution to different biomedical applications we worked on different plant based nanomaterials. The significant achievement of the group has been mentioned below.

Graphene-oxide-conjugated red-emitting fluorescent copper nanoclusters for *E. coli* biofilm degradation

We have rationally designed and developed graphene oxide (GO) hosted copper nanoclusters (CuNCs). The size of Cu in the red fluorescence emitting Cu@GO@CTAB nanostructures was found to be ~16.7 ± 2.1 nm. The developed nanoassembly showed dual fluorescence emission maxima at ~474 and ~645 nm and revealed more promising antibiofilm potential for *E. coli* (MBIC50 ~74.1 ± 5.1 µg mL^{-1}) as compared to *S. aureus*. Interestingly, nanomaterials (NMs) have shown ratiometric interaction towards E. coli isolated extracellular matrix fibrils wherein an isoemissive point was obtained at ~569 nm. Confocal studies suggested that Cu@GO@CTAB NMs can preferentially penetrate and reduce the overall thickness of *E. coli* biofilm. Mechanistic assays for outer and inner membranes suggested that bacterial membrane disruption induced cell death. A displacement assay using BODIPY TR cadaverine (BC) revealed that the prepared NM showed strong binding to LPS of E. coli O26:B6. These studies may pave the path for developing antibacterial and antibiofilm coating agents.

Single-walled carbon nanotube conjugated cytochrome c for nanocatalytic therapy

Mitochondrial dysfunction has been reported to be one of the main causes of many diseases including cancer, type2 diabetes, neurodegenerative disorders, cardiac ischemia, sepsis, muscular dystrophy, etc. Under in vitro conditions, Cytochrome C (Cyt C) maintains mitochondrial homeostasis and stimulates apoptosis, along with being a key participant in the life-supporting function of ATP synthesis. Hence, the medicinal importance of Cyt C as catalytic defense is immensely important in various mitochondrial disorders. Here, we have developed a nanomaterial via electrostatically conjugating oxidized single-wall carbon nanotube with Cyt C (Cyt C@cSWCNT) for the exogenous delivery of Cyt C. The chemical and morphological characterization of the developed Cyt C@cSWCNT was done using UV–vis, FTIR, XPS, powder XRD, TGA/DSC, TEM, etc. The developed Cyt C@cSWCNT exhibited bifunctional catalase and peroxidase activity with Km (~ 642.7 µM and 351.6 µM) and Vmax (~ 0.33 µM/s and 2.62 µM/s) values, respectively. Also, through this conjugation Cyt C was found to retain its catalytic activity even at 60 °C, excellent catalytic recyclability (at least up to 3 times), and wider pH activity (pH = 3 to 9). Cyt C@cSWCNT was found to promote intracellular ROS quenching and maintain mitochondrial membrane potential and cellular membrane integrity via Na+/K+ ion homeostasis during the H2O2 stress. Overall the present strategy provides an alternative approach for the exogenous delivery of Cyt C which can be used as nano catalytic medicine.

Research group: Mohini Verma, Aqib I. Dar, Shiwani Randhawa, Trilok Chand Saini, Manik Bathla and Anjali Nisha.

Relevant Publications:

- Environmental Science: Nano. 2023. 10: 1077.
- International Journal of Biological Macromolecules. 2023, 233: 123466.
- Free Radical Biology Medicine. 2022, 193: 238–252.

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Artificial Intelligence and Machine Learning

Our research areas focus on various bioinformatics topics but basic themes include evolution, comparative genomics, system biology and functional genomics. Within this field, we are focusing on the major topics:

A) Artificial intelligence & Network biology based algorithms for drug discovery from the Himalayas for human health.

B) Artificial intelligence for plant immune system.

Further details are provided with the link: https://fgcsl.ihbt.res.in/fgcsl/research.php.

Machine intelligence approaches for Drug Discovery

Virtual screening (VS) aids in prioritizing unknown bio-interactions between compounds and protein targets for empirical drug discovery. In standard VS exercise, roughly 10% of top-ranked molecules exhibit activity when examined in biochemical assays, which accounts for many false positive hits, making it an arduous task. Attempts for conquering false-hit rates were developed through either ligand-based or structure-based VS separately; however, nonetheless performed remarkably well. Here, we developed an advanced VS framework —automated hit identification and optimization tool (A-HIOT)— comprised of chemical space-driven stacked ensemble for identification and protein space-driven deep learning architectures for optimization of an array of specific hits for fixed protein receptors. In conclusion, advantageous features impeded in A-HIOT is making a reliable approach for bridging the long-standing gap between ligand-based and structure-based VS in finding the optimized hits for the desired receptor. The complete resource (framework) code is available at https://gitlab.com/neeraj-24/A-HIOT **(Fig. 1)**.

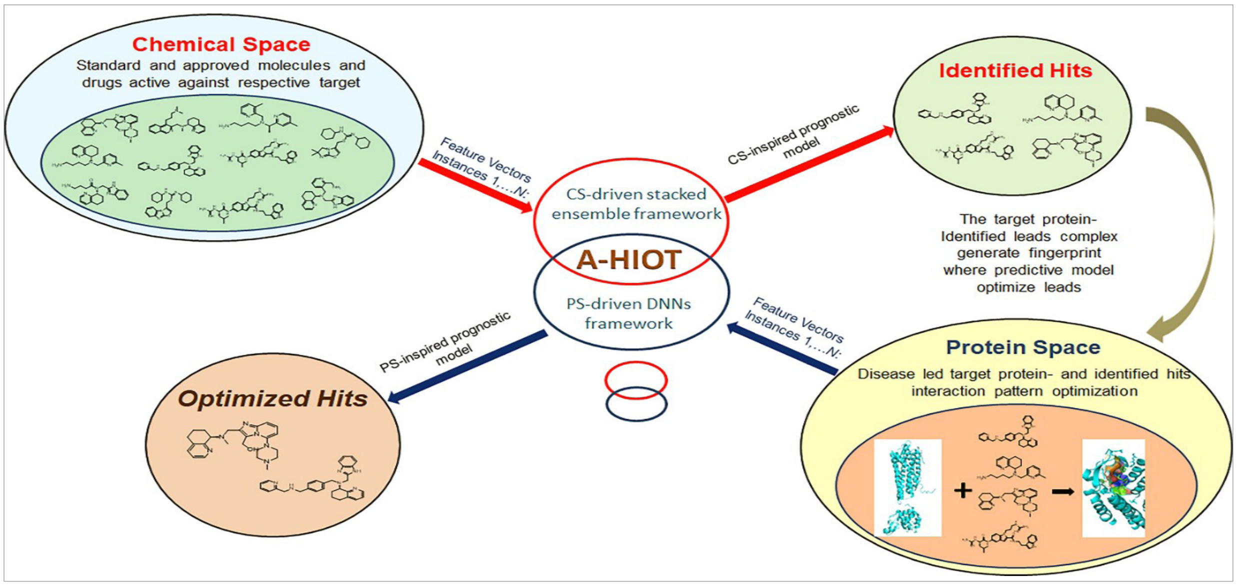

Fig. 1 Overview of A-HIOT workflow and function. Automated-hit identification and optimization tool (A-HIOT) utilizes ligand and receptor-structure information to bridge the long-standing gap between ligand- and structure-based virtual screening. The input data for A-HIOT comprises well-profiled molecules or drugs for an individual or set of specific protein targets belonging to a similar family. The ligands were transformed into feature vector representation and fed to a stacked ensemble. The true positive (TP) molecules are identified leads/hits that serve as input for the protein space (PS) module implemented in the A-HIOT framework. The true positives obtained from DNNs were further concatenated with protein-ligand interaction profiles and re-ranked as per the binding interaction to collect optimized hits.

Elucidating Host-Pathogen Rat Race through Deep Learning

Host plants are continually competing with pathogens and vice-versa for survival and development. Such interactions in agriculturally important species can directly impact crop yield. One of the major obstacles to attaining maximum plant yield is the severity of diseases caused by multiple pathogenic organisms. To overcome this, plants display dynamic, carefully controlled transcriptome alterations in response to pathogen challenges. Both positive and negative regulators regulate plant immune signaling. Balancing growth and defense responses to respond appropriately to environmental changes is critical. Interactome mappings in diverse plant species during the past 20 years have expanded of network biology premises. However, it was not enough to gain insights from a single molecular system description in plant-pathogen interactions. Therefore, to address this, we have developed such networks based on expression profile data of a model plant, here, rice in response to three biotic stresses, leading to the construction of DL-based supervised Net (DLNet). This is the first ever implementation of integrated deep learning and network biology approach to understand the adaptation of plant immune genes in response to multiple pathogens using genomics data. Deep learning protocol for host-pathogen interactions using genomics data with the link https://gitlab.com/ravisaroch/dlnet-host-pathogen-interaction was provided to the interested researchers. Additionally, RicePathDLNet: an online visualization repository for exploring network modules and other data is available at https://fgcsl.ihbt.res.in/RicePathDLNet.

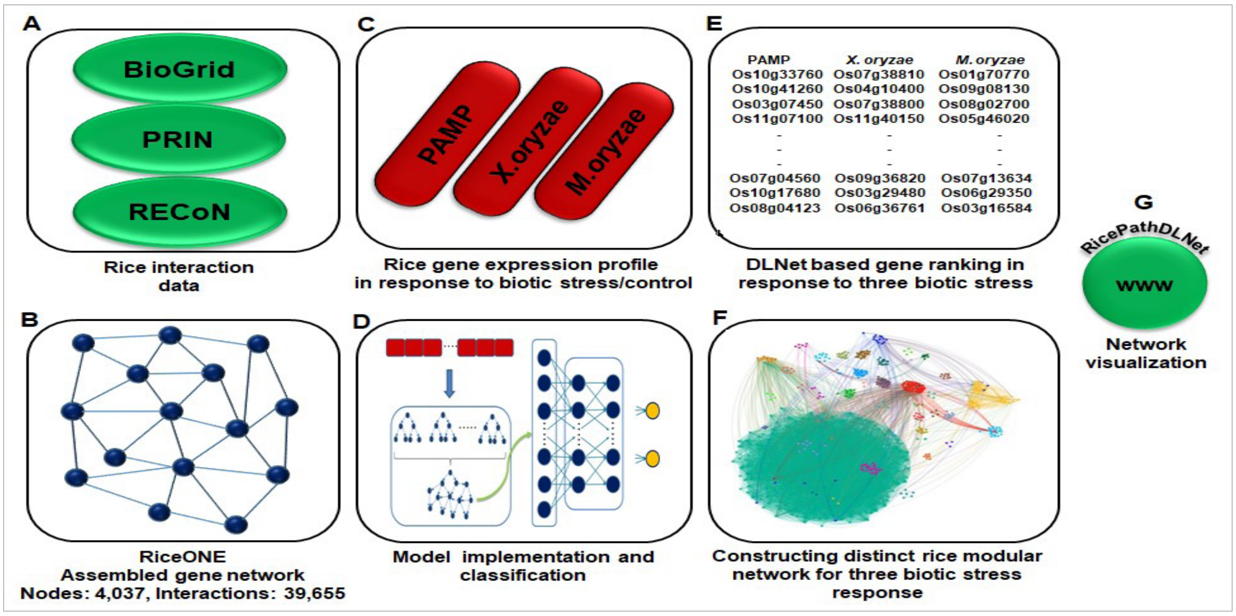

Fig. 2 Schematic diagram of the study methodology. (A) protein-protein interaction and abiotic stress response gene co-expression data were obtained from three databases. (B) Unreliable gene association data was filtered out. The remaining high-quality data was assembled into an integrative gene network with 4,037 genes and 39,655 interactions (RiceONE). (C) the mRNA expression profile of rice for three biotic stress responses was extracted for 4,037 genes identified in the previous step. (D) the model was trained and tested for the classification task using 10-fold cross-validation. (E) The DLNet model is applied to expression data to calculate the feature score for each gene. (F) DLNet-based modular networks for the three defense responses were constructed using expression profile and integrative interaction data. Permutation, 100 null hypothesis models, and student's t-test were performed to construct the modular network. (G) Network data visualization web browser (herein, named as RicePathDLNet) is developed.

Research group: Neeraj Kumar, Meetal Sharma, Nymphaea Arora, Ekjot Kaur, Ruhika Sharma, Ravi Kumar and Dipali Bhatia.

Relevant Publications:

- Computers in Biology and Medicine. 2023,153: 106525
- Journal of Cheminformatics. 2022, 22: 14(1): 48.
- iScience. 2022, 25(7): 104546

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Plant-microbe interactions

Our group is working to explore the beneficial microbes from rhizosphere of plants from different niches of Himalayas. We are also trying to elucidate the different developmental dynamics of *Crocus sativus* (Saffron plant) along with effect of various stresses and microbial factors. Another major aspect of our work is in area of biotic stress to unravel the plant-pathogen interaction mechanism and identify the gene pool involved in plant defence response.

Isolation of phosphate solubilising bacteria from rhizosphere of native plants growing at Rohtang Pass

Microbes previously isolated from rhizospheric soil of fifteen native plants of Rohtang Pass, HP were screened for beneficial growth promoting traits. Twelve bacteria were identified having high phosphate solubilising (PS) activity. All the 12 PS Bacteria (PSB) were further characterized for other plant growth promoting (PGP) traits including IAA production and ACC deaminase activity. Bacteria were sequenced based on 16S rRNA amplification, sequencing and blastn analysis. Three rhizobacteria RO3G_*Pseudomonas fulva*, RO13G_*Pantoea ananatis* and RO14D_*Pseudomonas brassicacearum* were identified as promising plant growth promoting rhizobacteria (PGPR) based on multiple attributes.

Growth regulators for *Crocus sativus* assessed

Multiple chemical and microbial growth regulator(s) were tested for *Crocus sativus* growth and development enhancement. Microbes like *Pseudomonas azotoformans* and chemical like Gibberelin were identified having positive effect on corm multiplication and flowering attributes.

Revealing the action of a fungal effector protein in chickpea-*A. rabiei* interaction

Among the plant pathogens, infection mechanism of necrotrophic fungal pathogen is still an enigma with no effector protein characterisation. To overcome this challenge, an effector protein from fungal pathogen *Ascochyta rabiei* was described as part of collaboration with NIPGR containing PEXEL-like Effector Candidate 25 (ArPEC25) that found indispensable for virulence **(Fig. 1)**. After entering host cells, ArPEC25 localizes to the nucleus and targets the host LIM transcription factor CaβLIM1a. CaβLIM1a is a transcriptional regulator of CaPAL1, which encodes phenylalanine ammonia lyase (PAL), the regulatory, gate-keeping enzyme of the phenylpropanoid pathway.

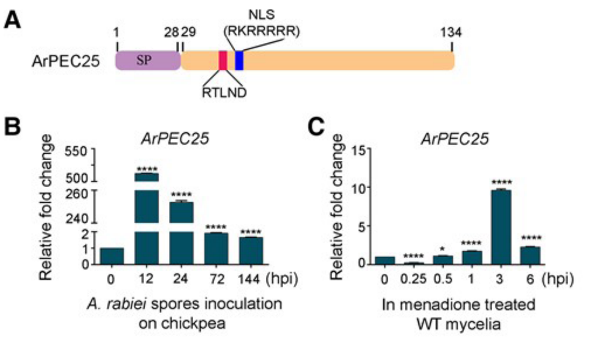

Fig. 1 ArPEC25 is a secretory protein having role in pathogenesis and get expressed under oxidative stress.

Research group: Anand Mishra, Tina Roy, Namo Dubey, Kanchan Yadav, Anjali Chaudhary, Pooja Yadav, Ankita Kumari, Sweta Arora, Ruchika Thakur, Shailja, Rupali Katoch and Mathan L.

Relevant Publications:

- The Plant Cell. 2023, 35(3): 1134–1159.
- Springer, Cham. 2022 doi.org/10.1007/978-3-031-12990-2_4.
- Transcription Factors for Biotic Stress Tolerance in Plants, Springer, 2022, https://doi.org/10.1007/978-3-031-12990-2_12.

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Plant Tissue Culture, Stress Physiology

Our group focuses on the development of highly-efficient *in vitro* protocols for mass propagation of economically and medicinally important high-altitude plants and study their molecular regulation during organogenesis and under abiotic stress.

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

Conventional propagation of *F. assafoetida* is restricted by long seed dormancy, thus an alternative method of propagation is the need of the hour to establish and propagate *en-masse*. Keeping this in mind we have standardized protocol for callus induction and up-scaling of calli, shoot induction, shoot multiplication, root induction under *in vitro* conditions of Iranian heeng. Hardening, acclimatization and genetic fidelity analysis in process **(Fig. 1)**.

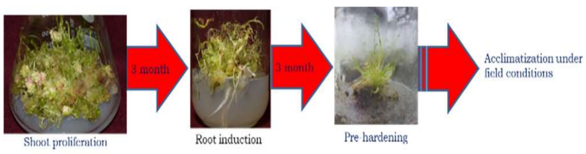

Fig. 1 Various stages of shoot multiplication, rooting and hardening in Iranian heeng.

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

Saffron (*Crocus sativus* L.) is the most expensive spice (dried stigma) of the world. No doubt in India, Kashmir has the virtual monopoly of saffron and contributes immensely to its agricultural economy. CSIR-IHBT has standardized tissue culture technologies for producing elite, disease free saffron corms. With the support of State Agriculture Department, H.P., we have propagated saffron corms at mass-scale under *in-vitro* conditions and establish its cultivation practices in Himachal Pradesh. In addition, capacity building program for farmers and artisans for *in vitro* propagation of saffron was also organized **(Fig. 2)**.

Fig. 2 Commercial-scale micropropagation of *Crocus sativus*, and its establishment at the Palampur region of H.P.

Commercial-scale propagation of different bamboo species

Bamboos are fast-growing nature and an inexpensive and renewable resource for biomass production. Therefore, to meet the increasing market demand we have established multiplication techniques employing either culm cuttings or rhizome (offset) in eight bamboo species, i.e. *Bambusa multiplex, Bambusa balcooa, Bambusa tuldoides 'ventricosa', Gigantochloa takserah, Dendrocalamus giganteus, Phyllostachys pubescens, Phyllostachys aurea 'Aurea'* and *Phyllostachys nigra 'nigra'* under National Bamboo Mission. Existing trade-off between phenotypic and photosynthetic traits has been reported as a key bottleneck for improving bamboo breeding programs (Kumari et al., 2022).

Demonstrated that elicitation of charged gold nanoparticles significantly improve the *in vitro* potential of *Nardostachtys jatamansi*

Nardostachys jatamansi is a critically endangered medicinal plant and endemic to the Himalayas, having high commercial demand globally. We reported that eliciting 60 µM of citrate-AuNPs and 40 µM of CTAB-AuNPs in the *in vitro* culture medium enhances the shoot and root

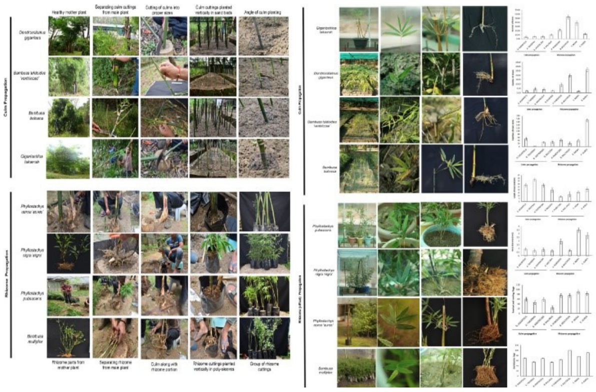

Fig. 3 Vegetative propagation of eight genotypes of bamboo by means of culm or rhizome cuttings and phenotypic characterisation of one year old plants.

proliferation. Further, photosynthetic pigments, antioxidant enzyme activities, phenolic compounds, internal hormone levels, and transcript analysis clearly indicated that the citrate-AuNPs and CTAB-AuNPs modulated the antioxidant properties (Joshi et al., 2022) **(Fig. 3&4)**.

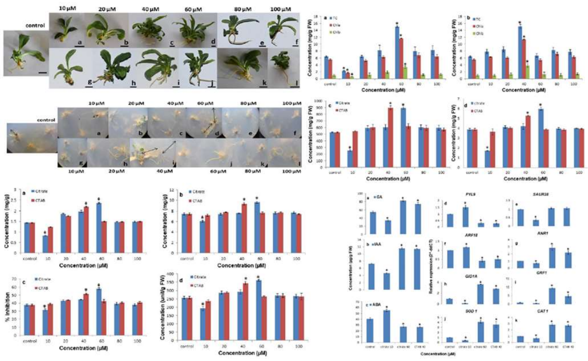

Fig. 4 The effect of citrate-AuNPs and CTAB-AuNPs on the *in vitro* growth, photosynthetic pigment, total soluble sugar content, antioxidant activity, endogenous hormone level and relative transcript abundance of genes regulating antioxidant enzyme activities of *N. jatamansi*.

Delineating the abiotic stress response mechanism in high-altitude plants

The cosmopolitan distribution and static nature of plants put them at risk of various environmental vagaries, such as drought, salinity, temperature, and nutrient deficiency, which contribute to 50% crop losses worldwide. To survive under these adverse conditions, plants have evolved to use a range of molecular mechanisms. The major regulatory pathway under abiotic stress involves the conversion of external stimulus into an internal signal that triggers a defence mechanism through a transcriptional cascade to counter stress **(Fig. 5, 6 & 7)**.

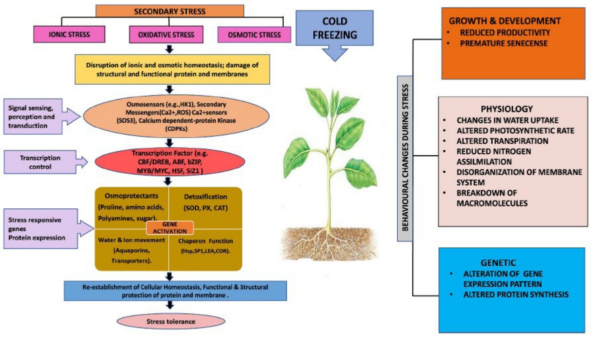

Fig. 5 Schematic representation of the physiological and molecular mechanisms under cold- and drought-stress interaction in plants.

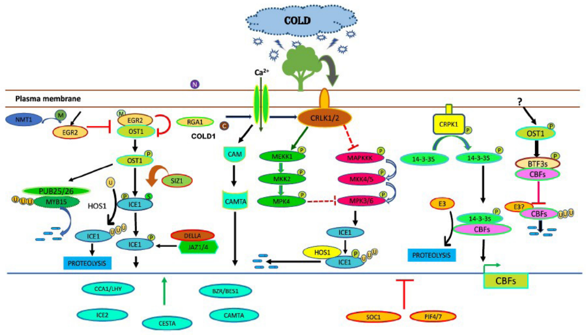

Fig. 6 Overview of cold-signal perception and signalling cascade.

Fig. 7 Schematic diagram representing the different root models used to predict root system architecture in response to various abiotic stresses.

Research group: Kiran Devi, Ajay Kumar, Kamlesh Kumari, Meghna Patiyal, Anita Kumari, Jhilmil Nath, Shubham Joshi, Suman Gusain, Khusbu Kumari, Meenakshi Rawat, Surjeet Kaur and Surbhi Kapoor.

Relevant Publications:

- South African Journal of Botany. 155: 196-204.
- Plant Physiology and Biochemistry. 197: 107646.
- Antioxidants. 11: 1962.

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Plant-Microbe Interaction, Plant Adaptation and Plant Physiology

Our group is exploring the endophytes of Himalayan medicinal plants for improvement of plant growth, secondary metabolite biosynthesis, and tolerance to environmental stress. We are also involved in the development of efficient genome-editing platform for *Camellia sinensis*.

Endophytes of important Himalayan medicinal plants

Endophytes associated with different Himalayan medicinal plants including *Valeriana jatamansi*, *Podophyllum hexandrum*, *Rhodiola imbricata, Fritillaria roylii*, *Picrorhiza kurrooa,* and *Siraitia grosvenorii* are being explored. Endophytes from these medicinal plants have been isolated and molecularly identified. Presence of important plant growth promoting (PGP) attributes such as IAA production, phosphorus solubilization, siderophore production, ACC deaminase production in the isolated endophytes have been also tested. Testing of important PGP attributes showed presence of several endophytes with multiple PGP characteristics. Inoculations of selected endophytes isolated from *V. jatamansi* could improve photosynthesis of their host plants and promoted plant growth due to having plant growth promoting attributes **(Fig. 1)**. Selected endophyte of *V. jatamansi* inoculations could increase the biosynthesis of hydroxy valerenic acid in leaves by modulating the expression of various genes of the iridoid biosynthetic pathway.

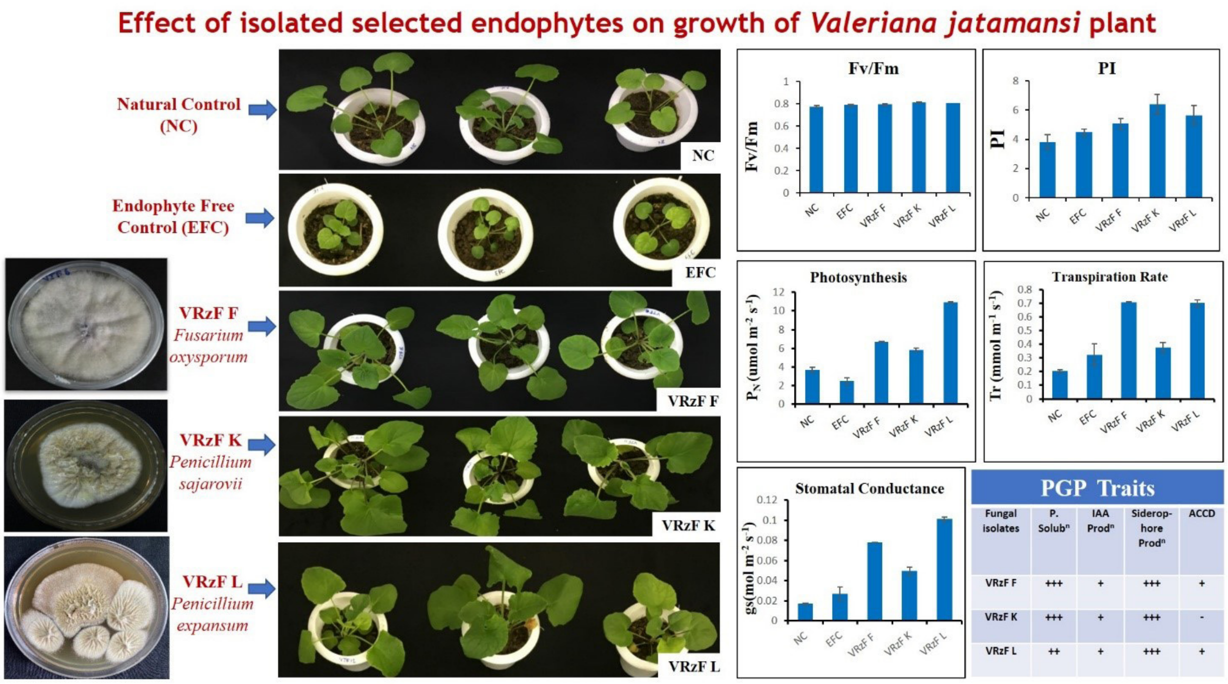

Fig. 1 Effect of selected endophytes inoculation on photosynthesis and plant growth of *Valeriana jatamansi* plants.

In the case of *P. hexandrum*, inoculation of some of the isolated fungal and bacterial endophytes could improve the growth of *P. hexandrum* plants **(Fig. 2)**. Selected endophytes inoculation induced the biosynthesis of podophyllotoxin (PTOX) in leaves (which is generally not detected in leaves or present in traces) by increasing the expression of aromatic-amino-acid transaminase (AAAT) and prephenate dehydrogenase (PD), responsible for biosynthesis of phenylalanine, a key precursor for the biosynthesis PTOX.

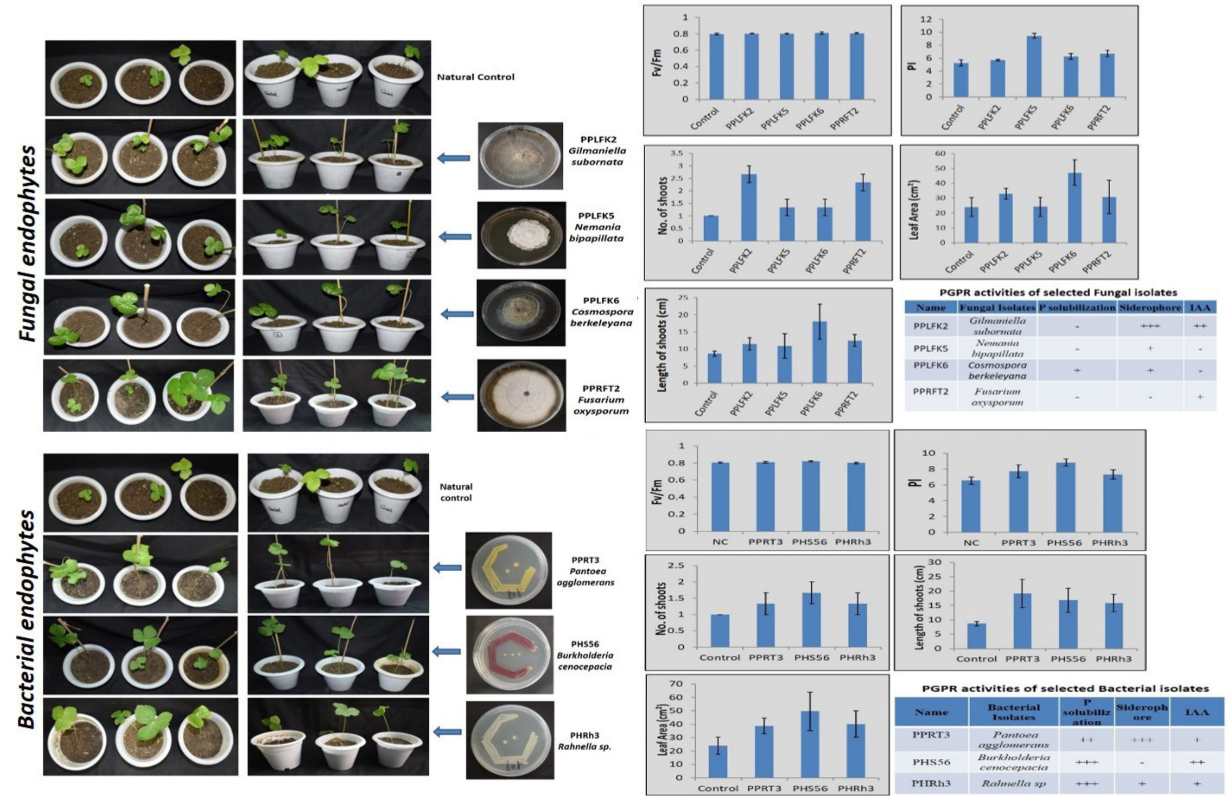

Fig. 2 Effect of selected endophytes inoculation on *Podophyllum hexandrum* plants.

Endophytes isolated from *R. imbricata, F. roylii* and *P. kurrooa* are being tested for their potential to improve the hardening efficiency and acclimatization of plants and also for increasing the biosynthesis of therapeutically important secondary metabolites in plant *in-vitro* systems. In the case of *Siraitia grosvenorii*, potential endophytes are being searched that have role in the biosynthesis of mogrosides.

Camellia sinensis improvement through genome-editing

We are establishing an efficient genome-editing platform for improvement of *Camellia sinensis*. In this we are using CRISPR/Cas9 system to silence polyphenol oxidase and caffeine synthase in *C. sinensis* to reduce the tea browning during leaves processing and caffeine content, respectively. Amplification of the target genes (*TCS* encoding Caffeine synthase and *PPO* encoding Polyphenol oxidase) from the selected cultivars of *C. sinensis* have been performed, and the amplified genes have been cloned in cloning vector and sequenced. gRNAs for the silencing of the target genes have been identified and synthesized. These are cloned in the CRISPR-Cas9 plant transformation vector (pKSE401). Developed CRISPR constructs have been transformed in the *Agrobacterium* strain GV3101. These are being used for the transformation of selected cultivars of *C. sinensis*. Transformation of selected tea cultivars (Him Sphurti, UPASI-9, TV23, Kangra Asha) are being carried out. Successful callus induction and proliferation has been achieved from the cv. TV23, UPASI-9 and Him Sphurti. Multiple approaches are being standardized for efficient tea transformation.

Research group: Abhishek Kumar, Ankita Thakur, Manju Kumari, Jyoti Sharma, Nikhil Rawat, Aahuti Sharma, Vipul Phalane, Amanpreet Kaur, Aarti Kansara and Rahul Bodh.

Relevant Publications:

- Photosynthesis Research. 2023, 155: 1–21.
- Microbiological Research. 2022, 263: 127148.

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Plant tissue culture and cell culture, hydroponic and aeroponic cultivation

Research work aimed to develop alternative approaches for metabolite production from high-altitude Himalayan medicinal plants using tissue culture, cell culture, and modern farming techniques.

a) Micropropagation and callus culture initiation and maintenance of *Valeriana jatamansi*

Due to the various medicinal properties of *Valeriana jatamansi*, it is harvested from the wild to meet market demand. Over-harvesting of this plant puts huge pressure on the species in the natural habitat. Therefore, there is a need to develop well-standardized protocols for micropropagation and cell culture for enhanced metabolite production. For this, different media combinations with various plant growth regulators and culture conditions were standardized for shoot culture and callus culture initiation using nodal **(Fig. 1)** and leaf explant **(Fig. 2)** in *Valeriana jatamansi,* respectively. Media supplemented with 1 mg/L IBA showed well-developed multiple shoot cultures, whereas media supplemented with 2 mg/L NAA was found effective for callus culture initiation.

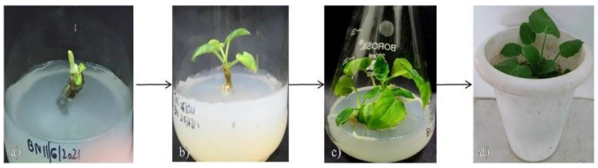

Fig. 1 Micropropagation stages in *Valeriana jatamansi*- a) Inoculated shoot bud (0 day), b) Shoot bud with multiple leaves (after 2 weeks), c) Established multiple shoot sub culturing after one month, d) Hardened plants.

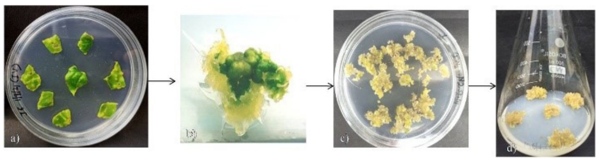

Fig. 2 Callus culture using leaf explant in *Valeriana jatamansi*- a) Inoculated leaf explant on MS media (0 day), b) Callus initiation after 3 weeks, c)-d) Proliferated callus biomass after 6 weeks.

b) *Ex-vitro* acclimatization of elicitor treated *Stevia rebaudiana*

Stevia rebaudiana Bertoni is a commercially important herb due to the sweetening properties of its leaves, which are estimated to be approximately 300 times sweeter than cane sugar. Sexual and asexual propagation methods are not good enough to keep up with the demand for propagules needed for commercial cultivation. So, *in vitro,* propagation is a better alternative to produce large-scale quality planting material and enhance its taste profile. *Ex-vitro* acclimatization of tissue culture-raised plants to determine their fate in a field environment. Alginate and polyethylene glycol-treated plantlets were hardened under a climate-controlled greenhouse. Enhanced growth and metabolite accumulation was recorded in PEG-treated plants **(Fig. 3 & Fig. 4)**.

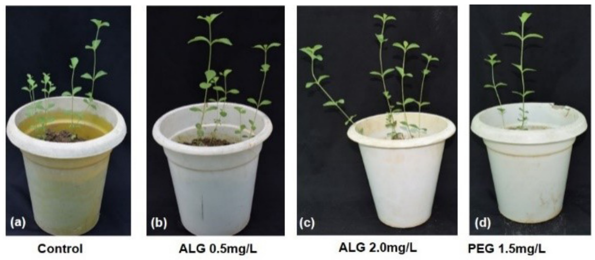

Fig. 3 One-month-old *ex-vitro* acclimatized elicitor-treated *S. rebaudiana.*

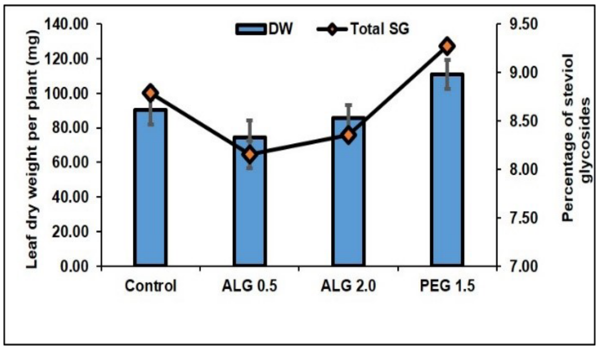

Fig. 4 Leaf biomass and total steviol glycoside yield per plant of elicitor-treated hardened *S. rebaudiana.*

c) Development of cell suspension culture in *Picrorhiza kurroa*

Picrorhiza kurroa is an industrially important Himalayan medicinal herb known for its therapeutic potent picrosides compounds. Plant cell suspension culture is an alternate approach for secondary metabolite production in significantly less time. In *P. kurroa*, the cell suspension culture approach was developed by using Murashige and Skoog (MS) medium supplemented with 0.5 mg/L thidiazuron (TDZ) and 0.3 mg/L indole-3-butyric acid (IBA) **(Fig. 5)**. The inoculum density (3 g/75 mL), subculture by pouring method, shaking speed (80 rpm), and pH (5.8) were appropriate for higher cell biomass production in suspension culture. Significant levels of picrosides (P-I, P-II, and P-III) and their precursors' metabolites (vanillic acid, caffeic acid, cinnamic acid, catalpol, and aucubin) were quantified in suspension culture. The study offers a feasible and sustainable alternative to conventional metabolites production platforms and can be used in industrial and therapeutic uses.

Fig. 5 Cell suspension culture of *Picrorhiza kurroa*.

d) Development of cell suspension culture in *Rhodiola imbricata*

Precursor feeding is a potential strategy for increasing specialized metabolite production in plant cell culture systems. In the present investigation, cell suspension cultures were developed and subsequently assessed for the precursor feeding approach. Cell suspension cultures were established in Murashige and Skoog (MS) medium containing 0.5 mg/L thidiazuron (TDZ) + 1 mg/L α-naphthalene acetic acid (NAA) **(Fig. 6)**. Precursor, phenylalanine feeding of 0.5 mM, 1 mM, 2 mM, and 3 mM concentrations were added to the cell suspension of *R. imbricata* and further, it was evaluated for the cell growth and production of phenylpropanoids (rosavin, rosarin, and *p*-coumaric acid). The cell suspension cultures treated with 1 mM phenylalanine accumulated the maximum biomass on day 15, while rosavin and rosarin content on 12 days. The maximum content of *p*-coumaric acid was detected on 12 days in 3 mM precursor-treated suspension cultures of *R. imbricata*. The main outcome of this study is optimized precursor concentrations and increased rosavin, rosarin, and *p*-coumaric acid yield. These findings suggest that phenylalanine treatment of *R. imbricata* cell suspension cultures successfully enhances metabolite synthesis. Therefore, the effective use of pathway-specific precursors to increase desired bioactive metabolite production in plant cell culture could be a pivotal consideration for the year-round production of desired bioactive compounds.

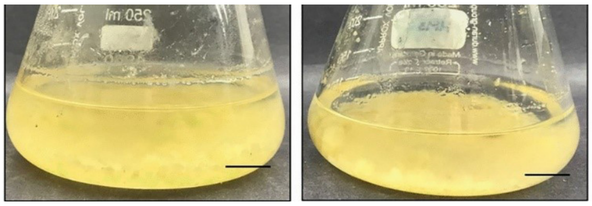

Fig. 6 Cell suspension culture of *Rhodiola imbricata*.

Research group: Ashrita, Shashi Rani, Amit Kumar and Kanika

Relevant Publications:

- Industrial Crops and Products. 2023, 198, Pp. 116667.
- South African Journal of Botany. 2023, 153, Pp. 172-177.
- Plant-Microbe Interaction-Recent Advances in Molecular and Biochemical Approaches, Academic Press. Pp. 311-330.

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Stress biology and Proteomics

Research in our lab explores the therapeutic potential of medicinal plants at the peptide level. *Picrorhiza kurroa* Royle ex Benth. is a high-altitude plant having great medicinal value. However, its medicinal value at the peptide level is still unknown, which limits its utility in the development of peptide-based therapeutics. Using the peptidome approach we aimed to identify bioactive peptides and characterize their role in the prevention of lifestyle disease. Further, we are also focusing on developing peptide-based formulation(s) in pharmaceuticals to treat life-threatening disease.

In our previous work, we report a novel bioactive peptide, ASGLCPEEAVPRR (BP1), having antioxidant potential and showing angiotensin-converting enzyme (ACE) and dipeptidyl peptidase-IV (DPP-IV) inhibitory activities (Annual report 2018-19). Here, we validate this hypothesis and characterized the antioxidant potential of BP1 using a well-established *in vitro* oxidative stress model (HEK 293 cell line).

BP1 protects HEK293 Cells from H_2O_2-induced oxidative damage by reducing intracellular ROS/MDA and activates the intrinsic antioxidant defense system

MTT assay showed no significant cytotoxic effect on the cell viability of HEK293 cells, which suggests that BP1 was not toxic to the cells up to 800 µg/mL **(Fig. 1A)**. Subsequently, 50, 100, and 200 µg/mL concentrations were selected to evaluate the antioxidant potential of BP1 using HEK293 cell. The result showed that the viability of HEK293 cells was decreased by 37% when treated with H_2O_2 for 12 h compared to the control. However, in the cells pre-treated with BP1 for 4 h prior to H_2O_2 treatment, the viability increased from 73 to 96% as the concentration increased from 50 to 200 µg/mL **(Fig. 1B)**. Thus, BP1 protects HEK293 cells from H_2O_2-induced oxidative damage in a concentration-dependent manner and cells are almost recovered from oxidative damage at a concentration of 200 µg/mL. Further, phase contrast microscopy result reveals signs of apoptosis as significant morphological changes like cell sinkage, loss of viability, and blebbing of the cell membrane in cells exposed to H_2O_2 for 12 h compared to the control group **(Fig. 1C)**. In contrast, cells pre-treated with BP1 for 4 h before exposure to H_2O_2 retained a normal morphology without significant reduction in the cell number in a dose dependent manner, further suggesting that BP1 protects HEK293 cells from H_2O_2-induced oxidative damage. Next, DCFDA-H2 fluorescent probe assay reveals 6-fold higher DCF fluorescence signal in the H_2O_2-induced group compared to control (Figure 1D, E;$p < 0.0001$) leading to oxidative damage. However, pre-treatment of HEK293 cells with BP1 (50, 100, and 200 µg/mL) reduces the intensity of DCF fluorescence significantly suggesting BP1 protects HEK293 cells from H_2O_2-induced oxidative damage by reducing intracellular ROS accumulation. Furthermore, we evaluate the antioxidant effects of BP1 in terms of its ability to inhibit lipid peroxidation by determining the MDA content. A 3-fold increase ($p < 0.0001$) of MDA was found in H_2O_2-treated cells compared to the control **(Fig. 1D & E)**. However, preincubation of HEK293 cells with BP1 at 100 and 200 µg/mL concentrations significantly inhibits the formation of MDA ($p < 0.001$ and $p < 0.0001$, respectively), whereas no significant effect was observed at 50 µg/mL concentration **(Fig. 1F)**. Subsequently, we investigated the effects of BP1 on the cellular activity of ROS-scavenging enzymes. As shown in (**Fig. 1G,H**), a substantial decrease ($p < 0.0001$) was observed in intracellular SOD and catalase activity when the cells were treated with H_2O_2, whereas pre-incubation with BP1 at 200 µg/mL attenuated this decline. However, no significant difference was observed in catalase activity at 50 and 100 µg/mL, while SOD activity was significantly restored at the 100 µg/mL concentration. Taken together, these results suggest that BP1 protects the HEK293 cells from oxidative damage by reducing ROS, eliminating oxidative products, and activating the intrinsic antioxidant defense system.

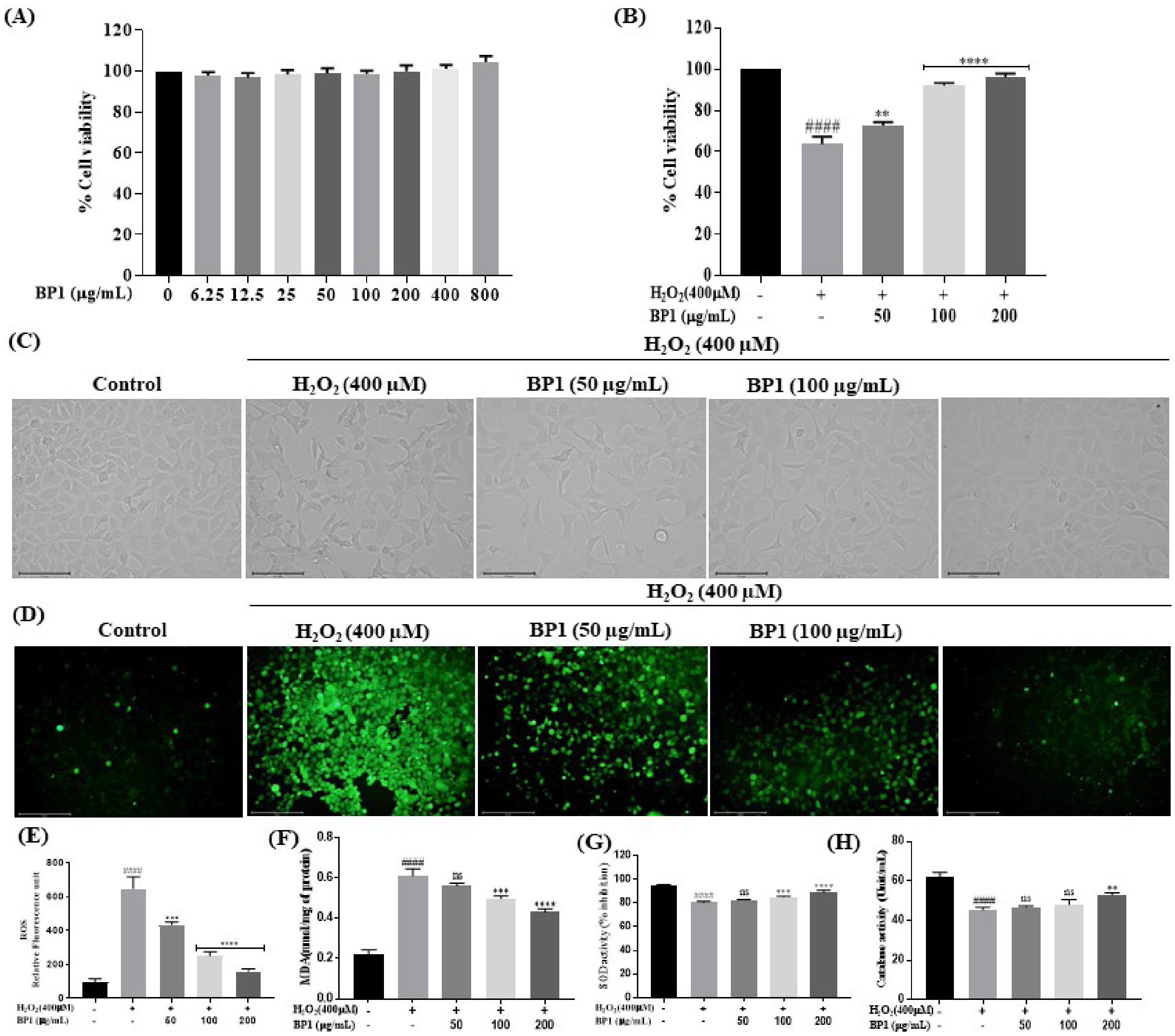

Fig. 1 Antioxidant activity of BP1 against H_2O_2-induced oxidative damage in HEK293 cells. MTT assay (A) and (B), morphological changes induced by H_2O_2 using phase-contrast microscopic (C), DCFDA-H2 staining for intracellular ROS estimation (D, E), Catalase activity, (F), SOD activity (G), and lipid peroxidation (H). Data are expressed as mean ± SD (n = 3). #### ($p < 0.0001$) in comparison to the control group and **, *, and **** represent statistically significant differences with $p < 0.01$, $p < 0.001$, and $p < 0.0001$, respectively, in comparison to the H_2O_2-treated group.**

BP1 restores the mitochondrial membrane potential and reverses the apoptotic effect of H_2O_2 in HEK293 cells

Here, we speculate that BP1 might alter the apoptosis pathway that provides protection against H_2O_2-induced cell death. To test this hypothesis, we investigated mitochondrial membrane potential (Δψm) and caspase 3/7 activity using JC-1 dye. The ratio of red (healthy cells) to green (apoptotic cells) fluorescence directly indicates Δψm. A high value indicates healthy cells with higher Δψm, and a lower value indicates unhealthy/apoptotic cells. We observed that H_2O_2 treatment rapidly increases green fluorescence and decreases red

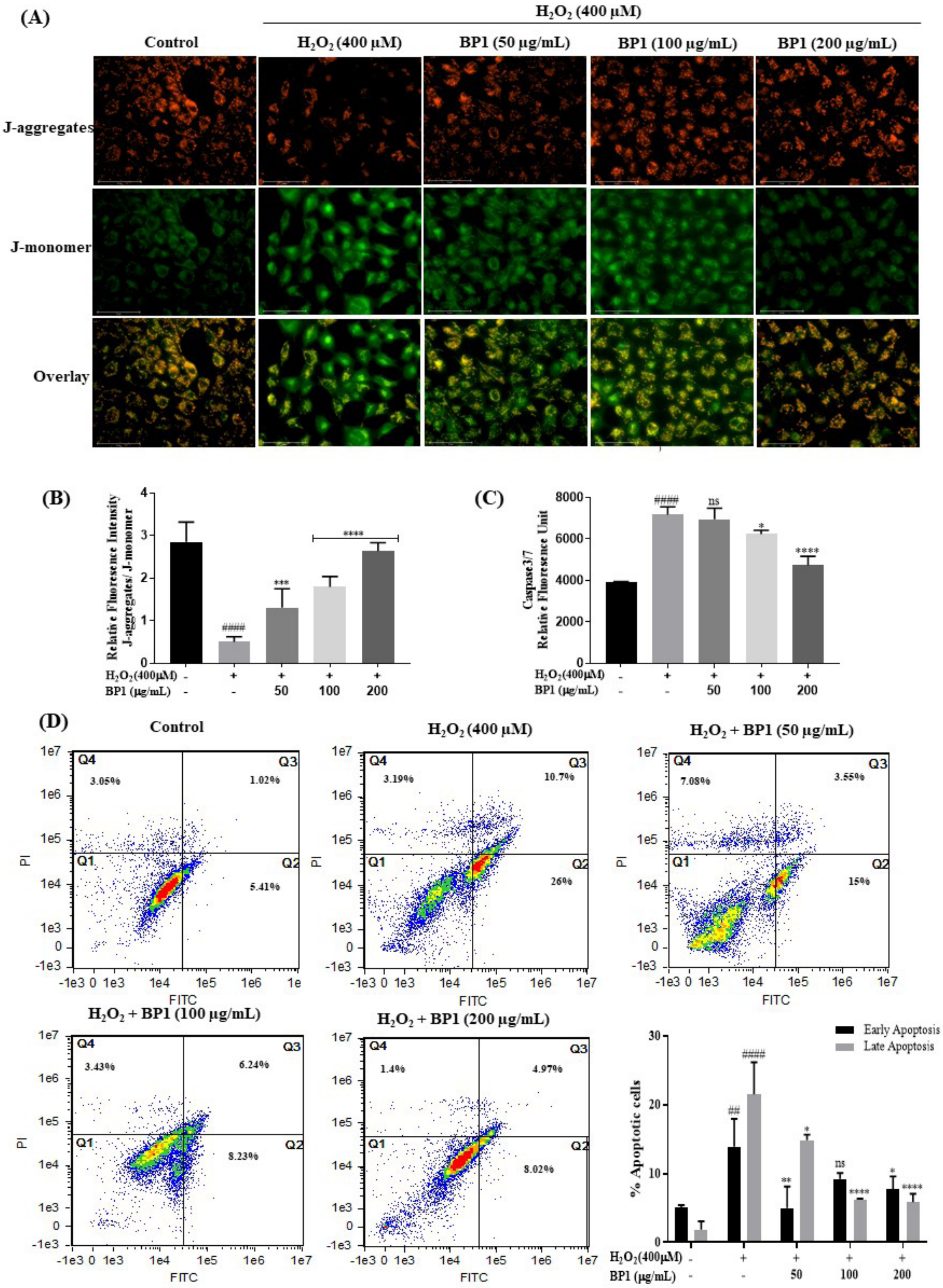

Fig. 2 Anti-apoptotic effects of BP1 in HEK293 cells. Analysis of mitochondrial membrane potential (Δψm) using JC-1 dye (A), graphical representation of the quantitative results using ImageJ software (B), caspase 3/7 activity in different groups (C), flow cytometry images of apoptosis in different groups (F). Data are expressed as mean ± SD (n = 3). ## and #### represent statistically significant differences with $p < 0.01$ and $p < 0.0001$, respectively in comparison to the control, and *, **, *, and **** represent statistically significant differences with $p < 0.05$, $p < 0.01$, $p < 0.001$, and $p < 0.0001$, respectively, in comparison to the H_2O_2-treated group.**

fluorescence, indicating a decrease in Δψm of HEK293 cells, leading to cell damage **(Fig. 2A)**. The ratio of red to green fluorescence was found to be low (0.502) in H_2O_2-induced cells, while it was high (2.850) in control cells ($p < 0.0001$). Preincubation of BP1 at different doses (50, 100, and 200 μg/mL) prior to H_2O_2 treatment in HEK293 cells was observed to alleviate the damage. Precisely, a 50 μg/mL dose of BP1 increases the ratio 2.5-fold ($p < 0.001$) compared to that of H_2O_2-treated cells, whereas a 200 μg/mL dose restores the ratio close to that of the control cells ($p < 0.0001$), indicating the restoration of Δψm by BP1 **(Fig. 2B)**. Additionally, fluorescence-based apoptotic assays indicated 1.8-fold higher caspase 3/7 activity in H_2O_2-treated cells compared to the control, which was subverted to 1.2- and 1.5-fold ($p < 0.05$ and $p < 0.0001$) by pre-treatment at 100 and 200 μg/mL, respectively, compared to that of the H_2O_2 group **(Fig. 2C)**. However, no significant effect was observed at 50 μg/mL. Furthermore, an annexin V-FITC/PI-based flow cytometric assay indicated similar responses. As shown in Figure 2D, the lower left quadrant represents the percentage of live cells that are both FITC- and PI-negative. The lower and upper right quadrants represent early and late apoptotic cells, respectively, whereas cells in the upper left quadrant depict the percentage of dead cells. Our result indicates that the percentage of early ($p < 0.01$) and late apoptotic ($p < 0.0001$) cells were found to be higher in the H_2O_2-treated group in comparison to the control. In contrast, pre-incubation of HEK293 cells with BP1 was found to subsidize the effect and reduce the percentage of early and late apoptotic cells **(Fig. 2D)**. Therefore, these data provide evidence that BP1 protects HEK293 cells from H_2O_2-induced mitochondrial-dependent cell apoptosis.

Research group: Manglesh Kumari, Shweta Thakur, Satyakam, Ashwani Punia, Vishal Saini and Monika Chauhan.

Relevant Publications:

- Journal of Plant Growth Regulations. 2023, doi: 10.1007/s00344-023-10961-w.
- Frontiers in Genetics. 2022, 25(13): 909007.
- Sustainable Agriculture Reviews book series, 2022, 57.

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Molecular Biology and Biochemistry Lab

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 are bioprospecting 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.

Dissecting molecular determinants of tolerance/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. During host-pathogen interactions, reactive oxygen species (ROS) play an important role in pathogen virulence and plant defense. For example, necrotrophic pathogens induce ROS production to damage host cells, whereas the host can incite ROS to kill the pathogen. From the host perspective, it is essential to understand how the antioxidant machinery maintains a delicate balance of ROS to protect itself from its lethal effects. We investigated the pathogen-induced accumulation of ROS and implicated damage in two rice genotypes (PR114, susceptible; ShB, moderately tolerant) varying in the level of susceptibility to *R. solani* AG1-IA. Compared to PR114, ShB exhibited a better antioxidant response and reasonably lesser oxidative damage. Further, we observed elevated levels of jasmonic acid (JA) in ShB, which was otherwise decreased in PR114 in response to pathogen infection. To further ascertain if the heightened antioxidant response is JA-dependent or independent, methyl jasmonate (MeJA) was exogenously applied to PR114, and antioxidant response in terms of gene expression, enzyme activities, and oxidative damage was studied in *R. solani* infected samples (Kumar et al., 2023). Surprisingly, the exogenous application of MeJA complemented the antioxidant response and reduced oxidative damage in PR114, thus suggesting that the antioxidant defense system is under transcriptional control of JA **(Fig. 1)**.

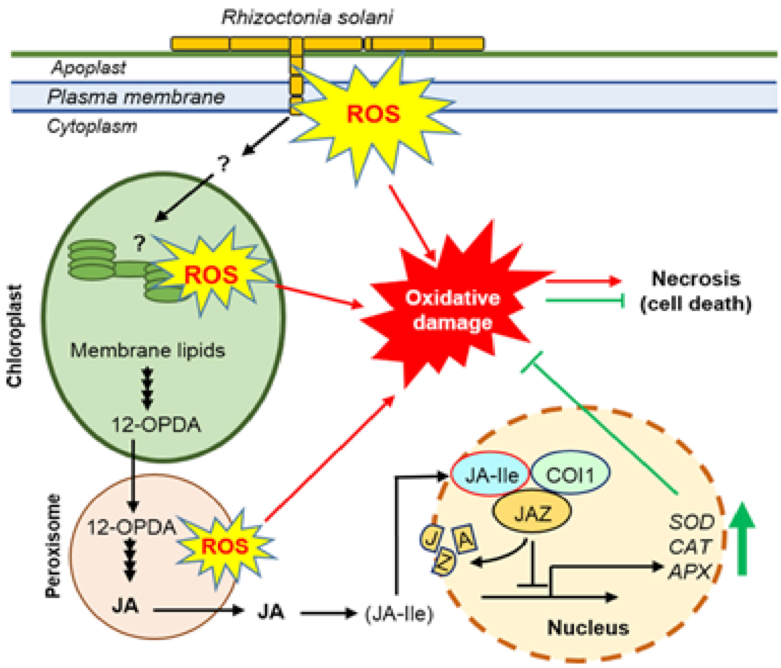

Fig. 1 Proposed model summarizing the interplay between ROS and Jasmonic acid signalling during Rice-*R. solani* interaction. *R. solani* infection induces ROS production through unknown mechanisms that cause oxidative damage in various cellular compartments. Oxidation of membrane lipids leads to the production of Jasmonic acid. The active form of JA (JA-Ile) is recognized by COI1 receptor leading to proteasomal degradation of JAZ repressors (negative regulator of JA-mediated signalling). This triggers the expression of antioxidative defense machinery, including SOD, CAT, and APX, that help scavenge ROS and reduce oxidative damage and necrosis in rice.

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

CSIR-IHBT has a rich Himalayan plant repository that has been screened using biocomputational tools to identify potential plant-based molecules having strong activity against SARS-CoV-2 proteins. Our lab endeavours to validate these results by doing *in-vitro* interaction studies of these molecules with M^{pro} protein. Using wet-lab and *in-silico* studies, we identified theaflavin 3-gallate as a potential inhibitor of SARS-CoV-2 and deciphered its mechanism of action (Chauhan et al., 2022). Several other natural molecules varying in their potential for inhibition of SARS-CoV-2 were also identified. Interestingly, we also identified a plant based peptide (ricin) to be a potential inhibitor of M^{pro} (Kashyap et al., 2022). It was revealed that a ricin-based peptide from barley with no allergenicity and hemolytic activity was able to inhibit the M^{pro} with IC50 of 0.52 nM. To understand the binding of BRIP and M^{pro}, 3D structure of BRIP was predicted and used for finding the potential binding pockets on the surface of M^{pro} of SARS-CoV-2. The BRIP peptide was completely covering the catalytic pocket of M^{pro} at the metastable conformation. This work was done in collaboration with Dr. Rituraj Purohit. A limited number of protein-peptide structures have been experimentally solved in comparison to the protein-ligand complexes with respect to the anti-COVID drug finding. This study opens the gateway of possibilities to find anti-COVID solutions in nature-inspired therapeutic peptides.

Research group: Vinod Kumar, Aishwarya Singh, Mahima Chauhan, Asheesh Kumar, Apoorva Prasad, Akshita Goyal and Naveen Kumar.

Relevant Publications:

- Plant Physiology and Biochemistry. 2023, 196: 520-530.
- Scientific Reports. 2022, 12: 13146.
- Scientific Reports. 2022, 12: 12802.

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Biotechnology (Plant Molecular Biology)

Research interests and long-term goals of our lab are (i) decoding stress-induced and chloroplast-triggered retrograde signaling activating the cognate responses; (ii) understanding the adaptive mechanisms in high-altitude plants; (iii) deciphering the epidermal cell differentiation mechanisms promoting the formation of outgrowth and secondary metabolite accumulation. In line with these goals, we are currently working on the following projects:

Decoding stress-induced and chloroplast-triggered retrograde signaling activating the cognate responses

Various stress factors directly affect the photosynthetic electron transport chain generating ROS. The ROS, thus generated, primarily target photosynthetic machinery leading to reduced efficiency. In response, chloroplast activates retrograde signaling pathways to reprogramme nuclear gene expression and trigger cognate response to deal with adversity. Using the model plant *Arabidopsis thaliana*, we are investigating stress-induced changes in chloroplast homeostasis. In addition, we are also investigating the high light- and high-temperature-induced changes in chloroplast protein homeostasis (proteostasis) to identify and map the oxidative damage in proteins. In recent years, we have mapped stress-induced chloroplast oxi-proteome, which is being validated using gene editing, site-directed mutagenesis and identifying natural variants of these proteins in the Himalayan plants. For this work, we have selected proteins involved in light-dependent and light-independent reactions of photosynthesis. We have generated multiple site-directed mutagenesis-based cis-genic lines in wild-type and cognate mutants in *A. thaliana*, which are being characterized.

The sub-lethal stresses induce growth inhibition in plants by arresting chloroplast division and cell cycle and activating programmed cell death (PCD). However, the precise mechanism is not clear. To decipher this retrograde signaling, we carried out a chemical-based mutagenesis screening of an Arabidopsis mutant with dysfunctional chloroplasts, cell cycle defects, and light-dependent cell death. Several second-site mutants showing attenuation of cell death, chloroplast, and growth defects are identified and under characterization.

PPO is a tetrameric copper-containing chloroplast thylakoid localized enzymes that catalyze oxidation of phenols. PPO is known to convert catechins into brown pigments, theaflavins, during processing of green tea into black tea. A growing body of evidence implicated PPO in defense against biotic and abiotic stresses; however, the precise mechanism of action is largely unexplored. We found that PPO activity increases under drought stress leading to accumulation of theaflavins, and cell death. To further ascertain this connection, studies were conducted in *A. thaliana* using black tea extract and pure theaflavins, which revealed that theaflavins likely induce cytosolic folding stress, also referred to as ER stress, by inhibiting folding machinery, thereby leading to unfolded protein response (UPR) and PCD via canonical ER stress pathway. Further studies are underway to dissect the genes involved in activating PCD.

Besides, we have identified stress-induced phytomolecules, which may modulate folding machinery to induce growth inhibition and cell death

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

Despite exposure to environmental extremes such as fluctuating temperatures (warmer days and cooler nights), high-intensity radiations such as UV-B, low partial pressure of gases, and inadequate availability of water and nutrients, high-altitude plants sustain and complete their life cycle. Deciphering the mechanisms by which these plants deal with these cues is essential for understanding the adaptability of these extremophiles. To understand adaptive mechanisms in Himalayan plants, we are focusing on *Mollisima himalaica* and Foxtail millet to decipher their excess energy dissipation and ROS scavenging mechanisms activated by retrograde signaling in these plants. We recently explained that modulating activation and relaxation of non-photochemical quenching (NPQ) by targeting key carotenoid epoxidase and de-epoxidase (VDE and ZEP) and lumen pH sensing protein PSBS, photosynthetic efficiency can be improved under fluctuating light conditions **(Fig. 1)**.

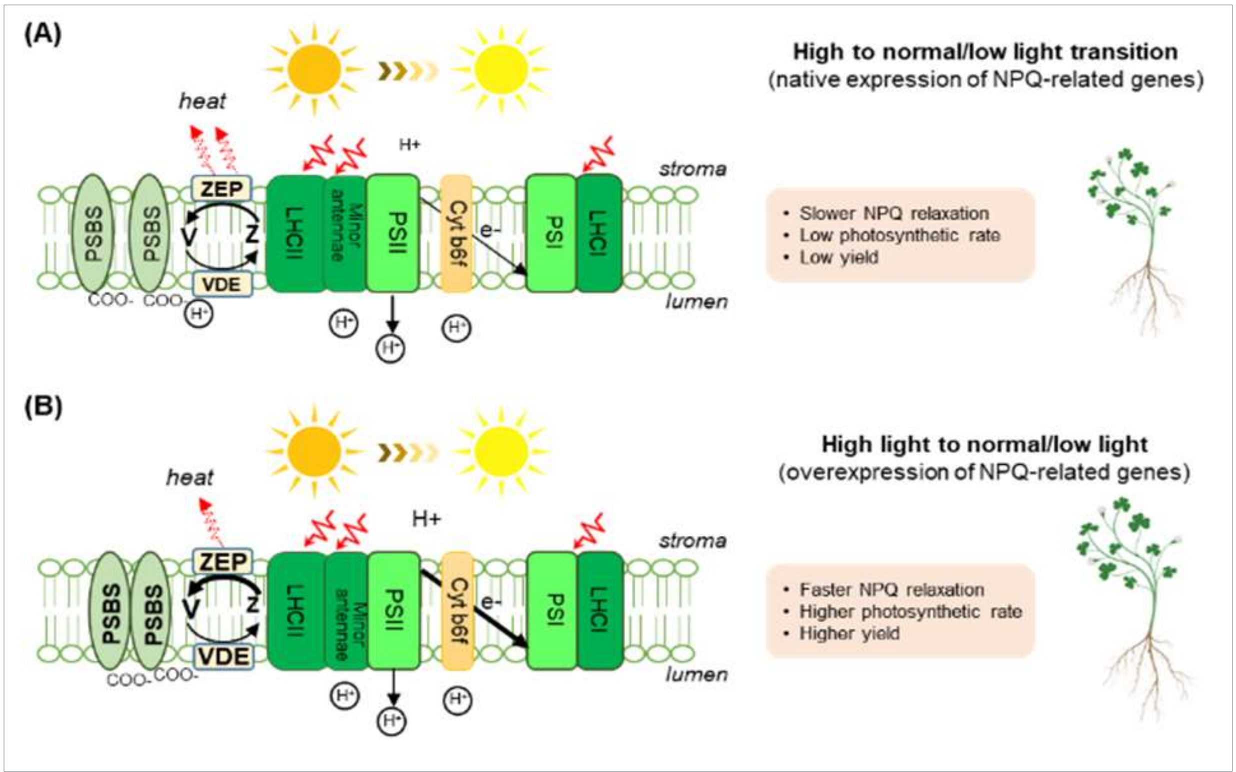

Fig. 1 Accelerated non-photochemical quenching (NPQ) relaxation enhances photochemical quenching and photosynthetic output under high-to-low light transitions. (*Ghosh et al. 2023, Trend Plant Sci*).

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

Many plants undergo epidermal cell differentiations to form various outgrowths such as trichomes, bladders, and prickles accumulating secondary metabolites. We are investigating the relevance and mechanism of such an epidermal differentiation process. Roses bear prickles on their stems and leaves. We have recently deduced a transcriptional module that seems to have a role in prickle morphogenesis and secondary metabolite accumulation in Rose. We are now engineering prickle-less roses where overexpression, VIGS, and CRISPR constructs are being prepared for the transformation in Rose calli.

Research group: Rimpy Diman, Rahul Michael, Shagun Bali, Sandhya Yadav, Dipanshu Ghosh, Sumanta Mohapatra, Twinkle, Rashmi Arora, Aarzoo Dhiman and Ayushi Gautam.

Relevant Publications:

- Trends in Plant Science. 2023, 28(3): 264-266.
- Plant Physiology and Biochemistry. 2023, 196: 520-530.
- Physiologia Plantarum. 2022, 174 :e13814.

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Adaptation, Climate Change, Genomics/Epigenomics

In our lab, we work on crops of the Himalayan region (e.g., Amaranth and potato) and also try to answer fundamental questions of plant biology by using *Arabidopsis thaliana* as a model system. The specific research interests are advancing the mechanistic understanding of plant responses to global climate change factors such as rising atmospheric CO_2, temperature and drought.

Dissecting high-temperature responses in plants

A current trend in climate comprises adverse weather anomalies with more frequent and intense temperature events. Heatwaves are a serious threat to global food security because of the susceptibility of crop plants to high temperatures. Almost every stage of plant growth and development is impacted by heat stress.

Among various developmental stages, even a slight rise in temperature during reproductive development proves detrimental, thus making sexual reproduction heat vulnerable. In this context, male gametophyte or pollen development stages are the most sensitive ones **(Fig. 1)**. Likewise, high-temperature stress impedes potato tuber development (tuberization), negatively impacting tuber yield. Thus, there is a need to understand plant responses to high-temperature stress. Also, crops that are already climate-resilient must be used in the agricultural

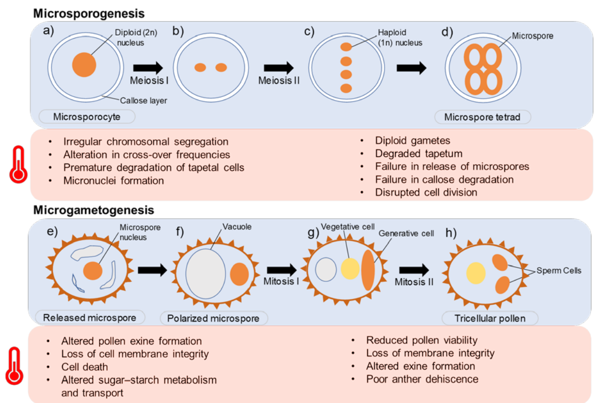

Fig. 1 Schematic representation of heat stress impact on male gametophyte development.

system. In this context, we are studying crops like potato and pseudocereals of the family Amaranthaceae.

Pseudocereals

Underutilized crops have the potential to become future climate crops due to their high climate resilience and nutritional quality. In this context, C4 pseudocereals such as grain amaranths are very important as C4 crops are more heat tolerant than C3 crops. However, the thermal sensitivity of grain amaranths remains unexplored. Here, *Amaranthus hypochondriacus* was exposed to heat stress at the vegetative and reproductive stages to capture heat stress and recovery responses. Heat Shock Factors (Hsfs) form the central module to impart heat tolerance, thus we sought to identify and characterize Hsf genes. Chlorophyll content and chlorophyll fluorescence (Fv/Fm) reduced significantly during heat stress, while malondialdehyde (MDA) content increased, suggesting that heat exposure caused stress in the plants. The genome-wide analysis led to the identification of thirteen AhHsfs, which were classified into A, B and C classes. Gene expression profiling at the tissue and developmental scales resolution under heat stress revealed the transient upregulation of most of the Hsfs in the leaf and inflorescence tissues, which reverted back to control levels at the recovery time point. However, a few Hsfs somewhat sustained their upregulation during the recovery phase. The study reported the identification, physical location, gene/motif structure, promoter analysis and phylogenetic relationships of Hsfs in Amaranthus hypochondriacus. Also, the genes identified may be crucial for future gene functional studies and develop thermotolerant cultivars.

Potato (*Solanum tuberosum*)

Potato is a temperate crop consumed globally as a staple food. High temperature negatively impacts the tuberization process, eventually affecting crop yield.

DNA methylation plays an important role in various developmental and physiological processes in plants. It is a conserved epigenetic mark determined by the dynamic concurrent action of cytosine-5 DNA methyltransferases (C5-MTases) and demethylases (DeMets). However, C5-MTases and DeMets remain unidentified in potato, and their expression patterns are unknown under high temperatures.

We performed genome-wide analysis and identified 10 C5-MTases and 8 DeMets in potatoes. Analysis of their conserved motifs, gene structures, and phylogenetic analysis grouped C5-MTases into four subfamilies (StMET, StCMT3, StDRM, and StDNMT2) and DeMets into three subfamilies (StROS, StDML, and StDME). Promoter analysis showed the presence of multiple cis-regulatory elements involved in plant development, hormone, and stress response. Furthermore, expression dynamics of C5-MTases and DeMets were determined in the different tissues (leaf, flower, and stolon) of heat-sensitive (HS) and heat-tolerant (HT) genotypes under high temperatures. qPCR results revealed that high temperature resulted in pronounced upregulation of CMT and DRM genes in the HT genotype. Likewise, demethylases showed strong upregulation in HT genotype as compared to HS genotype. Several positive (*StSP6A* and *StBEL5*) and negative (*StSP5G*, *StSUT4*, and *StRAP1*) regulators are involved in the potato tuberization. Expression analysis of these genes revealed that high temperature induces the expression of positive regulators in the leaf and stolon samples of HT genotype, possibly through active DNA demethylation and RNA-directed DNA methylation (RdDM) pathway components.

Our findings lay a framework for understanding how epigenetic pathways synergistically or antagonistically regulate the tuberization process under high-temperature stress in potatoes. Uncovering such mechanisms will contribute to potato breeding for developing thermotolerant potato varieties.

Also, a comparative analysis of heat-sensitive and tolerant genotypes at physiological, biochemical, and transcriptional levels is underway. Dissecting genetic and epigenetic regulators underpinning tuber development under high-temperature stress can help breed heat-tolerant potato varieties. Moreover, genome editing can provide an excellent toolbox to develop potato varieties with new traits (**Fig. 2**).

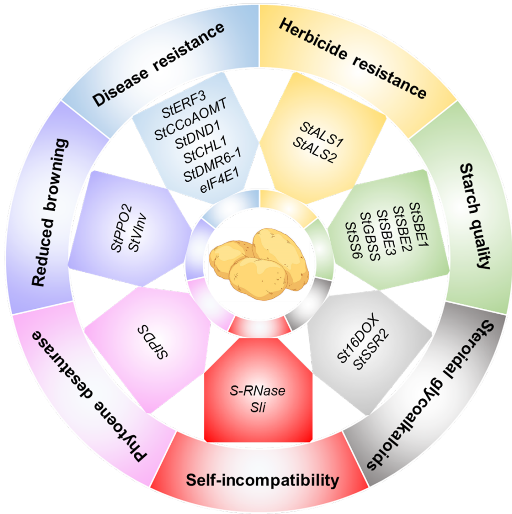

Fig. 2 CRISPR/Cas mediated genome editing in potato (*Solanum tuberosum* L.).

Arabidopsis thaliana

Arabidopsis thaliana is an excellent model system to answer fundamental questions of plant biology, because of its short generation time, availability of high-quality genome data, and genetic resources. Global temperature rise is an emerging threat to humanity. The two facets of temperature rise are a rise in the average temperature (warming) and the occurrence of extreme heat events (heating). Warming and heating trigger varied plant responses. For example, warming accelerates developmental processes (flowering and leaf elongation), while heating inhibits growth and photosynthesis and causes floral abortion. In our lab, we are dissecting the molecular signatures underpinning these high-temperature regimes (warming and heating) in the model plant *Arabidopsis thaliana*. So, far phenotypic and transcriptional data have been generated in the lab. We are in the process of functional validation of genes.

Research group: Asha Kiran Singh, Komal Goel, Pravesh Kundu, Madhushree Dutta, Vidhi Raturi, Surbhi Mali, Shiwali Thakur, Sanjeet Kumar and Narender Kumar.

Relevant publications:

- Frontiers in Plant Science. 2022.
- Frontiers in Plant Science. 2023.
- Plant Cell Reports. 2023.

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Plant Developmental Biology, Metabolic Engineering

Our lab is involved in understanding saffron plant developmental biology, mainly flowering regulation and corm development. Flowering determines saffron crop yield, whereas vegetative growth determines corm quality, the only source of its propagation.

Flowering in saffron is regulated by temperature. In appropriate temperatures at the flowering stages result in flower atrophy and reduced or no flowering. The effect of temperature on saffron flowering was investigated using morphological studies coupled with transcriptomics and metabolic studies of meristem-enriched tissue collected from corms stored and grown at two different temperatures [high (25°C) and low (8°C)] during flowering. The findings are discussed below

High temperature during the dormant/ storage stage of corms is required for flowering

Saffron corms remain dormant during summers, without any visible growth aboveground and no roots. We stored freshly harvested dormant corms in the dark at three different temperatures to test the effect of temperature on saffron flowering. One set of corms was stored at 25°C another at 8°C continuously, while the third set was kept at a gradient temperature of 25°C-20°C and 15°C for three months in the dark and observed for flowering. As seen in **Fig. 1**, corms stored at all the temperatures sprouted while only corms kept at 25°C and gradient temperatures showed flowering, suggesting that high ambient temperatures promote flowering in saffron corms. No flowering was observed in corms stored at 8°C. Comparatively, corms stored at 8°C, showed slower growth but produced normal leaves similar to 25°C corms.

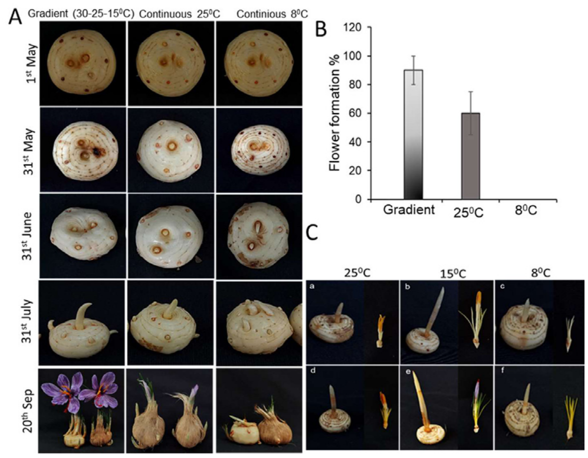

Fig. 1 (A) Saffron corms were stored at three different temperatures during (May-July), Gradient (30-25-15°C), 25°C continuous and 8°C continuous and then transferred to 15°C/20°C night and day temperatures for flowering. Early and maximum flowering can be seen in corms stored at gradient temperatures, followed by those stored at 25°C. No flowering was observed in corms stored at 8°C. (B) Percentage of flowering in corms stored at different temperatures. (C) Low temperature promotes vegetative growth. (a-f) Flower and leaf development in corms at different temperatures 25°C, 15°C and 8°C respectively. Corms were stored in the dark for 3 months in mentioned temperatures and then moved to 8hlight/12hdark for flowering (a,d) Corms stored at 25°C develop only flowering tissue (b,e) Corms at 15°C develop both flower and leaves and bigger in size compared to others (c,f) Corms at 8°C only develops leaves with no flowers. Leaves are comparatively bigger at 8°C than grown at 25°C.

Transcriptome and metabolite analysis identifies sugar metabolism genes and metabolites involved in temperature-mediated flowering induction

Transcriptome data showed significant upregulation of genes involved in the process of sugar metabolism. Correlating with the transcriptome data significant changes in terms of sugar metabolism were observed between contrary temperature conditions. The inductive condition (25°C) favoured starch degradation enzymes like amylase while the non-inductive (8°C) showed upregulation of starch synthesis genes like AGPase. In the study, increased sucrose levels were observed in apical buds whereas a contrasting pattern was observed in storage corm tissues. Comparatively, more levels of sucrose in flowering apical buds might be due to the efficient transport of sucrose into them compared to non-flowering where sucrose is accumulated in corm tissues. The degradation of sucrose to simple sugars is known to be aided by invertases. Invertase was highly upregulated in inductive conditions (25°C) whereas downregulated in non-inductive (8°C).

Temperature acts via modulation of floral integrator gene expression, mainly CsatFT3

We investigated the temperature-mediated regulation of floral integrator genes identified earlier. Expression analysis of *CsatFT1-3* genes, during the flower induction stage at ambient high (25°C, flowering) and low (8°C, non-flowering) temperatures compared with the dormant stage, showed no significant change in *CsatFT1* and *CsatFT2* expression at the induction stage, while both of these genes showed upregulation compared to the dormant stage. Comparatively, *CsatFT3* expression showed upregulation in only flowering corms (25°C) at the flower induction stage. *CsatTFL1-1* and *CsatTFL1-2* showed downregulation at the flower induction stage without any significant change in flowering and non-flowering corms.

Further, we checked the correlation between floral integrator genes, temperature and sugars. We did sugar-feeding experiments to with exogenous sucrose, glucose and fructose by vacuum infiltration. Control and treated corms were morphologically observed under the microscope after 5 weeks of incubation at 8°C. Flower induction compared to control corm was observed in sucrose-treated corms, while no significant change was observed in glucose and fructose-treated corms. As the flowering regulator FT3 gene was suppressed by low temperature we also tested whether exogenous sugar feeding can induce its expression. Expression analysis suggested that CsatFT3 expression was induced by sucrose treatment at a low temperature (8°C), compared to control and other two FT homologs (CsatFT1 and CsatFT2), suggesting sucrose might mediate via induction of FT3 in regulating flowering. Overall our results based on transcriptomics, coupled with morphological and metabolic studies suggests that the environmental temperatures alter the sugar metabolism of the corms, which mediates temperature-dependent flower induction in saffron corms via regulation of the *CsatFT3* gene **(Fig. 2)**.

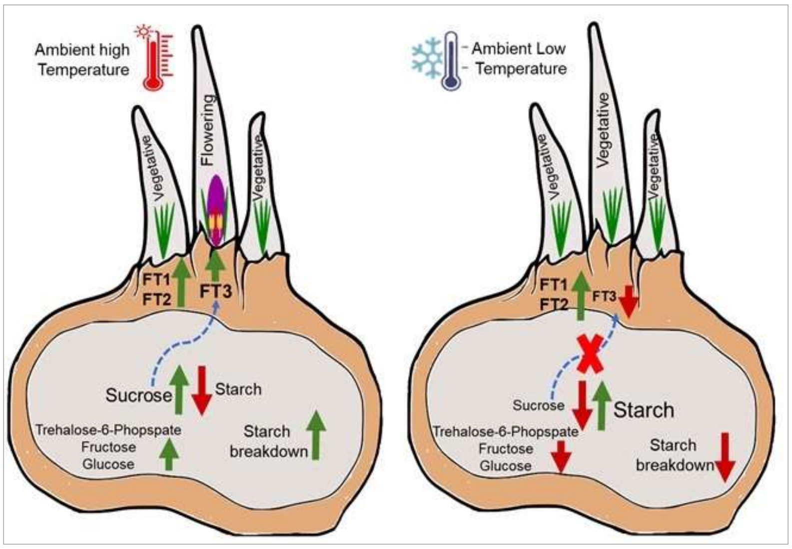

Fig. 2 Hypothetical model depicting temperature-dependent flowering regulation in saffron.

Research group: Diksha Kalia, Joel Jose Santhi, Firdous Sheikh Rasool, Deepika Singh, Sahiba Sharma and Diksha Kumari.

Relevant Publications:

- Frontiers in Plant Science. 2023, 14: 1107172.
- Environmental and Experimental Botany. 2023, 206: 105150.
- Industrial Crops and Products. 2022, 189: 115817.

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High Altitude Microbiology Laboratory (HAM-lab)

Our research group focuses on microbial community analysis from the alpine regions and utilizes the cold–adapted bacteria for organic waste management in Himalayan regions. This year we analyzed the microbial community of Chhota Sigri glacier and utilized alpine bacteria for product development for organic waste management. The high vitamin D soup prepared from the *shiitake* mushroom was assayed for its bioavailability on human subjects. Further, overall research and product development and its validation is categorized as follows:

Microbial community analysis from environmental samples of high-altitude region revealed primary succession, nutrient recycling, and xenobiotics degradation

The forefield sites of a highly retreating, benchmark glacier in the western Himalayas were explored for microbial diversity and succession studies. The microbiome analysis revealed the presence of a great diversity of microbes at the glacier forefield. The microbial abundance was richer at the sites near the glacier terminus compared to the sites away from the terminus, whereby the soil temperature and pH were the determining factors for microbial diversity. The heterotrophic groups of microbes were replaced by autotrophic/chemoautotrophic groups across the forefield. Further, the role of microbes in carbon, sulfur, and nitrogen cycling and even xenobiotics degradation at the glacier forefield sites was highlighted. Microbial colonization in a deglaciated site is challenged by harsh conditions like cold, desiccation, low nutrients, and osmotic and oxidative stress due to intense UV radiation. The prevalence of stress response proteins like cold-shock proteins, osmoprotectants, glutathione, and superoxidase dismutase in the soil metagenome depicted the microbial cold adaptation strategies for survival in the harsh glacier forefield. Overall, the study revealed the microbial succession gradients across a young forefield and their role in nutrient cycling and ecosystem development at the deglaciated site.

Valorization of agro-residual resources using cold-adapted bacteria

A potent cellulase producing cold-adapted bacterium *Exiguobacterium sibiricum* K1 was isolated from a compost sample of the cold region of Sikkim Himalaya. Media optimisation yielded 3.8 U/ml cellulase in 0.2 % (w/v) CMC at 15 ℃ and pH 5. The exoglucanase and xylanase activity observed was 3.3 U/mL and 3.1 U/mL using 1% avicel and birchwood xylan as substrates. Crude cellulase proficiently degraded agro-residual wastes namely sugar cane bagasse (SCB), wheat bran (WB), corn stover (CS), and oil extracted lemongrass (LG) within 24 hrs at 15 ℃. The scanning electron micrograph of the enzyme-treated wastes showed structural breakages in the form of pores and cracks, while, no significant changes were observed in untreated groups **(Fig. 1)**. Gas chromatography–mass spectrometry showed the release of 13 products in both SCB and WB enzymolysis, 12 in CS, and 14 in LG degradation. The identified products were categorized into alcohol,

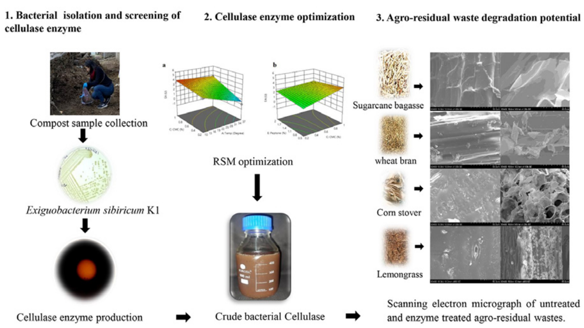

Fig. 1 Schematic representation of agro-residual waste degradation using bacterial cold-active cellulase enzyme.

saccharide, acid, ketone, ester, alkane, aldehyde, and furan which can further act as a versatile, initial material for biotechnological applications. Atomic absorption spectroscopy revealed the availability of six phytonutrients such as Fe, Mn, Cu, Zn, Ca, and K in the enzyme-treated hydrolysate. The study demonstrated the applications of cold-active cellulase as a potential candidate in the degradation of agro-residual waste under cold conditions.

Genome analysis of bacteria for elucidating pigment biosynthesis

An atypical red-pigmented *Janthinobacterium* sp. ERMR3:09 was isolated and identified from a glacier moraine of Sikkim Himalaya **(Fig. 2 a)**. The red prodigiosin pigment has immense pharmacological significance, including antioxidant, antimicrobial and anticancer properties. The first complete genome of the prodigiosin-producing *Janthinobacterium* sp. was reported to gain insights into its genetic makeup for prodigiosin biosynthesis. Nanopore sequencing and Flye assembly of the ERMR3:09 genome resulted in a single contig of 6,262,330 bp size and 62.26% GC content. The genome provides information on the key cold and stress-responsive genes that facilitates bacterial survival in a cold glacier environment, further supported by the expression analysis of some of these genes under low temperature. The genome deciphered the unique genes and biosynthetic gene cluster and predicted the pathway involved in prodigiosin biosynthesis in ERMR3:09 **(Fig. 2 b)**. Comparative genome analysis identified the unique genes responsible for prodigiosin synthesis in the red-pigmented *Janthinobacterium* sp. The ambiguous phylogenomic branching and under-threshold ANI and dDDH values with its closest neighbors suggest that ERMR3:09 may be a putative novel strain. The efficient antioxidant activity of the ERMR3:09 pigment highlights its significant potential for application in food or pharmaceutical sectors as a natural antioxidant agent. The bacterium can be the next powerhouse of bioactive prodigiosin production. The research work was resulted in one publication.

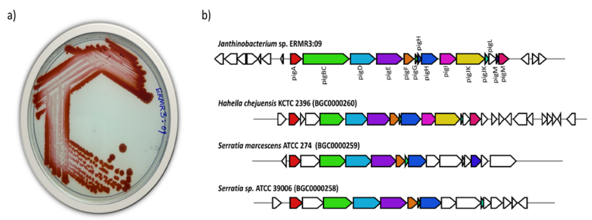

Fig. 2 (a) *Janthinobacterium* sp. ERMR3:09 in Antarctic Bacterial Medium agar plate, (b) Identification of the prodigiosin biosynthetic gene cluster in *Janthinobacterium* sp. ERMR3:09 using antiSMASH 6.0.

Development of high vitamin D_2 enriched *shiitake* soup and its bioavailability assay on human subjects

The project delivered a formulation/ finished product of Vitamin D_2 enriched *shiitake* soup (consisting of 30,000 IU vitamin D_2) **(Fig. 3)**. The nutritional profiling, safety evaluation (microbiological parameters and aflatoxin content), and vitamin D_2 stability studies have also been evaluated. The human intervention studies were conducted to assess the bioavailability of the developed shiitake soup among healthy humans deficient in serum 25-hydroxyvitamin D. Out of 101 screened subjects, 60 patients were recruited as per the assigned inclusion and exclusion criteria. The subjects are randomized as per three arms (1. Vitamin D_2 enriched experimental *shiitake* soup (30,000 IU), 2. Commercial supplement

Fig. 3 Value added products of vitamin D_2 enriched *shiitake* mushroom. (a) Fresh and dried vitamin D_2 enriched *shiitake* mushroom (b) Vitamin D_2 enriched *shiitake* powder (c) Vitamin D_2 enriched *shiitake* soup formulation.

Vitamin D_2, and 3. Experimental non-irradiated shiitake soup). The developed shiitake soup has helped in alleviating the serum 25-hydroxyvitamin D (25-OHD) from 30.7 ± 8.2 nmol/l (baseline) to 41 ± 22.1 nmol/l after administration of soup for four weeks. Vitamin D_2 enriched *shiitake* soup will help cater the population affected with vitamin D deficiency.

Research group: Aman Thakur, Aman Kumar, Ayush Lepcha, Sareeka Kumari, Krishna Kanta Pandey and Nidhi Maurya.

Relevant Publications:

- Ecological Indicators. 2022, 144: 109565.
- Biomass Conversion and Biorefinery. 2022, 1-11.
- Gene. 2023, 857: 147178.

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Biotechnology (Applied Phycology & Food Technology)

Our group is focused on utilizing microalgae for production of nutraceuticals, micronutrient enriched foods and animal feed. In addition, we are into developing various value added products and processes utilizing Himalayan bioresources mainly wild edibles like flowers, fruits and vegetables. We are actively engaged in industrial collaboration and offer consultancy services to micro and small scale industries (MSMEs), farmer produce organizations (FPOs) and co-operative societies in the area of food processing, value addition to agri-horti crops and microalgae processing.

Bio-efficacy of microalgae fortified foods for combating iron and protein deficiency

We utilized microalgae, Arthrospira platensis (Spirulina) to fortify some traditional foods of the Indian subcontinent, namely sattu (multigrain beverage mix) and chikki (peanut bar) and evaluating their ability to promote recovery from protein and iron deficiency anaemia (IDA) using albino Wistar rats. Addition of Spirulina (at 4% w/w Spirulina inclusion levels) enriched the protein content by 20.33% in sattu and 15.65% in chikki while the iron content was enhanced by 45% in sattu and 29.6% in chikki. In addition, the total carotenoid and polyphenol content and antioxidant capacity of the food products improved after Spirulina incorporation. Supplementation of 100 g of Spirulina fortified food products meets more than 50% of recommended dietary allowances (RDA) of protein, dietary fiber, iron and zinc for the age group 3 to 10 years of children. Spirulina contributed between 11% and 22% of RDA for protein and iron, respectively; however, it contributed very negligibly to RDA of dietary fibre with respect to the nutrient requirements for the target age group. Supplementation of Spirulina fortified foods individually promoted bodyweight gain in malnourished rats and restored haemoglobin, serum protein, albumin, serum iron, and hepcidin levels and reduced the iron binding capacity indicating recovery from IDA. Spirulina supplementation ameliorated malnutrition induced oxidative stress in the liver, spleen and kidneys by reducing the lipid peroxidation and enhancing superoxide dismutase and glutathione activities. Histopathological analysis revealed that supplementation of Spirulina fortified foods reversed pathological changes such as fatty changes in the liver cells, thinning of cardiac muscle fibers and degeneration of intestinal villi. Fe–protein deficiency significantly altered the gut microflora by reducing the abundance of beneficial microbes. However, supplementation of Spirulina fortified foods improved the levels of beneficial gut microbes such as *Lactobacillus reuteri* and *Akkermansia muciniphila* while reducing the abundance of Helicobacteraceae, Enterobacteria and Clostridia. In summary, supplementation of Spirulina fortified foods promoted recovery from protein and iron deficiency indicating the bioavailability of nutrients (iron and protein) from Spirulina at par with casein and ferrous ascorbate **(Fig. 1)**.

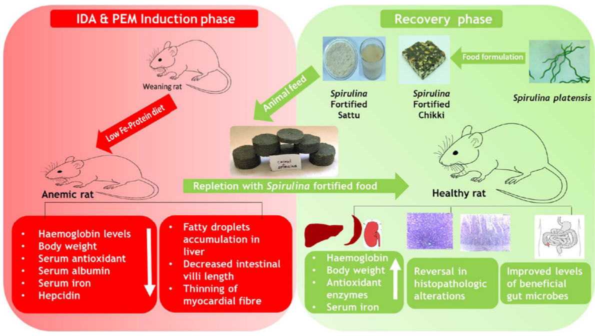

Fig. 1 Mechanism of the ability of *Arthrospira platensis* to promote recovery from protein and iron deficiency.

Microalgae as natural growth promotor – alternative to antibiotics in poultry feed

Poultry contributes to 50% of India's meat production, estimated at 4.06 million tonnes (DHFD, MoFPI, 2022). Antibiotic growth promotors (AGPs) like doxycycline, kanamycin, and colistin sulphate are provided for improving growth, body weight, and feed consumption efficiency (FCR) in commercial feed. Excessive use of AGPs has resulted in antibiotic resistance and the emergence of superbugs. This necessitates the identification of alternative natural growth promotors. Microalga, Arthospira platensis (Spirulina) offers new possibilities owing to the presence of essential micronutrients, bioactive molecules like carotenoids, polyunsaturated fatty acids (PUFA), and phycobiliproteins. In the present study, we replaced commercial AGPs with Spirulina biomass and evaluated the performance of the commercial broiler strain, Cobb 430 under a deep litter system. Spirulina biomass was supplemented at three levels (1-3%) and the performance was compared to birds receiving commercial AGP feed. The control group received AGP-free feed. Spirulina supplementation did not influence feed intake, hematology, and serum biochemistry. However, maximum growth and body weight, and lower FCR scores were observed for the 1% Spirulina group similar to the AGP-fed group. The inclusion of Spirulina beyond 1% resulted in reduced growth performance. Carcass traits like live weight, % dressing, leg, and breast were similar for 1% Spirulina and AGP-fed groups. Meat quality parameters such as redness, drip loss, cooking loss, and water holding capacity were similar among 1% Spirulina and AGP feeds. Unsaturated fatty acid levels, specifically PUFAs, were higher in Spirulinasupplemented feeds compared to control AGP-free feeds. It can be concluded that 1% spirulina inclusion in the feed could effectively replace synthetic antibiotics **(Fig. 2)**.

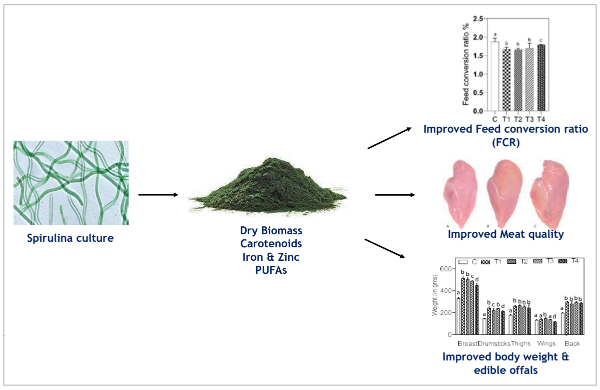

Fig. 2 Bioefficacy of microalgae (*Arthrospira platensis*) based antibiotic free poultry feed.

Nutritional characterization and value addition of Wild edibles of Western Himalayas

Wild edible plants constitute significant component of the traditional foods and dietary patterns of ethnic groups of Western Himalayas. In this context, we evaluated the nutritional, phytochemical and and in vitro antioxidant properties profiling of few Wild edible flowers such as *Bauhinia variegata* (Kachnar), *Tropaeolum majus* (Nasturtium), *Matricaria chamomilla* (Chamomile), *Tagetes erecta* (Marigold), Buransh (*Rhododendron arboreum*) and vegetables such as lasura (*Cordia obliqua*), trayambal (*Ficus auriculata*), Chulai (*Amaranthus spinosus*), tirmira (*Zanthoxylum armatum*) were. Through the UHPLC-QTOF-IMS-based metabolomics approach, more than 200 compounds were tentatively identified consisting of phenolic acids, flavonoid glycosides, terpenoids, amino acid, and fatty acid derivatives. Many of the wild edible flowers were rich source of polyunsaturated fatty acids specifically alpha linolenic acid **(Fig. 3)**.

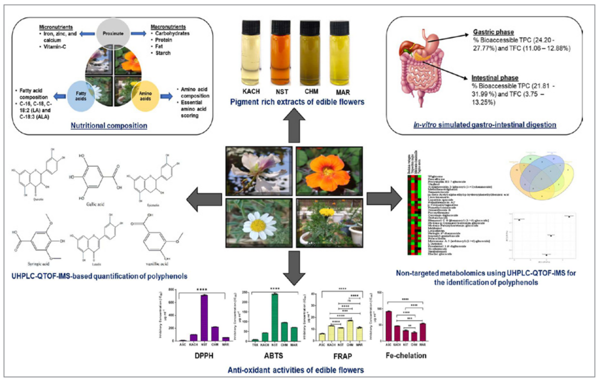

Fig. 3 Nutritional and phytochemical characterization of Wild Edible plants of Western Himalayas.

Integration of fortified foods and value added foods in POSHAN Abhiyaan

CSIR-IHBT in collaboration with Integrated Child Development Services, Distt. Kangra conducted a pilot scale nutrition supplementation study in the Panchrukhi block, tehsil Palampur, Himachal Pradesh. The fortified food products developed by CSIR-IHBT namely

- Iron and zinc enriched Spirulina based energy bar
- Protein and fiber enriched multigrain energy bars
- Multigrain protein beverage mixes
- Iron and calcium enriched fruit bars

were supplemented to the beneficiaries comprising severely acute malnourished children (SAM), moderately acute malnourished children (MAM), high risk pregnant and lactating women. A total of 150 nos. of beneficiaries were covered. After 6 months of supplementation, there was a significant improvement in terms of weight gain among malnourished children leading to reduction in the numbers of SAM and MAM children in the block. Further the products were tested for their bio-efficacy in terms of promoting recovery from iron deficient anaemia and general debility in collaboration with Rajiv Gandhi Government Post Graduate Ayurvedic College & Hospital, Paprola, Kangra. Clinical evaluations indicated that the fortified food products developed at CSIR IHBT such as Iron and zinc enriched Spirulina bar, multigrain protein mixes promoted haemoglobin recovery, mean corpuscular volume and haemoglobin and reduced serum glutamate pyruvic transaminase and glutamate oxaloacetate transaminase enzyme levels indicating hepatoprotective function and recovery from iron deficient anaemia. Supplementation among beneficiaries improved their health status and resulted in reduction in percentage of SAM and MAM children. The CSIR-IHBT products have been officially approved under Mukhya Mantri Balsuposhan Yojana, an intensive nutrition supplementation program initiated by Govt. of Himachal Pradesh **(Fig. 4)**.

Fig. 4 Societal outreach and integration of CSIR-IHBT fortified food products in malnutrition programs.

Research group: Raman Kumar, Athrinandan S Hegde, Smriti Gupta, Sampa Das, Kalit Sharma, Priyanka Parmar, Birinchi Bora, Neha and Aditi Guleria.

Relevant Publications:

- Food & Functions. 2023, 14: 1160-1178.
- Food Research International. 2022, 157(5): 111338.
- Frontiers in Plant Science. 2023, 14.

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Plant Molecular Genetics and Genomics Lab

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

Quantification of lignin content in rose germplasm for prickle morphogenesis

The rose (Rosa sp.) is the world's most important ornamental crop having great commercial, cultural, and symbolic importance. Its variable ploidy level may suggest that it is the most favourable feature for the genetic development of rose plants, making this crop resistant to biotic and abiotic factors and allowing it to survive in various environments in the field. Prickles are sharp-pointed structures, defensive, non-vascular epidermal outgrowths that resemble trichomes. Plants appear to be protected against environmental stressors and herbivory through lignification and the formation of secondary metabolites. It was known that lignin mainly accumulates in cell walls. The protein-free cell wall (PFCW) fraction was determined in the mature stage of prickle formation. In our germplasm (192 rose accessions), we have observed that the amount of lignin content varied from 39 to 137.4 mg/g of fresh weight in hybrid tea genotypes, followed by 46.2 to 141.4 mg/g of fresh weight in floribunda roses, 59.4 to 135.1 mg/g of fresh weight in miniature roses and 101.6 to 127.7 mg/g of fresh weight in climber roses **(Fig. 1)**.

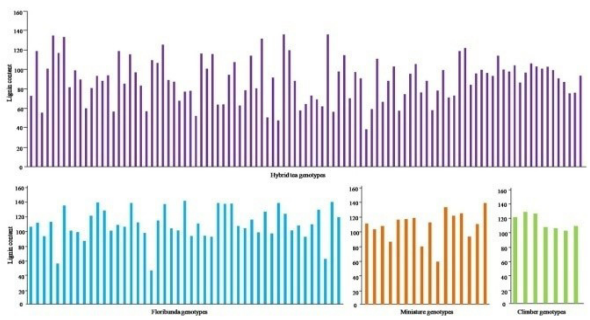

Fig. 1 An acetyl bromide (AcBr) protocol determined lignin content in prickles. Bars in the graph indicate means of 3 replicates ± SD.

The work provided here may provide insights into prickles that will be useful for future research into prickle genetics. Overall, the findings may explain the substantial genetic variety across rose germplasms, suggesting that the species has a remarkable ability to adapt to adverse environmental conditions and diseases.

Identification and comprehensive analysis of MIPSs in Rosaceae and their expression under abiotic stresses in rose (*Rosa chinensis*)

The Myo-Inositol-1-phosphate synthase (MIPS) gene family is involved in the myo-inositol synthesis and plays a significant role in signal transduction, membrane biogenesis, oligosaccharides synthesis, auxin storage and transport, programmed cell death, and abiotic stress tolerance in plants. This study comprehensively identified the MIPS genes in Rosaceae plant species, and 51 MIPS genes were identified from 26 Rosaceae species. The phylogenetic analysis divided the MIPSs into two clades (clade I; subfamily Amygdaloideae specific, and clade II; subfamily Rosoideae specific). MIPS genes of all 26 Rosaceae species consist of similar gene structure, motif and domain composition, which shows their conserved nature **(Fig. 2)**. The cis-regulatory elements (CREs) analysis revealed that most Rosaceae MIPS genes play a role in growth, development, and stress responses. Furthermore, the qRT-PCR analysis also revealed the involvement of the *RcMIPS* gene in plant development and response to abiotic stresses, including drought and heat **(Fig. 3)**. The results of the present study contribute to the understanding of the biological function of Rosaceae MIPS genes, and that could be used in further functional validations.

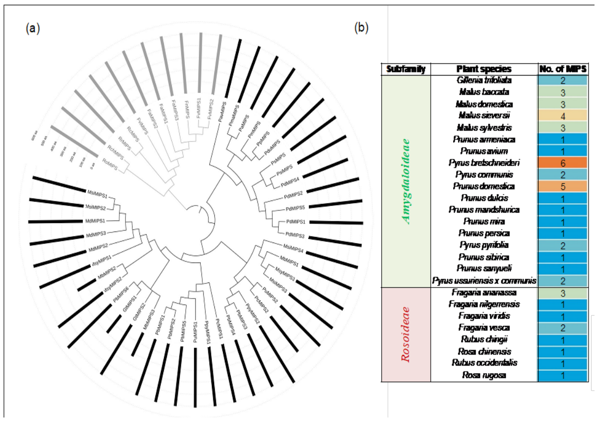

Fig. 2 Phylogenetic relationship among MIPSs belonging to the 26 Rosaceae plant species.

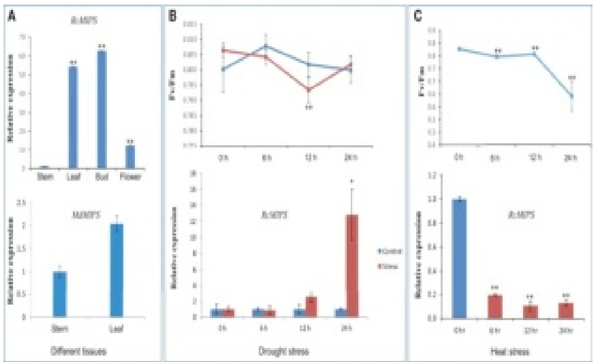

Fig. 3 The relative expression level of MIPS in (A) different plant tissue, during (B) drought and (C) heat stress.

Genetic enrichment of Saffron (*Crocus sativus* L.) through polyploidization

Saffron (*Crocus sativus* L.) is the most expensive spice in the world, known as "red gold". It is triploid (2n=3x=24) in nature. Due to meiotic abnormalities that lead to abnormal chromosomal separation this crop became sterile. The triploid condition in saffron only permits vegetative multiplication and led to a narrow genetic base. Polyploidization and mutation are the possibilities to facilitate normal meiosis and enhance plant growth in saffron. For this purpose, we treated corms with colchicine, oryzalin, trifluralin, ethyl methanesulfonate (EMS), and N-ethyl-N-nitrosourea (ENU). Saffron corms of the 6-11g size were dipped in different concentrations (colchicine 100-1250μM; oryzalin 250-500μM; trifluralin 10-150μM; ethyl methanesulfonate 0.2-0.3%; N-ethyl-N-nitrosourea 0.2-0.3%) of the chemicals along with the control (water). The treatments were given at different time intervals (May, June, July, August, September and October) for varying durations of time 12h, 24h, 24h discontinuous and 36h during crop harvesting to the next sowing. Generally, saffron flower has three stigmas, three stamens and six tepals. Our investigation identified two floral variants; one with five tepals and the other with one stamen **(Fig. 4)**. In order to determine their DNA content and ploidy, we performed stomatal investigations **(Fig. 5)**, cytology, flow cytometry **(Fig. 6)**, and examined morphological growth also. We found that there is no significant difference in ploidy of these variants. The genetic basis of these variations will be confirmed in next season. The identified variants will show to be valuable resources in understanding the molecular mechanism and genetic basis in saffron.

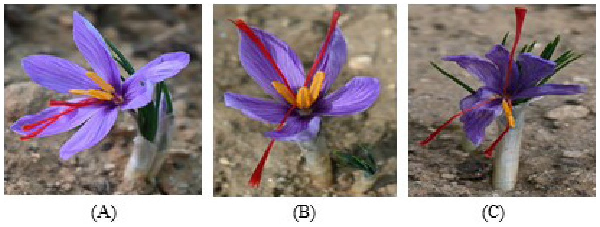

Fig. 4 Morphological variation (A) Control *C. sativus* (B) Variant 1 with 5 tepals (C) Variant 2 with single stamen.

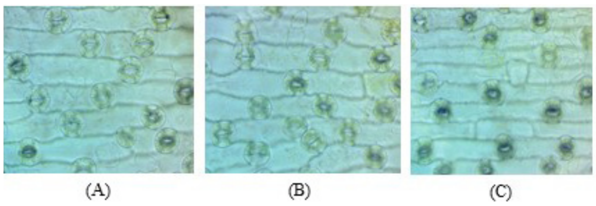

Fig. 5 Assessment of stomatal density with 40x objective lens (A) Control (B) Variant 1 (C) Variant 2.

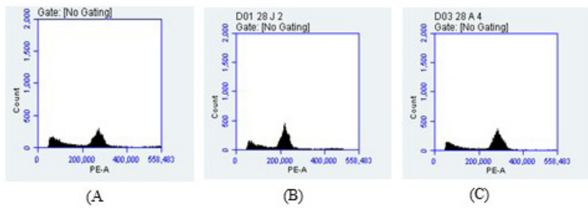

Fig. 6 Histogram obtained after isolation of nuclei from *C. sativus* (A) Control (B) Variant 1 (C) Variant 2.

Research group: Priya Kumari, Vishek Choudhary, Himanshi Gangwar, Anita Choudhary and Vishal Kumar.

Relevant Publications:

- Frontiers in Plant Science. 2022, 13: 1021297.
- Molecular Biological Reports. 2022, 49(12): 11695-11703.
- Journal of Plant Growth Regulation. 2022, 42(3): 1-17.

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Biotechnology (Fermentation Technology and Microbiology)

Our research team is looking at the therapeutic potential of several probiotic cultures derived from various dairy and non-dairy-based traditional fermented foods of the cold desert of the Western Himalayas. As microbial enzymes have gained interest for their widespread uses in industries and medicine due to their stability, catalytic activity, and ease of production and optimization compared to plant and animal enzymes, we are also working on extremophilic microbial enzymes acquired from cold desert regions of the Western Indian Himalaya.

Microbial profiling of various dairy based traditional food products of cold desert of Western Himalaya

The dietary culture and gastronomy of people living in the Indian Himalayan regions of North East India, Jammu, Kashmir, Himachal Pradesh, Ladakh, and Uttarakhand are much different from other parts of India. More than 200 different community-specific, major, minor, endangered and exotic fermented foods and beverages are traditionally prepared by the ethnic Himalayan people using 'ethno-microbiological" indigenous knowledge through 'natural/ spontaneous food fermentation or 'back-slopping' method for more than 5000 years. Therefore, we have done 16s RNA metagenome sequencing of 15 different dairy food samples (milk, curd and chhurpi) collected from cold desert regions of Western Himalaya for the identification of culture-dependent and culture-independent microorganisms present in these food samples. In 16S rRNA metagenomics study, the most abundant phylum present in all the samples was Firmicutes in all the samples **(Fig. 1)**. Further at genera level, the diversity was predominated by *Lactobacillus* followed by *Lactococcus*, *Leuconostoc*, *Streptococcus*, *Enhydrobacter*, *Pseudomonas*, *Acetobactor*, *Gluconacetobacter*, and three unidentified genera in the samples of milk and curd. In the samples of chhurpi, the most abundant genera included *Lactobacillus*, *Lactococcus*, *Streptococcus*, and *Acetobactor*, etc.

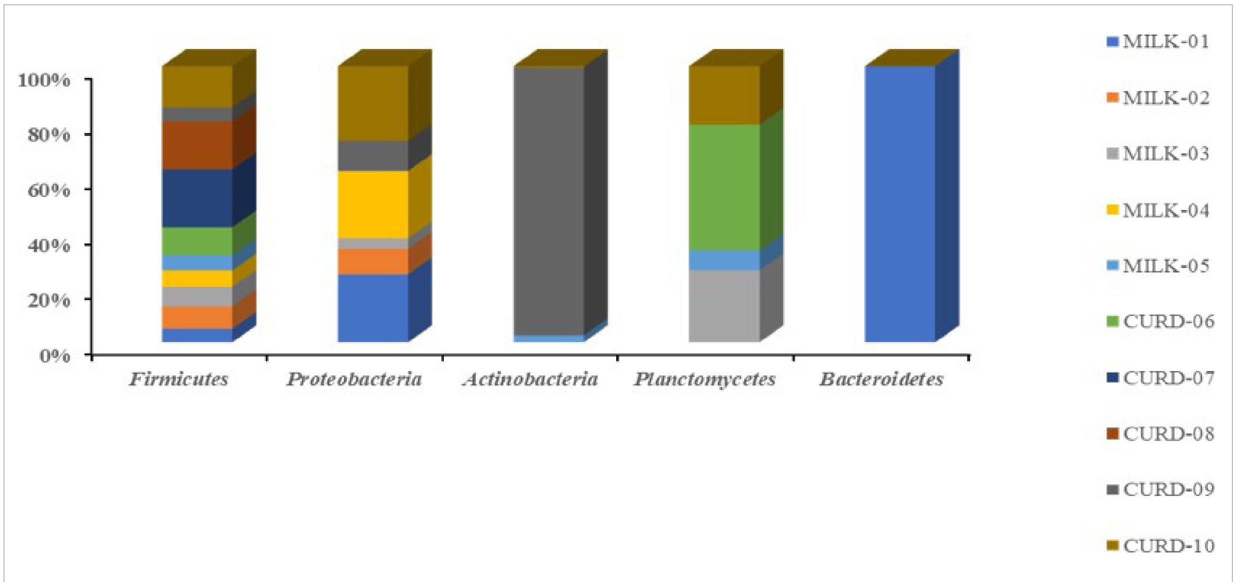

Fig. 1 Bar plot showing the taxonomic distribution of various samples at the Phylumlevel.

Metagenomics insight into geothermal geyser and hot springs located in Himalayan Geothermal Belt (Trans-Himalayan Plateau) Ladakh, India

In the past two decades, a myriad of extreme environments has been extensively studied for their microbial diversity, including hot springs, hydrothermal vents, fumaroles/stream vents, and volcanic soils. Cultivation-independent methods are essential for understanding microbial diversity since most microorganisms in such extreme conditions are non-cultivable. Investigations into the microbiological or geomicrobial richness of hot springs have not only produced remarkable scientific breakthroughs but have also enriched our knowledge of life in extreme conditions. Therefore, we have done whole genome metagenome sequencing of different water, sediment and soil samples from Panamik Hotspring, chumathang hotspring, and Puga geothermal geyser, Ladakh for the identification of culture-dependent and culture-independent microorganisms present in these samples **(Fig. 2)**.

Bacterial genera Firmicutes and Proteobacteria were dominant in water, while the most abundant bacteria in geothermal soil were Proteobacteria, and Bacteroidetes in all the samples. Archeal communities in soil and water were dominated by the genera Crenarchaeota and Euryarcheota etc.

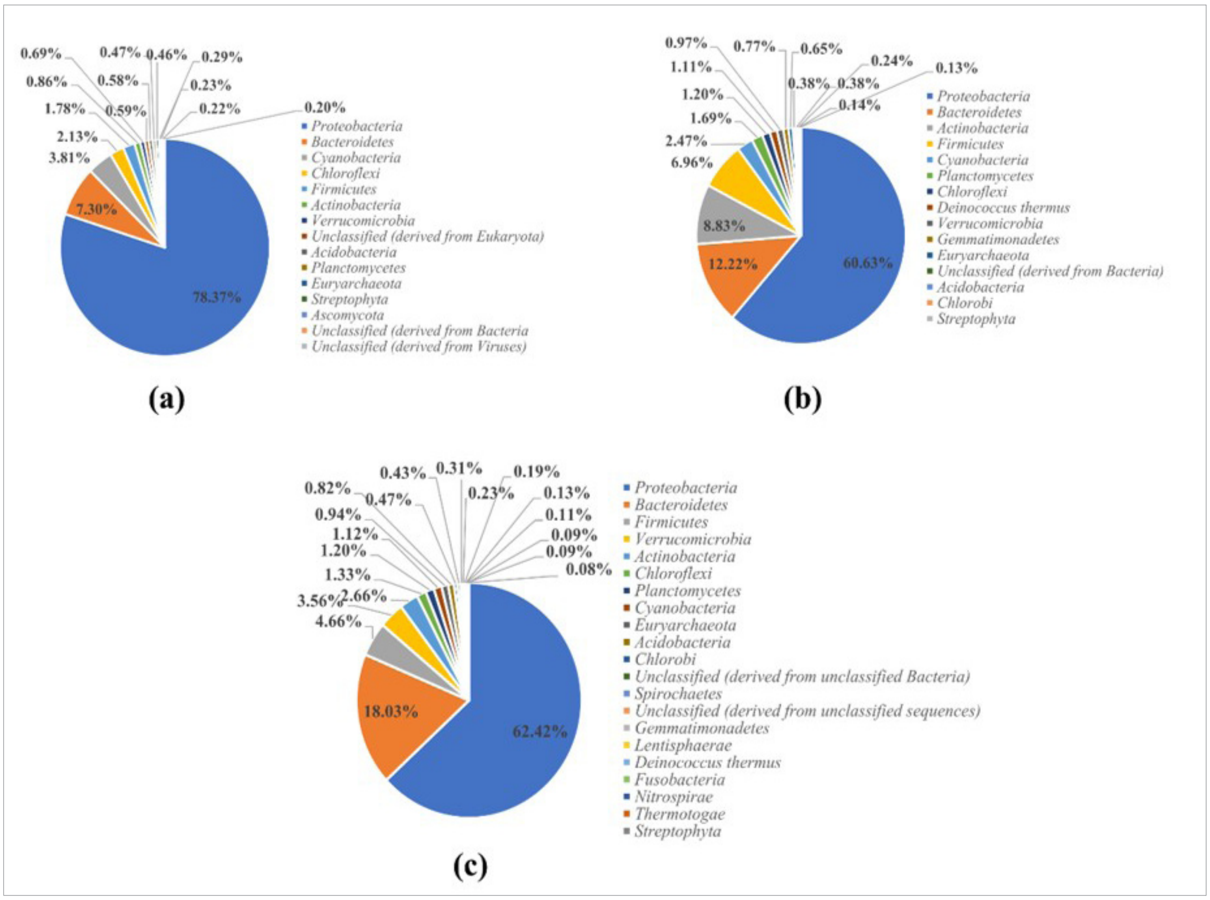

Fig. 2 Pie chart showing the taxonomic distribution of the samples (a) Water (b) Sediment and (c) Soil sample of Panamik Hot spring, Ladakh at the Phylum level.

Research group: Kumari Shanu, Kumari Anu, Shalini Kumari, Sahdev Choudhary and Geetanji Choudhary.

Relevant Publications:

- Springer. 2023, Pp. 291-322. DOI: 10.1007/978-981-19-8501-0_9.
- Elsevier, 2023, Pp. 441-453. https://doi.org/10.1016/B978-0-12-816109-8.00030-1.
- Springer. 2022, Pp. 511-537. DOI: 10.1007/978-981-19-4101-6_25.

CHEMICAL TECHNOLOGY DIVISION

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Chemical Technology Division

Research methodology: Our research group has been dedicatedly involved for nano-catalyst development, characterization and their applications in organic transformations, methodology development for bioactive molecules synthesis and CO fixation reactions for high value chemicals synthesis.

Lignocellulosic bio-mass conversion to high value chemicals: Lab scale process has been developed for commercially important 5-hydroxymethyl furfural (HMF), furfuraldehyde, 5-methylfurfuryl alcohol (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 under progress for future technology development.

Dimethyl carbonate solvent assisted efficient conversion of lignocellulosic biomass to 5- hydroxymethylfurfural and furfural

An efficient, economic, and one-pot process has been developed for direct conversion of untreated biomass (corn-cob, sugarcane bagasse, rice-straw, and corn-straw) into 5- hydroxymethylfurfural (HMF) and furfural (FF) synthesis in dimethyl carbonate (DMC) solvent conditions under a pressurized hydrothermal steel vial system. The use of DMC as a green solvent under acidic medium was explored first time for this conversion. Moreover, the DMC solvent under acidic environment partially produced CO_2 that facilitates the depolymerization of each recalcitrant biomass substrate, and subsequently participates in conversion under the set conditions. Notably, the influence of various parameters such as temperature, time, solvent, and the synergistic function of $AlCl_3$ and HCl was critically examined to obtain 35–60% and 61–98% yields of 5-HMF and furfural, respectively, in 6 h at 180 °C. The quantification of products was scrutinized through UPLC and further reconfirmed *via* NMR and ESI-MS analysis techniques **(Fig. 1)**.

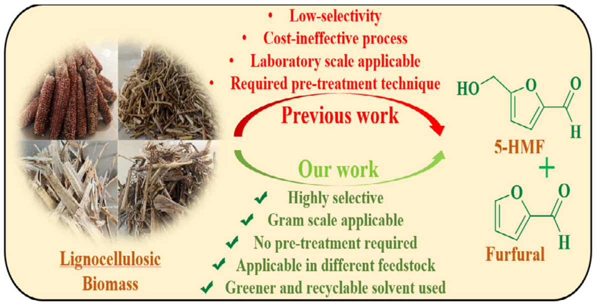

Fig. 1 Conversion of lignocellulosic biomass to 5-HMF and furfural.

A solid acid catalysed one-pot selective approach for 2,5-diformylfuran synthesis from fructose/carbohydrate feedstocks

A metal catalyst free synthesis of 2,5-diformylfuran (DFF) from fructose has been established using a one-pot greener approach. A user-friendly solid acid (Amberlite IR 120 H) was explored for the transformation of fructose into DFF to achieve the highest yield. High chemo-selectivity, recyclability of the solid acid up to seven cycles, and scalable and environmentally benign approaches are some remarkable advantages of the present process. In addition, the devised process was used to obtain DFF from a variety of low-cost feedstocks including fructose, sugar, sugarcane molasses, and jaggery, in an acceptable yield **(Fig. 2)**.

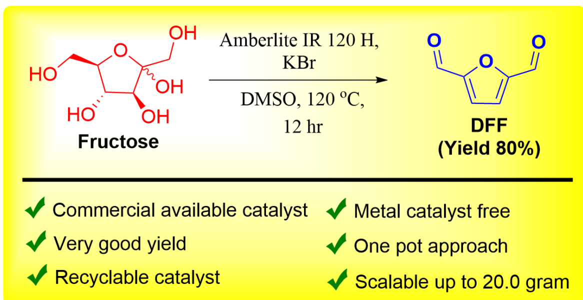

Fig. 2 One pot synthesis of 2, 5-Diformylfuran directly from fructose/ carbohydrate feedstocks.

Catalytic transformations for agro-waste conversion to 5-hydroxymethylfurfural and furfural: Chemistry and scale-up development

The overabundance of agro-waste and environmental concerns need sustainable and economical pathways as alternative sources of energy and vital industrial materials. In this review, we summarized a comprehensive view of the research on direct valorization of sugarcane bagasse, corn-stover, wheat straw, rice straw and husk to 5-hydroxymethylfurfural (5-HMF) and furfural (FAL) productions. The review briefly covers the journey of the scientific community over the last century in this area. The review pays special attention to the extraction and purification processes of such furans from reaction media, and then their further scale-up and commercial development. In addition, the challenges being faced by companies in commercial production have also been addressed. Therefore, this review will provide an in-depth knowledge to the readers about the chemistry of biomass conversion to 5-HMF and FAL, and gives future directions for further development in this area **(Fig. 3)**.

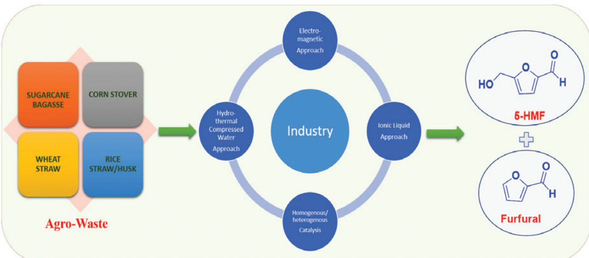

Fig. 3 General overview of agro-waste utilization to 5-HMF and furfural.

Supported-Pd catalyzed carbonylative synthesis of phthalimides and isoindolinones using oxalic acid as *in situ* CO surrogate with 2-iodobenzamides and 2-iodobenzylanilines in ppm-level catalyst loading

Polystyrene supported palladium (Pd@PS) nanoparticles (NPs) catalyzed intramolecular aminocarbonylation of 2-iodobenzamides and 2-iodobenzylanilines using bench stable oxalic acid as *in situ* CO source for the synthesis of phthalimides and isoindolin-1-one has been described. Low catalyst loadings (0.2 mol%, 2000 ppm Pd) with appreciable recyclability up to six cycles, external base free, oxalic acid as inexpensive and safer *in situ* C1 source and vast substrate scope are some remarkable features of the present protocol. Furthermore, we scale up the present reaction up to 1.5 gram **(Fig. 4)**.

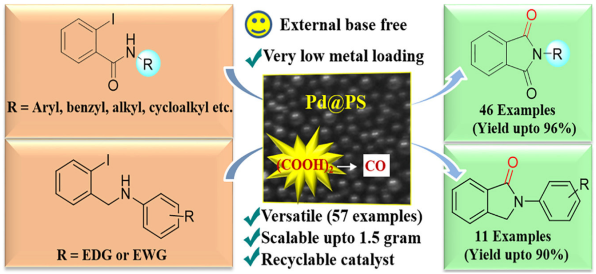

Fig. 4 Synthesis of phthalimides and isoindolinones under Pd@PS catalyzed conditions.

Methanol as a greener C1 synthon under non-noble transition metal-catalyzed conditions

The methanol valorization as safe, easily accessible as well as environmentally benign C1 synthon has captivated gigantic attention worldwide. It has surfaced as an increasingly powerful tool for the synthesis of various C-methylated, *N*-methylated, and O-methylated products having prominent application in materials, pharmaceuticals, drug designing and bulk chemicals.

Furthermore, from a sustainability viewpoint, the study and development of 3d-series based catalysts continue to be a significant step in stimulating the ecological as well as the economic value of any process. So, this review summarized as well as critically highlighted the recent ameliorations realized in the development of non-noble metal-based complexes as catalysts and their further application in methanol valorization for the synthesis of various highly valued pharmaceuticals, chemicals, and materials. Furthermore, the existing limitations and challenges in the concerned area, as well as the future outlook for the active expansion of the concerned field have also been discussed **(Fig. 5)**.

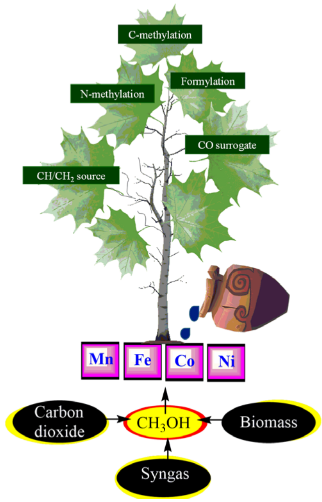

Fig. 5 Non-noble metal catalyzed methanol valorization as C1 surrogate.

Polystyrene stabilized Pd-Au nanoalloy for efficient synthesis of bis(indolyl) methanes from aryl iodides using oxalic acid as CO and H_2 source

A heterogeneously catalyzed carbonylative synthesis of bis(indolyl)methanes from aryl iodides in one-pot and single-step manner has been introduced. The reaction was catalyzed in efficient manner by polystyrene supported bimetallic Pd-Au (Pd-Au@PS) nanoparticles (NPs) in comparison to various supported monometallic Pd-catalysts. This protocol involves the application of oxalic acid as economic, solid, and safe multi-functional reagent which acts as a CO, H_2 source as well as acid co-catalyst with PEG-200 as green solvent reaction medium for delivering moderate to excellent yields of the desired bis(indolyl) methanes. The developed protocol is additive, phosphine ligand-free under air/moisture stable recyclable catalyst bearing easy accessibility/affordability to starting materials **(Fig. 6)**.

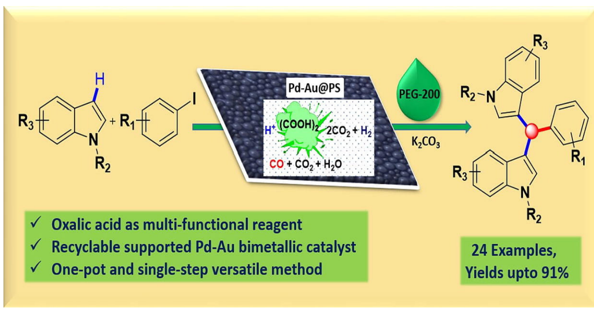

Fig. 6 Supported Pd-Au catalyzed carbonylative synthesis of bis(indolyl)methanes.

Recent Advances in Supported Bimetallic Pd-Au Catalysts: Development and Applications in Organic Synthesis with Focused Catalytic Action Study

Supported Pd-Au bimetallic catalysts (BMCs) can efficiently execute various important organic transformations. The major reason for launching Pd-Au bimetallic catalysis is either to perform the reaction with good atom economy under low catalyst/metal loading or to introduce a reaction, which cannot be performed by its monometallic variants. The optimized tuning between the catalyst support and the Pd/Au ratio always have been a deciding key factor for selectivity, stability, and activity of these catalysts as suggested by various mechanistic studies. This Review summarizes the recent advances in supported Pd–Au BMCs in terms of design strategies, characterizations for deep insight mechanistic study during the reaction course. The present review article could be really useful for researchers working in this dimension via providing them a clear catalyst design idea, preparation method, support selection strategy, and right substrate screening for carrying out the targeted synthetic transformation **(Fig. 7)**.

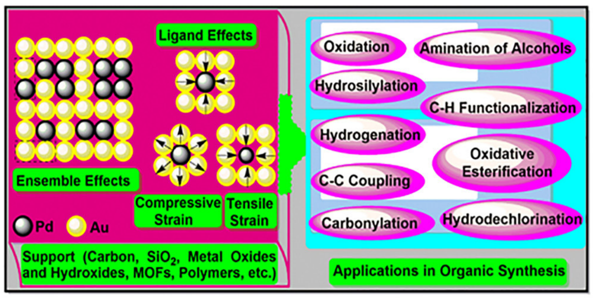

Fig. 7 Supported bimetallic Pd-Au catalysts and their applications in organic synthesis.

Research group: Mahender Kumar, Poonam Sharma, Pushkar Mehara, Rohit Bains, Ashish Kumar, Sheetal, Ajay Kumar Sharma, Arvind Singh Chauhan, Yamini, Ajay Kumar and Shankar Ram.

Relevant Publications:

- Green Chemistry. 2022, 24: 6125-6130.
- Renewable Energy. 2022, 197: 237-243.
- Journal of Industrial and Engineering Chemistry. 2022, 119: 199-207.

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Natural Product Chemistry and Bioprospection

Our research team is focuses on Natural Products Chemistry, specifically the extraction of essential oils (EOs) from various aromatic plants found in the Himalayan region, such as *Tagetes minuta*, *Dracocephalum heterophyllum*, *Juniperus communis*, *Hedychium spicatum*, and *Valeriana Jatamansi*. Our scientific research involves the isolation and characterization of novel compounds from these medicinal plants, as well as the evaluation of their in vitro activities. Additionally, we aim to enhance their value through semisynthetic derivatization and assess their biological properties. Furthermore, we are also providing training programs on quality control, standardization and botanical studies of electrohomeopathic medicines to support electrohomeopathic doctors.

Synthesis of Sulfur Containing Analogues of Hedychenone, a Labdane Diterpenoid from *Hedychium spicatum*

The labdane diterpene hedychenone, isolated from *Hedychium spicatum*, is an example of a furan-containing natural product. Herein, a new and efficient method for the synthesis of 19 new thio analogues of hedychenone is reported. The present methodology exhibits a broad substrate scope with good to excellent yields without metal or base under mild reaction conditions. The natural compound **1** and four semisynthetic derivatives (**3a**, **3b**, **3i**, and **3j**) exhibited strong α-glucosidase inhibition activity with IC_{50} values of 15.93 ± 0.29, 9.70 ± 0.33, 11.82 ± 0.06, 12.23 ± 0.33, and 12.15 ± 0.14 µg/mL, respectively. In addition, compound **3e** (6.0 ± 0.04 mm; zone of inhibition) displayed antibacterial activity against *Staphylococcus aureus*. This study increases the chemical diversity of bioactive hedychenone derivatives and provides a direction for the development of antidiabetic agents.

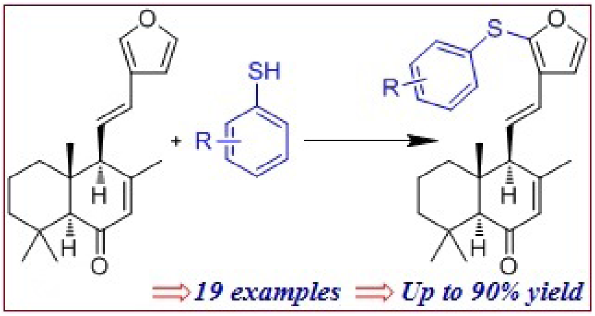

Fig. 1 Sulfur Containing Analogues of Hedychenone.

Essential Oil Composition, *in vitro* Biological Activities and Safety Evaluation of Cultivated *Hedychium spicatum* Seeds

The objective of this study was to examine essential oil composition, biological activities and safety evaluation of *Hedychium spicatum* seeds. The phytochemical constituents of essential oil were investigated using gas chromatography-flame ionization detector (GC-FID) and gas chromatography-mass spectrometry (GC-MS). Twenty-three components were characterized, representing 97.8 % of the total essential oil. Major components of the essential oil were found as β-pinene (64.0 %), α-pinene (17.0 %), α-humulene (5.4 %) and E-caryophyllene (4.2 %). The obtained essential oil was evaluated for anticancer activity against human skin carcinoma A431, human lung carcinoma A549 and human cervical cancer SiHa cells, which showed half maximal inhibitory concentration values 71.2, 96.9 and 171.7 µg/ml, respectively. The toxicity of the essential oil was assessed against mouse splenocytes using (3-(4,5-dimethylthiazol-2-yl)-2,5-diphenyltetrazolium bromide) assay. Also, the oil was tested against a series of gram-positive and gram-negative bacteria. *Bacillus subtilis* MTCC121 was the most susceptible to the essential oil with minimum inhibitory concentration at 1 % v/v. The observed findings indicated that essential oil possess good cytotoxicity as well as antibacterial properties.

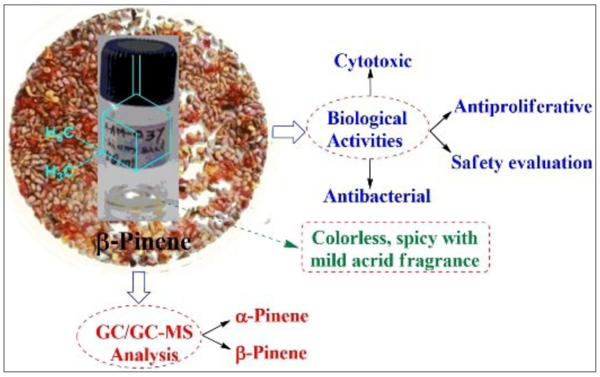

Fig. 2 Essential Oil Composition, *in vitro* Biological Activities of *Hedychium spicatum* Seeds.

Chemical profiling and α-glucosidase inhibitory activity of essential oils extracted with two methods from some North western Himalayan aromatic crops

Solvent-free hydrodistillation adsorption apparatus (HDA) and normal clevenger hydrodistillation (NC) were applied to obtain *Juniperus communis*, *Valeriana jatamansi* and *Hedychium spicatum* essential oils (EOs). The yields, chemical compositions and α-glucosidase inhibitory activity of the EOs were investigated. Obtained EOs were analyzed using GC-FID, GC-MS and nuclear magnetic resonance (NMR) instruments. Recovery improvement was observed in HDA method (30.4%, 27.3% and 29.0% more recovery of EOs than NC method for *V. jatamansi*, *H. spicatum* and *J. communis*, respectively). Present results demonstrated NCV (*V. jatamansi* EO (essential oil) by NC method) had highest α-glucosidase inhibitory activity with half-maximal inhibitory concentration (IC_{50}) values of 8.20 µg/mL. As a result, HDA method is considered to be the promising theme for producing EOs with high production recovery. Furthermore, current findings demonstrated that the selected EOs may be a good natural antidiabetic.

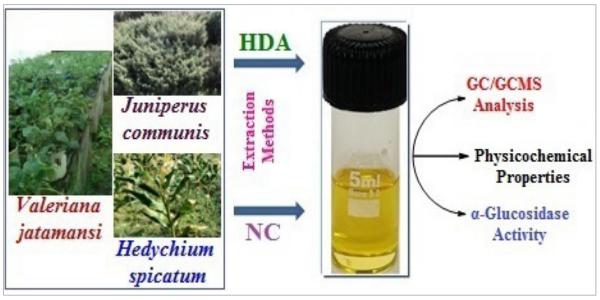

Fig. 3 Chemical profiling and α-glucosidase inhibitory activity of essential.

Chemical Diversity and α-Glucosidase Inhibitory Activity in Needles Essential Oils of Four *Pinus* Species from Northwestern Himalaya, India

This work describes the study of the chemical profiling and α-glucosidase inhibitory activity of essential oils (EOs) from four *Pinus* species (*P. wallichiana*,*P. patula*,*P. roxburghii*and*P. gerardiana*). The identification and quantification of EOs metabolites were performed by GC-MS, GC-FID and ^{13}C-NMR. The needles of *P. wallichiana* and *P. gerardiana* presented the highest oil yields (0.35 % and 0.36 %, respectively). Twenty-four constituents were characterized in among samples exhibiting 93.8–97.7 % of the total EOs. The components and yields of the targeted samples were varied according to the species. Major components of the oils were α-pinene (20.5–34.1 %), β-pinene (1.4–53.0 %), δ-3-carene (0.2–47.0 %), limonene (1.7–13.4 %), β-phellandrene (0.2–23.4 %), β-myrcene (1.8–7.2 %) and α-terpinolene (0.6–7.9 %). The extracted EOs showed strong α-glucosidase inhibitory activity, which was close to the positive control, acarbose. This study showed that the EOs of *Pinus* species may be used as natural antidiabetic.

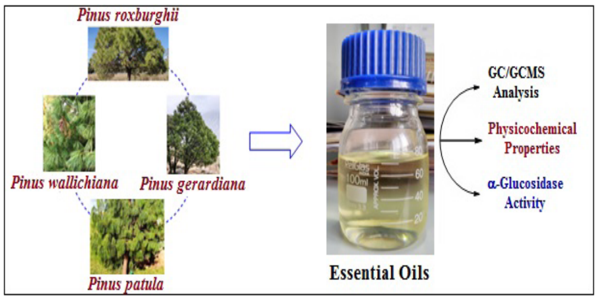

Fig. 4 Chemical Diversity and α-Glucosidase Inhibitory Activity in Needles Essential Oils of Four *Pinus* Species.

In vitro antidiabetic and antimicrobial activity of _Dracocephalum heterophyllum_ Benth. essential oil from North-western Himalayas India

Dracocephalum heterophyllum belongs to family Lamiaceae is an annual or perennial wild herb native from the north Indian region of higher altitude including Ladakh, Himachal Pradesh. Uttarakhand and Sikkim *D. heterophyllum* utilized for isolation of EOs. The EOs extracted from different sites had variation in the yield (0.1–0.8 % v/w) and composition with β-citronellol (31.5–83.7 %) as a principal component. The EOs showed promising antimicrobial activities and anti-diabetic activity exhibits excellent α-amylase and better *α*-glucosidase enzymes inhibitor properties.

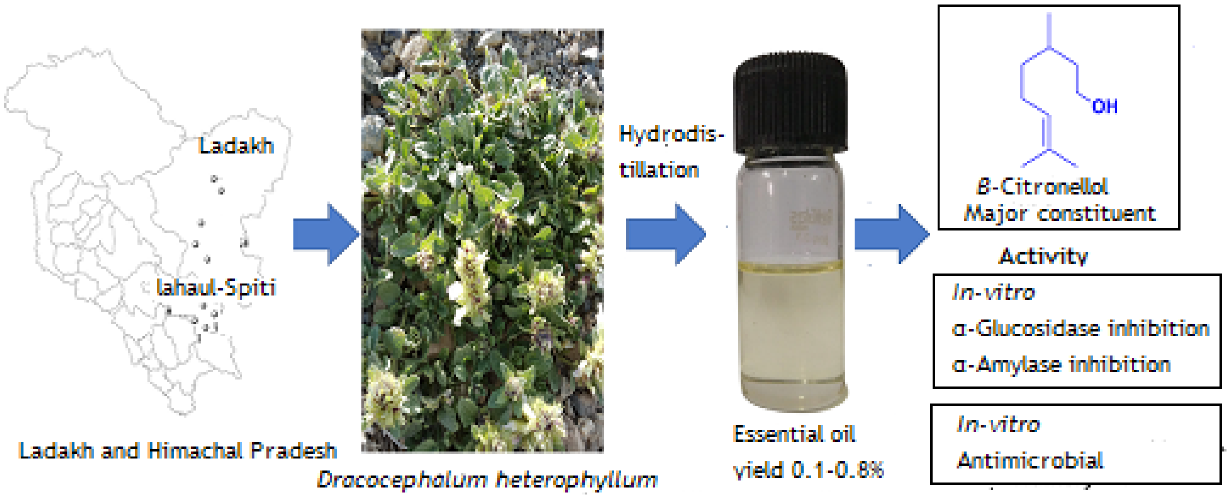

Fig. 5 Collection sites and activities of _D. heterophyllum_ essential oil.

Research group: Ram Chander

Relevant Publications:

- Journal of Natural Products. 2022, 85(7): 1691-6.
- Natural Product Research. 2023, 37(4): 638-41.
- Chem. Biodivers. 2022, 19(12): e202200428.

Mohit Sharma, Principal Scientist
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Chemical Technology Division

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

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

Essential oils are the main economic ingredient of the aromatic crops which are extracted by means of distillation. To enable farmers to distill the oil from their crop four improved multipurpose essential oil distillation units were designed, fabricated, installed commissioned at Lahaul & Spitti, Kangra & Una to various registered societies under Mission Aroma Phase-II **(Fig. 1)**

Fig. 1 Installation and commissioning of improved distillation units at farmers' sites under Mission Aroma Phase-II.

Experimental study on application of multicomponent natural deep eutectic solvents as a super solvent for the efficient extraction of steviol glycosides (rebaudioside A) from *Stevia rebaudiana*

Using biomass to produce valuable chemicals has tremendous economic significance; however, in some cases, it poses environmental challenges due to the use of organic solvents. Natural Deep Eutectic Solvents (NADESs), a sustainable and bio-based functional liquid medium, can be a greener substitute for organic solvents to extract chemical scaffolds from biomass. Although water is an environmental-friendly solvent, it's challenging to tune its selectivity toward extracting a particular class of molecules from biomass. In contrast, NADESs selectivity toward extracting diverse types of molecules can be easily adjusted by a simple variation of the molar ratios of its components. In the current study, *Stevia rebaudiana*, a well-known calorie-free sweetener, was targeted to extract steviol glycosides. The quantification results revealed that *NADES 50* (lactic acid: glycerol: malic acid: glucose, 1:1:1:1) was most efficient to extract, *e.g.*, 38.24 ± 2.22 mg/g and 114.58 ± 5.89 mg/g of rebaudioside A (**SG2**) and stevioside (**SG3**), respectively. However, *NADES 36* (choline chloride: lactic acid: oxalic acid: glycerol, 2:2:1:1) extracted all targeted analytes (90.69 ± 3.10 mg/g) along with untargeted compounds. The extraction carried out with the optimized parameters was improved by 33.77% and 24.86% in terms of extraction yields of steviol glycosides by *NADES 50* and *NADES 36,* respectively. The crude steviol glycosides were efficiently separated from the NADESs using HP-20 resin. The extraction efficiency of recovered NADES was 30–36% lower than that of their fresh counterparts. The structure of both NADES *i.e., NADES 50 and NADES 36* matrices, was characterized by NMR spectroscopy to confirm their structural arrangement. The current study concluded that multicomponent NADESs have excellent extractability of steviol glycosides from the leaves of *S. rebaudiana* compared to binary NADESs.

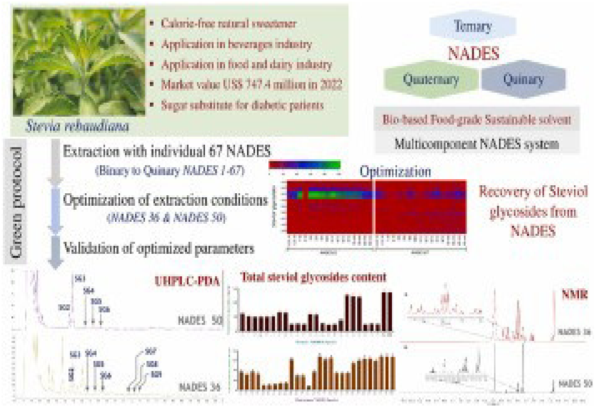


Fig. 2 NADES based extraction of steviol glycosides.

Development of process for extraction volatile compounds from *Valeriana jatamansi*

In our continued previous work, an efficient process is developed for extraction of volatile oil from *Valeriana jatamansi* rhizomes. The pre extraction parameters such as temperature and pressure, flowrate, extraction time etc. were also optimized. The qualitative comparison of essential oil has been done between the essential oil obtained from hydro distillation and supercritical fluid extraction. **(Fig. 3)** Salient highlight of the process is:

- *Valeriana jatamansi* essential oil is extracted from rhizome and is high valued due to its therapeutic properties (Priced 30000/kg)
- Conventional method hydro distillation (HD) for oil extraction is lengthy (24 hrs) and oil yield is low (1-2.2% w/w basis)
- Efficient, less time consuming Supercritical fluid extraction (SFE) based process is developed with average max. oil yield 6.59 % (w/w basis) in 180 minutes with superior quality

Fig. 3 Efficient process for *Valeriana jatamansi* oil extraction.

Value addition and Product Diversification in Tea (DBT-NER sponsored project)

Tea industries mainly do primary processing of green tea leaves in form of green, black, oolong tea, etc. and most of the tea is exported in its primary processed form. Due to the steady production of tea, the world market price of processed tea got stagnated with supplies being stable and escalating production costs with decreasing returns for the tea growers. Tea contains a range of soluble substances such as caffeine, theanine, chlorophyll, organic acids, and vitamins (Graham, 1992). The value addition to tea by introducing new process innovations will open diversified application of these products in many industries such as pharmaceuticals, cosmetics etc. Therefore, there is a need to look into new innovative processes, diversified products to fetch more returns and make it more economical. Thus, value addition and product diversification in tea will help improve the profit margin from commercial aspects and consumer acceptance with a new outlook, flavor, taste, and health benefits. In this project we have developed a lab scale process for multi –product (polyphenols, lipids, pigments) extraction from green tea leaves. Tea residue studies for nutraceutical potential is under way.

Demonstration of Process Technology to stakeholders

Demonstration of process for extraction of colouring compounds from *Arnebia eucroma* with an overall yield of 2.7 % was shown to representative of M/s Nanotech Chemical Brothers Pvt. Ltd, Chandigarh at pilot plant chemical technology division (CTD) as per MoU with firm **(Fig. 4)**.

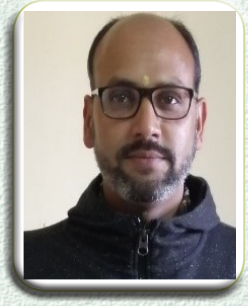
Fig. 4 Demonstration of colour extraction process at pilot plant.

Processing of Damask rose flowers on pilot plant: Fresh damask rose flowers were processed on pilot plant. Total 935 kg rose flowers were distilled to produce 800 liters rose water for sale and complimentary samples.

Formulation of Stevia with industry:

Production of Stevia liquid & powder formulation was done as per developed green process for direct processing of dry stevia leaves into formulated liquid drops on processing charges basis as per MoU terms & conditions with following parties for

- M/s USAS, Palampur
- M/s Agri Natural India, Ludhiana



Upendra Sharma, Principal Scientist

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

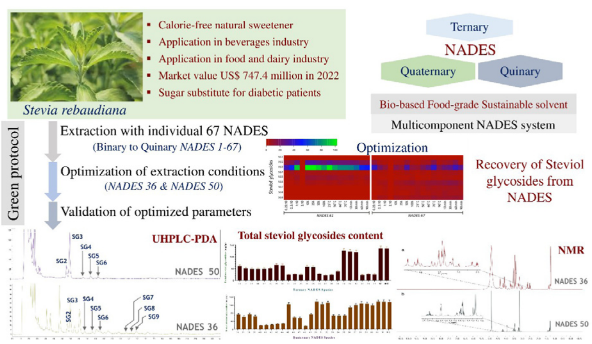
Our group is involved in the development of a catalytic method for the synthesis of bioactive quinolines. This year five novel catalytic methods have been developed for the synthesis of >115 new quinolines derivatives via innovative C-H activation/ functionalization strategy.

In natural product chemistry, our group is involved in phytochemical investigation of medicinal plants. This year we have developed NADES based new approach for the selective extraction of important metabolites from *Stevia rebaudiana* and Trillium *govanianum*. Phytochemical investigation of *Cissampelos pareira* led to the isolation of three molecules including a new alkaloid. Further LC-MS/ MS and GC/GC-MS based methods were developed and applied for the qualitative analysis of *Ferula assa-foetida*.

Phytochemical Investigation

Commercially Important Crops

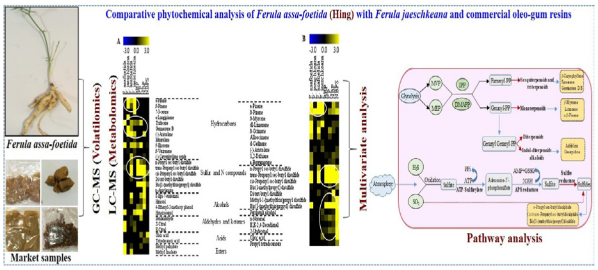
Multicomponent natural deep eutectic solvents: Super solvents for the efficient extraction of steviol glycosides (rebaudioside A) from *Stevia rebaudiana*: Using biomass to produce valuable chemicals has tremendous economic significance; however, in some cases, it poses environmental challenges due to the use of organic solvents.



Journal of Cleaner Production, 2023, *385*, 135639.

Natural Deep Eutectic Solvents (NADESs), a sustainable and bio-based functional liquid medium, can be a greener substitute for organic solvents to extract chemical scaffolds from biomass. Although water is an environmental-friendly solvent, it's challenging to tune its selectivity toward extracting a particular class of molecules from biomass. In contrast, NADESs selectivity toward extracting diverse types of molecules can be easily adjusted by a simple variation of the molar ratios of its components. In the current study, *Stevia rebaudiana*, a well-known calorie-free sweetener, was targeted to extract steviol glycosides. The quantification results revealed that NADES 50 (lactic acid: glycerol: malic acid: glucose, 1:1:1:1) was most efficient to extract, e.g., 38.24±2.22 mg/g and 114.58±5.89 mg/g of rebaudioside A (SG2) and stevioside (SG3), respectively. However, NADES 36 (choline chloride: lactic acid: oxalic acid: glycerol, 2:2:1:1) extracted all targeted analytes (90.69±3.10 mg/g) along with untargeted compounds. The extraction carried out with the optimized parameters was improved by 35.57% and 24.86% in terms of extraction yields of steviol glycosides by NADES 50 and NADES 36, respectively. The current study concluded that multicomponent NADESs have excellent extractability of steviol glycosides from the leaves of *S. rebaudiana* compared to binary NADESs.

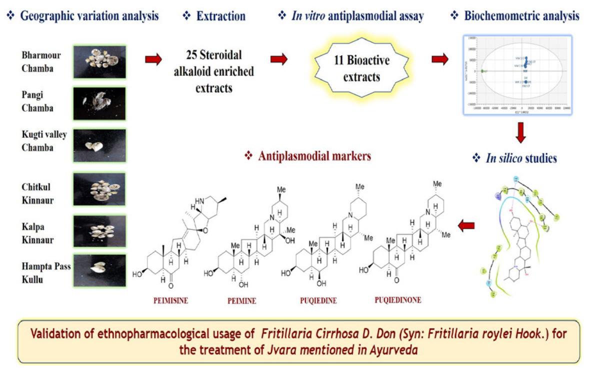
Comparative phytochemical analysis of *Ferula assa-foetida* with *Ferula jaeschkeana* and commercial oleo-gum resins using GC-MS and UHPLC-PDA-QTOF-IMS: *Ferula assa-foetida* is an important species of the genus Ferula, best known for its oleo-gum resin, mainly used as a flavoring agent. *Ferula jaeschkeana* is another Himalayan medicinal plant of this genus, known for its contraceptive effect but not used in food applications. This study aimed to do a detailed phytochemical analysis of *F. assa-foetida* growing under controlled conditions in India using GC-MS/headspace and UHPLC-PDA-QTOF-IMS. Further, a comparative analysis of *F. assa-foetida* was performed with *F. jaeschkeana* (collected from its natural habitat) and commercial samples of *F. assa-foetida* oleo-gum resin (collected from the local market). UHPLC-QTOF-IMS profiling of *F. assa-foetida* led to the identification of foetisulfide C, assafoetidnol A, gumosin, flabellilobin (A/B), and foetisulfide A. In total, 141 metabolites were identified, including vitamins, nucleosides, sulfur compounds, flavonoids, sugars derivatives, and others, using METLIN database. Characteristic sulfurous compounds (*n*-propyl-*sec*-butyl disulfide, *trans*-propenyl-*sec*-butyl disulfide, *cis*-propenyl-*sec*-butyl disulfide, and bis[1-(methylthio)propyl] disulfide) were identified in all samples except *F. jaeschkeana*. PCA and cluster analysis showed a significant difference in the volatile constituents of rhizomes of both species. The current study demonstrates, "why only *F. assa-foetida* is used in culinary applications instead of *F. jaeschkeana*"?



Food Chemistry International, 2023, *164*, 112434.

Traditionally Important Crops:

Antiplasmodial activity of the bulbs of *Fritillaria cirrhosa* D.Don (Syn: *Fritillaria roylei* Hook.): UPLC-IM-Q-TOF-MS/MS-based biochemometric approach for the identification of marker compounds: The aim of this study was to investigate the antiplasmodial effects of the extracts/fractions of *F. cirrhosa* bulbs by the biochemometric approach and to rationalize its ethnopharmacological usage for jvara (fever) related conditions such as malaria. This study involves the UHPLC-MS-based plant material selection, preparation, quantification, and assessment of *F. cirrhosa* bulb extracts against CQ-sensitive *Pf* 3D7 & CQ-resistant *Pf* INDO strains. Further, UPLC-IM-Q-TOF-MS-based biochemometric approach has been applied for the identification of marker compounds responsible for the observed antiplasmodial effects. The identified marker compounds were also assessed for their *in silico* ADMET properties and binding efficacy with the drug transporter *Pf* CRT. Different *F. cirrhosa* bulb extracts/fractions showed promising antiplasmodial activity with IC_{50} values 2.71 - 19.77 µg/mL for CQ-resistant *Pf* INDO strain and 1.76 - 21.52 µg/mL for CQ-sensitive *Pf* 3D7 strain. UPLC-IM-Q-TOF-MS-based biochemometric analysis revealed four marker compounds *i.e.*, peimine (m/z 432.3448), peimisine (m/z 428.3504), puqiedinone (m/z 414.3379), and puqiedine (m/z 416.3509) responsible for the observed antiplasmodial activity. The identified marker compounds showed excellent binding efficacy with *Pf* CRT and suitable drug-like properties *in silico*.

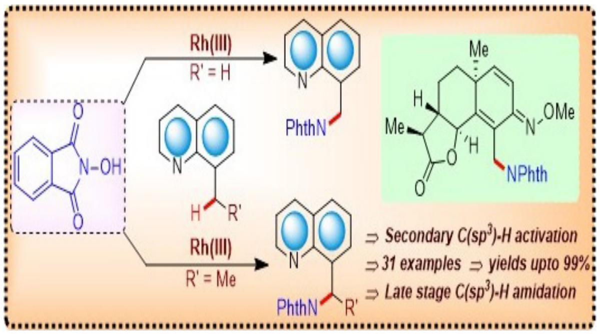


Journal of Ethanopharmacology, 2023, *310*, 116389.

Organic Synthesis and Catalysis:

Regioselective C(sp^3)-H Amidation of 8-methyl Quinolines with N-hydroxyphthalimides: A Rh(III)-catalysed C(sp3)-H bond amidation of 8-methylquinolines by using *N*-hydroxyphthalimides as amidation source is explored. Diversely substituted 8-methylquinolines were well tolerated and furnished the amidated products in excellent yields with high regioselectivity. The developed reaction conditions were also applied successfully for the secondary C(sp^3)-H amidation of 8-ethylquinolines.

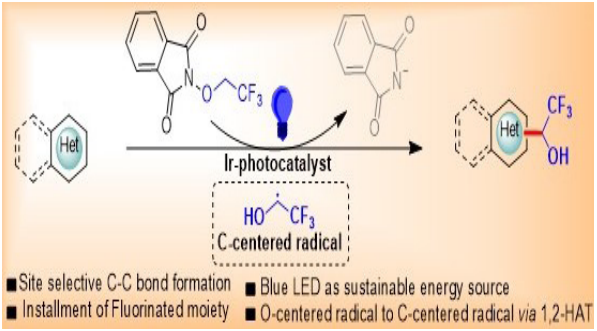
Besides that the reaction is also applicable for the gram-scale synthesis of the amidated product. In addition, the late-stage amidation of santonin oxime as well as carvone oxime and the diversification of the amidated product was also carried out to illustrate the relevance of the developed methodology. The mechanistic studies revealed that the current reaction proceeds through a five-membered rhodacycle intermediate and does not involve the radical pathway.



Chemical Communications, 2022, 58, 13151-13154.

Photoredox Minisci-type hydroxyfluoroalkylation of isoquino-lines with N-trifluoroethoxyphthalimide:

A straightforward photocatalytic approach has been demonstrated to incorporate trifluoroethanol unit onto the isoquinolines. Herein, we report *N*-trifluoroethoxyphthalimide as hydroxyflouroalkyl radical precursor, enabling efficient synthesis of trifluoroethanol substituted heteroarenes. Radical quenching experiments confirmed the involvement of free radical pathway under developed photocatalytic condition. The DFT calculations confirmed the intramolecular 1, 2-HAT reactivity of O-centered trifluoroethoxy radical (generated from N-trifluoroethoxyphthalimide under photocatalytic condition) to C-centered trifluoroethanol radical. Fluorescence quenching studies suggested that isoquinoline was responsible for the quenching of Ir-photocatalyst emission. A catalytic cycle involving trifluoroethanol radical reaction with isoquinolines has been proposed.



The Journal of Organic Chemistry, 2023, *88*, 2314-2321.

Research group: Ankita Thakur, Anmol, Devesh Chandra, Diskha Parmar, Gaurav Aggarwal, Manisha, Manish Kumar Gupta, Mehak Sharma, Prateek Singh Bora, Prithvi Pal Singh, Raman Singh, Rohit Kumar, Sachin, Sarthi, Shiv Shankar Gupta, Shivani, Shivani Puri, Sumit, Surekha Kumari and Tamanna Sharma.

Relevant Publications:

- Food Chemistry International. 2023, 164: 112434.
- Journal of Cleaner Production. 2023, 385: 135639.
- Chemical Communications. 2022, 58: 13151-4.

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Chemical Technology

In the area of natural colors/dyes, our group is involved in the development of green routes for extraction and stabilization of natural pigments from plants/vegetables and valorization of left over after color extraction. This year we had studied the effects of various parameters i.e. temperature, sunlight, oxygen and storage for color attributes and shelf life of anthocyanins and also valorized the red cabbage pomace for extraction of pectin and its utilization as stabilizing agent to anthocyanins from *Rhododendron arboreum*.

In phytochemical investigation of medicinal plants, our group is involved in isolation and structure elucidation of bioactive molecules from *Swertia* species (*chirata, cordata* & *ciliata*), *Thalictrum foliolosum, Juglans regia* and *Rhododendron arboreum*. Besides, quantitative and qualitative analysis have also been carried out using UPLC and UPLC-IMQTOF-MS/MS. In *Rhododendron arboreum* a total of 25 compounds have been characterized. In another plant, *Juglans regia*, 5 compounds have been quantified in samples of different regions of Himachal Pradesh and Jammu & Kashmir and also characterized 62 compounds by UPLC-IMQTOF-MS/MS.

Natural colors/dyes

1. Impact of temperature, oxygen, sunlight and storage in anthocyanins of Red cabbage

The study insights into the effect of temperature (80-160 °C), oxygen, sunlight, and storage on color attributes, shelf-life, and anthocyanins content on red cabbage (RC) anthocyanins (ANS) and their in-vitro bioaccessibility. After optimization of various encapsulating agents, the maltodextrin in combination with RC waste derived-pectin (MPC) was used to stabilize the anthocyanins. The stability of encapsulated and non-encapsulated anthocyanins was accomplished in terms of total anthocyanin content under temperature, oxygen, sunlight, and storage. Under different parameters, the individual content of 3, 5-*O*-diglucoside and 3-*O*-glucoside of cyanidin in anthocyanins encapsulated with MPC observed was 1.76% (sunlight), 1.56% (oxygen) & 1.8% (4 °C), 1.62% (25°C) and 0.17% (sunlight), 0.15% (oxygen) & 0.259% (4°C), 0.258% (25°C) respectively. The encapsulated anthocyanins showed significantly improved stability against oxygen, sunlight, high temperature, and storage, with the highest anthocyanin retention, color, and hue angle, inducing very few color differences (ΔE). Besides, the MPC-ANS appeared to be a suitable encapsulating agent to delay anthocyanin release throughout the simulated gastrointestinal digestion **Fig. 1**.

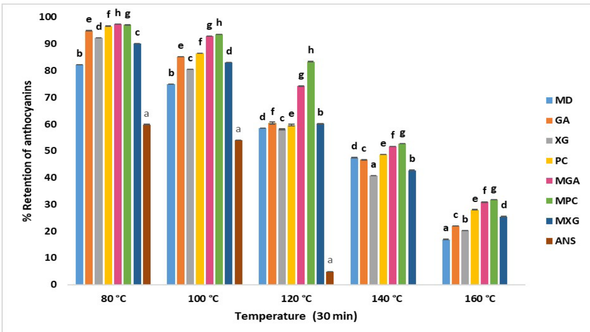


Fig. 1 Percentage retention of red cabbage anthocyanin based microcapsules during thermal exposure in the range 80 °C-160 °C; over 30 min.

In-vitro anthocyanin release study in artificial gastrointestinal juices

The results exhibited that MPC exhibited higher encapsulation efficiency (95.74±0.88 %) compared to other encapsulates. In addition the MPC, also exhibited efficient thermal stability and shelf life stability. Thereby, MPC and RC were evaluated for *in vitro* anthocyanin release study in artificial gastrointestinal juices. Interestingly, a significant difference ($p<0.05$) with maximum anthocyanin release as 70.91±1.87% and 49.64±0.11% was observed among RC and MPC respectively at 120 min **(Fig. 2)**. The probable reason could be the exposure of RC and MPC to heat *via* incubation at 37 °C for a longer duration (Norcino et al., 2022). However, in SIF the anthocyanins exhibited a constant release till the end of digestion with a minimum release of 29.67±1.01 % in MPC compared to RC unveiling anthocyanin release of 68.18±1.20 %. This could attribute to the conversion of anthocyanins into hemiketal, quinoidal, and chalcone at higher pH of SIF responsible for maximum degradation and lower anthocyanin bioavailability. Fascinatingly, maltodextrin and pectin encapsulation resulted in maximum anthocyanin stability with sustained release positively correlated to the previously reported literature for anthocyanin release in gastrointestinal conditions. Additionally, maltodextrin has also been reported for inhibiting the conversion of anthocyanins demonstrating its suitability for encapsulation. Therefore, the present study provides substantial evidence on the interaction between the suitability of matrices (maltodextrin and pectin) w.r.t. anthocyanin stability in gastrointestinal conditions.

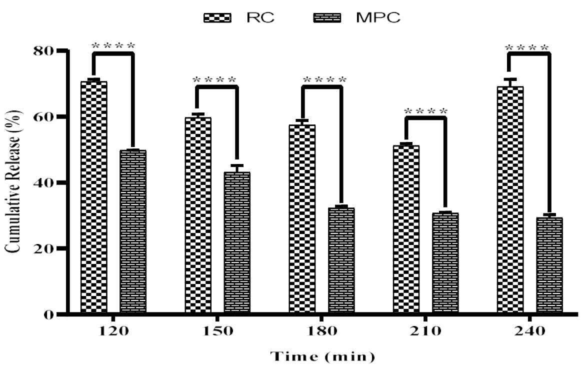
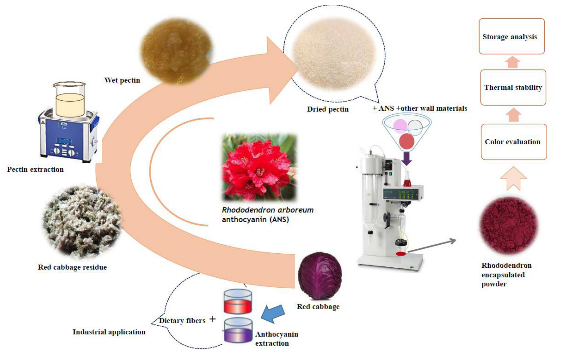


Fig. 2 Release profiles of MPC encapsulated and non-encapsulated red cabbage anthocyanins at simulated stomach and intestinal pH conditions over 250 min.

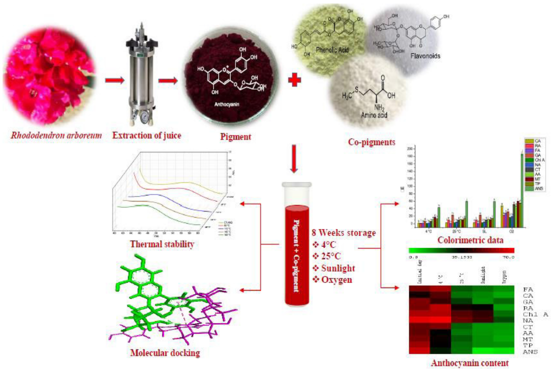
2. Valorization of red cabbage pomace for stabilization of anthocyanins in *Rhododendron arboreum*

This study was envisioned to valorize red cabbage pomace, an industrial waste produced during color and nutrition processing for extraction of pectin and its utilization to improve the stability of anthocyanins from commercially important *Rhododendron arboreum* flowers. To formulate microcapsules of anthocyanins by spray drying process; four distinct wall materials i.e., maltodextrin, gum arabic, pectin, xanthan gum and, their blends were used. The characteristic physicochemical properties of microencapsulated anthocyanins were evaluated for moisture content, glass transition temperature, water activity, particle size and morphology. The stability of microcapsules was evaluated for wall materials, heat, storage at different temperatures (25, 4 and -20 °C) and color parameters (L* a* b* E*) for 90 days of analysis. The findings revealed that combination of maltodextrin/pectin (2/1) exhibited the highest encapsulation efficiency and anthocyanins retention. These results are important findings to provide promising evidence on the possibility of utilizing red cabbage waste for useful biopolymers like pectin as a functional ingredient in the food industry.



3. Effect of co-pigments on anthocyanins of *Rhododendron arboreum* and insights into interaction mechanism

The impact of intermolecular copigmentation between five phenolic acids, two flavonoid and three amino acids with *R. arboreum* anthocyanins (ANS) and its isolated cyanidin-3-*O*-monoglycosides were investigated through experimental and theoretical approach. On addition of different copigments, phenolic acid induced strong hyperchromic (0.26-0.55 nm) and bathochromic shift (6.6-14.2 nm). The color intensity and stability of ANS with, storage at 4 °C & 25 °C, sunlight, oxidation and heat were evaluated by chromaticity, anthocyanin content, kinetic and structural simulation analysis. The strongest copigmentation reaction was observed with narningin (NA) and also showed high thermostability and highest half-life i.e. 3.39 h-1.24 h at 90-160 °C. The cyanidin-3-*O*-monoglycosides were analysed for their copigmentation effect and observations revealed that NA displayed best copigmentation effect to cyanidin-3-*O*-arabinoside (B) followed by cyanidin-3-*O*-galactoside (A), and cyanidin-3-*O*-rhamnoside (C). Additionally, structural simulation and steered molecular dynamics insights NA the most favourable co-pigment involving π-π stacking and H-bonding.



Effect of temperature on co-pigmented anthocyanins

After optimization of pigment to co-pigment molar ratio, the effects of selected co-pigments on the thermal stability of co-pigmented ANS solution and control were treated at 90 °C, 110 °C, 140°C, 160°C and analysed for spectrophotometric parameters and kinetic studies. Results depicted that higher temperature induced hypsochromic shift owing to more degradation under the temperature exposure.

Furthermore, the kinetic study was determined to evaluate the stabilization effects of co-pigmentation, and the results were summarized in Table 1. The R^2 indicated that the thermal degradation of anthocyanin profile followed the first order kinetic model. As shown in table 1, the degradation rate constant (k) value and half-life period ($t_{1/2}$) of all samples were affected by the temperature. The elevated temperature led to the rise in k values and reduction in $t_{1/2}$ values, which accounted for the degradation of anthocyanins under the heating treatment. From the results, it is concluded that the amino acids accelerated the degradation of anthocyanins. Under the treatment of 110°C-160°C, the $t_{1/2}$ values of NA-anthocyanin solution were higher than that of chlorogenic acid, rosmarinic acid and other copigmented- anthocyanin solutions, with a similar trend as that of 90°C. This thermal stability might be because of strong binding affinities of formed molecular complexes

Table 1 Parameters fitted to the degradation kinetics model of co-pigmented *R. arboreum* anthocyanins and control after thermal treatment at 90°C, 100 120°C, 140°C, and 160°C.

Samples	80°C		110°C		140°C		160°C	
	k×10^{-3} (min^{-1})	$t_{1/2}$(h)	k×10^{-3} (min^{-1})	$t_{1/2}$(h)	k×10^{-3} (min^{-1})	$t_{1/2}$(h)	k×10^{-3} (min^{-1})	$t_{1/2}$(h)
NA	3.4 (0.9785)	3.40	4.8 (0.9792)	2.41	6.0 (0.9851)	1.93	9.3 (0.9896)	1.24
RA	5.0 (0.9576)	2.31	4.9 (0.9883)	2.36	8.4 (0.9934)	1.38	11.6 (0.9844)	1.00
Chl A	6.2 (0.9752)	1.86	5.7 (0.9951)	2.03	10.9 (0.9871)	1.06	12.6 (0.9885)	0.92
CA	7.3 (0.9448)	1.58	9.3 (0.9959)	1.24	13.4 (0.9866)	0.86	21.1 (0.9821)	0.55
FA	8.0 (0.9093)	1.44	8.1 (0.9648)	1.43	13.1 (0.0131)	0.88	23.4 (0.9937)	0.49
GA	10.0 (0.958)	1.16	14.0 (0.9604)	0.83	18.9 (0.0189)	0.61	23.4 (0.9759)	0.49
AA	13.0 (0.9878)	0.89	18.6 (0.9913)	0.62	27.6 (0.9903)	0.42	29.6 (0.9783)	0.39
MT	13.2 (0.9422)	0.88	18.1 (0.9918)	0.64	26.6 (0.997)	0.43	31.5 (0.9815)	0.37
TP	12.0 (0.9833)	0.96	20.7 (0.9977)	0.56	23.0 (0.998)	0.50	29.6 (0.9968)	0.39
ANS	13.0 (0.9956)	0.89	20.9 (0.9936)	0.55	70.3 (0.9569)	0.16	0	0.00

Impact of co-pigments during storage

In order to evaluate the stability and to assess the influence of the investigated three different class of co-pigments, the co-pigmented samples were subjected to different storage conditions. Since oxygen and temperature are the most

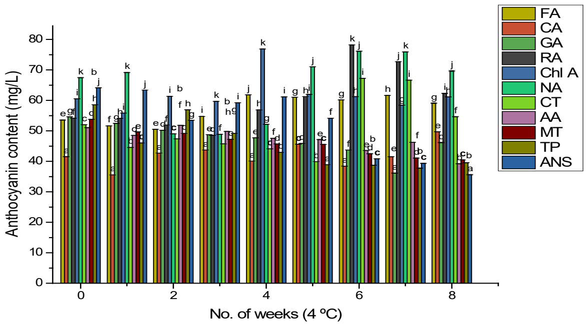


Fig. 3 Effect of co-pigmentation on anthocyanin content (mg/L) of *R. arboreum* model solution during 8 weeks of storage period at 4 °C.

detrimental factors for the degradation of anthocyanins, the samples were stored at 4 °C, 25 °C, together with exposure to sunlight and oxygen. The TAC (mg/L) at the first day of the experiment and during the storage of 8 weeks has been shown in the Fig. 3&4. At the start of storage, significant difference was observed between all analysed samples. On initial day of analysis, the TAC of the control was 64.19 mg/L while NA-copigmented anthocyanins exhibited significant increased TAC 67.51 mg/L ($p<0.05$).

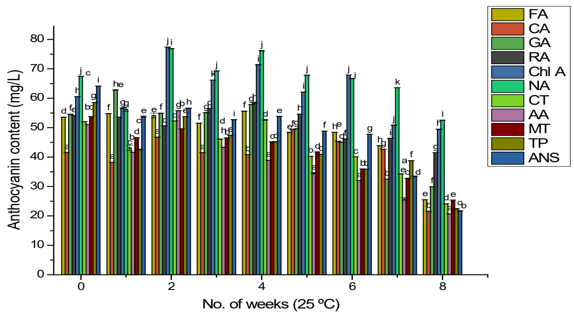


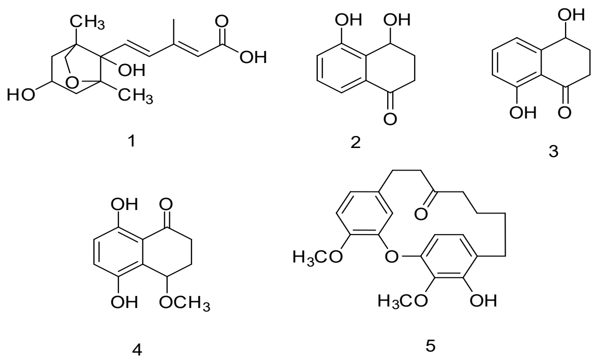
Fig. 4 Effect of co-pigmentation on anthocyanin content (mg/L) of *R. arboreum* model solution during 8 weeks of storage period at 25 °C.

4. Quantitative determination of specialized metabolites in different parts of *J. regia* L. and *C. illinoinensis* (Wangenh.) K. Koch by UPLC-DAD-QTOF-MS/MS

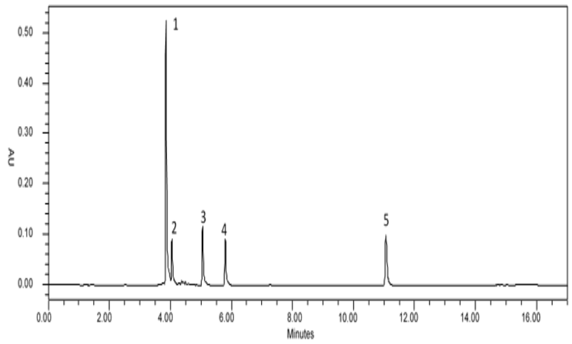
Juglans regia L.(walnut) and *Carya illinoinensis* (Wangenh.) K. Koch. (pecan) are two nut-producing tree species of the *Juglandaceae* family. These nuts provide nutritious kernels and are hence prized across the globe for the food and cosmetic industry. The literature described the origin of the *J. regia* plant in Persia, whereas *C. illinoinensis* in North America, however, their dissemination occurs worldwide including in Eastern China, Japan, and North India (Jammu and Kashmir and Himachal Pradesh).

C. illinoinensis is valued for its phenolic acids, flavonoids, flavonoid glycosides, tannins, naphthoquinones diarylheptanoids, and tetralones. The *J. regia* shares a similar secondary metabolite profile and is mainly phenolics however, it differs in unsaturated fatty acids content viz. linoleic acid (61%), oleic acid (15%), α-linolenic acid (12%), from the *C. illinoinensis* (oleic acid (45%) linolenic acid (43%) and palmitic acid (7%)). The *J. regia* has an ethnobotanical legacy and almost every part has been used, the bark possesses astringency and is applied as a miswaks in toothache. Topically fresh leaves are used in rheumatism and fever. The inflammatory bowel diseases were treated by kernels, whereas seed coats were used due to their wound-healing properties.

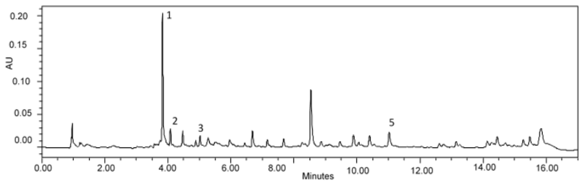
Here, we report the quantification of dihydrophaseic acid **(1),** 4, 5-dihydroxyteralone **(2),** 4, 8-dihydroxyteralone **(3),** 4, 8-dihydroxy-4-methoxyteralone **(4),** and juglanin A **(5)** in the pericarps and leaves of *J. regia*. and *C. illinoinensis*. Furthermore, using the hyphenated analytical method (UPLC-DAD-QTOF-MS/MS), a total of 62 compounds were tentatively characterized in different samples.



Structures of compounds



UPLC-chromatogram of Standards



UPLC chromatogram of samples at 271 nm (**1**: Dihydrophaseic acid, **2**:4, 5-dihydroxyteralone, **3**:4, 8-dihyroxyteralone, **4**: 4,8-dihydroxy-4-methoxy-teralone, **5**: Juglanin A

Research group: Shinde Bhagatsing Devidas and Nitisha Sendri.

Relevant Publications:

- Journal of Ethanopharmacology. 2023, 300: 115714.
- Industrial Crops and Products. 2022, 187: 115371.
- Journal of Separation Science. 2022, 45(14): 2555-65.

Dinesh Kumar, Principal Scientist

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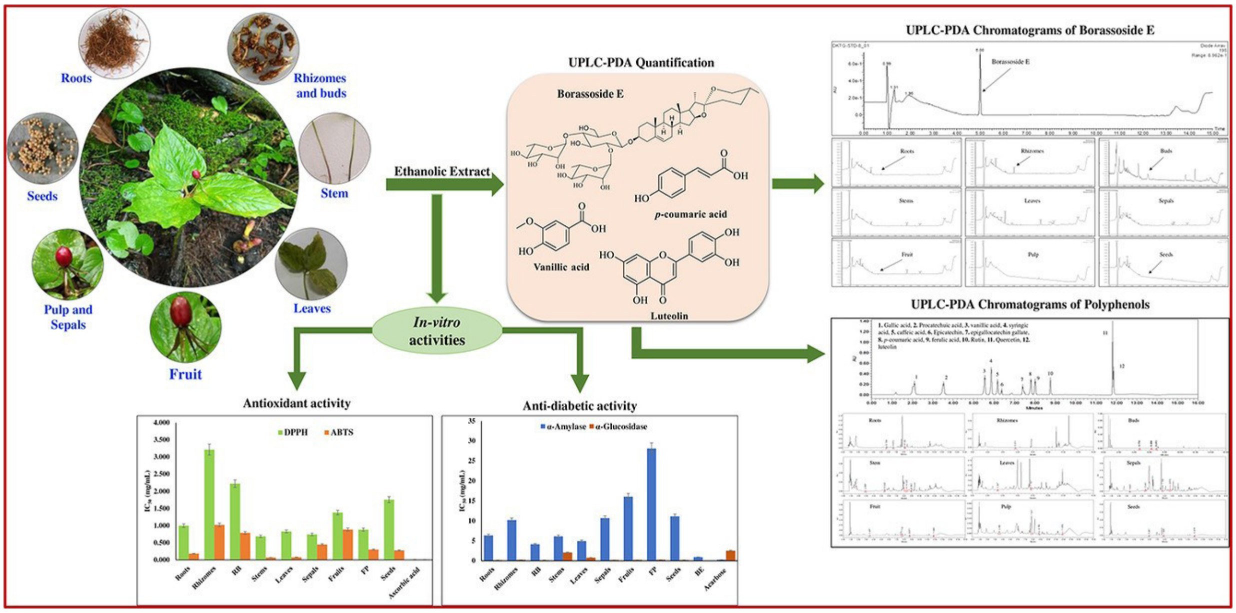
Chemical Technology Division, NMR, Metabolomics and Natural Product Chemistry

Bioresources of western Himalayas including medicinal and aromatic plants have a huge demand in herbal/ Pharmaceutical, food and cosmeceutical market. The potential demand causes intentional adulteration and non-standardized products. It was also observed that there is lack of chemical markers, quality control methods as well as scientifically developed products. Thus, to meet the industrial, MSMEs, startups and researcher/interventors requirements, our group has isolated chemical markers, developed methods and chemical signatures as quality control perspectives. Two products under CSIR missions have been developed that are under Phase-III clinical trial and Human intervention studies, respectively. Further, Various products [Hand sanitizer, hand wash, soap, hair oil, immunomodulator product (Tablet & syrup), Cartilage health product, Tea products, herbal dhoop etc.] were also developed and their technologies/ formulas were transferred successfully to the entrepreneurs. Furthermore, Various CM startup related products have also been developed and disseminated into the market and two of them are under clinical trial in Ayush mode. Furthermore, group is also working to find out mechanistic role of medicinal plants and their derived products. Process, Formulation and value addition is one of our key focused area.

Metabolomics studies

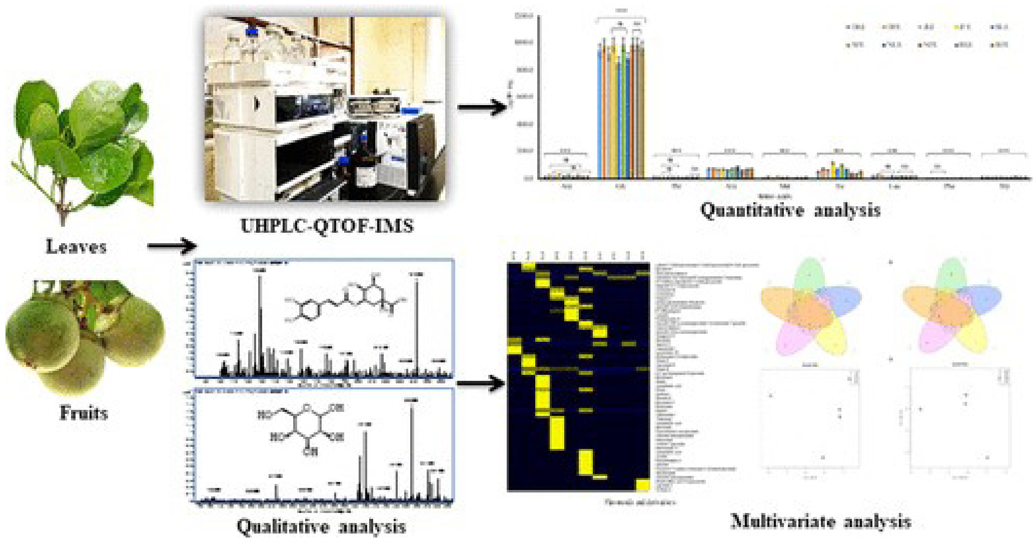
Metabolite profiling, antidiabetic, and antioxidant potential of different tissues of *Trillium govanianum* Wall. ex D. Don

Trillium govanianum Wall. ex D. Don (Melanthiaceae) is a medicinally important herbaceous plant and its rhizomes are claimed to have therapeutic effects in traditional health practices. In earlier reports, only rhizomes have been well explored for chemistry and efficacy, while aerial tissues are still underutilized. Due to overexploitation of *T. govanianum* for rhizomes, it is listed as extinct. To understand the potentials of aerial tissues in comparison to rhizomatous tissues, the present study was focused to estimate polyphenols, flavonoids, and saponin (Borassoside E) as well as *in-vitro* antidiabetic and antioxidant potentials. Ethanolic extract of fresh tissues (roots, rhizomes, rhizomatous buds, stems, leaves, sepals, fruits, fruit pulp, and seeds) were analysed to determine the total phenolics, flavonoids, and saponins content using spectrophotometric methods. Whereas, Borassoside E and targeted polyphenols were determined using UPLC-PDA methods. Current findings disclosed that phenolics and saponins were enriched in aerial tissues (sepals, fruits, and leaves) while borassoside E was found only in underground parts. All samples showed free radical scavenging and *α*-amylase inhibitory activity, while *α*-glucosidase inhibitory activity was present in all, except borassoside E. Both aerial and underground tissues of *T. govanianum* contained valuable polyphenols including flavonoids, and saponins. Borassoside E was found as a specific *α*-amylase inhibitor and will helps to prevent the degradation of starch. Alteration of targeted metabolites and activities were also observed within plant tissues. These results highlight the importance of aerial tissues for futuristic utilization and value addition. Further, study will help in quality control, agrotechnological interventions for captive cultivations.



UHPLC-QTOF-IMS-based metabolite fingerprinting of underutilized *Cordia myxa* fruits and leaves: A nutraceutical source

The present investigation focused on the chemical composition and metabolomics of *Cordia myxa* fruits and leaves collected from five locations in Himachal Pradesh, India. Both fruits and leaves exhibited a substantial amount of phenolics in the range of 9.65–26.22 mg GAE/g and 5.35–33.28 mg GAE/g, respectively, followed by appreciable flavonoid content. Higher antioxidant activity was detected in Shahpur leaf extract (SLE) (IC50ABTS 0.27 mg/mL) and Raja ka Talab fruit extract (RFE) (IC50ABTS 0.21 mg/mL) among different harvesting locations of C. myxa. A higher amount of vanillic acid and rutin was detected in Nagrota Surian fruits extract (NFE) by ultra-performance liquid chromatography quadruple time-of-flight ion mobility separation (UHPLC-Q-TOF-IMS). However, glycine, alanine, and isoleucine (ile) were also quantified at higher levels. Fruit extracts exhibited a promising amount of ascorbic acid and macro elements and microelements, whereas a total of 44 unknown compounds were identified by ultra-performance liquid chromatography quadruple time-of-flight ion mobility separation (UHPLC-Q-TOF-IMS) based on a non-targeted approach. This comprehensive metabolomics report brings new insights into metabolite distribution and its possible future implementations in food and nutraceuticals.

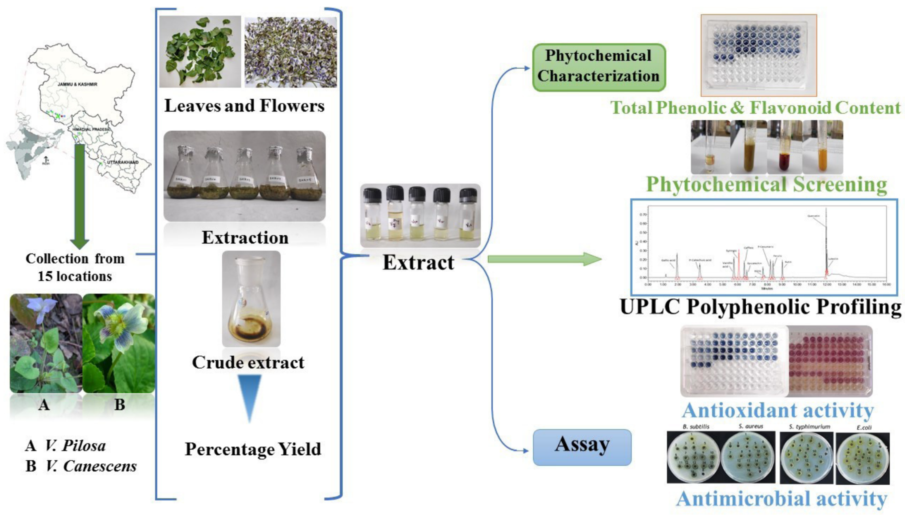


Polyphenolic profiling, antioxidant, and antimicrobial activities revealed the quality and adaptive behavior of Viola species, a dietary spice in the Himalayas

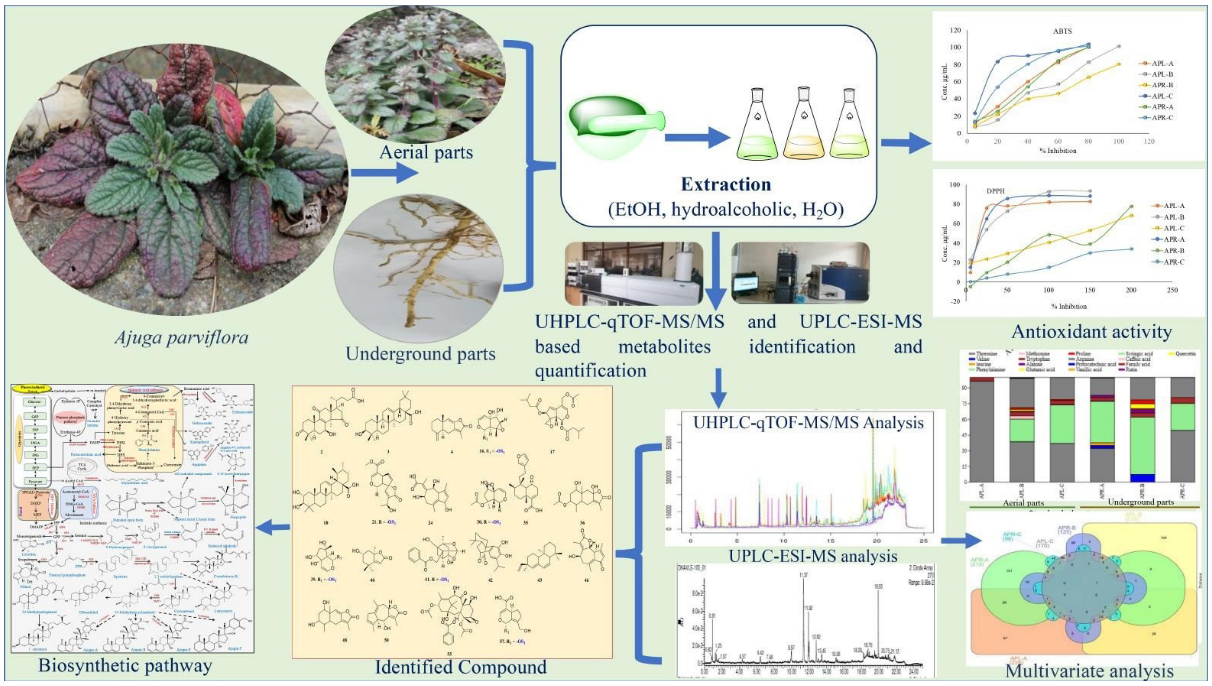
Background: Himalayan Viola species (Banksha) are traditionally important herbs with versatile therapeutic benefits such as antitussive, analgesic, antipyretic, antimalarial, anti-inflammatory, and anticancerous ones. The current investigation was focused on exploring polyphenolic profiles, antioxidant, and antimicrobial potentials of wild viola species at 15 gradient locations (375–1829 m). Methods: Morphological, physiochemical, and proximate analyses were carried out as per WHO guidelines for plant drug standardization. Total polyphenolic and flavonoid content were carried out using gallic acid and rutin equivalent. UPLC-DAD was used to profile the targeted polyphenols (gallic acid, vanillic acid, syringic acid, p-coumaric acid, ferulic acid, rutin, quercetin, luteolin, caffeic acid, and epicatechin). Similarly, all samples were screened for antioxidant and antimicrobial activity. Statistical analysis was used to correlate polyphenolic and targeted activities to assess Viola species adaptation behavior patterns. Results: Viola canescens (V. canescens) and Viola pilosa (V. pilosa) were found abundantly at their respective sites. Among flowers and leaves, flowers of V. canescens and V. pilosa showed higher total polyphenolic and flavonoid content (51.4 ± 1.13 mg GAE/g and 65.05 ± 0.85 mg RE/g, and 33.26 ± 0.62 mg GAE/g and 36.10 ± 1.41 mg RE/g, respectively). Furthermore, UPLC-DAD showed the uppermost content of p-coumaric acid in flowers and ferulic acid in leaves, while rutin was significant in both the tissues. Conclusions: The adaptive behavior of Viola species showed variability in morphological characters with the altitudes, while targeted polyphenols and activities were significant at mid-altitudes. This research helps in the selection of right chemotype for agrotechnological interventions and the development of nutraceutical products.

Metabolome analysis, nutrient and antioxidant potential of aerial and underground parts of *Ajuga parviflora* Benth

Ajuga parviflora is a traditionally important herb to treat fever, diarrhoea, obesity, and diabetes. Earlier reports suggested that a limited chemical including nutritional information's are available for *A. parviflora*. Hence, its metabolome analysis, nutritional and antioxidant activities are required to understand the role in health benefits. Metabolomics studies of aerial and underground part extracts (water, ethanol and 50 % ethanol) of *A. parviflora* were performed using UPLC-ESI-MS, UHPLC-Q-TOF-IMS coupled with multivariate statistical analysis. An UPLC-ESI-MS had identified sixty metabolites while 675 were using UHPLC-Q-TOF-IMS data-based search against METLIN database. Among thirteen targeted polyphenols, eight polyphenols were shown presence with higher concentration of vanillic acid (0.057 ± 0.002 mg/g), caffeic acid (0.002 ± 0.001 mg/g), and ferulic acid (3.766 ± 0.054 mg/g). Further, total phenolics (TP), flavonoids (TF), iridoid (TI) contents, nutritional components, amino

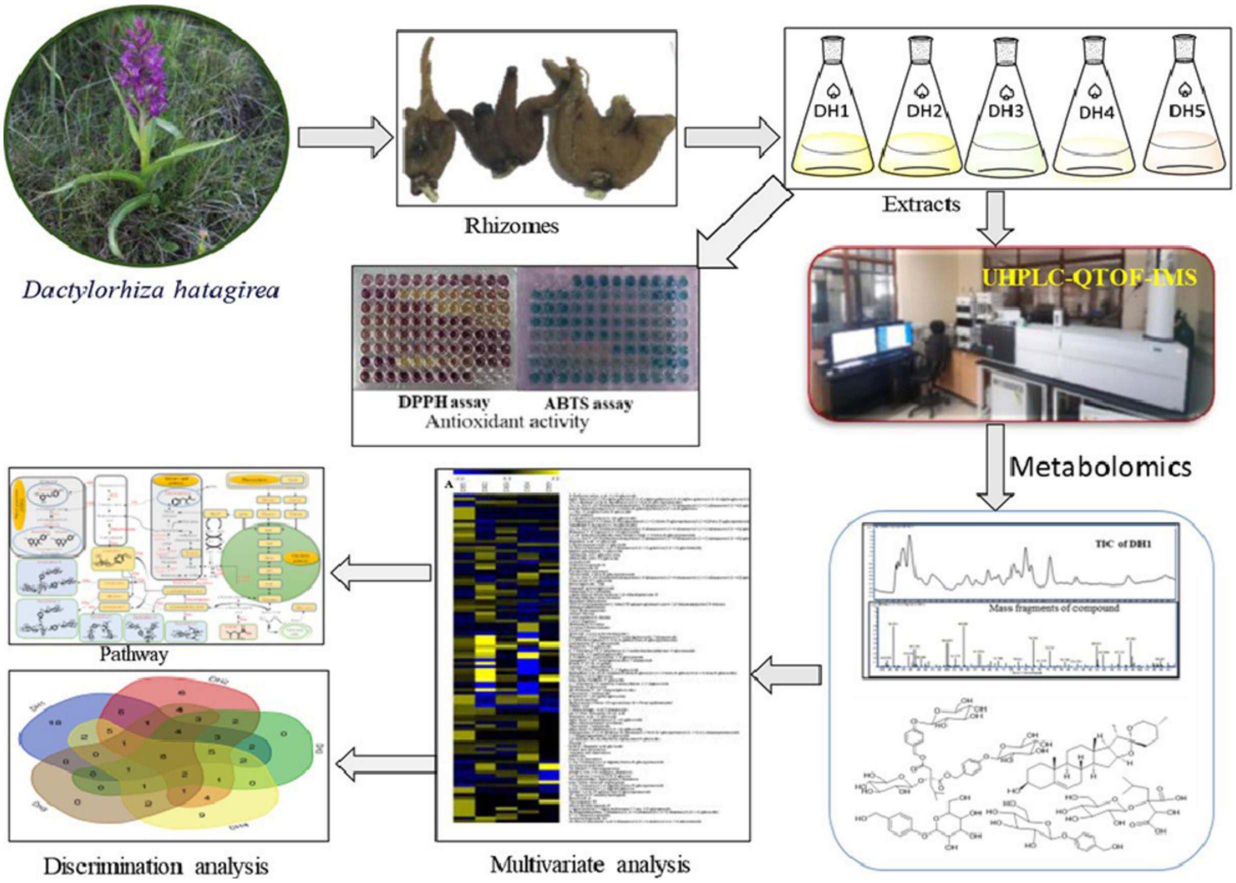


acids, and antioxidant activities of extracts were conducted and found significant. Ethanol extracts of *A. parviflora* showed highest TP, TF, and TI contents while energy value was between 0.826 and 3.964 Kcal. Moreover, targeted, and untargeted metabolites diversifications among samples were monitored by multivariate statistical analysis. The metabolic variabilities were visualized with the percentage variance in PC 1–5 as 77.26, 21.06, 1.26, 0.25 and 0.15, respectively. The metabolomics-based information predicted a speculative metabolites biosynthetic pathway. The current understandings of metabolome information, nutritional component and antioxidant activities has supported *A. parviflora* for health benefits. This comprehensive investigation will help in quality agrotechnological interventions and value-added health benefit products.



Metabolome analysis of *Dactylorhiza hatagirea* (D.Don) Soo reveals a significant antioxidant and nutritional potential of its tubers.

Dactylorhiza hatagirea (D.Don) Soo (Vern. Salam Panja) is a highly valued terrestrial dietary orchid from Himalaya, whose tubers are traded for possessing medicinal uses to human health benefits. The current research was focused on chemical exploration, along with evaluation of the nutritional and antioxidant potential, of its tuber extracts, which were procured from traders as well as from its natural habitats. Total phenolics, flavonoids, sugars, amino acids, macro- and micro- elements were estimated in the tuber extracts. It was found that phenolics and flavonoids (73.61 ± 0.92 and 48.59 ± 0.71 mg/g) were higher in methanolic extracts of marketed sample (DH2) than DH1, the methanolic extract of sample collected from natural habitat. The free amino acids and sugars were also found promisingly. The extracts showed antioxidant potentials with IC50 ranges from 1.58 to 4.41 and from 0.19 to 0.48, mg/mL in DPPH and ABTS assays, respectively. Further, UPLC-DAD analysis revealed the presence of vanillic acid in all samples (ranging from 0.21 to 0.58 mg/g). Further, dactylorhin A (0.12–0.81 mg/g) and B (0.62–0.88 mg/g) were also determined in all the samples except water extract (DH5). Further, UHPLC-QTOF-IMS analysis enabled the identification of 152 diversified metabolites such as sugars, terpenoids, steroids, amino acids, polyphenols, nucleosides, saponins, organic and fatty acids. The heavy metals (Cd, Hg, Pd, As) were absent while the micro- (Mn, Na, Zn, Cu) and macro- (Ca, Fe, Mg, K) elements were present in tubers. Furthermore, the variability in diversity of targeted metabolites was visualized using multivariate analysis and accounting 77.169 and 17.62% variance in PC1 and PC2 components, respectively. The current finding unleashed the chemical information including tentative biosynthesis of metabolites, nutraceutical and medicinal values of dietary orchid. Thus, this research will contribute to future agricultural and biotechnological interventions for a higher quality produce, thereby reducing 'over-exploitation' pressures on natural populations and also contributing to sustainable generation of this important bioresource.



Determination of Picrosides, Phenolics and Cucurbitacins by Ultra-High Performance Liquid Chromatography-Diode Array Detection in *Picrorhiza kurroa* Royle Ex Benth

Picrorhiza kurroa in the Indian system of medicine is used to treat jaundice, fatty liver, diabetes and respiratory disorders. Quality control methods have been reported earlier for picrosides-I and II, but extended coverage of markers is required for reliable authenticity. Therefore, the present study is aimed to develop and validate a UHPLC-DAD method for concurrent estimation of picrosides (I–III), p-hydroxyacetophenone glucoside, cucurbitacin B hydrate, gallic, caffeic, syringic and cinnamic acids. The method was developed and validated as per the International Council for Harmonisation guidelines for linearity, limits of detection and quantification, precision (inter- and intra-day), reproducibility, stability and recovery. This method was applied to estimate picrosides, phenolics and cucurbitacins in leaves and rhizomes. The separation of molecules was achieved at 260 nm in 20 min on a C-18 BEH column (2.1 × 100 mm, particle size of 1.7 μm) with gradient elution using 0.1% formic acid in water and 0.1% formic acid in acetonitrile. Linearity (r2) of standards was found to be 0.999, limits of detection and quantification were between 0.06–1.4 and 0.19–4 μg/mL, respectively. The recoveries of molecules were in the range of 86.6–102.7%. The method was found to be reproducible, uniform and specific.

The contents of identified analytes in rhizomes were the highest in ethanol, followed by methanol and water extracts, whereas water extract of leaves contained the highest content of analytes followed by ethanol and methanol. The UHPLC-DAD method was validated for the first time to estimate simultaneously nine analytes. This method will help in quality control of Picrorhiza based material and agriculture interventions.

Research group: Dinesh Kumar, Bindu Rawat, Vandana Kumari, Anil Kumar, Manish Kumar, Rishabh Kaundal, Rajinder Kumar, Sachin Vishisath, Ritesh Kumar, Rishabh Bhardwaj, Pragati, Shiv Kumar, Vijaylata Pathania, Ramesh Kumar, Pawan and Virat Abhishak.

Relevant Publications:

- Microchemical Journal. 2023, 187: 108451.
- South African Journal of Botany. 2022, 150: 431-42.
- Molecules. 2022, 27(12): 3867.

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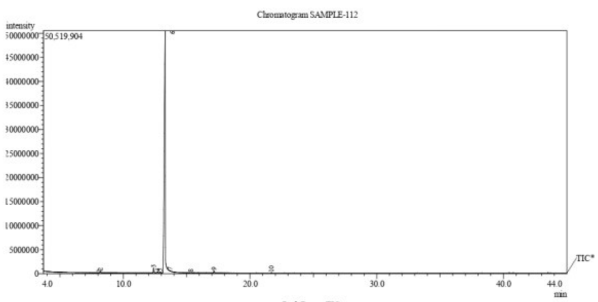
Chemical Engineer, Chemical Technology Department

Our group has been working on product and process development using chemistry and chemical engineering based unit operations, for process intensification and downstream process technology for bio resource based products.

Value addition and downstream process technology for Peppermint oil and its derivatives under Himalayan Bio Resource Mission

The essential oil is the mixture of terpenes and other volatile compounds, many of them hold important industrial applications. Mint is perennial plant of aromatic herbs belonging to the genus Mentha within the family Lamiaceae, is the most important essential oil crop including its aroma chemicals like menthol and menthone. Peppermint Oil is described as a colourless or pale yellow liquid having a strong, penetrating odour of peppermint and a pungent taste, followed by the sensation of coldness when air is drawn into the mouth. Peppermint Oil is a generally recognized as safe (GRAS) ingredient for use in dietary supplement. India is at present the leading producer, consumer and exporter of menthol-mint oil in the world market with more than 80% of global share. Mentha crystals as well as De-Mentholised Oil, both hold industrial importance. Farmers, entrepreneurs and small scale industries can be directly benefited out of developed process technology. Various extraction techniques have been performed and their parameters have been evaluated for the better quality and high yield of Peppermint oil. There is global demand for high quality mentha crystals. Hence preliminary study was undertaken and it was observed that >50% I-menthol concentration and > 20% menthone concentration was achieved in the oil as well as in hydrosol. Extraction of menthol from peppermint oil using cooling technique resulted in the formation of menthol crystals within 30-35 days with 95-98%. The GC-MS method has been used for the determination of the total menthol content. SEM technique has been developed to study the structure and size of the crystals.

Fig. 1 Menthol crystals



Peak Report TIC

Peak#	R.Time	Area	Height	Area%	Name
1	8.075	140305	39617	0.05	
2	8.198	864404	284697	0.28	DIHYDRO-.ALPHA.-IONONE
3	12.393	3396968	1046600	1.11	l-Menthone
4	12.719	965811	236139	0.32	Cyclohexanone, 5-methyl-2-(1-methylethyl)-, trans-
5	12.917	771707	210483	0.25	(-)-Menthoxyacetyl chloride
6	13.298	297672216	50289118	97.27	ISOMENTHOL DB5-835

Fig. 2 GC-MS Chromatogram of menthol crystals.

Extraction/distillation and value addition of some selected natural essential oils under Floriculture Mission

Experimental work on different high value flowers like tuberose, jasmine etc was carried out. To extract the essential oil from these flowers, latest as well as traditional techniques were tested. By using solid- liquid and liquid- liquid extraction method tuberose absolute and tuberose-wax was extracted from tuberose concrete. The determination was done with GC-MS chromatogram.

Tuberose wax has been used in making aroma-candles and the tuberose absolute has been used in the formation of body spray and body–roll-on as value added products.

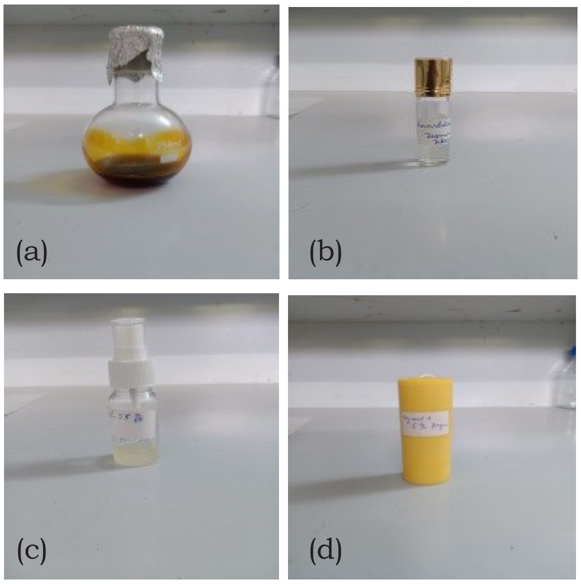


Fig. 3 (a) Tuberose absolute, (b) Body roll-on, (c) Body spray, (d) Aromatic Candle.

Green Process for Mogroside enriched extract from Monk Fruit on Semi-Pilot Scale

Process has been developed for 5 kg raw material and has been simulated to optimized on a semi pilot scale facility. Numerous unit operations have been applied like solid- liquid extraction, ion exchange chromatography, liquid-liquid extraction and spray drying etc for optimized extraction of mogroside from monk fruit in powdered form. UHPLC method has been developed & validated for determination of total mogrosides (on the basis of Mogroside V, 11-Oxo-Mogroside V, Siamenoside I, Mogroside IIIE). The developed green process enhanced the Total Mogroside concentration in final product in different range of products i.e. from 10%-40%.

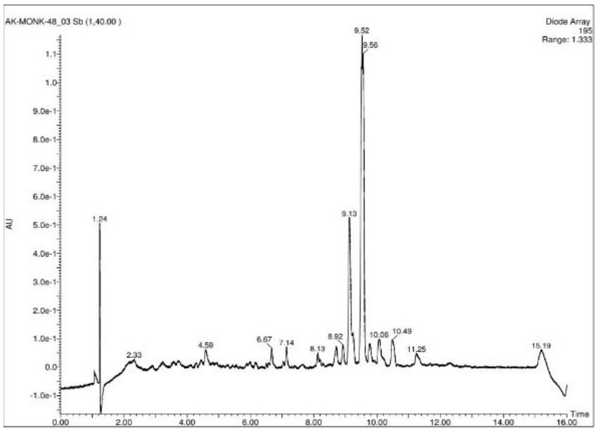


Fig. 4 UHLC Chromatograms of enriched product.

DIETETICS AND NUTRITION TECHNOLOGY DIVISION

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Division of Dietetics and Nutrition Technology

Our research at CSIR-IHBT is guided by the principle of establishing sustainable alternatives for the production of phytoconstituents using Plant Cell and Organ Culture Technology. In this context, attempts are being made to find environmentally friendly substitutes for the manufacture of high-value phytochemicals that not only help in the conservation of the plants' but also serve as a regenerative source of quality raw material for the food, cosmetics, and herbal industries.

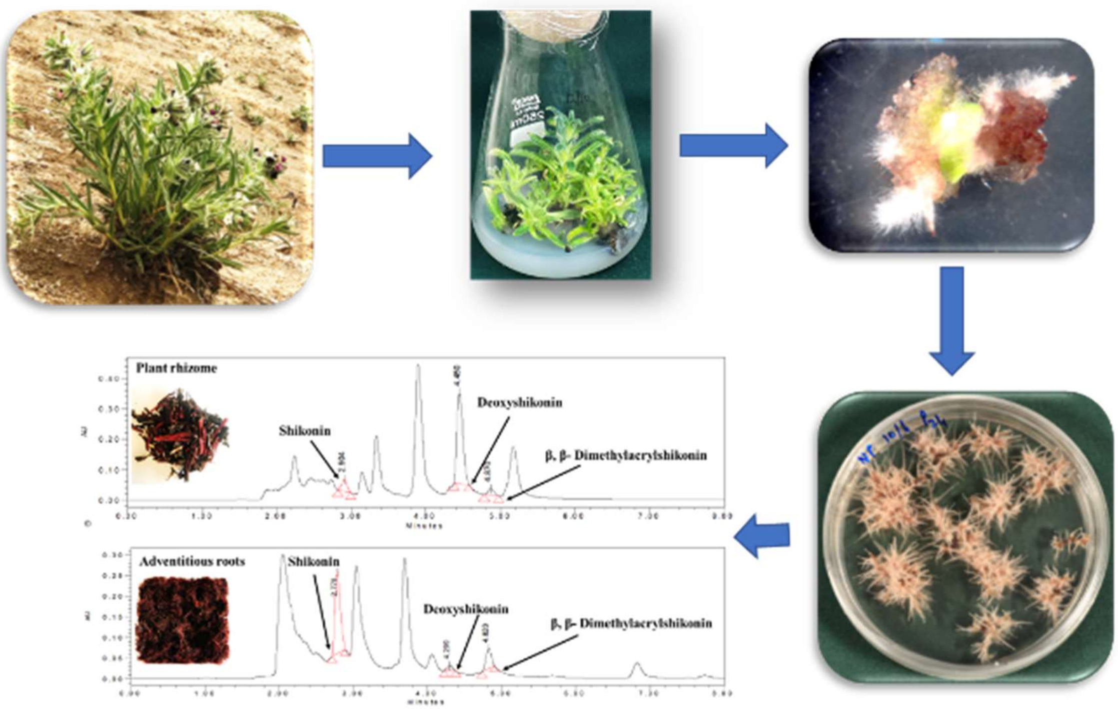

Fig. 1 *In vitro* approach for the production of naphthoquinone pigments using adventitious root cultures of *A. euchroma*.

Regenerative source for the production of natural pigments

Arnebia euchroma is an important Himalayan herb from which red naphthoquinone pigments with uses in the food, cosmetic, and pharmaceutical sectors are indiscriminately extracted from the roots. The key objective of the research was to cultivate the adventitious roots of *A. euchroma* and use them to make naphthoquinone pigments. A variety of mediums and auxin types were tested for the *in vitro* development of adventitious roots from *A. euchroma* leaves. In this regard, the data showed maximum root induction on Schenk & Hildebrandt (SH) medium fortified with indole-3-butyric acid (2.5 mg/L). In addition, factors like inoculum density and sucrose concentration were also optimized to maximize adventitious root growth and pigment production in liquid shake flask cultures (Devi et al., 2022). A comparative chemical profile of *in vitro* induced adventitious roots was found with parent plant roots. The proposed approach **(Fig. 1)** appears to be an effective substitute for the generation of natural pigments, especially given the shorter cultivation cycle (4 weeks) and regenerative ability of induced adventitious roots together with a comparable metabolic profile.

Plant cell and organ culture is now a well-established *in vitro* technology for the large-scale production of phytoconstituents having wider application in pharmaceuticals, personal care formulations, food, and cosmetic industries. In order to maximize process productivity during sequential scaleup, the factors like shaking speed **(Fig. 2)** and inoculum density were also optimized in leaf-induced *A. benthamii* cell cultures under submerged conditions. A significant effect of shaking speed (70-rpm) and inoculum density (5%) was observed on cellular growth during sequential scale-up (Kumar et al., 2023). Additionally, it appears that the cultivation conditions and pigment production are directly related to the physiological and biochemical responses of cell cultures. It is evident from the data that the variables optimized are crucial for the large-scale cultivation of *A. benthamii* cells and the sustainable production of natural red pigments.

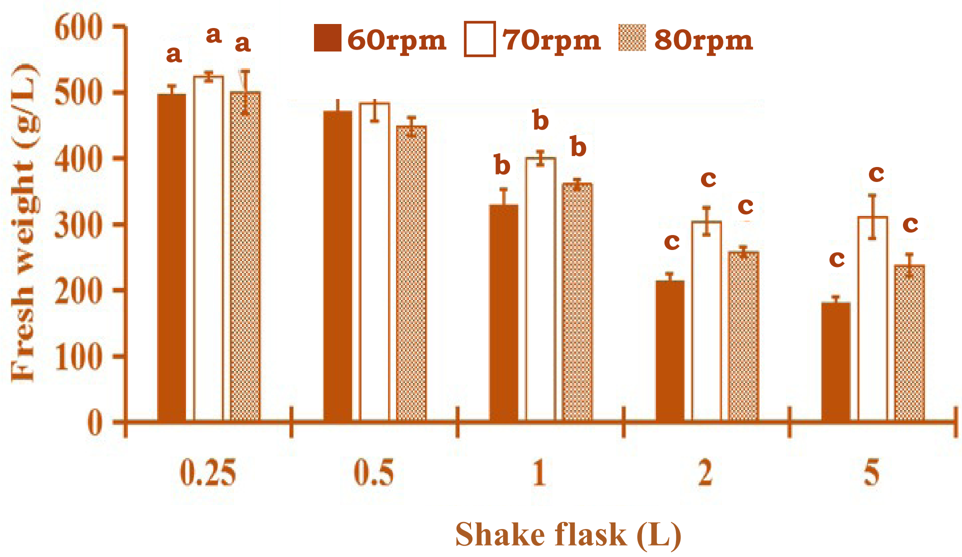

Fig. 2 Effect of shaking speed on cell biomass accumulation at different shake flasks volume.

Research group: Prashant Kumar, Deepika Choudhary, Manjeet Singh, Jyoti Devi and Ashok Gehlot.

Relevant Publications:

- Industrial Crops and Products. 2022, 187: 115461.
- Plant Biotechnology Reports. 2023.

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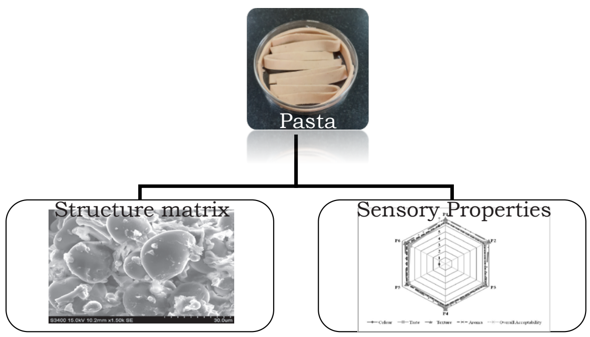
Study the techno-functional, morphological and phenolic properties of hull-less barley and buckwheat-incorporated pasta

Pasta contains a low nutritional profile and is still famous globally. So, sources are the need of the hour to meet and enhance the nutritional requirement of the growing population. In this regard, supplementing pasta with nutritionally rich sources will be an excellent way to overcome this problem. Hence in this study, nutritionally enhanced pasta was prepared with common wheat and supplemented with highland crops, i.e., hull-less barley and buckwheat. Pasta samples were prepared using different ratios of hull-less barley and buckwheat from 0-40%, and their nutritional, functional, phenolic, textural, and organoleptic properties were evaluated. Adding barley and buckwheat flour enhanced the phenolic and flavonoid content compared to control pasta. As per the organoleptic results of the pasta samples, adding barley and buckwheat positively affects the color, texture, and taste of prepared pasta. Results obtained encourage new pathways for further consumption of these nutritional crops in the food industry for various product development. Hence, hull-less barley and buckwheat of highland have the potential functional crops for value addition in food products.



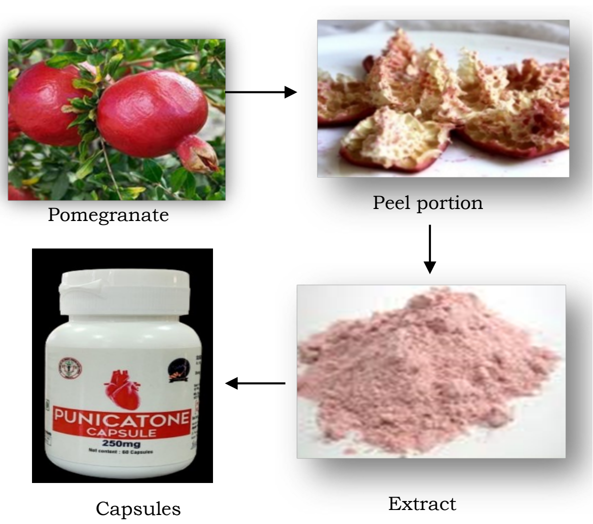
Punica granatum nutraceutical for cardio protection – Human Intervention Study under

CSIR Mission Project on Immuno Modulatory Function of Nutritionals and Nutraceuticals for Health and Wellness

As per the work package objectives, a nutraceutical-based product is developed from the pomegranate peel in the form of capsules. The pre-clinical animal studies demonstrate the efficacy of pomegranate peel extract formulation in lowering blood glucose and plasma triglyceride along with stabilization of atherosclerotic plaque, indicating significant overall improvement in cardiometabolic health.

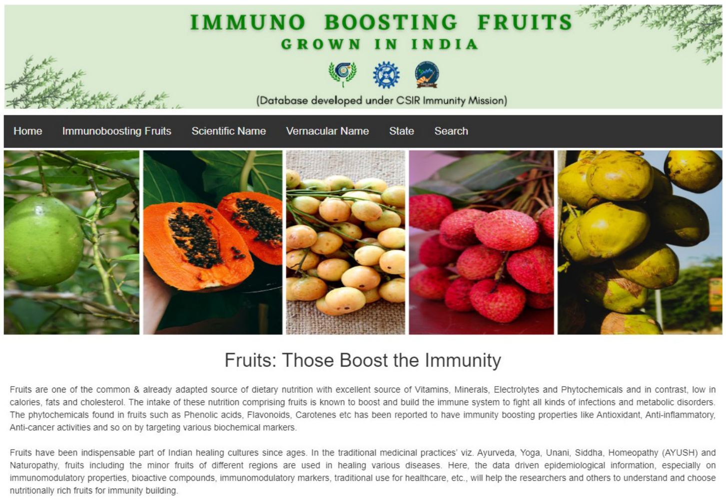
A process for Punicalagin enriched extract from Punica granatum peel and seed has been optimized. Pomegranate peel powder is subjected to hot water treatment at 80°C for 30 minutes in the water bath, further concentrated in a rotary evaporator, and dried in a lyophilizer.

Its formulation in the form of capsules to enhance the oral bioavailability of punicalagin-rich extract in the body has been studied. Further safety and toxicity studies have been done on the zebrafish model.



Acute oral toxicity study of pomegranate peel extract as per OECD guides lines 423 found no toxic found in the liver and kidney up to 2000 mg/kg body weight of peel extract. Results showed that pomegranate peel extract-fed mice demonstrated decreased plaque necrosis and decreased inflammation.

Approval of the protocol was taken from the Institutional Ethics Committee of the Ayurvedic College, Paprola. The protocol was registered with clinical trial registration at the Clinical Trials Registry- India (CTRI) hosted at the ICMR-National Institute of Medical Statistics with no REF/2022/02/052020. The GMP manufacturing of extract and its formulation capsule and placebo, along with packaging and labelling as per GMP certified norm completed. A separate proforma such as Patient Information Sheet, Consent Form, Case Report Form 1 – Screening (Before Treatment), Research Proforma, Case Report Form 2 (Ayurvedic Parameters), Short-Form (Sf) - 36-Health Survey has been prepared for this study. At present, 76 patients have been recruited, and to date, 26 patients satisfactorily completed the trials; remaining patient follow-ups are in progress to finalize the outcome of this study.



Digital data portal of fruits from India with immune boosting capacity Epidemiological and Scientific evidence-based digital portal

CSIR-IHBT targeted the fruits in the eight following agro climate zones (Zone 1,6,7,8,9,13,14,15) based on immunity modulator efficacy for upload in the digital portal. Documented the immunity-boosting fruits based on initial screening of available literature along with information such as immunomodulation with reference to the available data on associated organs, immunomodulatory markers and others. Information on 120 fruits is collected for updating in the portal. A draft of the digital portal on "Indian Immunity Boosting Fruits' has been designed. In collaboration with the CSIR-NEIST, finalizing the data points in Excel sheets for the trial version of the digital portal has been prepared. The "Web portal" has been updated, including 76 fruits available in the different Agro-climatic Zone as stated in the proposal with required data, information, verticals, Disclaimer, Timeline, and Search button and tried to make it a user-friendly approach and layout. Rest are under progress based on the literature and documentation of various parameters, including nutritional and biochemical markers for immunomodulatory efficacy, till 30 fruits were selected and compiled the information.

Research group: Vikas Dadwal, Rashim Kumari, Shreya Bhatt, Manoj Aroor, Karishma Devi, Rahul Dev, Astha Sharma and Tanvi Phull.

Relevant Publications:

- Food Chemistry. 2022, 402: 134529.
- Food Research International. 2023, 164: 112329.
- Food Chemistry Advances. 2022, 1: 100055.

Yogendra Padwad, Principal Scientist
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Pharmacology and toxicology lab work in safety/toxicity and efficacy evaluation of phyto-formulations and active principles by addressing their underlying molecular mechanism with special emphasis on inflammation, ageing, diabetes and cancer.

Iridoid glycosides enriched fraction of *Picrorrhiza kurroa* improves insulin sensitivity and supports glucose uptake by activating PI3K/Akt signaling in 3T3-L1 adipocytes

Therapeutic failure and drug resistance are common sequelae to insulin resistance associated with type 2 diabetes mellitus (T2DM). Consequently, there is an unmet need for alternative strategies to overcome insulin resistance and associated complications. To demonstrate whether Kutkin (KT), iridoid glycoside enriched fraction of *Picrorhiza kurroa* extract (PKE) has the potential to increase the insulin sensitivity vis à vis glucose uptake in differentiated adipocytes, different cell-based assays were performed supported by *in silico* analysis.

Molecular interactions of KT phytoconstituents, picroside-I (P-I) & picroside- II (P-II) with peroxisome proliferator-activated receptor gamma (PPARγ), phosphatidylinositol 3-kinase (PI3K) and protein kinase B (Akt) were analyzed *in silico*. Cellular viability and adipogenesis were determined by following 3-(4, 5-Dimethylthiazol-2-Yl)-2, 5-Diphenyltetrazolium bromide (MTT) assay and Oil Red-O staining. Further, ELISA kit-based triglycerides, and diacylglycerol-O-Acyltransferase-1 (DGAT1), adiponectin and tumor necrosis factor alpha (TNF-α) were assessed in differentiated adipocytes. However, Flow cytometry and immunofluorescence-based assays were employed to measure the glucose uptake and glucose transporter 4 (glut4) expression in differentiated adipocytes, respectively. Further, to explore the targeted signaling axis, mRNA expression levels of PPARγ, CCAAT/enhancer binding protein α (CEBPα), and glut4 were determined using qRT-PCR and insulin receptor substrate-1 (IRS-1), Insulin receptor substrate-2 (IRS-2), PI3K/Akt, AS160, glut4 followed by validation using immunoblotting for the expression of different proteins in differentiated adipocytes.

In silico analysis revealed the binding affinities of major constituents of KT (P-I& P-II) with PPARγ/PI3K/Akt. The enhanced intracellular accumulation of triglycerides with concomitant activation of PPARγ and C/EBPα in KT-treated differentiated adipocytes indicates augmentation of adipogenesis in a concentration-dependent manner. Additionally, at the cellular level, KT upregulated the expression of DAGT1 and decreased fatty acid synthase (FAS) and lipoprotein lipase (LPL), further affirming improvement in lipid milieu. It was also observed that KT upregulated the levels of adiponectin and reduced TNFα expression, thus improving the secretory functions of adipocytes along with enhanced insulin sensitivity. Furthermore, KT significantly promoted insulin-mediated glucose uptake by increasing glut4 translocation to the membrane via PI3/Akt signaling cascade. The results were further validated using PI3K specific inhibitor, wortmannin, and findings revealed that KT treatment significantly enhanced the expression and activation of p-PI3K/PI3K and p-Akt/Akt even in case of treatment with PI3K inhibitor wortmannin alone and co-treatment with KT in differentiated adipocytes and affirmed that KT as an activator of PI3K/Akt axis in the presence of inhibitor as well.

Collectively, the KT fraction of PKE showed anti-diabetic effects by enhancing glucose uptake in differentiated adipocytes via activation of the PI3K/Akt signaling cascade. Therefore, KT may be used as a promising novel natural therapeutic agent for managing T2DMand to the best of our knowledge, and this is the first report showing the efficacy and potential molecular mechanism of KT in enhancing insulin sensitivity and glucose uptake in differentiated adipocytes.

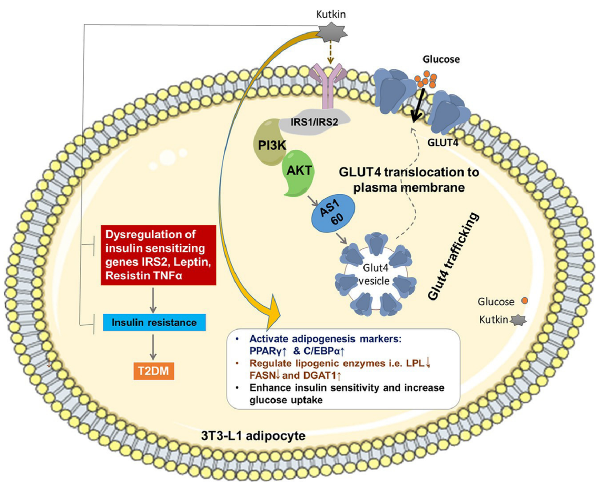

Fig. 1 A unified framework for understanding the molecular mechanism of effect of KT on insulin resistance and glucose uptake in differentiated adipocytes via activation of PPARγ and PI3K/Akt axis using *in silico* and *in vitro* analysis approaches.

Phytoconstituents present in Berberis lycium fruits like berberine and rutin mitigate collagen–CFA-induced arthritis (CIA) by improving GSK3β/STAT/Akt/MAPKs/NF-κB signaling axis mediated oxi-inflammation and articular joint damage in a murine model

Rheumatoid arthritis (RA), a chronic auto-immune disease, often results from persistent and misdirectional inflammation and cannot be effectually resolved by single-target selective drugs. The present study attempted to uncover the anti-arthritic efficacy and governing molecular mechanism of BLFE and its phytoconstituents berberine and rutin, with a focus on dysregulated oxi-inflammation and structural integrity during articular damage using Collagen II–CFA-induced RA mice model. NMR-based phytometabolomic analysis revealed the presence of phenolics and alkaloids such as berberine and rutin. BLFE, rutin and berberine remarkably mitigated Collagen II–CFA-induced disease severity index, articular damage, immune cell influx and pannus formation. An effective decrease in levels of TNF-α, IL-6, IL-1β, IFN-γ, IL-13, IL-17, MMPs, RORγt, Ob-cadherin, Cox-2, iNOS and enhancement in IL-10, IL-4 and IL-5, BMP-6/7 was observed in BLFE, rutin and berberine treatments. The molecular mechanistic analysis demonstrated a reduction in expression of p-STAT-1/3, p-PI3K, p-Akt, p-JNK, p-p38, p-IκB, p-NF-κB and β-catenin via BLFE, rutin and berberine. Furthermore, reduced activation of p-ERK and p-GSK3β and enhanced splenic Tregs were only noticed in BLFE and berberine. Thus, the signifying presence of these phytoconstituents could contribute to the above-mentioned findings. These findings imply that BLFE could be beneficial for assuaging deleterious aspects of RA mediated via perturbed inflammation.

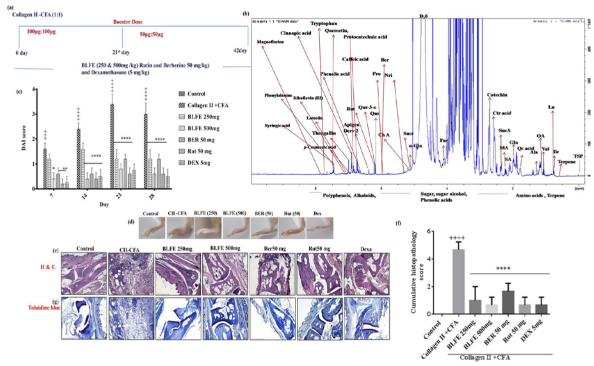

Fig. 2 Investigating the effect of BLFE (250 and 500 mg/kg b.w) and its phytoconstituents rutin (Rut) (50 mg/kg b.w) and berberine (BER) (50 mg/kg b.w) in CII and CFA-induced RA. b ^{1}H NMR-based NMR metabolomics of BLFE. c–g BLFE and its phytoconstituents rutin and berberine ameliorate progression of CIA and paw joint architecture damage. c DAI score d Representative images of paw tissue e Haematoxylin and eosin stained of paw joint sections f Summary of the histological scores g Toluidine blue staining. Values are mean±SD. (++++) $p \leq 0.0001$ versus control; (*) $p \leq 0.05$, (**) $p \leq 0.01$ and (****) $p \leq 0.0001$ versus CIA group.

Relevant Publications:

- Phytomedicine. 2022, 154204.
- The Journal of Nutritional Biochemistry. 2022, 109068.
- Inflammopharmacology. 2022, 30(2):655-666.

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We work on the safety and efficacy assessment of natural products, nutraceuticals and synthetic molecules in animal models.

Green tea catechins prevent obesity-induced kidney damage

Obesity is an epidemic and one of the significant risk factors for developing various chronic diseases. Obesity is a major risk factor for chronic kidney disease. Catechins belong to flavonoids and constitute >75 % of polyphenols in green tea leaves. We evaluated the preventive effect of green tea catechins against obesity-induced kidney damage. In the renal cell lines, the fatty acid-treated NRK-52E cells showed reduced fat accumulation and modulated expressions of lipogenic and fibrotic genes after catechins treatment. In high-fat diet-fed obese rats, the effect of catechins was assessed at different doses. A significant reduction in weight gain and improved serum kidney function parameters were observed after catechins treatment. The treatment also reduced the degenerative changes, fibrous tissue, and mesangial matrix proliferation in the rats. Further, catechins promote a healthy gut by improving the abundance of microbes like *Akkermansia muciniphila* and *Lactobacillus reuteri*. Overall, catechins prevented obesity-induced kidney damage by reducing fat deposition and maintaining gut health in rats.

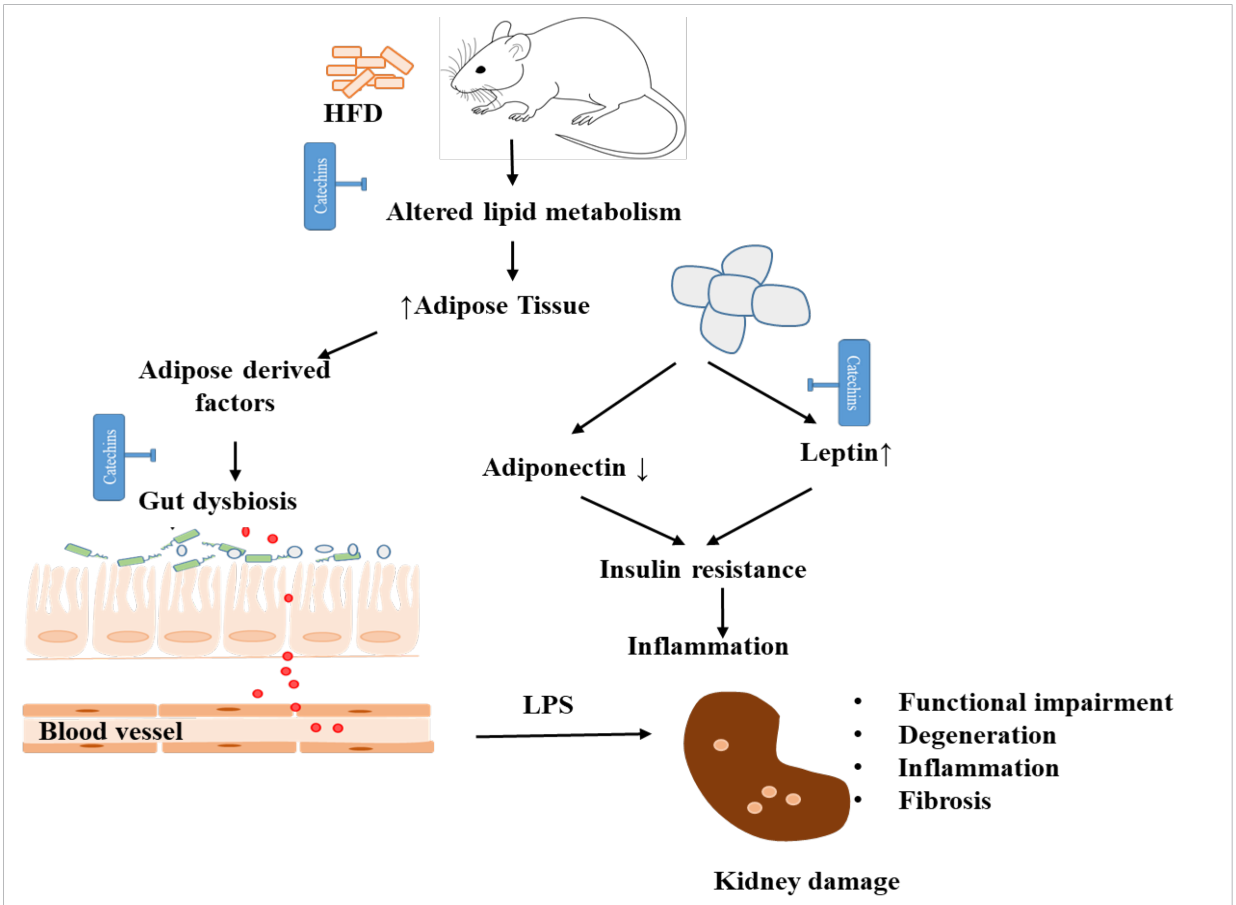

Fig. 1 Mechanism of action of green tea catechnis against obesity induced kidney damage.

Spirulina fortified food for protein malnutrition and iron deficiency

Protein malnutrition and iron deficiency anaemia affects almost 30% of Indian children below five years of age and greater than 50% of Indian women of reproductive age between 18 and 49 years. Synthetic micronutrients have poor bio-efficacy due to lower oxidative stability, binding of anti-nutrition factors from cereals and side effects, such as nausea, constipation and acidity. In this context, we evaluated the potential of Spirulina platensis as a source of proteins and micronutrients for such conditions. Spirulina-fortified food products promoted recovery from diet-induced protein and iron deficiency symptoms in the experimental rat model. 1 to 1.5-fold increase in hemoglobin levels, serum total protein and albumin levels were observed in malnourished rats. The supplementation also resulted in a 2-fold increase in total serum iron content and ameliorated oxidative stress in the liver, spleen and kidneys. Spirulina-fortified food products reversed the fatty changes in the liver induced due to protein and iron deficiency. Overall, Spirulina-fortified food products enhanced protein and iron absorption and ameliorated the symptoms associated with malnutrition.

Phloretin mitigates the progression of non-alcoholic fatty liver disease

Non-alcoholic fatty liver disease (NAFLD), with a 25–35% global prevalence, is one of the leading causes of chronic liver damage. The potential of phloretin to prevent the progression of non-alcoholic fatty liver disease (NAFLD) was evaluated in mice. Phloretin treatment induced autophagy-mediated hepatic lipid clearance and restored mitochondrial membrane potential and redox homeostasis. It also reduced the fatty changes, inflammation and fibrosis in the liver tissues of the Western diet-fed mice. Altogether, phloretin effectively attenuated the NAFLD progression via activating autophagy-mediated lipid breakdown and inhibiting oxidative damage, hepatic inflammation and fibrosis in the liver.

Development of nutraceutical for kidney health

Renal disease is one of the most critical non-communicable diseases related to a remarkable economic burden globally. Natural products can offer a promising solution for renal disease prevention due to their combinatorial efficacy and rare toxic effects. Therefore, we developed a polyherbal formulation for improving kidney health and validated its efficacy in preclinical models. The formulation showed a cytoprotective effect in high glucose-treated renal cell lines. It has reduced ROS production, pro-inflammatory cytokines and proliferation markers. The formulation improved the renal function parameters and reduced the renal inflammation and cellular damage in the rat model of kidney disease.

Research group: Vinesh Sharma, Swati Katoch and Anchal.

Relevant Publications:

- Life Sciences. 2023, 121437.
- Food & Function. 2023, 14: 1160-1178.
- Journal of Nutritional Biochemistry. 2022, 109062.

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Our research work aims to explore and validate the therapeutic potential of western Himalayan region plants in experimental animal models. The main aim is to develop neuroprotective nutraceuticals for modifying diseased states in humans.

Development of citrus fruits peel-based Nutraceutical to combat epilepsy

The peel of citrus fruits is an abundant by-product of agro-food industries. A significant part is dumped in an open environment, and a small portion is used as animal feed. A comparative extraction optimization, flavonoid quantification, and antioxidant activity of different peels were carried out to encourage waste valorization. The peel of five industrially important citrus fruits [Citrus grandis (Chakotra), *Citrus reticulata* Blanco (orange), *Citrus reticulata* c.v. (Kinnow), *Citrus sinensis* (Malta) and *Citrus limetta* (Mausambi)] were subjected to extraction using different solvent combinations. It was followed by total phenolic and flavonoid quantification. Thereafter, HPLC-based quantification of major flavonoids of nutraceutical importance was carried out. Amongst all, 80% ethanol provided the maximum extract yield. Citrus reticulata extracts showed the highest amount of polyphenolics (*Citrus reticulata* Blanco) and flavonoids (*Citrus reticulate* c.v.) content. *Citrus reticulate* c.v. peel extract showed the highest amount of hesperidin and possessed potent antioxidant, anti-inflammatory, and acetylcholinesterase inhibitory activities compared to the other extracts. *In silico* assessment using the Prediction of Activity Spectra for Substances software revealed a high (Probable activity score > 0.7) activity score for lipid peroxidase inhibitory, antioxidant, membrane integrity agonistic, free radical scavenging, and anti-inflammatory activities, thus supporting its neuroprotective potential.

As *Citrus reticulata* c.v. peel extract showed better efficacy in vitro; therefore, it was selected for further in vivo studies. The efficacy of the peel extract was studied in a mouse model of pentylenetetrazole (PTZ)-induced kindling and associated neurobehavioral impairments **(Fig. 1)**. The epileptic kindled mice were

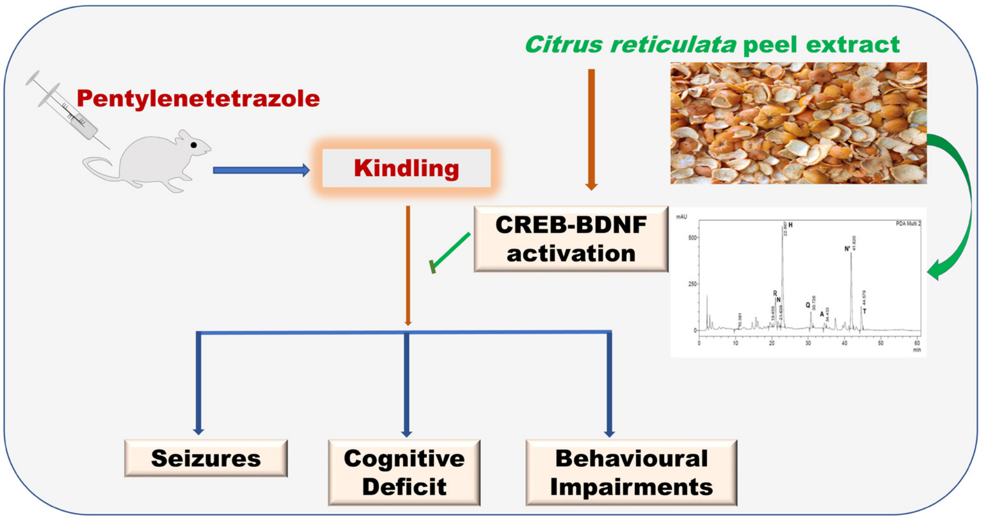

Fig. 1 Schematic representation showing the efficacy of *Citrus reticulata* c.v. peel in pentylenetetrazole-induced kindling and associated neurobehavioral impairments mouse model.

administered daily with 100 and 200 mg/kg of the extract and challenged with a sub-convulsive dose of PTZ every 5th day. Behavioral and cognitive performance tests were performed at the end of the treatment. The extract administration reduced epileptic seizure severity following 20 days of the treatment. The treatment resulted in a significant increase in spontaneous alternations in the T-maze test. There was a reduction in depression-like behaviour in epileptic animals after the extract treatment in both forced swim and tail suspension tests. The hippocampal Bdnf and Creb expression was increased, whereas the level of glutamate-to-GABA ratio was decreased in the treated epileptic animals.

The extract showed a significant antiseizure response after 20 days of the treatment, probably due to the poor solubility of the flavonoids present in it. Hence to increase the solubility, a solid dispersion of *Citrus reticulata* c.v. peel was prepared, and its in vivo antiseizure efficacy was studied **(Fig. 2)**. Solid dispersion of *Citrus reticulata* c.v. peel extract was developed using Soluplus® (a fourth-generation copolymer). The was spray dried with Soluplus polymer matrix. The developed dispersion was studied morphologically under a scanning electron microscope, and its molecular interactions were observed by Fourier transform infrared spectroscopy. The results revealed a better antiseizure response of the solid dispersion in mouse and zebrafish seizure models. *In vitro*, dissolution of the hesperidin in the extract showed a steady increase in dissolution percentage with a burst release in the initial 20 min to around 50% in a simulated intestinal fluid media.

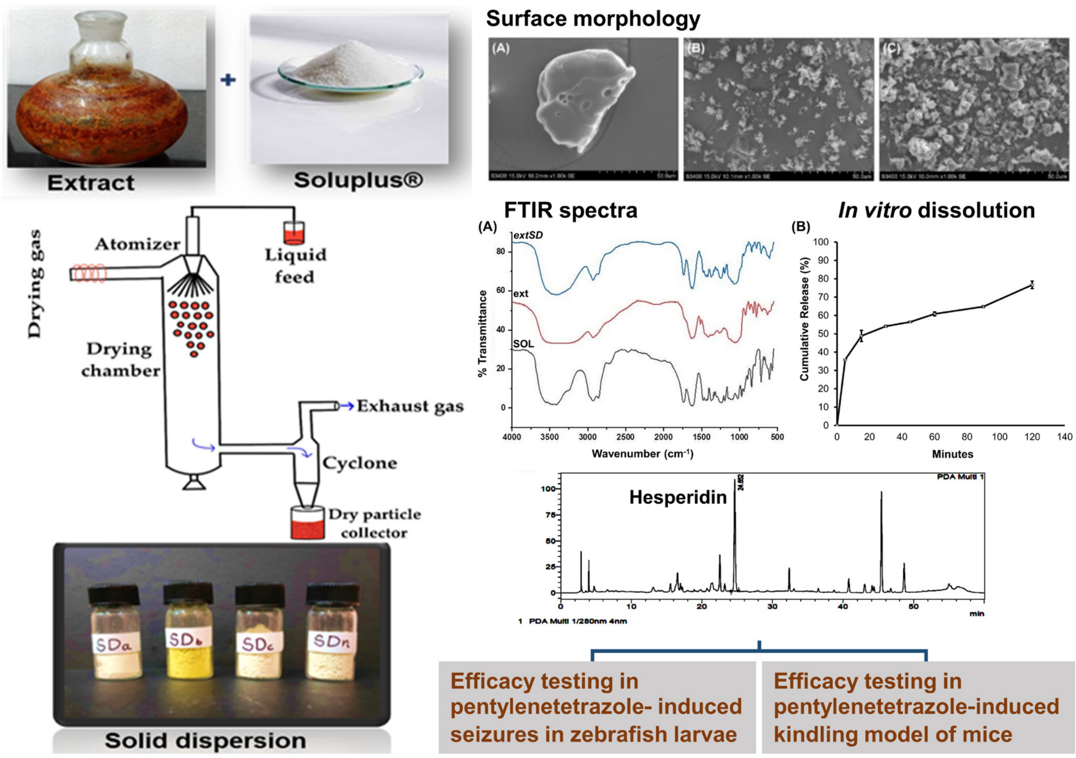

Fig. 2 Schematic representation of *Citrus reticulata* c.v. peel-based solid dispersion development, characterization, release, and *in vivo* testing in seizure models.

Research group: Savita Kumari, Amit Kumar, Shubham Nilkanth Rahmatkar, Poonam Dhiman, Rajneesh Kumar, Shiv Kumar and Pooja Sharma.

Relevant Publications:

- Journal of Drug Delivery Science and Technology. 2023, 81: 104238.
- Behavioural Brain Research. 2023, 438: 114158.
- Nutritional Neuroscience. 2022, doi: 10.1080/1028415X.2022.2071807.

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Division of Dietetics and Nutrition Technology

Our group is working on understanding the role of different determinants in the pathogenesis of pulmonary disorders like allergic asthma and skeletal inflammatory conditions like osteoarthritis (OA). We use different non-infectious, inflammatory laboratory animal models for evaluating molecular mechanisms involved in the progression of different diseases.

Validation of traditional knowledge for mitigating respiratory and skeletal pathologies:

Chronic respiratory diseases are among the most common non-communicable diseases worldwide due to the ubiquity of noxious environmental, occupational, and behavioral inhalational exposures. Close to 545 million people worldwide had a chronic respiratory disease in 2017, an increase of 39·8% since 1990. The most prevalent chronic respiratory diseases were COPD (3·9% global prevalence) and asthma (3·6%). Chronic respiratory diseases accounted for 3·9 million deaths in 2017 (an increase of 18·0% since 1990) and were responsible for 1470 disability-adjusted life-years (DALYs) per 100 000 individuals (112·3 million total DALYs, an increase of 13·3% since 1990). Similarly, the global prevalence of knee was 16.0% in individuals aged 15 and over and 22.9% in individuals aged 40 and over; the incidence was 203 per 10,000 person-years in individuals aged 20 and over; the prevalence and incidence increased with age, peaked at the advanced age on prevalence and at 70–79 years old on incidence. Additionally, Rheumatoid Arthritis (RA) has an incidence of 0·5% to 1%, with an apparent reduction from north to south (in the northern hemisphere) and from urban to rural areas. These diseases tend to have many similarities in the progression of pathogenesis. The global herbal medicine market size was estimated to be US$ 83 billion in 2019 and is expected to reach US$ 550 billion by 2030 at a CAGR. The role of nutraceuticals from different sources, such as plants, marine and microbial, has gained attention in preventing respiratory disorders. Thus, we aim to find out the role of such important nutraceuticals in mitigating the above-mentioned diseases.

Efficacy of nutraceuticals (Adhatoda vasica and Vitex negundo) for maintaining immunomodulatory function and human intervention studies of previously developed formulations

Immunomodulators are a group of drugs that have many ways to work, including working on the immune system directly by turning down some proteins and turning up others. These drugs can cause side effects such as drowsiness, fatigue, constipation, low blood cell counts, and neuropathy (painful nerve damage). There is an unmet need to find alternative safe therapeutics. Our group at CSIR-IHBT assessed the influence of Vitex negundo and Adhatoda vasica on LPS-induced mice models individually and in combination. After completion of the live phase, organs were collected, and the cytokines milieu was measured. It was observed that V. negundo and A. vasica combination modulated the ratio of pro-inflammatory/ anti-inflammatory cytokines, which are considered the cornerstone in the pathology of inflammatory disorders. V. negundo and A. vasica extracts were standardised for product formulation. *In vitro* investigation was carried out for individual extracts as well as their combinations. *In vivo* study for checking the effect of the formulation in animal models was also performed.

In order to combat cartilage health issues such as osteoarthritis, a polyherbal formulation was developed using Vitex negundo and Cissus quadrangularis extracts. These plants are mentioned in the traditional literature for relieving musculoskeletal pathologies. To validate these important properties of the plants, their combinational effect was evaluated in vitro and in vivo experiments previously. Formulations were developed as oral (water-dispersible) powder and topical cream formulations. The preclinical experiments showed beneficial effects in ameliorating pathologies and modulating various molecular pathways involved in the progression of osteoarthritis pathology. To further validate their potential in clinical conditions, a human intervention trial was carried out in collaboration with Rajiv Gandhi Government Post Graduate Ayurvedic College, Paprola. The trial was registered with CTRI through the registration number. Patients with minor to mild osteoarthritic stages were recruited to assess the effect of formulations. These patients underwent the trial of 2 months with follow-up, and afterwards, clinical efficacy was assessed by checking improvement in various parameters.

Similarly, we are assessing the role of Linum usitatissimum and Prunus armeniaca in the modulation of inflammation-associated rheumatoid arthritis. Preclinical evaluation using skeletal cell lines and animal models is underway. Various molecular mechanisms are being studied. In future, we aim to develop cheap, affordable alternative products for arthritis.

Research group: Monika Kumari and Avisha Sharma.

Relevant Publications:

- Inflammopharmacology. 2022, 30(2): 655-666.
- International Immunopharmacology. 2022, 106:108579.
- Computer and Structural Biotechnology Journal. 2023, 21: 1292-1311.

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Dietetics & Nutrition Technology Division

Our laboratory works on two aspects, viz. (i) the development of value-added products from aromatics and herbals and (ii) the development of nutraceutical formulations to improve bioavailability and therapeutic efficacy.

Development of value-added products from aromatics and herbals

India is endowed with about 8000 medicinal and 1200-2500 aromatic plants. They have been extensively used to prepare drugs in various systems of medicine, herbal cosmetics and functional foods. Further, essential oils from aromatic plants have also been extensively used in flavour, fragrance, cosmetics industries and aromatherapy. The main focus of our laboratory is to develop value-added products from medicinal and aromatic plants utilizing pharmaceutical technology (formulations) to produce commercially marketable products. In this context, we are developing herbal topical formulations such as multipurpose creams, sunscreen, and 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 dietary phytochemicals is consistently linked with protection from chronic diseases such as diabetes, cardiovascular disease, cancer and neurodegenerative diseases. However, these phytochemicals have major therapeutic limitations because of their low aqueous solubility, low permeability, short half-life and low bioavailability to humans. Advanced pharmaceutical technologies can overcome these limitations. The current theme of our laboratory is to utilize self-emulsifying drug delivery systems (SEDDS), solid dispersions, cyclodextrin complexes, nano-emulsions, lipid nanocapsules and polymeric particles based approaches to enhance the bioavailability as well as the therapeutic efficacy of nutraceuticals. We are working on bioactive constituents such as phloretin, epicatechin, genistein, formononetin, and alpha-lipoic acid in this context. These phytochemicals exhibit various pharmacological activities such as antidiabetic, antioxidant, anti-inflammatory, and anticancer. However, their efficacy is hampered due to their poor aqueous solubility and bioavailability being rapidly and extensively metabolized. Therefore, to overcome these issues, we are utilizing formulation-based approaches to improve the bioavailability of these bioactive constituents to enhance their therapeutic efficacy. Recently zebrafish (Danio rerio) have emerged as a promising model for assessing nanomedicines because of their fecundity, physiological and anatomical similarity to mammals, optical transparency and genetic malleability. It can act as an efficient alternative vertebrate screening model to decrease the number of experiments in higher vertebrates. Our group is also working to understand the fate of formulations using zebrafish as a model organism.

Deciphering the interactions of genistein with β-cyclodextrin derivatives through experimental and microsecond timescale umbrella sampling simulations

Genistein (GEN), an isoflavone, exhibits a wide array of biological activities such as antioxidant, anti-inflammatory, cardioprotective and neuroprotective effects. However, despite tremendous biological activities, its incorporation into functional foods and supplements is limited due to its low aqueous solubility and instability. In this regard formation of cyclodextrin complexes is a promising approach to augment the solubility of nutraceuticals. Considering this, we unveil the molecular mechanism of inclusion of GEN inside the cyclodextrins (CDs) cavities with special emphasis on the correlation of experimental methods with molecular dynamics (MD) simulations. Overall, this study presents the basic mechanism behind GEN/CD inclusion complexes formation using experimental and computational approaches.

Development of R-α-lipoic acid conjugate with d-α-tocopherol polyethylene glycol 1000 succinate for augmenting the therapeutic efficacy of lipoic acid

α-Lipoic acid (LA), a dithiol micronutrient, acts as a vital cofactor in various cellular catabolic reactions and is also known as a universal antioxidant. The therapeutic efficacy of LA is compromised by poor aqueous solubility and a short half-life. In the present study, LA was conjugated to d-α-tocopherol polyethylene glycol succinate (TPGS) using a carbodiimide acid–alcohol coupling reaction.

The synthesized conjugate (TPGS-LA) was characterized using 1H and 13C nuclear magnetic resonance (NMR), Fourier transforms infrared spectroscopy (FT-IR), UV–vis spectroscopy, and matrix-assisted laser desorption/ionization time-of-flight mass spectrometry (MALDI-TOF MS). The TPGS-LA conjugate was demonstrated to be biocompatible and have better anticonvulsive activity than native LA in pentylenetetrazol (PTZ)-induced convulsions in zebrafish. Moreover, zebrafish larvae pretreated with TPGS-LA conjugate demonstrated a significant ($p < 0.05$) reduction of protein carbonylation levels and downregulation of c-fos expression during seizures compared to native LA. Conclusively, the present findings demonstrate that the TPGS-LA conjugate can be a promising approach for the delivery of LA **(Fig. 1)**

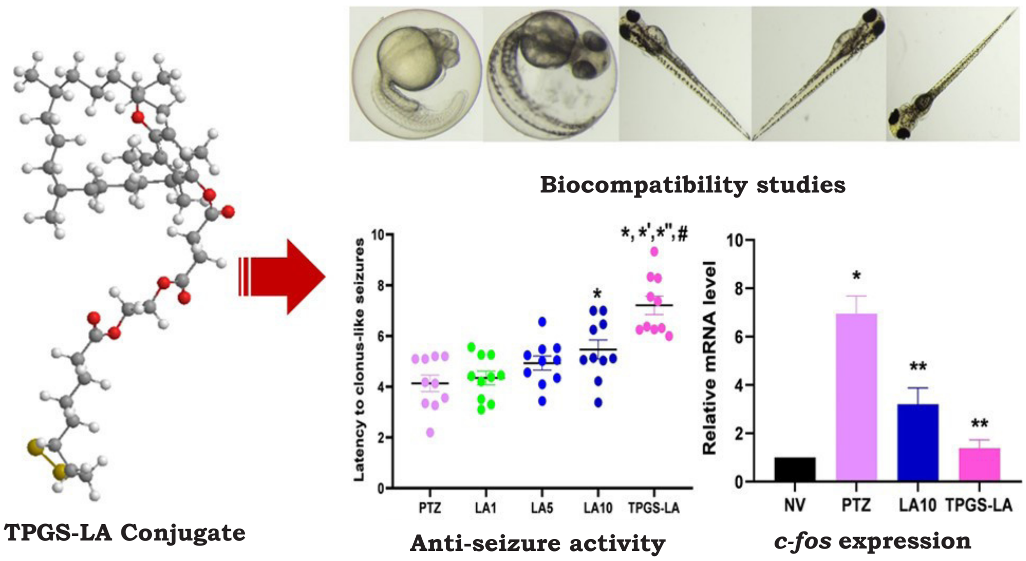

Fig. 1 The conjugation of lipoic acid (LA) with d-α-tocopherol polyethylene glycol succinate (TPGS) demonstrated to be biocompatible and have better anticonvulsive activity as compared to native LA in pentylenetetrazol (PTZ)-induced convulsions in zebrafish.

Research group: Rakesh Kumar DhritlahreRuchika, Nabab Khan, Neha Bhardwaj and Kajal Kaiya.

Relevant Publications:

- Journal of Molecular Liquids. 2023, 374: 121259.
- Foods. 2023, 12: 1363.
- Journal of Agriculture and Food Chemistry. 2023, 70: 7674-7682.

ENVIRONMENTAL TECHNOLOGY DIVISION

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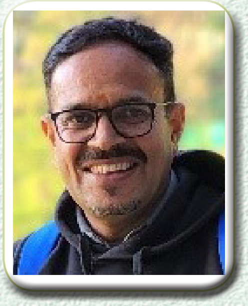
Biodiversity Conservation, Ecology, and Traditional Knowledge



Our group primarily conducts field oriented studies wherein we characterize natural vegetation, monitor species, document traditional knowledge, and maintain repositories.

Field explorations: Ten field surveys were carried out to the Kinnaur, Lahaul & Spiti, Chamba, Kangra and Kullu regions of Himachal Pradesh and a total of 200 specimens were collected this year.

Treeline characteristics of Chitkul: At the sampled sites in the area, the treeline primarily comprised of *B. utilis* and scattered individuals of *S. foliolosa*. The average tree height (7.99±0.86 m), girth (58.09±6.23 cm), and basal area (468.56±50.23 cm^2) were higher for *B. utilis*. The Kernel density estimation of height and girth revealed low range distribution of *Sorbus foliolosa* while *Betula utilis* reported a hump-shaped pattern with wide distribution of height and girth of tree individuals (**Fig. 1**).

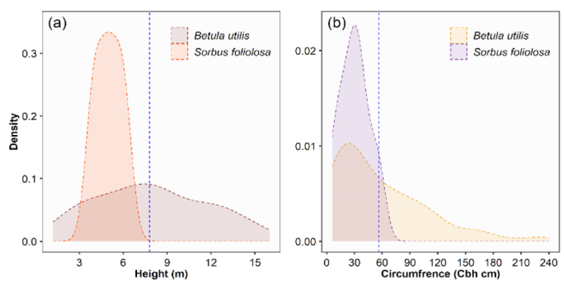


Fig. 1 Kernel density of height (a) and CBH (b) of tree species (vertical blue line represent the mean tree height and girth).

Fodder resource use and knowledge: Traditional Knowledge (TK) of rural communities on fodder resources for effective livestock management is acknowledged worldwide. A study was conducted amongst the *Bhangalis* of western Himalaya to document their TK on fodder species and analyze TK variations with age, gender, and education of the *Bhangalis*. Overall, 47 fodder species were cited by the *Bhangalis*, however, only 32 of them were used (**Fig. 2**). We found elderly individuals to hold more TK than younger people (B= 0.013, p=<2e-16***), and the females to be more knowledgeable than males (B= -0.128, p=0.005**).

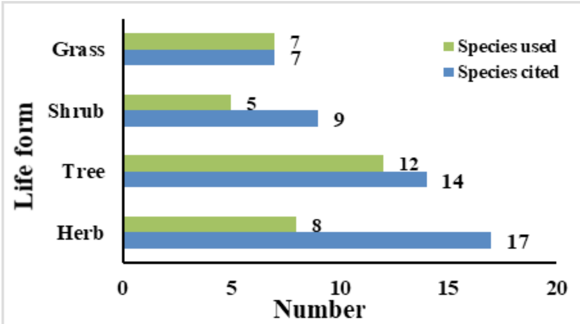


Fig. 2 Lifeform spectrum of fodder species used.

Wild edible plants of Spiti: Traditional food and species comprise unique products and recipes made with specific raw materials that have cultural, social and ecological importance. A semi-structured open-ended questionnaire was used to document the traditional foods and wild edible species consumed in Spiti region. It was revealed that the residents prepared foods based on cereals (n=22), wild edible plants (n=37), meat (n=5), and dairy products (n=2). Among the wild edible plants, majority belonged to the Polygonaceae and Brassicacceae (05 each) families (**Fig. 3**).

Fig. 3 Field recording of wild edible species used by the residents of Spiti region.

Medicinal use of plants in Lahaul valley: Five villages namely Gondhla, Kardang, Khangsar, Tholang, and Yangla were surveyed and information on plant species used as medicines were collected. Fortyone plant species belonging to 25 families were recorded to be used for treating 10 different categories of human ailments (**Fig. 4**). Highest number of species were used to treat digestive problems (n=17). Leaves were (39%) the most commonly used part while the highest use value was recorded for *Angelica glauca* (UV=0.88). This highlights the importance of the species in the area.

Fig. 4 *Thymus linearis* (a) and *Inula racemosa* (b) are amongst the commonly used medicinal species.

Distribution and use of Seabuckthorn in Nubra valley, Ladakh: Through primary field surveys and secondary information, occurrence of *Hippophae rhamnoides* was mapped in the Nubra valley (**Fig. 5**). Further, a total of 22 processing units were recorded in the valley that were noted to process 464.25 MT (metric ton) of pulp. Also, mean collection of fuelwood amounting to 31.0 kg/household/day (one person from a household is involved in collection) was recorded by surveying 10 villages (**Fig. 6**).

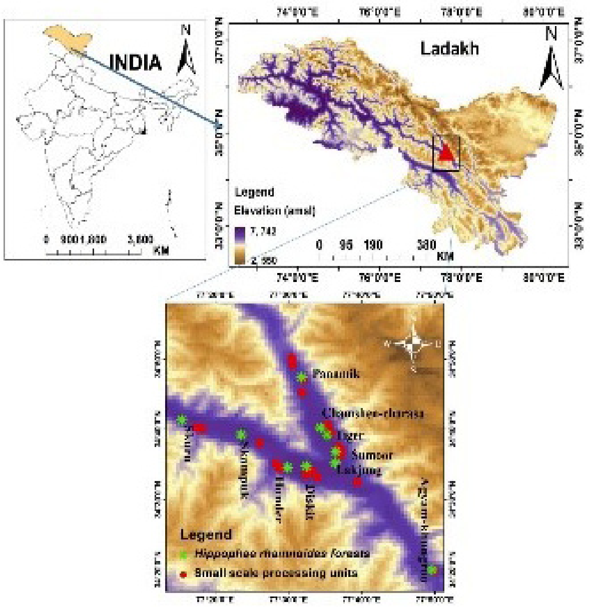


Fig. 5 Map of Nubra showing Seabuckthorn forests and small-scale processing units.

Fig. 6 Estimation of fuelwood collected.

Automated Phenological monitoring: The phenophases monitoring of a *Betula utilis* forest and snow cover patterns continued. During the reporting period, more than 800 images were auto-clicked and saved. Snow cover and green up patterns revealed temporal trends. These long term continuous images have implications for global change studies.

Enriching the CSIR-TKDL Point of Presence: A center targeting Trans Himalaya System of Medicine (Sowa Rigpa) has been established at the Institute. It continued digitization of information available in Bhoti language. Close to 600 new records were added to the database during the current year.

Relevant Publications:

- Vegetos. 2022, https://doi.org/10.1007/s42535-022-00403-5.
- Urban Climate. 2022, 45: 101239.
- National Academy Science Letters. https://doi.org/10.1007/s40009-022-01194-8.

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Remote Sensing and GIS

This year we have focused on satellite multispectral remote sensing for mapping forest fire, field hyperspectral remote sensing for medicinal crops, and prioritising area for the cultivation of high-value crops using the Ecological Niche Modeling technique.

Hotspot and trend analysis of forest fires

Western Himalayan Forest Fires Hotspots were Mapped using satellite data **(Fig. 1)**. Fire hotspots (radiation, frequency, density) were highest in Uttarakhand followed by Jammu & Kashmir, Himachal Pradesh, and Ladakh. The start of fire season was observed as February in Uttarakhand, March in Himachal Pradesh, April in Jammu & Kashmir, and May in Ladakh. An increase in population, high forest cover density, and availability of litter during fire season were found responsible for increased fires. Fire events increased towards low latitude and higher longitude regions.

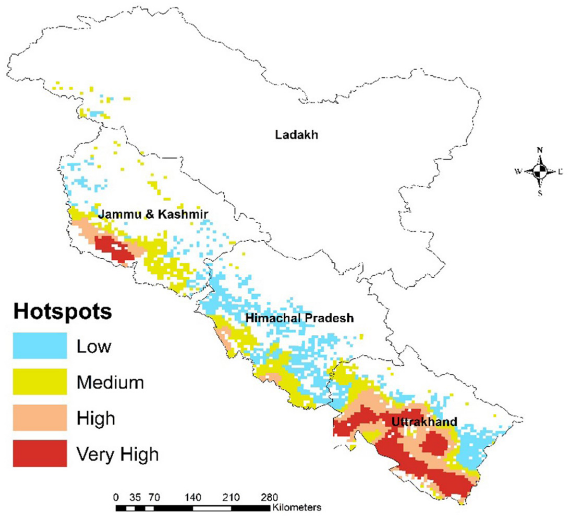

Fig. 1 Forest fire hotspot map of western Himalaya.

Modelling forest phenology using time series images and weather data

Under the Indian Space Research Organisation (ISRO) Geosphere-Biosphere Programme, the CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT), Palampur has collaborated with the Space Applications Centre (SAC) on a national-level project, "Modelling Forest Phenological Parameters from Time Series Remote Sensing Data." The goal is to understand the influence of climate change on Chir Pine forest, for which a PhenoMet Station was installed at Baba Balaknath Temple in Deotsidh, district Hamirpur, Himachal Pradesh **(Fig. 2)**.

Fig. 2 PhenoMet station at Baba Balaknath Temple (Deotsidh), Hamirpur, Himachal Pradesh.

Non-invasive techniques for leaf chlorophyll estimations

Leaf chlorophyll is vital for plants because it helps them get energy through the process of photosynthesis. Thus, a review was carried out and it was found that hyperspectral remote sensing along with Artificial Intelligence (AI) and Machine Learning (ML) techniques can be utilised for efficient and rapid estimations of leaf chlorophyll content on local and regional scales.

High-resolution NextGen remote sensing for medicinal crops

This study aimed at exploring the capability of high-resolution Hyperspectral remote sensing data and machine learning techniques in identifying medicinal plants of the Indian Himalayan region. Identification of medicinal plants in the field requires taxonomic skills, which is one of the major bottlenecks in the conservation and management of these plants. The spectral data of *Picrorhiza kurrooa*, *Saussurea costus*, and *Valeriana jatamansi* were recorded (**Fig. 3**) from farmer's fields from various locations of Himachal Pradesh and Uttarakhand between 800 to 4590 m amsl. The green (555-598 nm), red (605 nm), and NIR (725-840 nm) wavelength regions were identified as suitable for the discrimination of these threatened medicinal plants using a random forest classifier. Thus, an approach for rapid and onsite identification of the medicinal plants in the field was identified using hyperspectral remote sensing techniques.

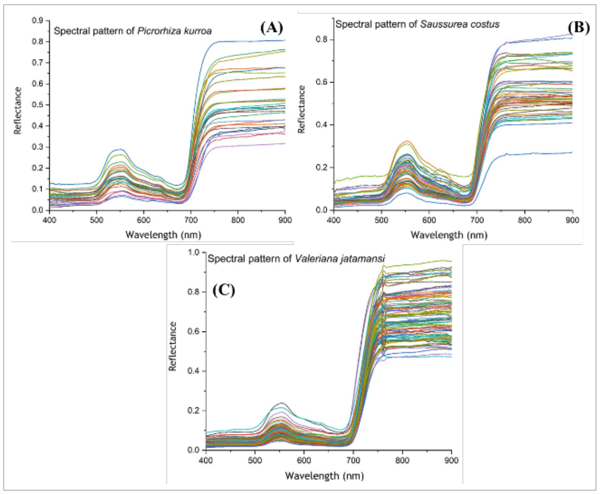

Fig. 3 Spectral signature of (A) *Picrorhiza kurroa* (B) *Saussurea costus* and (C) *Valeriana jatamansi.*

Ecological Niche Modeling for the Saffron cultivation in the non-traditional regions

The *Crocus sativus* L. (Saffron) is a globally used expensive spice. India contributes 5% of the world's total production of which 90% is supplied only from its Jammu and Kashmir (J&K) regions. Therefore, 'MaxEnt' modelling was carried out using 103 environmental variables, 20 presence data and topographic parameters (elevation, slope and aspect) to find out suitable regions for saffron cultivation in unconventional areas of India (**Fig. 4**). The length of stigma of saffron in the new locations was found at par with an average length of stigma from J&K. The obtained yield was at par with the national average yield.

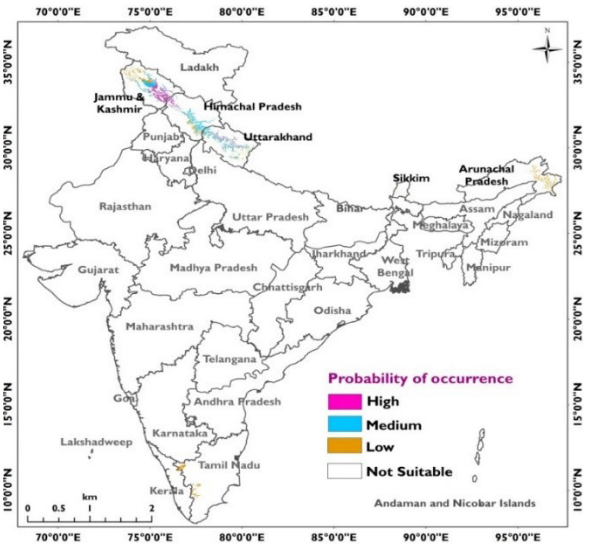

Fig. 4 Modeled potential habitat for Saffron cultivation in India.

Research group: Kishor Chandra Kandpal, Ankit, Vivek Dhiman, Akash, Meenakshi, Kajal, Manisha and Archana Sharma.

Relevant Publications:

- Scientific Reports. 12: 11925.
- Natural Hazards. 114: 3529-3544.
- Critical Reviews in Analytical Chemistry. https://doi.org/10.1080/10408347.2023.2188425.

Amit Chawla, Principal Scientist
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Plant Ecology

(I) Studying Impact of Climate Change on Treeline and Alpine plants

(a) Monitoring of timberline forests

The data recorded at the 04 Long Term Ecological Research (LTER) sites was utilized to train ecosystem models. The parameterization of BIOME BGC model resulted in simulation of Net Primary Productivity (NPP) Leaf Area Index (LAI) and Water Use Efficiency (WUE) of the timberline forests. The modelled simulated mean annual NPP ranged from 134 to 386 gC m^{-2} yr^{-1} **(Fig. 1a)**. The model simulations also suggested future predictions of NPP of timberline forests.

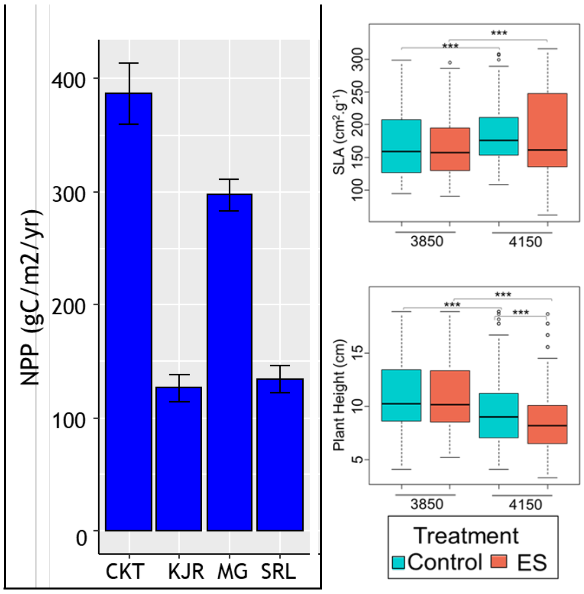


Fig. 1 (a) The range of simulated NPP at the 04 sites (b) A comparison of control and treatment (ES) on alpine plant species.

(b) Monitoring of alpine vegetation

Field studies and ecological monitoring was undertaken in the LTER site at Rohtang. The data on phenology of dominant alpine species was collected along with population assessment and recording of vegetative and reproductive traits. We found that species occurring at contrasting elevations respond differently to Early Snowmelt **(Fig. 1b)**. Further, the species with acquisitive and conservative strategies give an elevation specific response to increase in Growing Season Length (GSL).

(II) Studying adaptation strategies of high altitude plants

(a) Alpine shrub-herb interactions

In order to assess the potential impacts of dominance of shrubs on carbon cycle, carbon fluxes in the three dominant high altitude shrub communities (*Rhododendron anthopogon*, *Juniperus polycarpos*, *Caragana versicolor*) and their adjacent herbaceous communities in the alpine ecosystem of western Himalaya with altitude ranges from 3500-5000m amsl were assessed in a comparison study. Our results indicate the higher uptake C-uptake in the evergreen shrubs might be due to their evergreen nature which might be due to their greater photosynthetic area (in both *R. anthopogon* and *J. polycarpos*) as compared to deciduous, *C. versicolor* and suggest that evergreen shrubs may sequester more carbon under the future climate change scenario.

(b) Study of transcriptome of *Rhododendron anthopogon* for understanding cold acclimation process

Leaves were sampled at an elevation of 3990 m amsl in western Himalaya (at Rohtang), at 10 time-points spanning a period of one year for studying the variation in transcriptome and physiological adjustments occurring across the year at high elevation environments in the leaf tissue of *Rhododendron anthopogon*, an alpine evergreen and broad leaf shrub of Himalaya. It was observed that on the basis of profiling of a total of 9,881 differentially expressed genes, 04 time-points could be segregated into four clusters directly correlating with the distinct phases of acclimation during the growth cycle of plant. It was also found that with a drop in both ambient air temperature and photoperiod towards onset of winter, the freezing resistance of plants increased, resulting in 'cold acclimation'. Further, 'de-acclimation' was associated with a decrease in freezing resistance and increase in photosynthetic efficiency of leaves during spring.

(III) Ecological studies on high altitude vegetation

With continuation of floristic studies in Pangi valley, a total of 771 species of higher plants were authenticated to be occurring in various elevation zones.

(IV) Conservation of threatened medicinal plants

The field genebank, established at CSIR-Centre for High Altitude Biology was further enriched with multiple accessions of threatened plant species and accessions of additional 02 species were added with collection from different locations in Himachal Pradesh.

We continued with studies on understanding the biology of *Dactylorhiza hatagirea*, a threatened terrestrial orchid of Himalaya and their metabolome was studied. The tubers were found to have a significant nutritional potential which included phenolics and flavonoids, free amino acids, carbohydrates, macro and microelements, and others present in promising amounts. The current investigation also found dactylorhins A and B, in the alcoholic or hyroalcoholic extract, which was found to be more potent than water extract.

In a first of a kind study with much practical relevance, the areas suitable for re-wilding or Assisted Colonization (AC) of *D. hatagirea*, in the current and future scenarios were predicted using Ecological Niche Modelling. The suitable sites, area and extent of AC required for conservation of its populations were estimated for the State of Himachal Pradesh **(Fig. 2)**, where the current assessment suggests it to be included in IUCN Red List's 'Vulnerable' category. We found that the habitats of *D. hatagirea* in the State are extremely vulnerable to future shifts and alterations in the climate patterns.

The findings from the present study, thus, could be utilized to alleviate the threats to the survival of populations of this species by carrying out activities such as protecting the habitats, studying the unexplored populations, re-wilding and AC programmes within the Protected Areas (PAs), for planning of conservation and management strategies.

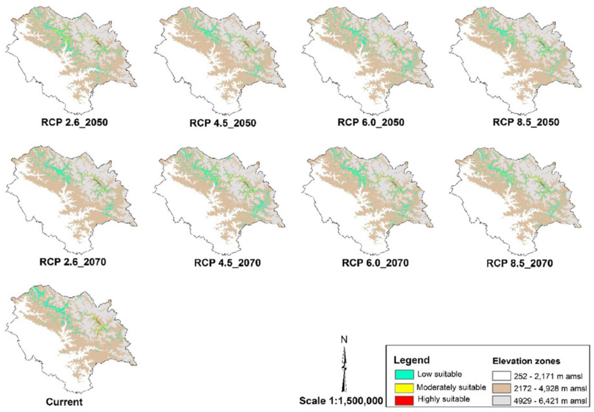
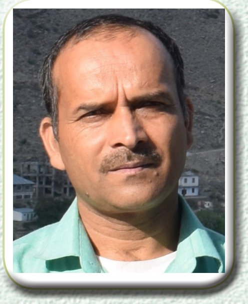


Fig. 2 Current and future distribution maps of *D. hatagirea* populations in Himachal Pradesh (Source: Sharma et al., 2023).

Research group: Om Prakash, Girjanand, Kumari Sita, Shailika Gautam, Lakhbeer Singh, Nandita Mehta, Elennie Hopak, Anupam Bhatt, Manish Sharma, Bittu Ram, Amit Chauhan, Kanika Kumari and Anil Kumar.

Relevant Publications:

- South African Journal of Botany. 154: 203-218.
- Scientific Reports. 12:1553.
- South African Journal of Botany. 150: 431-442.



Ashok Singh, Senior Scientist
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Plant Ecology

Our group mainly works on the generation of information related to ecological studies, and population assessment along with the morphological characterization of threatened, and economically important plant species in the Trans Western Himalayan regions of the Indian Himalaya. Also, I am involved in *ex-situ* conservation studies under the plant conservatory at the *Centre for High Altitude Biology* (CeHAB of CSIR-IHBT) Ribling, Lahaul and Spiti (HP).

High Altitude Ecological Research: Focused ecological studies on the targeted medicinal and aromatic plants were carried out. A survey was conducted along with different habitats in the high-altitude areas of Himachal Pradesh (Kinnaur, Lahaul & Spiti, Chamba, and Kullu districts) to observe their ecological and phenological parameters under different projects. A total of 30 sites were surveyed along with an altitudinal range of 1435 to 3753masl. Population assessment and diversity with distribution patterns along plant communities of species such as *Eremurus himalaicus*, *Polygonatum cirrihifolium*, *Arnebia euchroma*, etc. were recorded **(Fig 1, 2 & 3)**. To develop a field gene bank, variable sample accessions were collected from the surveyed sites.

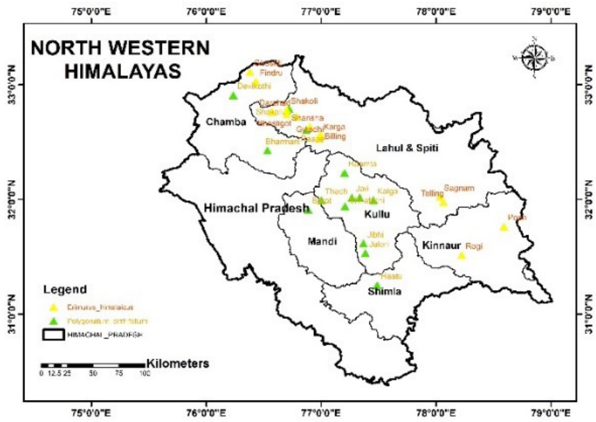

Fig. 1 The distribution pattern of *Eremurus himalaicus* and *Polygonatum cirrihifolium* species in the Western Himalaya.

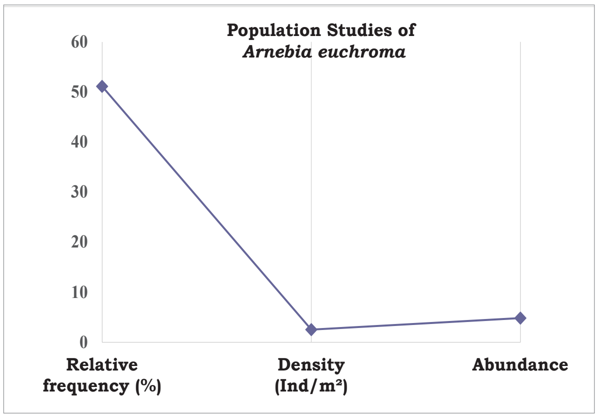

Fig. 2 Population status of *Arnebia euchroma*.

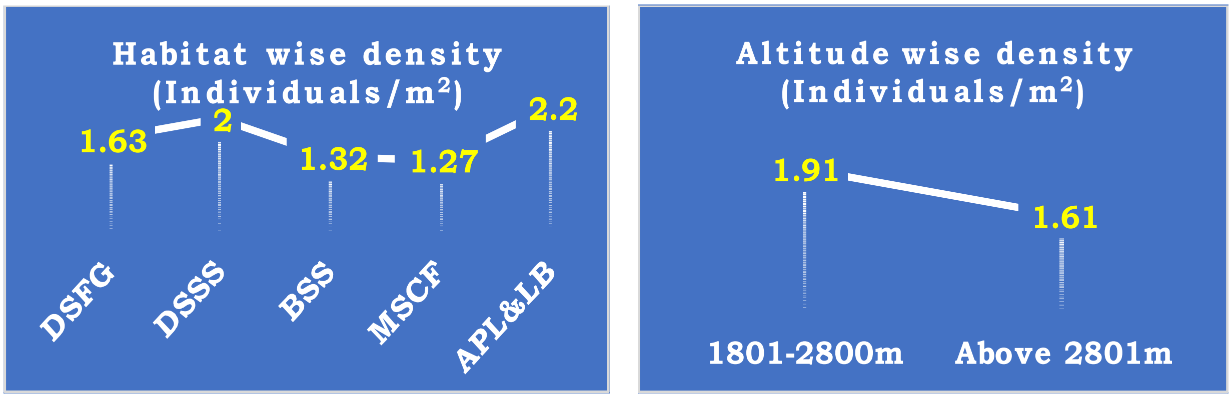

Fig. 3 Habitat suitability and distribution of targeted medicinal plant *Eremurus himalaicus* in the Himachal Pradesh.

Environmental Niche Modeling:

Niche modeling predicted the distribution of *Angelica glauca* with 5316 km^2 (very high and high suitable class), 5785 km^2 (medium suitability area) in the HP state; *Arnebia euchroma* with 3656 km^2 (very high and high suitable class), 3146 km^2 area (medium suitability covers) in the HP state; *Carum carvi* with 1138 km^2 (very high and high suitable class), 721 km^2 (medium suitability covers) in the HP state.

Status of Field Gene-bank Conservatory:

Aimed studies for the conservation of threatened medicinal species were done *at* CeHAB Ribling, Lahaul & Spiti, HP (3450 masl), and CSIR-IHBT Palampur (1328 masl).

- ***Eremurus himalaicus*:** Successfully conserved 15 accessions from Himachal Pradesh in the CeHAB Centre Ribling **(Fig. 4a)**.
- ***Polygonatum cirrihifolium*:** Conserved 15 accessions from Himachal Pradesh with root cuttings in the CeHAB Centre Ribling **(Fig. 4b)**.
- ***Angelica glauca*:** Conserved 19 different accessions collected from Western Himalayas. About 2200 quality plants were successfully raised by seeds and root cuttings in the field gene bank at CeHAB of CSIR-IHBT and CSIR-IHBT Palampur (HP) **(Fig. 4c)**.
- ***Carum Carvi*:** Conserved 20 accessions of *Carum carvi* in the CeHAB farm, farmer's field at Lahaul, and Kullu. Also, conserved 25000 quality plants and harvested 4 Kg seeds from the nursery at CeHAB of CSIR-IHBT Ribling, Lahaul & Spiti (HP) **(Fig. 4d)**.
- ***Arnebia euchroma*:** Conserved 25 different accessions in the CeHAB field gene bank and nursery at CSIR-IHBT. The plants are being propagated through seeds with conventional methods **(Fig. 4e)**.
- ***Aconitum heterophyllum*:** Experimented 5 accessions of different years with seeds harvested from the CeHAB Ribling, Lahaul & Spiti and tested the viability and establishment in the CSIR-IHBT Palampur under field conditions.
- ***Sinopodophyllum hexandrum*:** A total of 20 accessions were conserved at CeHAB Ribling, and produced seeds as quality planting material for the sowing **(Fig. 4f)**.

Characterization for the selection:

Elite accessions of *Arnebia euchroma*; *Carum carvi*; *Angelica glauca*; *Sinopodophyllum hexandrum*, *etc.* were selected based on their superior physical appearances.

Seed bank conservatory of MAP species at CeHAB: about 20 species conserved.

Fig. 4a *Eremurus himalaicus*

Fig. 4b *Polygonatum cirrihifolium*

Fig. 4c *Angelica glauca*

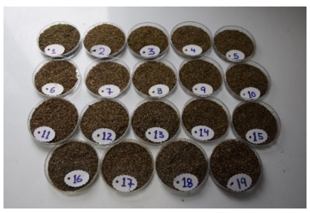

Fig. 4d *Carum carvi* seeds

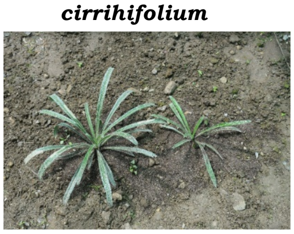

Fig. 4e *Arnebia euchroma*

Fig. 4f *Sinopodophyllum hexandrum*

Research group: Rajat Bhardwaj and Phoola Devi.

Relevant Publications:

- Sustainable Water Resources Management. 8:103.
- Arid Ecosystems. 12(3): 251-271.
- Journal of Applied Research on Medicinal and Aromatic Plants. 100447.

Vikas Kumar, Scientist
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Plant Taxonomy

Our team is working on taxonomic studies on Himalayan flora. Presently, we are revising the Genus *Cremanthodium* Benth. for India. *Cremanthodium* is a complex and endemic genus of the Himalaya which is found in alpine to subalpine region. We are also involved in conservation of medicinal and threatened plants through establishment of Herbal garden.

Floristic survey and collection of plant specimens: Five field tours were conducted in different parts of the Himalayas viz. Himachal Pradesh, Uttarakhand, Sikkim and Arunachal Pradesh during 2022-23, and ca 210 samples were collected of which 180 were identified and processed for herbarium. A few propagules of medicinal plants were also collected for conservation purpose.

Taxonomic novelties: *Morina ludlowii* (M.J. Cannon) D.Y. Hong, a threatened and endemic species of Himalaya, is rediscovered after a gap of 84 years from Tawang district of Arunachal Pradesh, India. The conservation status 'Endangered' is also assessed as per IUCN guidelines. While exploring the alpine region of the Tawang district of Arunachal Pradesh as a part of the floristic study we collected *Saxifraga bergenioides* C. Marquand and reported it as a new distribution record for the India. Besides two species viz., *Acronema hookeri* (C.B.Clarke) H.Wolff and *Impatiens falcifera* Hook.f. were collected and reported as new distributional records for the state Arunachal Pradesh **(Fig. 1)**.

Fig. 1 a. *Morina ludlowii* (M.J. Cannon) D.Y. Hong; b. *Saxifraga bergenioides* C. Marquand; c. *Acronema hookeri* (C.B.Clarke) H.Wolff; d. *Impatiens falcifera* Hook.f.

Taxonomic studies of the genus *Cremanthodium*: The taxonomic revision of the genus *Cremanthodium* Benth. in India is being carried out. DNA sequence data of the nrDNA ITS region and the chloroplast trnC-petN intergenic spacer were generated for 9 species of *Cremanthodium*. Based on type specimens and protologue the taxonomic ambiguity of *Cremanthodium arnicoides* was resolved. Besides lectotypification of two names viz. *Cremanthodium arnicoides* and *Ligularia arnicoides* were also designated as per ICN guidelines.

Conservation of Medicinal Plants in Herbal Garden: A herbal garden is established for conservation of high valued medicinal herbs. About 100 species of medicinal plants have been conserved which were collected from different parts of the Himalaya **(Fig. 2)**.

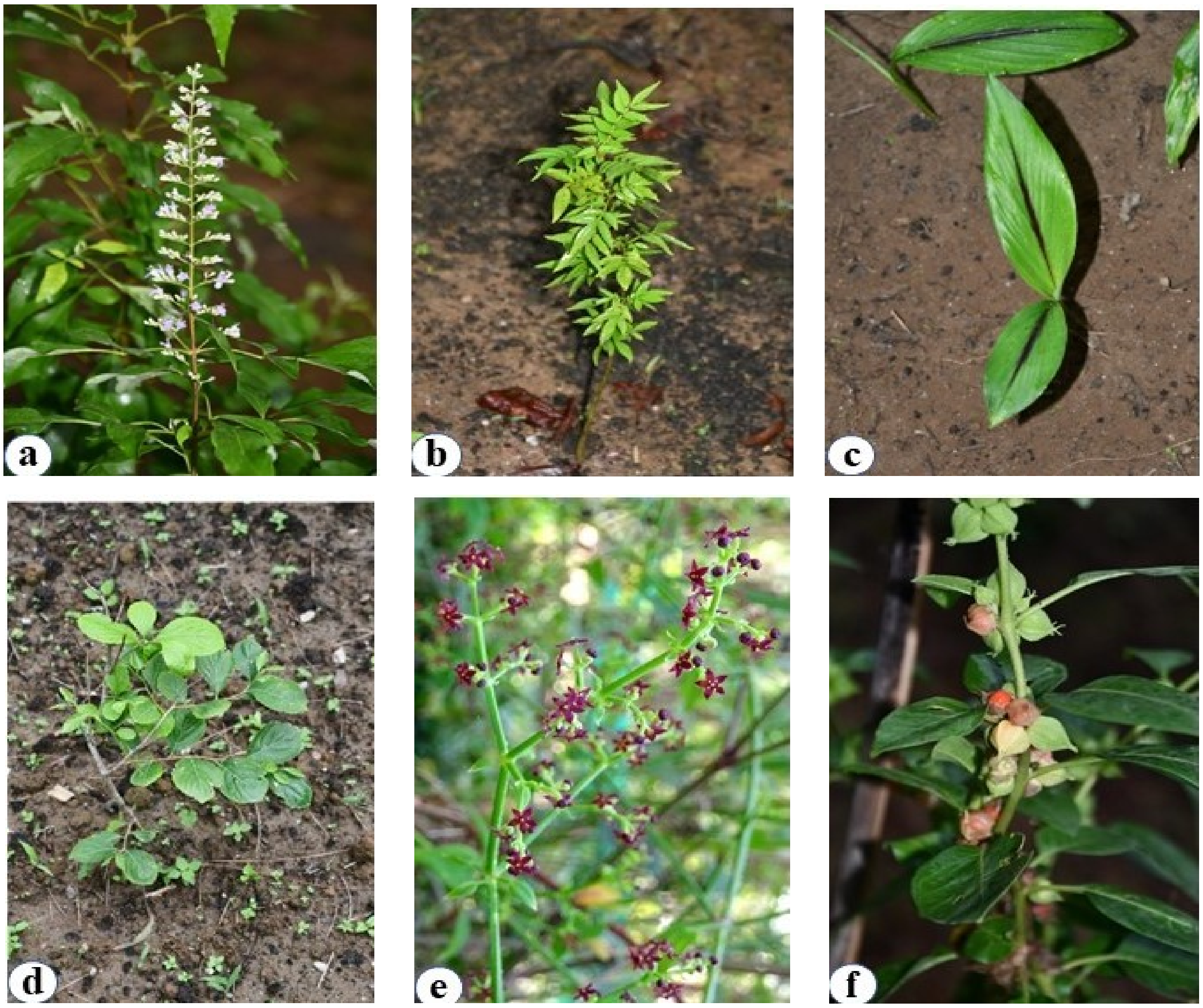


Fig. 2 a. *Vitex negundo* L.; b. *Zanthoxylum armatum* DC.; c. *Curcuma cassia* Roxb.; d. *Celastrus paniculatus* Willd.; e. *Rubia cordifolia* L.; f. *Withania somnifera* (L.) Dunal.

Research group: Rahul Kumar.

Relevant Publications:
- Phytotaxa. 2023, 591(2): 177-180.
- Phytotaxa. 2023, 595(2): 236-239.

CENTRE FOR HIGH ALTITUDE BIOLOGY (CeHAB)

Centre for High Altitude Biology (Estbl. 2011)

Location: Ribling, V.P.O. Tandi, Lahaul & Spiti (32°34'13.9"N, 76°58'32.0"E, 3450 m asl (11,200ft)

Area: 20 ha (50 acres)

Mission:

Connect to Innovate for Ecology, Economy and Societies of Higher Himalayas through Fundamental and Industrial Research

The research centre has been established with the primary objective of utilizing the bioresources of high altitudes for the benefit of people living in the tribal areas of Himachal Pradesh. The centre 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. With an infrastructure setup of Research Farm with green houses, shade nets, drying and storage areas, and a laboratory complex, the Research Centre envisages to be a hub of for excellance in biological research and extension in the high altitude tribal region.

Objectives:

- Mapping and bioprospecting of genetic resources of high altitudes
- Study and predict the effects of climate change and understanding adaptation strategies of high altitude plants
- *Ex situ* conservation of native, endemic and threatened plants including establishment of conservatories
- To develop strategies for conserving and promoting high altitude bio-resource.
- Societal upliftment through extension of technologies and skill development programmes

The progress made under the defined objectives is given as follows: -

I. Mapping and bioprospecting of genetic resources of high altitudes

- Floristic studies were conducted in Pangi valley, and a total of 771 species of higher plants were recorded and finally authenticated to be occurring in various elevation zones (Main Investigator: Dr. Amit Chawla).
- Surveyed the populations of *Eremurus himalaicus* and *Polygonatum cirrihifoium* in the Himachal Pradesh (Main Investigator: Dr. Ashok Singh).
- Surveyed the populations of *Onosma hispida*, *Physochlaena prealtea* and *Hyssopus officinalis*, and collected germplasm for Field Genebank (Main Investigator: Dr. Amit Chawla).
- The Ecological Niche Modelling (ENM) was utilized to map the populations in Himachal Pradesh, and its distribution analysis revealed its current threat status in HP as 'Vulnerable' based on IUCN range loss criterion A3(c) (Main Investigator: Dr. Amit Chawla).
- The metabolome of tubers of *Dactylorhiza hatageria* was studied which revealed a significant nutritional potential and important metabolites such as Dactylorhins A and B (Main Investigators: Dr. Dinesh Kumar & Dr. Amit Chawla)

II. Study and predict the effects of climate change and understanding adaptation strategies of high altitude plants (Main Investigator: Dr. Amit Chawla).

(i) The previously established LTERs in treelines (Chitkul, Mulling, Khanjar and Sural Bhatori) and alpine zones (at Rohtang) were studied for prediction of changes in ecosystem processes and impacts on vegetation.

(a) The BIOME BGC Model was trained to predict changes in ecosystem processes in the timberline forests such as Net Primary Productivity (NPP) and Water Use Efficiency (WUE). The modelled simulated mean annual NPP ranged from 134 to 386 gC m^{-2} yr^{-1}.

(b) Similarly, at an alpine site in Rohtang, our study suggested that species occurring at contrasting elevations respond differently to Early Snowmelt. Further, the species with acquisitive and conservative strategies give an elevation specific response to increase in Growing Season Length (GSL).

(ii) The study of 03 dominant high altitude shrub communities (*Rhododendron anthopogon*, *Juniperus polycarpos*, *Caragana versicolor*) and their adjacent herbaceous communities in the alpine ecosystem suggested that evergreen shrubs may sequester more carbon under the future climate change scenario.

(iii) Using the ENM (Ensemble model approach), the future predictions of populations of *Dactylorhiza hatagirea* were undertaken which revealed reduction in highly suitable range of habitats in Himachal Pradesh. The future predictions were utilized to strategize re-wilding efforts in the State.

(iv) Among the studies undertaken to understand the adaptation strategies of high altitude plants, transcriptome of *Rhododendron anthopogon* was investigated for knowing the change in gene expression profiles during the cold acclimation and de-acclimation processes. On basis of profiling of a total of 9,881 differentially expressed genes, 04 time-points could be segregated into four clusters directly correlating with the distinct phases of acclimation during the growth cycle of plant. It was also found that with a drop in both ambient air temperature and photoperiod towards onset of winter, the freezing resistance of plants increased, resulting in 'cold acclimation'. The 'de-acclimation' phase was evident during was spring when snow-melt occurred and was associated with a decrease in freezing resistance and increase in photosynthetic efficiency of leaves during spring.

III. *Ex situ* conservation of native, endemic and threatened plants including establishment of conservatories

(i) Establishment of mass propagation protocols for *Fritillaria roylei* (Main Investigator: Dr. Kiran Devi)

a. Complete *en masse in vitro* propagation system established in *Fritillaria roylei* for sustainable resource generation and conservation and hardened plants rehabilitation to natural habitat in field of a collector of wild medicinal plants turned grower. The beauty of the protocol was formation of storage organ that could be directly shifted to field without an inteveing hardening stage. Another aim was to give farmer an alternate option of income generation and minimize the exhaustive harvest from wild.

Development of *in vitro* systems (Proliferation and storage organ production) for propagation of *F. roylei.*

(ii) Optimizing tissue culture protocols for *Colchicum* sp. (Main Investigator: Dr. Kiran Devi) Callus culture established using leaf explant in this sp. for indirect shoot formation and secondary metabolite production.

In addition to the above, efforts are being made to establish cultures of other important medicinal crops of high altitude and lillium bulb production which is currently becoming an important crop for people of high altitude including Ladakh.

(iii) Establishment & Enrichment of Field Gene Bank (FGB) at Ribling

a. A total of 40 threatened plant species with multiple accessions (~250) of live plants have been transplanted in the field gene bank CeHAB. The FGB was enriched with more accessions. Further, 04 new threatened species such as *Colchicum luteum*, *Onosma hispida*, *Physochlaena prealtea* and *Hyssopus officinalis* were added in the existing FGB. Herbarium samples have also been collected.

b. Also Enriched the Field Genebank at Ribling with the following species: -

Eremurus himalaicus and *Polygonatum cirrihifoium*

IV. To develop strategies for conserving and promoting high altitude bio-resource.

(A) Studies on developing Good Agricultural Practices of *Inula racemosa*

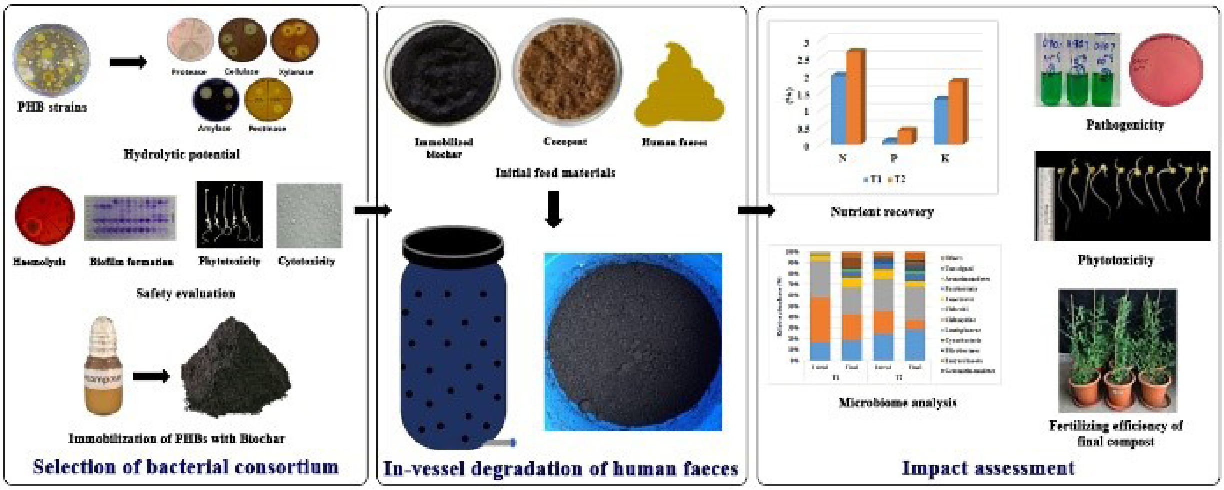
(i) Effect of crop geometry and fertilizer levels on dry root yield of *Inula racemosa*

To standardize the agrotechnology for *Inula racemosa*, a field experiment was conducted at CeHAB, Ribling farm to evaluate the effect of spacing (30 × 30, 30 × 45 and 45 × 45 cm) and fertilizer dose (0, 90-60-30, 120-75-40, and 150-90-50 kg ha^{-1} of N-P-K) on its dry root yield. The results showed that among different crop geometry, highest dry root yield was obtained with 30 × 45 cm of plant spacing, whereas, NPK @ 120-75-40 kg ha^{-1} out-performed over other fertilizer levels.

V. Societal upliftment through extension of technologies and skill development programmes

(i) 'Compost Booster' as solution to the problem of Night Soils in High Altitude Himalaya.

The high-altitude regions, particularly the Himalaya experiences heavy snowfalls and landslides that cause soil erosion and increase the rate of nutrient leaching, reducing soil fertility. The waterless composting toilets (CTs) provide a low-tech option for nutrient recycling from human faeces (HF) and sustaining agro-ecosystems in the region. However, CTs are often faced with delayed composting process, foul odour, and prevalence of heavy metal content due to different co-composting materials. The study explored an effective approach for HF degradation at low temperatures through biochar-immobilised psychrotrophic bacterial consortium. Based on the hydrolytic potential, pathogenicity, cytotoxicity, and phytotoxic effects, 14 potential bacteria were selected to prepare a novel consortium. The non-pathogenic indigenous psychrotrophic hydrolytic bacterial (PHB) strains were immobilized in bamboo biochar and evaluated for HF degradation at low temperatures. The results demonstrated that PHB amendment with coco peat as a bulking agent (T2) decomposed HF within 90 days compared to the un-inoculated treatment (T1) and achieved the standard composting parameters. The PHB-amended treatment also enhanced the bacterial community structure in the final compost with acceptable pathogen levels. The study demonstrated that the final compost in T2 was free from phytotoxic effects (123 ± 2.24) compared to the un-inoculated treatment (58.2 ± 4.72). Similarly, soil fertilized with T2 compost showed higher fertilizing efficiency than T1, with an increase in yield and growth of Pisum sativum var. AS-10. The outcome of this study has considerable potential for HF degradation at low temperatures, and the resultant compost has high agronomic value with low environmental impact (Fig 1). The composting strategy using biochar-based formulation can benefit composting toilet users existing in ecologically fragile Himalaya, mountaineers travelling to remote locations, and CTs in other low temperature regions.



In-vessel study of human faeces degradation at 10°C and assessment of final compost for fertilizing efficiency.

PLANNING, PROJECT MONITORING AND EVALUATION - BUSINESS DEVELOPMENT AND MARKETING UNIT

PLANNING PROJECT MONITORING & EVALUATION (PPME)

Institutional Research Planning: Formulation of various documents sent to CSIR headquarters, compiled AYUSH projects info, KPI, information on women scientist, demand for additional grant, RE-BE-2023-24, details of institute's technologies mapped against identified problems of line ministries, compiled slides of Institute achievements and roadmap of themes, Panel of expert (Technical), information on Action point from society meeting, information for AcSIR NIRF 2023, monthly report covering significant achievements, quarterly report, and action taken towards achievement of goals were regularly furnished to the competent authority.

For constant updating of institutional data on various domains, 25 proforma and report on daily basis were uploaded on to C-DIS portal during 2022-23. PPME recorded initiation of 31 new projects funded by various agencies (DBT, DST, NMPB, ICMR, MSME etc.). As a part of routine activity it carried out the updation and maintenance of databases pertaining to projects, staff, papers, patents, ECF, resource management etc. For facilitating decision making, the Division carried out monitoring of institutional performance with respect to publication, ECF, patent, technology transfer and societal impact. The Division also compiled Institutional information for CSIR Annual Report. PPME furnished inputs to 44 parliament questions received from CSIR.

Resource planning and monitoring: Facilitated in the fund allocation and expenditure as per the need and mandate of the Institute. Coordinated meetings to plan new infrastructures and equipment. To cater to manpower need of the institute, appropriate steps were taken to seek approvals and induct new manpower. Lab strategic Group (LSG) has been formed in accordance with CSIR guidelines and monitoring meeting of major projects are taken-up on weekly basis.

IT based activities: The information related to Institute's activities were promptly posted in social media (Facebook, Tweeter, YouTube etc.) and sent to CSIR headquarters for its inclusion in CSIR in Media news bulletin. Information were regularly updated and flashed in intranet as well as Institute website.

Right to Information: Furnished information on 74 queries under RTI Act and filed quarterly report to RTI portal www.rti.gov.in.

PPME organized the events of national importance as detailed below:

- ➢ National Technology Day (11th May, 2022)
- ➢ World Environment Day (6th June, 2022)
- ➢ CSIR-IHBT Foundation Day (2nd July, 2022)
- ➢ CSIR Foundation Day (15th November, 2022)
- ➢ One Week One Lab Programme (20-25th February, 2023)
- ➢ National Science Day (28th February, 2023)
- ➢ International Women's Day (6th March, 2023)

The Division conducted 63rd and 64th Meeting of Research Council of the Institute on 28th July and 17-19th December, 2022, respectively.

PPME proactively supported the following programmes organized at the institute:

- ➢ CSIR-HRDG Pre-Examination Meeting (13-15th May, 2022)
- ➢ Aromatic Marigold Day-Harbinger of Golden Revolution (24th May, 2022)
- ➢ Director's Conference (28-29th October, 2022)
- ➢ Visit of Dr. NK Kalaiselvi, DG CSIR and Secretary, DSIR (30th October, 2022)
- Induction programme for newly recruited scientists (45th batch) organized by CSIR-HRDC, Ghaziabad at CSIR-IHBT (13-18th February, 2023)

BUSINESS DEVELOPMENT AND MARKETING UNIT (BDMU)

This Unit is making all its efforts to convert high end R&D technologies into the business. BDMU is involved in economic and social impact analysis, organizing scientific & industrial meets, promoting technologies, responding to the queries of farmers and entrepreneurs regarding different technologies, facilitating technology transfers through Agreements, Material Transfer Agreements (MTAs), Incubation Facilities under "Chief Minister's Start up Scheme", need based incubation, MoU with farmer societies for installation of essential oil units, processing of disseminating technologies and products to the society.

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, procurement of services related to open / global tenders, socio-economic impact analysis of technologies/ services from third parties and providing input for drafting technology specific documents.

Sukhjinder Singh, Senior Scientist
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Coordinator Business Development & Marketing Unit.

Research Focus: Transfer of Technology, Business Development, Techno-economics, Promotion of technologies, Establishing Institute's linkages with Industries/ Startups/ Farmers and R&D Institutes/Academia. Worked as PI in DSIR Sponsored Project, "Studies on Technology and Innovation". Nodal Scientist for Vertical, "Establishing effective domestic and international market linkage" in CSIR Floriculture Mission. Acted as Co-PI in the project, "Agro-ecology in Himalayan States with Special Emphasis on Marketing". Registered Technology Transfer Professional (RTTP) by Alliance of Technology Transfer Professionals (ATTP). https://attp.info/current-rttps/

Recognition:

- Received "Best Paper Award (Poster Presentation Award02022)" on the occasion of Regional Conference on "Speciality Agriculture in the Context of Farm Economy of Himalayan Region" organized by Division of Agril. Economics and Agribusiness Management, SKAUST, Jammu in collaboration with Indian Society of Agril. Economics, Mumbai w.e.f. September 21-22, 2022.
- Certificate of participation in International Workshop on, "Role of Science, Technology and Innovation (STI) in Achieving Sustainable Development Goals- 2023" a virtual event from 24-25 May, 2022 organized by NAM S&T Centre, New Delhi and Indian Ocean Rim Association (IORA), Ebene (Mauritius).

Business Development and Marketing unit is focusing on Transfer of Technologies, Business Development, Techno-economics, Procurement of R&D and technical services, Raising FVC, Promotion of technologies, and Liaison with Industries/ Startups/ Farmers and Institutes.

Transfer of Technologies: Interaction with the interested industries/ entrepreneurs/ startups/ farmers related to transfer the technologies/ materials. Drafted agreements/ MoUs/ MTAs as per mutually decided terms and conditions.

Total 360 MoU/ Agreements signed: 13 technology transfer agreements; 314 Material transfer agreements; 7 agreements with incubatees/ startups; 26 Misc. MoUs (including MoUs with Govt. Departments, Academic and R&D Institutions).

During 2022-23, CSIR-IHBT has signed thirteen agreements for transfer of technology i.e. to transfer the knowhow for Compost Booster, cultivation of Shiitake/ Oyster mushroom, Tissue culture technology of Saffron, Technology for fabricating distillation units, Technology for manufacturing/ processing of Granola/protein/energy bars - (millet and cereals, protein based) PRODUCTS, knowhow for instant protein beverage mixes, manufacturing/ processing of multigrain protein powder products, for making herbal incense cones and sticks, process for production of dual bio-products (bioplastic and violacein pigment) from Himalayan bacterial isolate PCH194, and Technology for artifact making from dry flowers.

Besides, this, three hundred and fourteen material transfer agreements (MTAs); twenty-six miscellaneous MoU's signed with different farmer societies, academic and R&D collaborations with government institutes/universities; and seven MoUs/Agreements under "Chief Minister's Start up Scheme" for incubation and facility use of CSIR-IHBT were also signed. Details of agreements/ MoUs signed are provided in Rolled out Technologies.

Business Development: New clients (more than 350 numbers) were added to the organization through ToT/MTA/ Consultancy agreement and technical services. Also focused on client retention; upsell and cross sale of technologies to the customers; and industry's feedback/ satisfaction.

Facilitating industry partners/ startups to market outreach their CSIR-IHBT technology based products.

Techno-economic feasibility evaluation of technologies: Floating Expression of Interest (EOI) on institutes websites for transfer of technologies available at CSIR-IHBT. Evaluating techno-economic feasibility/ cost of production of technologies as this information is required during deal for transfer of technologies. Also evaluated charges for different consultancy projects, sponsored projects, training programmes and availing facilities.

Promotion of technologies: Participated in national and international exhibitions/ trade fairs to represent CSIR-IHBT for promotion of technologies through virtual platforms. Some of the major events we participated are as:

- Participated in **Indian Science Congress (ISC) - 2023**, Mega Science Exhibition held at R.T.M. Nagpur University, Nagpur, Maharashtra from 3-7 January, 2023 and displayed CSIR-IHBT technologies. CSIR Pavilion was adjudged as **"Best Exhibitor of the year" Award**.
- Participated in "VISION Rajasthan-2022" at Sirohi, Rajasthan from 1-3 November, 2022 and CSIR got 1st prize for "Best Stall".
- Participated in the Mega Science and Technology Exhibition at India **International Science Festival (IISF)- 2022** being organized during January 21-24, 2023 at MANIT, Bhopal, Madhya Pradesh and displayed CSIR-IHBT technologies. CSIR Pavilion won the **'Best Pavillion in the Expo' Award**.
- Participated in "Alluring Rajasthan-2023" at Udaipur, Rajasthan from 23rd to 25th February, 2023 and CSIR got 1st prize for "Best Stall" under 'Research and Development Category'.

Linkages amongst Academia/ R&D Institutes and Industry: We also studied the extent of linkages amongst different academia/ R&D Institutes and Industry in the state of Himachal Pradesh through DSIR sponsored project. Data was compiled and analysed through suitable techniques (Descriptive Statistics, Regression Analysis) to find out the results for linkages amongst academia, R&D institutes and industries.

Besides this, we also created data base for Herbal, Food processing and NGO/ FPO database of Indian Himalayan Region under NITI Ayog sponsored project.

Procurement of Technical/R&D Services: Procured Technical R&D services by inviting tenders.

Relevant Publications:

- Journal of Crop and Weed. 18(3): 01-07.
- A Review" Agricultural Reviews. 2022, DOI: 10.18805/ag.R-2536.
- International Journal of Arts, Science and Humanities. 2022, 10 (02): 56-67.

PROJECT SCIENTIST, WOS-A INSPIRE FACULTY, CSIR-POOL OFFICER, RAMANUJAN FELLOW

Satish Singh, Ramanujan Fellow

Division of Dietetics and Nutrition Technology

Project Funding- "Ramanujan Fellowship RJF/2020/000070-Effects of alpha2-antiplasmin on fibrosis, neovascularization and inflammation in chronic deep vein Thrombosis."

Designing and cloning of a2AP's mutants and establishment of expression systems:

Based on homology modeling on mouse a2AP (PDB: 2R9Y) template, different structural mutants of human a2AP were designed and gene synthesis was done commercially (Thermo Scientific) in the provided vector. The synthesized genes have been tested for the DNA sequence, actual size, and compatibility for the restriction sites **(Fig. 1)**. More mutations will be created using specific primers when required. Expression and purification will be done in **CHO-S cells or *Pichia pastoris.* Both expression systems have now been established in the lab.** The proposed genes for a2AP/mutants will be cloned in pCHO 1.0 vector and transfected in CHO-S cells. The proteins will be expressed and purified using Ni-NTA chromatography to be tested in cell lines and animal models of venous thrombosis.

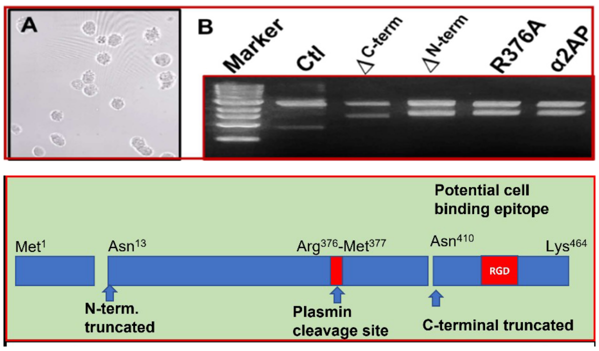


Fig. 1 Cloning and Expression of α2AP mutants Panel A shows Expi-CHO™ cells growing in Expi-CHO™ suspension medium, the cells were grown for 4 passages. Panel B shows the gene constructs for designed mutations. The vector-containing genes were digested with restriction enzymes and run on 1% Agarose gels. (Size=1.5kb for inserts). Ctl-unrelated plasmid DNA, $\Delta^{C\text{-}term}$ (C-terminal truncated human α2AP), $\Delta^{N\text{-}term}$ (N-terminal truncated human α2AP), R376A (α2AP mutant lacking plasmin inhibition activity), α2AP- full-length human α2AP. Lower Panel C shows a diagrammatic representation of the various mutants.

Screening of natural products for profibrinolytic or antithrombotic agents using human plasma clot lysis

We have recently developed a human plasma clot lysis assay (by clot turbidity method) for drug-discovery. This is a unique and gold-standard assay for drug screening to find potential and fibrinolytic molecules for cardiovascular diseases. This presents a comprehensive approach to examining the effects of various blood components and discovering their targets. The lead compounds will be finally confirmed in specific protein activity assays to finally test for in vivo activity. The goal of these experiments is to find potential leads of natural products for thrombotic cardiovascular complications to contribute to departmental/ institutional goals of the development of dietary and nutraceutical products.

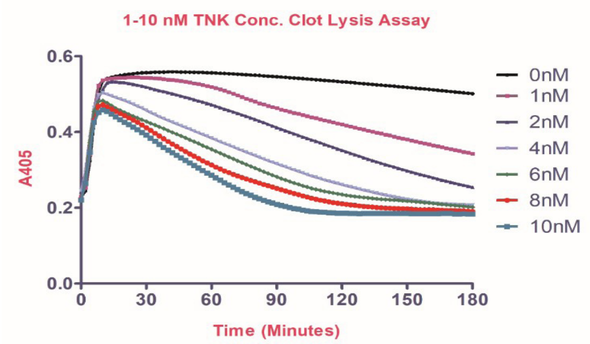


Fig. 2 Human Plasma Clot Lysis- Human Plasma clot lysis assays were done by clot turbidity method using BioTek Synergy microplate reader. Plasma was diluted 50% in Tris Buffer. Clotting was initiated by adding 1NIH units of human thrombin and 5-10 mM $CaCl_2$ in the wells of the microplate. For clot lysis, Tenecteplase was added in different concentrations and dose-response effects were examined on plasma clot lysis. Clot formation and lysis were measured at 405nm.

We have tested ~30 natural products to test the reproducibility of the assay for screening. A potential lead candidate was hypothesized to increase/decrease clot lysis by >25%, to which no compound has yet met the selection criterion. This is an ongoing activity to further refine the assay for compatibility with the required solvents and agents and will be later extended to peptides or small molecules for drug discovery.

Lab establishment, Institutional contribution, and Professional development

For institutional contribution, we have worked continuously to develop the "Protein Production Center" facility at CSIR-IHBT. The recent achievement in this direction is setting up a parallel fermenter of 4 vessels of 5 liters each with departmental support (PI, Dr. Yogendra Padwad, Pr. Scientist, CSIR-IHBT), to contribute to developing protein production strategies. The fermentation procedures have been tested and optimized for protein production in *Pichia pastoris* up to 5 liters of fermentation batches using specific gene constructs. While working on an institutional project (PI, Dr. Yogendra Padwad), we successfully achieved the high-scale production of highly purified endotoxin-free protein (a novel blood clot-dissolving agent), which further advanced to a non-human primate study in Ischemic Stroke. **By using this opportunity for institutional contribution, we have successfully established *Pichia pastoris* expression system for protein production.** We are currently focusing on establishing gene expression strategies in CHO-S cells, the most advanced system for the production of eukaryotic proteins and antibodies.

Research group: Pardeep Kumar

Salient Research Achievements for the current year:

- Submitted a proposal for "Core Research Grant, CRG", SERB 2023. "Alpha2-antiplasmin in neovascularization: the effects on dissolution of chronic blood clots in deep vein thrombosis."
- A review manuscript titled "Safely Targeting the Fibrinolytic System in Venous Thromboembolism-Current Treatments and Future leads" is ready and will be communicated soon.
- Two protein production systems (*P. pastoris* and CHO-S) have been established for recombinant protein production for commercial and therapeutic applications.
- IACUC approval for Animal protocols for doing venous thrombosis surgeries and IBSC approval for establishing the cell culture systems for recombinant protein production are secured. The plan is to establish different mice models of diseases at IHBT to test in vitro leads of therapeutic importance (natural products, small molecules) in cardiovascular, renal, and other diseases.
- Screening of natural products (as per institutional mandate) in a plasma clot lysis assay for potential therapeutic compounds in thrombotic cardiovascular diseases. To date, ~30 compounds have been screened, confirming the reproducibility of the assay that is being extended for large-scale screening.
- Lab establishment- A dedicated lab space for the implementation of the Ramanujan Fellowship is being developed as a part of the "Protein Production Center".

SCIENCE & TECHNOLOGY SUPPORT SERVICES

SHARDOOL HOSTEL:

Shardool Hostel inaugurated (online) by Dr. N. Kalaiselvi, Director General, CSIR & Secretary, DSIR, GOI on 13th February 2023 in the presence of Dr. Sanjay Kumar, Director, and staff of the institute. The Hostel is having 120 double bedded Rooms accommodation, modern kitchen, guest rooms, dinning halls etc. The project completed with approximate cost of Rs. 30.00 Crores having area of 7236 Sqm.

HOSTEL INAUGURATION:

ENZYME BIOPROCESSING FACILITY:

Enzyme Bioprocessing Facility inaugurated (online) by Dr. N. Kalaiselvi, Director General, CSIR & Secretary, DSIR, GOI on 13th February 2023 in the presence of Dr. Sanjay Kumar, Director, and staff of the institute. The facility is of 400 sqm area and completed at a cost of 8.00 crore.

FOOD PROCESSING FACILITY:

Food Processing Facility foundation stone laid by Dr. S. Chandrasekhar, Secretary, DST (GOI) on 12th August 2022 in the presence of Dr. Sanjay Kumar, Director, and staff of the institute. The facility is having an area of 400 sqm & work is near completion.

C/O 12 NOS. STAFF QUARTERS:

12 No. Staff Quarters foundation stone laid by Sh. Anurag Singh Thakur, Hon'ble Union Minister of State, Ministry of Finance, and Ministry of Corporate affairs on 1st March 2021 in the presence of Dr. Sanjay Kumar, Director, and staff of the institute. The work is under progress.

DISPENSARY BUILDING:

Dispensary inaugurated (online) by Dr. N. Kalaiselvi, Director General, CSIR & Secretary, DSIR, GOI on 13th February 2023 in the presence of Dr. Sanjay Kumar, Director, and staff of the institute. The facility is having an area of 230 Sqm with completion cost of Rs. 100 Lacs.

TISSUE CULTURE FACILITY:

Tissue Culture Facility inaugurated by Sh. Ashish Butail, Chief Parliamentary Secretary, Urban Development, Elementary Education, Higher Education (H.P. Govt.) on 20 February 2023, in the presence of Dr. Sanjay Kumar, Director, and staff of the institute. The facility is having an area of 700 sqm and completion cost is Rs. 2.00 crore.

ADMINISTRATION

The Administration carries roles & responsibilities to handle all the administrative matters of the Institute and to assist the Director/HoDs of the Institute to manage all the affairs including R & D activities to fulfil the mandate of CSIR-IHBT, Palampur in accordance with CSIR Bye-Laws/rules/guidelines.

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 all the employees including research scholars in their sphere of duty so that they can perform their task evenly.

Other major activities performed by the administration are enumerated as follows:

- Assist the Director/the Head of Departments/Principal Investigators on various issues and to take decisions of administrative nature viz. recruitment, assessment & promotion, DPC, establishment, vigilance, legal, RTI, finance related, store related, purchase related grievances of staff and others as the case may be. Maintaining liaison with CSIR Headquarters, New Delhi on administrative matters.
- Implement policies in pursuance of guidelines as issued by the CSIR Headquarters, New Delhi.
- Provide administrative support to various functional bodies (Committees/Functional Groups) within the organization.
- Provide conducive working conditions and environment in the laboratory through interpretation as well as implementation of governing rules and regulations.

The Administration is headed by the Controller of Administration/ Administrative Officer. He is supported by the Section Officers, a group of Assistant Section Officers, Senior Secretariat Assistants, Junior Secretariat Assistants and supporting staff including Security Services and Rajbhasha Cell.

Security Section

The Security Section is responsible for the complete safety and security of the valuable resources inside the premises of the 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.

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 premises of this Institute. In addition, it provides other essential assistance as and when required at the main entrance of the Institute.

Administration group: Virender Lamba, Prajwal Rai, Ranjeet Kumar Gupta, Sanjay Kumar, Didar Singh Patial, Parveen Singh, Santosh Kumari, Baldev, Kiran Kumar, Pooja Awasthi, Boni Kumar, Mukul Sharma, Ajay Singh Kaundal, Sandeep Kumar, Baleshwar Prasad and Thaman Bahadur.

FINANCE AND ACCOUNTS SECTION

Finance and Accounts Division caters to the financial needs of the Scientific, Technical and Administrative staff of the institute. The Division maintains Accounts of the institute on behalf of the Director. The utilization of the budget allocation received from CSIR Headquarters, New Delhi is monitored and advices for effective utilization is suggested to appropriate authorities by the Division. Apart from Budget Allocation, charges for Technical services, sponsored and Grant- in - aid projects constitute the major sources of income. The revenue received from training programmes is also source of receipt to the institute. F&A Division is handling its duties in time targeted manner in order to fulfil smooth and effective attainment of its goals on the one hand with financial prudence on the other.

The functions of the Finance & Accounts Division are as follows:

FUNCTIONS & DUTIES:

- Preparation and compilation of budget estimates, revised estimates and supplementary demands.
- Management of the financial resources received in the form of CSIR Grant and Externally Funded Projects & Lab Reserve Fund of the Institute with the due approval of the Competent Authority.
- Coordination with Head, PPME in Project monitoring and other project-related activities, etc.
- Ensuring that the economy measures of the Govt. of India are scrupulously followed and also exercising necessary budgetary controls.
- Releasing timely payments to all suppliers/contractors for their services through PFMS portal and commercial bank.
- Making payment to all staff for their personal claims and advances.
- Maintenance of Vouchers and Accounts Audit Registers/Ledgers.
- All matters related to Banks collecting debits, credits, bank statement, DDs, NEFT & RTGS transfers, etc.
- Concurring fixation of pay proposals and other financial matters.
- Monitoring Loans and advances paid to Staff, Govt. departments, Private parties, Hospitals, etc.
- Finalization of pension and issue of Pension Payment Orders, Family Pension, Superannuantion Pension, Retirment Gratuity, Commutation, etc.
- Liasioning and coordinating the works related to Internal Audit and External Audit (CAG) and furnishing replies to the concerned authorities.
- Generating various Financial Statements, Monthly Account, Annual Accounts, Transfer of funds statement, Monthly progressive expenditure statement, etc.
- Ensuring modernization and computerization of Finance & Accounts functions.
- Investment of funds from sponsored projects & lab reserve after obtaining necessary approval.
- To render advice to the Director on all financial matters and providing support services to all Scientific, Administrative & Technical staff.

Any other work assigned by CSIR/ Director.

STORES AND PURCHASE

The Stores and Purchase division ensures provision of adequate and timely supply various materials required for execution of various R&D projects & other non-R&D items required for Lab and Colony maintenances of as per rules in force. The items are procured primarily through GeM (Government eMarketplace), For the items, which are not available in GeM, the procurement is done through e-tendering and other modes of procurement as laid down in CSIR Manual on Procurement of Goods 2019. The entire Stores and Purchase operations were entirely carried through ERP (onecsir) end-to-end. The division also maintains stocks of stationery, cleaning and hardware items, which are regularly required in the Institute.

The division had purchased following major equipments during the financial year 2022-23

- Workstations/Servers
- Walk in Plant Growth Chambers
- Plant Growth Chambers with Temp., Light, RH Programmable
- Plant Growth Chambers with High/ Low Temp. control
- Plant Growth Chamber with Light Spectrum
- Plant Growth Chamber with High Light and UV option
- Ultrasonic Extractor along with accessories

- Continuous Pasta/Spaghetti Processing Line
- Multipurpose Essential Oil Field Distillation Units
- Plant Growth Chamber with adjustable Light irradiance

Stores and Purchase group: Sh.Sanjay Rawat, Sh.Ravinder Singh, Sh.Rajeev Sood, Sh.Rajinder Singh, Sh.Karandeep Sood, Sh.Ranjeet Singh, and Smt.Anupama Saini

COMPUTER SECTION

This section takes care of Managing Existing IT resources in the institute which has a fleet of servers 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 managed switches, indoor and outdoor wireless access points. All Internet users are managed centrally with the help of an authenticator.

Network Security hardware used for LAN & WAN comprises of almost high speed Managed switches, a Unified threat management System (UTM/Firewall), a Web application firewall, Wireless Authenticator, Wireless Controller on high availability, and its policies have been deployed to protect IHBT resources centrally.

Also facilitated Virtual Classroom and Video-Conferencing facilities for the Institute.

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

Computer Section group: Vikrant Gautam and Sanjeev Kumar.

KNOWLEDGE RESOURCE CENTRE (KRC): LIBRARY

IHBT Library is continuously contributing to achieve the scientific targets of the Institute making available the quality knowledge resources and database to the scientists, scholars and technical staff of the institute. The knowledge resources includes e-journals, databases and other materials such as books, reports, online databases in the field of science and technology. In addition, the library extends reference and consultation, circulation, document delivery, reprographic, resource sharing, information alert, user awareness using latest tools of the ICTs to users. In this way, library contributed in generating new knowledge by the scientists and other researchers working in the institute.

Relevant information on impact factor of journals, publishers' guidelines to authors, publishing policy of journals for selecting quality journals for publication of their research articles as well as online submission of research articles were provided. In this year, 32 books of research value, 165 Hindi books covering scientific and societal issues and 11 thesis were added to the library collection. The books, journals and other documents were updated in KOHA-an open source software of library management. The Koha software is available for access on internet/intranet through website http://library.ihbt.res.in.

OPAC- Online Public Access Catalogue: The library catalouge was updated and made available for access on intranet and internet. The OPAC is accessible and searchable online through http://14.139.59.218/. Users can view, online checkout status, reservation of books, and recommendation of new books, journals, etc. The records searched in this database by keywords, author, title, publisher, accession number, subject, ISBN, etc.

Similarity and Grammar Check: The library checked various documents with the iThenticate database for detection of similarity/plagiarism. Similarity reports provided to concern scientist and scholars. The Grammarly software made available and uploaded on all scientist and scholars PCs for grammar checks. Drafts of the documents were also checked by library staff with the Grammarly database for grammar correction and reports were provided for further improvement to scientist, scholars and staff.

Discovery Search: With the help of open Athens tool subscribed e-journals/ database can be accessed within and outside the campus, access of the tool is available on library webpage. Library staff generated a user id and password of users for the access of resources remotely. Users can access subscribed resources remotely through the ID and password. The resources can be searched in discovery tool through keywords, article name, author, journal, books, etc.

Printing and Photocopying Service: The library coordinate the printing and photocopying activities of the institute. The library staff have assisted S & T staff for layout settings of different types of the documents such as scientific & technical brochures, annual report, manuals, banners, products stickers, advertising materials, flyers of technology developed, official documents, project proposals & reports. The binding of documents was also facilitated through the library.

Press and Media Activities: IHBT Library coordinated the 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.

The library subscribed ten Hindi and English languages newspapers. The media coverage of this institute's events are scanned and communicated to directorate and the scientist for their information. The scanned news items were uploaded on blog at- http://ihbtinnews.blogspot.in/.

Library group: Saurabh Sharma, Jasveer Kaur and Rujala Devi.

PHOTOGRAPHY

The Institute's photographic and videography unit offers a broad range of services, which include recording lab research, documenting scientific and scholar-related activities, and showcasing institutional achievements. The team prioritizes quality and conformity to the best production levels by integrating cutting-edge technologies with traditional methods. Its primary goal is to ensure that the reproduction in various publications is of the highest standard.

A. Short films: Made the following R&D activity and knowledge-based short films for institutional promotions:

- **CSIR-IHBT Aroma Mission Activity**
- **Institutional Technology**
- **Edit of short films:**
  1. Conservation of Endangered Plant Species
  2. Microbial Enzymes from the Himalayas
  3. Mapping and Exploring Rich Himalayan Bioresource
  4. Himalayan Medicinal Plants
  5. Soil-less Cultivation to Boost Farmer's Income

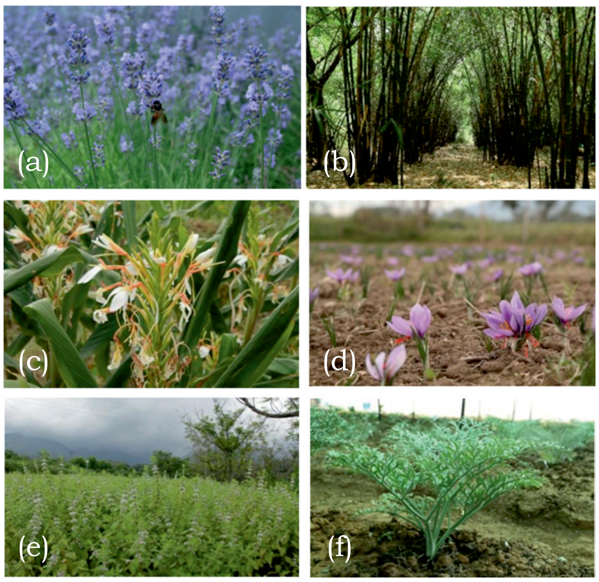
B. Photography and videography for documentation of farmer's field: Visited various demonstration plot visits, covered field activities, and conducted interviews with farmers. These were recorded using still photography and videography in the following regions:

1. **Sihunta, Salooni, Bharmoor** (District Chamba, HP) farmers' field and farmers' interview under CSIR-Aroma Mission
2. **Paragpur** (District Himirpur, HP) and **Una** (District Una, HP) farmers' field and farmers' interview under CSIR-Aroma Mission

3. **Gogardhar, IIT Mandi** (District Mandi, HP) farmers' field and farmers' interview under CSIR-Aroma Mission
4. **Baggi** (District Mandi, HP) to capture activities of the essential oil industry
5. **Barnala** (Punjab) *damask rose* field and farmers' interview under CSIR-Aroma Mission
6. **Fategarh** (Punjab) farmers' field and farmers' interview under CSIR-Floriculture Mission
7. **Gumarmi** (District Bilaspur, HP) farmers' field and farmers' interview under CSIR-Floriculture Mission
8. **Lahual Valley** (HP) Medicinal Crops
9. **Jagla** (Lahual, HP) farmers' field and farmers' interview under CSIR-Floriculture Mission

C. Photography & Videography of R&D activities

Recording, the Institute's activities in the CSIR-Aroma and Floriculture Mission. R&D recorded through still photography and videography done for crops like Wild marigold, Valeriana, Damask Rose, Picrorhiza, Crataegus, Ginkgo, Stevia, Rosemary, Geranium, Lemon Grass, Lavender, Saffron, Heeng cultivation, Monk fruit cultivation,



Photography and videography: Lavender field (a), Bamboo field (b) *hedychium spicatum* field (c), Saffron field (d), *Mentha* field (e), and Heeng field (f)

Floriculture Mission (Tulip, Lillium, Gerbera, Carnation, Crysentimum, Rose, Alstroemeria, Gladiolus, etc.), and also Bamboo, Tissue culture proses. Also, the glimpses of apiculture being practiced along with the Floriculture Mission were locked through the camera.

D. Inputs in R&D activities

- Time-to-time photography was done to capture **research results** in labs and demonstration plots for the scientists, research scholars, and project assistants.
- Provided advice in improving photographs of research results and edited previously taken photographs for better quality and higher resolution by colour correction, hue, saturation, and brightness-contrast balances, as well as sharpness adjustments and cropping etc.
- Re-aligned by modifying the file size of many images reduced by changing the file formats or through data compression file format to save storage space. The dpi/ppi also changed as per the need for journals/books etc.
- Assisted in photography for the publication of research results and was acknowledged by some authors.

E. Photo-video coverage of important events:

- CSIR-IHBT foundation day celebration
- CSIR foundation day celebration
- Independence Day celebration
- Republic Day celebration
- National Science Day celebration
- Technology Day celebration
- CSIR Directors' Conference, 28-29th Oct 2022
- CSIR FA meets, Nov 2022
- CSIR One week one lab programme

F. Designs & layout:

- **Annual Report** Cover page and layout and photographic inputs (2021-22)
- Designed the **Start-Up coffee book:** Designed and layout the CM Start-Up Profile consisting of details of technologies and their applications. Each product was exclusively photographed as per laid norms for the Technology Profile.
- Assisted with the coffee book of **CSIR-IHBT Journey**
- **Certificates** for participants of various training programmes, workshops, conferences, symposia, etc.

राजभाषा

संस्थान के समस्त कार्मिकों को संघ की राजभाषा नीति, राजभाषा अधिनियम के उपबंधों तथा आदेशों से अवगत कराना, अनुपालन हेतु सहयोग, राजभाषा तिमाही प्रगति रिपोर्ट, प्रोत्साहन योजनाओं को लागू करना, वातावरण निर्माण हेतु कार्यशाला एवं कार्यक्रमों का आयोजन तथा संस्थान की राजभाषा कार्यान्वयन समिति के निर्देशन में संस्थान में संघ की राजभाषा नीति का अनुपालन सुनिश्चित करना संस्थान के राजभाषा अनुभाग के प्रमुख दायित्व हैं।

हिंदी सप्ताह समारोह का आयोजन

संस्थान में हिंदी सप्ताह का मुख्य समारोह दिनांक 14 सितम्बर 2022 को बड़े हर्षोल्लास के साथ मनाया गया। समारोह के मुख्य अतिथि प्रो. अनिल कुमार त्रिपाठी, निदेशक, विज्ञान संस्थान एवं आचार्य, काशी हिंदू विश्वविद्यालय, बनारस ने 'विज्ञान की विकास यात्रा का भविष्यन्मुखी पुनरावलोकन' विषय पर अपना व्याख्यान दिया। अपने प्रशासनिक तथा शैक्षणिक अनुभवों को साझा करते हुए उन्होंने नई तकनीकों का राजभाषा हिंदी में प्रसार करने का आह्वान किया। उन्होंने वैज्ञानिकों एवं शोध छात्रों द्वारा हिंदी माध्यम से किसानों से जुड़ने के लिए आभार व्यक्त किया। उन्होंने अपने संबोधन में अत्यन्त रोचकता के साथ विज्ञान के क्रमिक विकास यात्रा का वर्णन किया तथा विज्ञान की उपलब्धियों और इसके दुष्परिणामों को सामने रखकर ही समाज के हित में आगे के शोध पर ध्यान केंद्रित करने को कहा। साथ ही, वर्तमान में आर्टिफिशियल इंटेलिजेंस में हो रहे शोधों को भारत की परिस्थितियों के अनुकूल करने का सुझाव दिया।

इस अवसर पर संस्थान के निदेशक डा. संजय कुमार ने अपने अध्यक्षीय संबोधन में कहा कि भावों को प्रकट करने के लिए मातृभाषा का होना जरूरी है। उन्होंने योग्यता आधारित आकलन और उसका समाज हित में सदुपयोग करने पर भी बल दिया। उन्होंने समाज को सशक्त करने के लिए किसी विषय के मूलभूत ज्ञान की उपयोगिता के महत्व को समझाया। डा. संजय ने संस्थान द्वारा विकसित प्रौद्योगिकियों को उनके उपयोगकर्ता तक पंहुचाने के लिए वैज्ञानिकों को सरल भाषा में प्रसार करने के लिए प्रेरित किया।

इस अवसर पर हिंदी सप्ताह के अन्तर्गत आयोजित प्रतियोगिताओं के विजेताओं को भी पुरस्कृत किया गया।

संस्थान के वरिष्ठ प्रधान वैज्ञानिक डा. विपिन हल्लन ने मुख्य अतिथि का परिचय करवाया तथा वित्त एवं लेखा अधिकारी श्री यशपाल ने समारोह में धन्यवाद प्रस्ताव प्रस्तुत किया। कार्यक्रम का संचालन हिंदी अधिकारी श्री संजय कुमार द्वारा किया गया।

विषयः हिंदी सप्ताह समारोह–2022

हिन्दी लोकप्रियविज्ञान लेखन प्रतियोगिता

प्रथम पुरस्कार – डा. रिम्पी धीमान

द्वितीय पुरस्कार – श्री विराट अभिषेक

तृतीय पुरस्कार – श्री शिव कुमार

हिंदी टिप्पण आलेखन प्रतियोगिता

प्रथम पुरस्कार – श्री बलदेव

द्वितीय पुरस्कार – श्री बोनी कुमार

तृतीय पुरस्कार – श्रीमती पूजा अवस्थी

हिन्दी टिप्पण प्रोत्साहन योजना के अन्तर्गत वर्ष 2021–22

1 श्री बोनी कुमार	प्रथम पुरस्कार
2 श्री मुकुल शर्मा	प्रथम पुरस्कार
3 श्री अविनाश चंद्र राणा	द्वितीय पुरस्कार
4 श्री बलदेव	द्वितीय पुरस्कार
5 श्रीमती संतोष	द्वितीय पुरस्कार
6 श्री अजय सिंह	तृतीय पुरस्कार
7 श्री प्रवीण सिंह	तृतीय पुरस्कार
8 श्रीमती पूजा अवस्थी	तृतीय पुरस्कार
9 श्रीमती अरुणा कुमारी	तृतीय पुरस्कार
10 श्री ईश्वर दास	तृतीय पुरस्कार

राजभाषा संबन्धी कार्यान्वय

- संस्थान द्वारा किये जा रहे शोध कार्यों को आम जनता तक पहुंचाने के उद्देश्य से विविध सामग्री/दस्तावेजों के अनुवाद, संपादन एवं प्रकाशन में सहयोग किया गया। जिनमें से प्रमुख हैं:
- 'सीएसआईआर–आईएचबीटी : क्रमिक विकास यात्रा'
- संस्थान का ब्रोशर
- शार्दूल होस्टल नामकरण संबन्धी प्रलेख हिंदी में तैयार किए गए
- खाद्य पुष्प–न्यूट्रास्यूटिकल का एक नया स्रोत
- बबुई तुलसी (*ऑसिमम बेसिलिकम* एल.) की उन्नत कृषि तकनीक
- अतीस
- नागछतरी
- हींग
- पोषण मैत्री अभियान के ब्रोशर आदि
- एक सप्ताह एक प्रयोगशाला संबन्धी सामग्री
- सभी समारोहों के प्रेस नोट तैयार करना
- प्रशस्ति पत्र
- प्रशासनिक दस्तावेज
- राजभाषा विभाग, भारत सरकार एवं परिषद् मुख्यालय द्वारा समय–समय पर जारी दिशानिर्देशों के अनुरूप हिन्दी में कार्य करने के लिए उचित वातावरण बनाने और राजभाषा हिंदी में मूल रूप से कार्य करने को प्रोत्साहित करने के लिए हिन्दी में प्रकाशित सहायक सामग्रियों जैसे पुस्तकें, कोश, पत्रिकाएं और अन्य संदर्भ साहित्य संस्थान में उपलब्ध करवाया, इसके अतिरिक्त विभिन्न प्रयोगशालाओं/संस्थानों द्वारा प्रकाशित पत्रिकाओं को भी संस्थान में उपलब्ध करवाया गया। इस वर्ष 16 हजार रुपये की 34 पुस्तकें खरीदी गई। इसके अतिरिक्त योजना, कुरुक्षेत्र, आजकल तथा बाल भारती की ग्राहकता का नवीनीकरण किया गया।
- प्रत्येक तिमाही में निदेशक महोदय की अध्यक्षता में संस्थान की राजभाषा कार्यान्वयन समिति का बैठक आयोजित करना, बैठकों की कार्यसूची व कार्यवृत्त तैयार करना एवं निर्णयों का अनुपालन सुनिश्चित करने के लिए आवश्यक अनुवर्ती कार्यवाई करना। तिमाही प्रगति रिपोर्ट के लिए विभिन्न अनुभागों/प्रभागों से आंकड़े प्राप्त कर रिपोर्ट सीएसआईआर मुख्यालय भेजी गई। राजभाषा कार्यान्वयन की दिशा में वार्षिक कार्यक्रम एवं सीएसआईआर मुख्यालय से प्राप्त निर्देशों के अनुपालन हेतु आवश्यक आदेश जारी किए गए।
- संस्थान के कार्मिकों का राजभाषा हिंदी ज्ञान संबंधी रोस्टर तैयार एवं अपडेट करना। 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।
- प्रबन्ध परिषद के कार्यवृत एवं एजेंडा और प्रशासन से संबन्धित विभिन्न प्रकार की सामग्री जैसे विज्ञापन के अनुवाद एवं संपादन में सहयोग।
- संस्थान द्वारा आयोजित किए जाने वाले विभिन्न समारोहों जैसे स्वच्छता पखवाड़ा, सतर्कता जागरुकता सप्ताह, कौमी एकता सप्ताह, सद्भावना दिवस, सीएसआईआर स्थापना दिवस, आईएचबीटी स्थापना दिवस, किसानों एवं उद्यमियों के लिए आयोजित प्रशिक्षण कार्यक्रमों, विभिन्न कार्यशालाओं /समारोहों के आयोजनों में सहयोग किया।

JIGYASA - CSIR SKILL DEVELOPMENT PROGRAMS - INCUBATION CENTRE - AcSIR - IMPORTANT EVENTS

JIGYASA PROGRAM

(For School Students and Teachers)

During 2022-23, CSIR-Institute of Himalayan Bioresource Technology (IHBT) organized various activities under "Jigyasa 2.0 Virtual Laboratory Program" to motivate and encourage students to pursue their career in science. This year, a total of 6083 students and teachers from various government and private schools participated in these activities (Table 1). They were appraised about various research and development (R&D) activities of Agrotechnology, Biotechnology, Chemical Technology, Dietetics and Nutrition Technology and Environmental Technology divisions of the Institute through demonstrations, exhibitions, lectures, visits, and hands-on trainings. Lab and field visits were conducted in different laboratories and fields *viz.* natural product chemistry, synthetic chemistry, internationally recognised herbarium, remote sensing and mapping facilities, regulatory research facility, biotechnology and microbiology labs, plant tissue culture, hydroponic & aeroponic facility, vertical gardening, bamboo museum, pilot plant for nutraceuticals, food processing facility, essential oil and herbals, bioinformatics fernery, herbal garden and tulip garden etc. A programme was organized at CSIR-IHBT Center, CeHAB, Ribling for students and teachers of Lahaul and Spiti (H.P.)

Table 1 Details of students and teachers participated in Jigyasa Programme

Sr. No.	Model of Engagement	Duration in days	Student Grade	No. of Teachers	No. of Students			
					KVs	NVs	State Govt. Schools	Other Schools
01.	One Day Visits	01 (62 different schools)	1st to 12th	255	172	-	1799	555
02.	Lab Specific Activities/ Onsite Experiments	01	10th to 12th	05	-	-	-	37
03.	Visits of Scientists to Schools/ Outreach Programme	05	6th to 12th	80	55	55	444	180
04.	Popular Lecture Series	05	6th to 12th	135	-	197	32	470
05.	Projects of National Children's Science Congress	03	6th to 12th	04	-	-	-	09
06.	Mentoring Programme for Adopted ATL schools	04	6th to 12th	30	55	-	-	-
07	Scientists as Students and Teachers as Scientists	01	6th to 10th	13	10	-	20	-
08	Teachers' Workshop	01	-	30	-	-	-	-
09	Micro Research Projects for Students	01	7th	01	-	01	-	-
10	Exhibitions	06	1st to 12th	100	-	50	293	909
11	International Linkage	01	9th	02	-	50	-	-
12	Innovation Programme	01	6th to 12th	05	-	-	-	30
			Total	660	292	353	2588	2190
			Grand Total		**6083**			

Different activities under Jigyasa Programme

Besides, 1519 students and teachers of various universities, institutes and colleges from 08 different states and UTs visited the institute during this year (Table 2).

Table 2 Visits of College, University & Institute students

Sr. No.	Name of College, University, Institute	No. of Students	No. of Teachers	Date
1.	College of Ayurved & Research Centre, Nigdi, Pune (MH)	55	02	07.04.2022
2.	Shri Guru Teg Bahadur Khalsa College, Shri Anandpur Sahib (PB)	37	07	08.04.2022
3.	Rayat-Bahara Group of Intitutions, Hoshiarpur (PB)	27	03	21.04.2022
4.	Career Point University, Hamirpur (HP)	33	02	20.05.2022
5.	MCM DAV College, Kangra (HP)	75	02	25.05.2022
6.	Punjab Agriculture University, Ludhiana (PB)	48	02	02.06.2022
7.	ISF College of Pharmacy, Moga (PB)	09	01	17.06.2022
8.	Shivaji College, University of Delhi, New Delhi	26	05	24.06.2022
9.	Eternal University, Baru Sahib, Sirmaur (HP)	52	03	30.06.2022
10.	Zakir Husain Delhi College, New Delhi	35	03	26.09.2022
11.	Rungta College of Science & Technology, Bhilai Durg, Chhattisgarh (CG)	39	02	13.10.2022
12.	Kanya Maha Vidyalaya, Jalandhar (PB)	31	05	04.11.2022
13.	Govt. PG College, Dharamshala (HP)	41	04	15.11.2022
14.	Himachal Pradesh Technical University, Hamirpur (HP)	25	01	16.11.2022
15.	Jaypee University of Information Technology, Solan (HP)	36	02	17.11.2022
16.	SCVB Govt. College, Palampur, Distt. Kangra (HP)	60	02	23.11.2022
17.	Khalsa College, Amritsar (PB)	42	05	02.12.2022
18.	KSNAHSU, Shivamogga, Karnataka	40	02	16.12.2022
19.	GGDSD College, Rajpur, Distt. Kangra (HP)	90	03	25.02.2023
20.	GGDSD College, Rajpur, Distt. Kangra (HP)	61	03	28.02.2023
21.	Atal Bihari Vajpayee Govt. Degree College, Takipur, Distt. Kangra (HP)	29	03	28.02.2023
22.	GGDSD College, Rajpur, Distt. Kangra (HP)	55	05	06.03.2023
23.	Sri Sai University, Palampur, Distt. Kangra (HP)	40	06	06.03.2023
24.	Chitkara University, Rajpura (PB)	08	0	06.03.2023
25.	Sri Sai University, Palampur, Distt. Kangra (HP)	60	03	09.03.2023
26.	College of Ayurved & Research Centre, Nigdi, Pune (MH)	37	02	10.03.2023
27.	Sanatan Dharama College, Hoshiarpur (PB)	03	02	13.03.2023
28.	Central University of Himachal Pradesh, Dharamshala, Distt. Kangra (HP)	50	02	13.03.2023
29.	Central Agricultural University, Imphal, Manipur (MN)	16	02	13.03.2023
30.	SRM University, Delhi-NCR, Sonepat (HR)	18	05	14.03.2023
31.	Sri Sai University, Palampur, Distt. Kangra (HP)	110	05	28.03.2023
32.	JC DAV College, Dasuya, Distt. Hoshiarpur (PB)	47	04	28.03.2023
33.	DAV University, Jalandhar (PB)	84	02	28.03.2023
	Total	1419	100	
	Grand Total	**1519**		

SKILL DEVELOPMENT PROGRAM

During 2022-23, a total of 641 persons were trained under different skill development programmes *viz.* CSIR-Integrated Skill Initiative Phase-II, Skill Vigyan program, sponsored by DBT-HIMCOSTE, HP State Department of Agriculture and self-sponsored skill programmes. Besides, hands on trainings were provided to different universities/ college students.

During this year, two LSSSDC approved courses *viz.* Quality Control Biologist and Lab Technician/ Assistant of three-month duration were successfully conducted.

The details of different skill development programmes:

Sr. No.	Date(s)	Title of SDP	No. of Trainees					Name(s) of Trainer(s)
			TOTAL	Male	Female	Reserved	General	
1.	29.11.2022-24.01.2023	Gardener	01	01	-	01	-	Dr. Bhavya Bhargava
2.	15.12.2022-13.02.2023	Floriculturist-Protected Cultivation	02	02	-	-	02	Dr. Bhavya Bhargava
3.	26.08.2022-24.09.2022	Basic techniques in biotechnology	05	-	05	03	02	CSIR-IHBT Faculty
4.	30.08.2022-31.08.2022	Capacity building program on bamboos for Agriculture Officers, Artisans and Farmers of Himachal Pradesh	62	51	11	-	-	Dr. Rohit Joshi
	12.09.2022-13.09.2022		38	27	11	-	-	
	19.09.2022-20.09.2022		45	26	19	-	-	
5.	14.09.2022-15.09.2022	Exposure visit: Farm livelihood community resource persons (Krishi and Pashu Sakhi) and Mahila Kisan	29	05	24	-	-	Dr. Ramesh
	21.09.2022-22.09.2022		20	03	17	-	-	
6.	10.10.2022-11.10.2022	Hands-on training in the area of Recombinant DNA technology	26	12	14	11	15	Dr. Arun Kumar
7.	22.10.2022 & 25.11.2022	Hands-on training in the area of Recombinant DNA cloning	61	09	52	-	-	Dr. Arun Kumar
8.	September to December, 2022 (2-3 month duration)	Agrotechnology *viz.* Plant Clinic, Agro-Industrial Attachment; Agronomical Interventions, Soil improvement and Plant Protection Interventions, Extension and Transfer of Technologies	09	05	04	02	07	CSIR-IHBT Faculty

Sr. No.	Date(s)	Title of SDP	No. of Trainees					Name(s) of Trainer(s)
9.	07.11.2022	Advanced scientific laboratory and instrumentation	17	10	07	-	-	CSIR-IHBT Faculty
10.	20.12.2022-23.12.2022	Crop Cultivation (medicinal, aromatic, floriculture, spice and crops)	24	15	09	15	09	CSIR-IHBT Faculty
11.	26.12.2022-30.12.2022	Crop Cultivation (medicinal, aromatic, floriculture, spice and crops)	12	06	06	10	02	CSIR-IHBT Faculty
12.	10.02.2023	Hands-on training in DNA isolation from plant extract	51	03	48	-	-	Dr. Arun Kumar
13.	14.02.2023		46	02	44	-	-	
14.	3 Months	Quality Control Biologist (LSSSDC approved)	11	02	09	05	06	CSIR-IHBT Faculty
15.	3 Months	Lab Technician/ Assistant (LSSSDC approved)	07	02	05	04	03	CSIR-IHBT Faculty

Summer and Winter Trainings at CSIR-IHBT, Palampur

Institute is providing trainings to Graduate/ Post Graduate/ Ph.D. students from different Institutes, Universities and affiliated colleges.

This year, 250 Graduate/ Post Graduate/ Ph.D. students from different Institutes, Universities and affiliated colleges were selected as research intern/ trainee for conducting dissertation/ project work/ research work at CSIR-IHBT, Palampur. Out of 250, 175 students completed their training programme and 75 are ongoing from 12 different states and 03 UTs *viz*. Himachal Pradesh, Punjab, Uttarakhand, Rajasthan, Maharashtra, Gujarat, Uttar Pradesh, Bihar, Madhya Pradesh, Odisha, Kerala, West Bengal and Jammu & Kashmir, Chandigarh, Delhi.

Details of trainings provided to Graduate/ Post Graduate/ Ph.D. students (April 2022-March 2023)

Sr. No.	Student Name	Affiliation	Course	Duration (Months)	Supervisor	Title of certificate
1	Mr. Aashin Sood	Guru Nanak Dev University, Amritsar, Punjab	B. Tech. (CSE)	3	Dr. Vishal Acharya	Database creation of chemical structures
2	Ms. Nipun Balyan	Amity University, Noida, Uttar Pradesh	M. Tech. Food Technology	4.5	Dr. Vidyashankar Srivatsan	Evaluation of downstream processing methods for enrichment of C-Phycocyanin from *Spirulina platensis*
3	Ms. Anchal Badjata	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	3	Dr. Ashish R. Warghat	Tissue culture approach for the production of *Valeriana jatamansi*
4	Ms. Diksha Koundal	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	3	Dr. Ashish R. Warghat	Practical exposure on tissue culture of *Carum carvi* & *Rhodiola imbricata*
5	Ms. Shiwali Sharma	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	3	Dr. Satbeer Singh	Morphological and molecular marker based characterization of breeding lines of German chamomile

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6	Ms. Neha Dadwal	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	3	Dr. Satbeer Singh	Genetic variation for flower yield traits and molecular markers among the populations of German chamomile
7	Ms. Bharti Dhiman	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	3	Dr. Ashish R. Warghat	Basic techniques in plant tissue culture and micropropagation of *Arnebia euchroma* and *Podophyllum hexandrum*
8	Ms. Surjeet Kaur	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	3	Dr. Poonam Kumari	*In vitro* propagation of rose (*Rosa x hybrid* var. Summer Snow)
9	Ms. Rama Jumwal	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	3	Dr. Rohit Joshi	To study the interaction of genotype, plant growth hormone and basal media composition on *in vitro* propagation of two *Dendrocalamus* species
10	Ms. Ravi Tanya	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	3	Dr. Rohit Joshi	Assessment of callus induction and proliferation in *Nardostachys jatamansi* using different cytokinin concentrations
11	Ms. Mansi Rana	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	3	Dr. Rajiv Kumar	Establishment of Callus and Suspension culture of *Picrorhiza kurroa* and its Molecular Analysis
12	Ms. Saloni	Dr. DY Patil Biotechnology and Bioinformatics, Pune, Mahrashtra	M.Sc. Biotechnology	3	Dr. Ankit Saneja	Development and characterization of active targets solid-lipid Nano particles for cancer chemotherapy
13	Ms. Dikshita Ramesh	St. Xavier's College, Ahmedabad, Gujarat	M.Sc. Biotechnology	2	Dr. Vivek Dogra	Basic techniques in molecular biology
14	Ms. Supriya Jha	Amrita Vishwa Vidhyapeetham, Kolam, Kerala	M.Sc. Biotechnology	3	Dr. Amitabha Acharya	Evaluating of antibacterial and antibiofilm potential of functional nanomaterials
15	Mr. Siddharth Singh Tomar	Jiwaji University, Gwalior, Madhya Pradesh	M.Sc. Biotechnology	4	Dr. Robin Joshi	Applications of UPLC, LC-MS, QTOF and MALDI-TOF in Metabolomics
16	Mr. Suryansh Yadav	UP Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan (Duvasu), Mathura, Uttar Pradesh	B.Sc. Biotechnology	3	Dr. Ashish R. Warghat	Basic techniques in cell culture of *Picrorhiza kurroa* Royle ex Benth and hydroponic cultivation of *Valeriana jatamansi* Jones ex Roxb
17	Mr. Vansh Sharma	UP Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan (Duvasu), Mathura, Uttar Pradesh	B.Sc. Biotechnology	3	Dr. Poonam Kumari	Micropropagation from nodal explant of rose (*Rosa hybrida* L. var. Wedding Bells)
18	Ms. Vijayalakshmi Suryavanshi	DY Patil Deemed to be University, Navi Mumbai, Maharashtra	M. Tech. Biotechnology	6	Dr. Rohit Joshi	Molecular dissection of the effect of gold nanoparticles in modulating morph-physiological and biochemical changes in *Siraitia grosvenorii* under *in vitro* conditions
19	Ms. Jhanvi Mahajan	Sher-E-Kashmir University of Agriculture Sciences and Technology, Jammu, Jammu & Kashmir	B. Tech. Biotechnology	4	Dr. Bhavya Bhargava	*In vitro* establishment in *Tulipa clusiana* (lady tulip

Sr. No.	Student Name	Affiliation	Course	Duration (Months)	Supervisor	Title of certificate
20	Mr. Paras Sharma	VCSG University of Horticulture and Forestry, Bharsar, Uttarakhand (Passout)	B.Sc. Horticulture	10	Dr. Gaurav Zinta	Physiological and molecular analyses of photosynthetic and tubuerization processes in crops
21	Ms. Rashmi Kumari	DAV University, Jalandhar, Punjab (Passout)	M.Sc. Zoology	6	Dr. Vikram Patial	Hands on training in different molecular biology and biochemistry techniques used in Pharmacology and Toxicology Lab
22	Mr. Harsh Raj	Lovely Professional University, Jalandhar, Punjab	B.Sc. Biotechnology	1	Dr. Arun Kumar	Tools and techniques of plant genetic engineering
23	Ms. Vanshika Duggal	Lovely Professional University, Jalandhar, Punjab	B.Sc. Biotechnology	1	Dr. Kunal Singh	Basic techniques in microbiology
24	Ms. Kritika	Lovely Professional University, Jalandhar, Punjab	B.Sc. Biotechnology	1	Dr. Vipin Hallan	Cloning and construct preparation of SVP like gene from saffron for its characterization
25	Ms. Minakshi Sharma	Lovely Professional University, Jalandhar, Punjab	B.Sc. Biotechnology	1	Dr. Vivek Dogra	Basic techniques in plant molecular biology
26	Ms. Japneet Kaur	Lovely Professional University, Jalandhar, Punjab	B.Sc. Biotechnology	1	Dr. Arun Kumar	Basic techniques in molecular biology
27	Ms. Eiva	Sardar Beant Singh State University, Gurdaspur, Punjab	B.Sc. Biotechnology	3	Dr. Jeremy Dhkar	*In-vitro* seed germination and molecular analysis of selected Bamboo species
28	Ms. Anchal Parmar	Jiwaji University, Gwalior, Madhya Pradesh (Passout)	M.Sc. Biotechnology	6	Dr. Ravi Shankar	Deep sequencing based transcriptome discovery in maize
29	Ms. Tanya	Sher-E-Kashmir University of Agriculture Sciences and Technology, Jammu, Jammu & Kashmir	B. Tech. Biotechnology	4	Dr. Ravi Shankar	Chromatin immunoprecipitation followed by high-throughput sequencing analysis and motif discovery for DNA binding regulatory proteins
30	Ms. Mishika Singh	Banasthali Vidyapith, Rajasthan	B.Sc. Biotechnology	1	Dr. Jeremy Dhkar	PCR amplification of the nuclear and chloroplast genes in black turmeric and black ginger
31	Ms. Shreya Bhardwaj	Banasthali Vidyapith, Rajasthan	B.Sc. Biotechnology	1	Dr. Vandana Jaiswal	Hands-on training on basic molecular techniques used in DNA fingerprinting
32	Ms. Shubhangi Jha	Banasthali Vidyapith, Rajasthan	B.Sc. Biotechnology	1	Dr. Rajiv Kumar	Hands-on training on proteomics and molecular biology techniques
33	Mr. Amit Kothari	DAVV Indore, Madhya Pradesh	M.Sc. Biotechnology	5	Dr. Vidyashankar Srivatsan	Process Optimization for Extraction, Purification, and Stabilization of C-Phycocyanin from *Arthospira platensis* (Spirulina)
34	Mr. Ayush Kumar	Jaipur National University, Jaipur, Rajasthan	B. Tech. Biotechnology	5	Dr. Gaurav Zinta	Molecular cloning of seed shattering genes from pseudocereal of Amaranthaceae
35	Mr. Vishal Kumar	Rama University, Kanpur, Uttar Pradesh	B.Sc. Agriculture	1	Dr. Bhavya Bhargava	Familiarity with plant tissue culture lab practices and techniques
36	Ms. Mahi Sonkar	Rama University, Kanpur, Uttar Pradesh	B.Sc. Agriculture	1	Dr. Poonam Kumari	*In vitro* propagation of ornamental crops

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37	Ms. Arpita Thakuri	Chandigarh University, Mohali, Punjab	B.Sc. Microbiology	1	Dr. Rakshak Kumar	Basic microbiological technique in handling bacterial culture, its maintenance and preservation
38	Ms. Kanika Nag	Amity University, Noida, Uttar Pradesh	B.Sc. Agriculture	1	Dr. Ramesh	An overview of production technologies of medicinal and aromatic crops and research lab tools
39	Ms. Pooja Devi	Chandigarh University, Mohali, Punjab	M.Sc. Biotechnology	1	Dr. Ankit Saneja	Hands-on training on basic analytical techniques: TLC, HPLC, SEM, DLS
40	Ms. Pooja Devi	Chandigarh University, Mohali, Punjab	M.Sc. Biotechnology	1	Dr. Vandana Jaiswal	Hands-on experience in molecular techniques
41	Ms. Sandeep Kaur	Kanya Mahavidyalaya, Jalandhar, Punjab	B.Sc. Biotechnology	1	Dr. Rohit Joshi	Micropropagation and Transcript Evaluation of *Nardostachys jatamansi* under *in-vitro* Conditions
42	Ms. Keshiha	Kanya Mahavidyalaya, Jalandhar, Punjab	B.Sc. Biotechnology	1	Dr. Rohit Joshi	Micropropagation and Transcript Evaluation of *Nardostachys jatamansi* under *in-vitro* Conditions
43	Ms. Vaani Arora	Kanya Mahavidyalaya, Jalandhar, Punjab	B.Sc. Biotechnology	1	Dr. Ashish R. Warghat	Basics of Plant Tissue Culture and Molecular Biology
44	Ms. Roshni	Kanya Mahavidyalaya, Jalandhar, Punjab	B.Sc. Biotechnology	1	Dr. Ashish R. Warghat	Basics of Plant Tissue Culture and Molecular Biology
45	Ms. Nivedita Thakur	Guru Nanak Dev University, Amritsar, Punjab	M.Sc. Pharmaceutical Chemistry	5	Dr. Upendra Sharma	Synthesis and Characterisation of Isoquinoline Derivatives
46	Ms. Shikha Thakur	Dayanand Ayurvedic College, Jalandhar, Punjab	M.D. (Ayurveda)	1	Dr. Dinesh Kumar	Basic training in analytical techniques
47	Mr. Prajwal Dhiman	National Institute of Technology, Hamirpur, Himachal Pradesh	B.Tech. CE	1	Er. Mohit Sharma	Basic unit operations involved in processing of aromatic and medicinal plants
48	Ms. Shimali	Graphic Era Deemed to be University, Dehradun, Uttarakhand	M.Sc. Microbiology	5	Dr. Dharam Singh	Probiotics characterisation of milk microbes from Indian trans-Himalayas
49	Mr. Asher Atif	Graphic Era Deemed to be University, Dehradun, Uttarakhand	M.Sc. Microbiology	5	Dr. Sarita Devi	Isolation and screening of potential microorganisms for the production of pectinase enzyme from various cold desert regions of Western Himalayas
50	Mr. Sreeragn	National Forensic Science University, Gandhinagar, Gujarat	M.Sc. Toxicology	3	Dr. Vikram Patial	A study on the effect of IHBT-VPCI in renal cell line and its acute oral toxicity in mice
51	Mr. Anuj Rana	Chandigarh University, Mohali, Punjab	B.Sc. Microbiology	1	Dr. Shiv Shanker Pandey	Isolation and identification of plant-associated microbes from medicinal plants
52	Ms. Nidhi	Chandigarh University, Mohali, Punjab	B.Sc. Microbiology	1	Dr. Rakshak Kumar	Basic microbiological technique in handling bacterial culture, its maintenance and preservation
53	Mr. Abhishek Pathania	Guru Nanak Dev University, Amritsar, Punjab	M.Sc. Microbiology	1	Dr. Vidyashankar Srivatsan	Characterization of pasteurized beverage from Rhododendron flowers
54	Mr. Arpit Sharma	Guru Nanak Dev University, Amritsar, Punjab	M.Sc. Microbiology	1	Dr. Vidyashankar Srivatsan	Nutritional and phytochemical characterization of Western Himalayan Flowers
55	Mr. Tathagata Pal	Thapar University, Patiala, Punjab	M.Sc. Biotechnology	1	Dr. Damanpreet Singh	Hands-on training in Molecular Biology techniques in Pharmacology & Toxicology Laboratory

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56	Ms. Akshima Thakur	Chandigarh University, Mohali, Punjab	B.Sc. Microbiology	1	Dr. Rakshak Kumar	Basic microbiological technique in handling bacterial culture, its maintenance and preservation
57	Ms. Sukriti	Indian Institute of Science Education and Research, Bhopal, Madhya Pradesh	BS-MS	2.5	Dr. Rajesh Kumar Singh	Cloning and characterization of Flowering Promoting Factor (FPF) gene from *Crocus sativus*
58	Mr. Prajwal Jakhmola	Graphic Era Deemed to be University, Dehradun, Uttarakhand	M Sc. Biotechnology	6	Dr. Vidyashankar Srivatsan	Effect of iron supplementation on the growth and metabolite profile of industrially important microalga *Arthospira platensis*
59	Ms. Hitakshi Vijay	Jaipur National University, Jaipur, Rajasthan	B. Tech. Biotechnology	2	Dr. Vishal Acharya	Basics of Machine Learning with R Programming: Case study of drug discovery framework
60	Ms. Parul	Jaypee University of Information Technology, Solan, Himachal Pradesh	M.Sc. Biotechnology	1	Dr. Ashish R. Warghat	Basic Techniques in Plant Tissue Culture
61	Ms. Surabhi Gurjar	Gautam Buddha University, Greater Noida, Uttar Pradesh	B. Tech. Food Processing	1	Dr. Vidyashankar Srivatsan	Extraction of Natural Blue Colorant C-Phycocyanin from Blue Green Alga *Spirulina platensis*
62	Ms. Shubhra Sinha	Gautam Buddha University, Greater Noida, Uttar Pradesh	B. Tech. Food Processing	1	Dr. Vidyashankar Srivatsan	Evaluation of blanching conditions in the nutritional quality of Green peas (*Pisum sativum* L.)
63	Ms. Anmol Rajpoot	Chandigarh University, Mohali, Punjab	M.Sc. Chemistry	1.5	Dr. Dinesh Kumar/ Dr. Robin Joshi	Identification of proteins and metabolites using mass spectrometry
64	Ms. Anandita	Chandigarh University, Mohali, Punjab	M.Sc. Chemistry	1.5	Dr. Dinesh Kumar/ Dr. Robin Joshi	Identification of proteins and metabolites using mass spectrometry
65	Mr. Nilesh Kumar Niraula	Chandigarh University, Mohali, Punjab	M.Sc. Chemistry	1.5	Dr. Pamita Bhandari	Identification of proteins and metabolites using mass spectrometry
66	Mr. Mridul Gautam	Jaipur National University, Jaipur, Rajasthan	B. Tech. Biotechnology	2	Dr. Arun Kumar	Gene cloning, heterologous expression and purification of superoxide dismutase
67	Ms. Dipanjli Kacchap	National Institute of Science Education and Research (NISER), Odisha	M.Sc. (Int.) Life Sciences	2	Dr. Gaurav Zinta	Molecular Cloning of AtHY5
68	Ms. Shagun Sandal	IISER, Mohali, Punjab	BS-MS	3	Dr. Arun Kumar	Preparation of plant expression construct and development of transgenic lines of *Arabidopsis thaliana*
69	Ms. Nikhita Thakur	Chandigarh University, Mohali, Punjab	M.Sc. Biotechnology	6	Dr. Arun Kumar	Agrobacterium-mediated genetic transformation of rice to enhance disease tolerance
70	Ms. Muskan	Panjab University, Chandigarh	M.Sc. Biotechnology	1	Dr. Yogendra Padwad	Basic animal cell culture and molecular biology techniques in type 2 diabetes mellitus study
71	Ms. Tanu Yadav	Guru Nanak Dev University, Amritsar, Punjab	M.Sc. Biotechnology	2	Dr. Shashi Bhushan	Hands-on training in basic molecular biology
72	Ms. Priya Sharma	DAV University, Jalandhar, Punjab	M.Sc. (Hons.) Zoology	5	Dr. Vikram Patial	*In-vitro* studies on high glucose treated renal cell lines and histopathological analysis of rat tissues

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73	Mr. Jigyasu Gaurav	Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh	B.Sc. Biotechnology	6	Dr. Rajesh Kumar Singh	Cloning and functional characterization of FT3 and SVP gene in Saffron (*Crocus sativus*)
74	Ms. Divyanshi	Chandigarh University, Mohali, Punjab	M.Sc. Botany	1.5	Dr. Ram K. Sharma	Handling of basic laboratory instruments for nutraceutical formulations
75	Ms. Varsha Sharma	Amity University, Jaipur, Rajasthan	M.Sc. Applied Chemistry	6	Dr. Pamita Bhandari	Formulation of Herbal crack cream using medicinal plant extracts
76	Mr. Rohan Gupta	Guru Nanak Dev University, Amritsar, Punjab	M.Sc. Biotechnology	2	Dr. Arun Kumar	Molecular and biochemical techniques in plant microbiology
77	Ms. Sneha Sambyal	Guru Nanak Dev University, Amritsar, Punjab	M.Sc. Biotechnology	2	Dr. Vandana Jaiswal	Understanding the molecular approaches utilised in DNA fingerprinting
78	Mr. Naveen	Guru Nanak Dev University, Amritsar, Punjab	M.Sc. Biotechnology	2	Dr. Arun Kumar	Genetic transformation of *Arabidopsis thaliana* for constitutive expression of selected genes
79	Ms. Deepika	Hans Raj Mahila Mahavidyalaya, Jalandhar, Panjab	M.Sc. Botany	1	Dr. Ashish R. Warghat	Practical exposure on plant tissue culture techniques
80	Ms. Mandeep Kaur	Hans Raj Mahila Mahavidyalaya, Jalandhar, Panjab	M.Sc. Botany	1	Dr. Ashish R. Warghat	Practical exposure on plant tissue culture techniques
81	Ms. Muskaan	Hans Raj Mahila Mahavidyalaya, Jalandhar, Panjab	M.Sc. Botany	1	Dr. Jeremy Dhkar	Hands-on training in plant tissue culture and molecular biology techniques
82	Ms. Raman Manpreet Kaur	Hans Raj Mahila Mahavidyalaya, Jalandhar, Panjab	M.Sc. Botany	1	Dr. Ashish R. Warghat	Practical exposure on plant tissue culture techniques
83	Mr. Rahul Kumar	Central University of South Bihar, Bihar	M.Sc. Biotechnology	6	Dr. Vipin Hallan	Cloning and Expression of *Arabidopsis thaliana* FBD associated F-box protein gene in pET-28a Vector
84	Ms. Ayushi Gautam	Chandigarh University, Mohali, Punjab	M.Sc. Biotechnology	3	Dr. Vivek Dogra	Molecular cloning of MBW complex genes of *Rosa hybrida*
85	Ms. Kritika Jain	Amity University, Jaipur, Rajasthan	B.Sc. Biotechnology	2	Dr. Gaurav Zinta	Cloning and construct preparation of SVP like gene from saffron for its characterization
86	Ms. Akanksha Sood	Chandigarh University, Mohali, Punjab	M.Sc. Biotechnology	6	Dr. Vipin Hallan	Cloning of *Arabidopsis thaliana* Wrky47 gene in pGEMT vector
87	Ms. Twinkle Devi	Chandigarh University, Mohali, Punjab	M.Sc. Biotechnology	6	Dr. Ashish R. Warghat	*In vitro* cultivation of Himalayas medicinal plants for industrial utilization and conservation perspective
88	Ms. Varinda	Panjab University, Chandigarh	B.Sc. Hons. Biotechnology	1	Dr. Arun Kumar	Techniques in molecular biology and biochemistry
89	Ms. Harshita	Panjab University, Chandigarh	B.Sc. Biotechnology	1	Dr. Arun Kumar	Basic techniques in Molecular Biology
90	Ms. Shaifali Sharma	Amity University, Jaipur, Rajasthan	B.Sc. Biotechnology	2	Dr. Yogendra Padwad	Techniques involved in preclinical assessment of Pharmaceuticals and Nutraceuticals
91	Mr. Shivank Parashar	Gautam Buddha University, Greater Noida, Uttar Pradesh	Integrated M. Tech.	6	Dr. Ravi Shankar	High Throughput and computational approaches in miRNA biology

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92	Ms. Sherry Sharma	DAV University, Jalandhar, Punjab	M.Sc. Chemistry	4	Dr. Pamita Bhandari	Phytochemical studies on *Viola canescens*
93	Ms. Devika S	Sree Narayana College, Kollam, Kerala	B.Sc. Botany & Biotechnology	2	Dr. Vipin Hallan	Basic concepts and techniques used in plant pathology
94	Ms. Damini Rana	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	2	Dr. Ashish R. Warghat	Hands on training on Plant Tissue Culture
95	Ms. Ravina Thakur	Sardar Patel University, Mandi, Himachal Pradesh	M.Sc. Botany	1	Dr. Rohit Joshi	Comparative histological analysis of *in vitro* and *ex vitro* bamboo species
96	Mr. Ashish Chauhan	Chandigarh University, Mohali, Punjab	M.Sc. Chemistry	1.5	Dr. Pamita Bhandari	Qualitative analysis of Berberine in *Berberis lycium*
97	Mr. Sahil Rana	Chandigarh University, Mohali, Punjab	M.Sc. Chemistry	1.5	Dr. Upendra Sharma	Phytochemical Investigation of Plants
98	Ms. Srishti Chauhan	SRM Institute of Technology, Tamil Naddu	B. Tech. Computer Science	1	Dr. Vishal Acharya	Basics of Machine Learning with R Programming
99	Ms. Pinki Mandal	Lovely Professional University, Jalandhar, Punjab	B.Sc. Biotechnology	2	Dr. Jeremy Dhkar	Hands on training in plant tisssue culture and molecular biology techniques
100	Ms. Shreya Raina	Lovely Professional University, Jalandhar, Punjab	B.Sc. Biotechnology	2	Dr. Vandana Jaiswal	Basic technical skills in DNA fingerprinting
101	Ms. Nidhi Mandloi	Devi Ahilya Vishwavidyalaya, Indore, Madhya Pradesh	M.Sc. Industrial Microbiology	6	Dr. Sarita Devi	Probiotic attributes of various microbes isolated from traditional fermented foods of Western Himalaya
102	Ms. Priyanka Devi	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	2	Dr. Rohit Joshi	Effect of light intensity and phytohormones on *in vitro* proliferation and nucleic acid content of different bamboo species
103	Ms. Amisha Thakur	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	2	Dr. Rohit Joshi	Histological and molecular analysis of *in vitro* micropropagated plants of *Piccrorhiza kurroa*
104	Mr. Anun Pandit	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	2	Dr. Gaurav Zinta	Cloning of heat shock factor of Amaranth grain
105	Mr. Aniket Rana	Maharaja Agrasen University, Baddi, Himachal Pradesh	M.Sc. Biotechnology	2	Dr. Vandana Jaiswal	Development of SSR- markers from the genes involved in phytic acid biosynthesis pathway in buckwheat
106	Ms. Mansi	Chandigarh University, Mohali, Punjab	M.Sc. Biotechnology	6	Dr. Shashi Bhushan	*In vitro* studies on callus culture of *Picrorhiza kurroa* for the production of picrosides
107	Ms. Ridhima Chandel	Sher-E-Kashmir University of Agriculture Sciences and Technology, Jammu, Jammu & Kashmir	MBA	1	Dr. Sukhjinder Singh	Training on methodologies, questionnaire and data collection related to techno-economics of food processing industries
108	Ms. Somiya Kaur Sodhi	Sher-E-Kashmir University of Agriculture Sciences and Technology, Jammu, Jammu & Kashmir	MBA	1	Dr. Sukhjinder Singh	Training on methodologies and questionnaire preparation and data collection related to comparative study on frozen foods

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109	Ms. Meenakshi Rana	Panjab University, Chandigarh	M.Sc. Microbiology	2	Dr. Arun Kumar	Expression optimization of a recombinant manganese superoxide dismutase and its purification trials
110	Ms. Anshika Sharma	Panjab University, Chandigarh	M.Sc. Microbiology	2	Dr. Kunal Singh	Testing of anti-microbial potential of crude extract of endophytic fungi of saffron
111	Ms. Manisha Thakur	Shoolini Institute of Life Sciences & Business Management, Solan, Himachal Pradesh	M.Sc. Biotechnology	2	Dr. Shiv Shanker Pandey	Basic Techniques of Microbiology
112	Ms. Muskan Tiwari	Punjab Agricultural University, Ludhiana, Punjab	B.Sc. Biotechnology	1	Dr. Arun Kumar	Basic techniques in plant molecular biology
113	Mr. Paras Pathania	Sher-E-Kashmir University of Agriculture Sciences and Technology, Jammu, Jammu & Kashmir	MBA	1	Dr. Sukhjinder Singh	Study of marketing channels for value added fruit products
114	Ms. Vineet Singh Sawhney	Panjab University, Chandigarh	M.Sc. Biotechnology	1	Dr. Vikram Patial	Hands on training in histopathology and molecular techniques
115	Ms. Vidhi Bidaliya	SGGRU, Dehradun, Himachal Pradesh	M. Pharmacy	6	Dr. Damanpreet Singh	Efficacy testing and mechanistic insight of IHBT-FF01 in zebrafish model of haemorrhagic stroke
116	Ms. Sakshi Dhiman	Sher-E-Kashmir University of Agriculture Sciences and Technology, Jammu, Jammu & Kashmir	MBA	1	Dr. Sukhjinder Singh	Training on determination of cost components incurred during post-harvest operations in oil seeds
117	Mr. Anas Rahmani	Jaipur National University, Jaipur, Rajasthan	B. Tech. Biotechnology	6	Dr. Rohit Joshi	To optimize the factors affecting in-vitro micropropagation and transformationin Monk Fruit (*Siraitia grosvenorii*)
118	Ms. Kirti Pathania	Sanatan Dharma College, Hoshiarpur, Puanjab University, Chandigarh	B.Sc. Biotechnology	1	Dr. Ashish R. Warghat	Hands on training on media preparation, sterilization techniques and micropropagation techniques
119	Ms. Jaspreet Kaur	Chandigarh University, Mohali, Punjab	B.Sc. Biotechnology	3	Dr. Damanpreet Singh	Hands-on training in different preclinical techniques used in Pharmacology and Toxicology Laboratory
120	Mr. Dilkhush	B.N. College of Pharmacy, Udaipur, Rajasthan	M. Pharmacy	6	Dr. Vikram Patial	Hepatoprotective effect of IHBT-VP10 against MCD-induced NAFLD in mice
121	Ms. Priya	DAV University, Jalandhar, Punjab	Ph.D.	3	Dr. Vipin Hallan	Molecular characterization of the virus causing severe mosaic and leaf curling disease in *Momordia charantia*
122	Mr. Prakash Sirvi	B.N. College of Pharmacy, Udaipur, Rajasthan	M. Pharmacy	5	Dr. Damanpreet Singh	Understanding the protective effect of IHBT - 01.V.P in Zebrafish model of Convulsion
123	Mr. Shubham Upadhayay	Central University of Punjab, Bathinda, Punjab	Ph.D.	1	Dr. Damanpreet Singh	Hands on training on basic handling techniques used in zebrafish research
124	Ms. Manisha Soni	Bhupal Noble's University, Udaipur, Rajasthan	M. Pharmacy	6	Dr. Yogendra Padwad	Investigation of the senescence inhibiting attributes of green tea polyphenol epigallocatechin gallate (EGCG) in murine macrophages

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125	Ms. Shivangi Jaryal	Guru Nanak Dev University, Amritsar, Punjab	M.Sc. Molecular Biology & Biochemistry	3	Dr. Vidyashankar Srivatsan	Extraction and purification of C- phycocyanin from industrially important microalgae *Arthrospira platensis* (Spirulina)
126	Ms. Avani Vyas	Mohanlal Sukhadia University, Udaipur, Rajasthan	M.Sc. Microbiology	1	Dr. Vidyashankar Srivatsan	Hands on training in Food Technology
127	Ms. Muskan	Sri Guru Gobind Singh College, Chandigarh	M.Sc. Biotechnology	3	Dr. Arun Kumar	Hands on training in molecular biology techniques
128	Ms. Shivkanya Sharma	Dayanand Ayurvedic College, Jalandhar, Punjab	M.D. (Drayaguna)	3	Dr. Dinesh Kumar	Pharmacognostical evaluation (quality control, physicochemical parameters, preliminary phytochemical parameters and chromatography) of Ayurvedic drugs
129	Dr. Rachana Bhardwaj	Dayanand Ayurvedic College, Jalandhar, Punjab	M.D. (Ayurveda)	1	Dr. Dinesh Kumar/ Dr. Vikram Patial	Pharmacognostical evaluation (quality control, physicochemical parameters, preliminary phytochemical parameters and chromatography and bioacitivty evaulation) of Ayurvedic drugs
130	Ms. Sahiba Chahal	Panjab University, Chandigarh	M.Sc. Zoology	3	Dr. Yogendra Padwad	Cellular and molecular biology techniques in screening and lead optimization for Type-2 Diabetes mellitus
131	Ms. Abha Gupta	Chandigarh University, Mohali, Punjab (Passout)	M.Sc. Biotechnology	3	Dr. Narendra Tirpude	Training on techniques involve in preclinical efficacy evaluation of developed formulations for immunomodulatory activity in murine model
132	Ms. Nisha Kumari	DAV University, Jalandhar	M.Sc. Biotechnology	3	Dr. Ashish R. Warghat	Micropropagation, callus induction and hydrophobic cultivation of medicinal plant
133	Ms. Navpreet Kaur	Sri Guru Gobind Singh College, Chandigarh	M.Sc. Biotechnology	3	Dr. Vikram Patial	Hands on training on in-vitro and in-vivo experimentation and molecular techniques
134	Ms. Prakhya Rani	Patna University, Patna, Bihar	M.Sc. Biotechnology	3	Dr. Ankit Saneja	Development and characterization of novel electrospun polyvinyl alcohol nanofibers encapsulating naringenin-methyl-β-cyclodextrin inclusion complex
135	Ms. Anjali Kumari	Patna University, Patna, Bihar	M.Sc. Biotechnology	3	Dr. Ankit Saneja	Preparation and characterization of electrospun pullulan nanofibers incorporated with formononetin cyclodextrin inclusion complexes for fast disintegrating oral delivery
136	Dr. Swati	Dayanand Ayurvedic college, Jalandhar, Punjab	M.D. (Ayurveda)	15 days	Dr. Dinesh Kumar/ Dr. Vikram Patial	Pharmacognostical evaluation (quality control, physicochemical parameters, preliminary phytochemical parameters and chromatography) and preclinical evaluation of Ayurvedic drugs

Sr. No.	Student Name	Affiliation	Course	Duration (Months)	Supervisor	Title of certificate
137	Dr. Nishi Choudhary	Dayanand Ayurvedic college, Jalandhar, Punjab	M.D. (Ayurveda)	1	Dr. Vikram Patial/ Dr. Dinesh Kumar/ Dr. Ashish Warghat	Pharmacognostical evaluation (quality control, physicochemical parameters, preliminary phytochemical parameters and chromatography); preclinical evaluation of Ayurvedic drugs and plant tissue culture techniques
138	Dr. Priyanka	Dayanand Ayurvedic college, Jalandhar, Punjab	M.D. (Ayurveda)	1	Dr. Vikram Patial/ Dr. Dinesh Kumar/ Dr. Ashish Warghat	Pharmacognostical evaluation (quality control, physicochemical parameters, preliminary phytochemical parameters and chromatography); preclinical evaluation of Ayurvedic drugs and plant tissue culture techniques
139	Dr. Monika Barya	Dayanand Ayurvedic college, Jalandhar, Punjab	M.D. (Ayurveda)	2	Dr. Dinesh Kumar	Pharmacognostical standardization and quality control of Varuna (*Crataeva nurvala*)
140	Ms. Anisha Singh	Banasthali Vidyapith, Rajasthan	B.Sc. Biotechnology	6	Dr. Vandana Jaiswal	Identification of Genes Involved in Phytic Acid Biosynthesis in Buckwheat (*Fagopyrum sp*)
141	Ms. Sanjana Nayak	Sri Guru Gobind Singh College, Chandigarh	M.Sc. Biotechnology	3	Dr. Vivek Dogra	Techniques in basic molecular biology
142	Ms. Prachi	Banasthali Vidyapith, Rajasthan	B.Sc. Biotechnology	6	Dr. Ram K. Sharma	Next generation sequencing application for plant improvement
143	Ms. Gudiya	Banasthali Vidyapith, Rajasthan	B. Tech. Biotechnology	6	Dr. Aparna Maitra Pati	Isolation and Characterization of PGPRs and Accessing its Impact on Plants
144	Ms. Komal	Banasthali Vidyapith, Rajasthan	B. Tech. Biotechnology	6	Dr. Aparna Maitra Pati	Screening of Bacteria for PGPR Attribute and Heavy Metal Tolerance
145	Ms. Nagma	Banasthali Vidyapith, Rajasthan	B. Tech. Biotechnology	6	Dr. Rajiv Kumar	Molecular cloning of proteasome beta subunit (PBD1) gene from *Picrorhiza kurroa*
146	Ms. Aarzoo Sharma	Shoolini University, Solan, Himachal Pradesh (Passout)	M. Tech. Environmental Engineering	3	Dr. Rakshak Kumar	Basic techniques in microbiology
147	Ms. Payal	Panjab University, Chandigarth (Passout)	M.Sc. Biotechnology	3	Dr. Aparna Maitra Pati	Screening of bacteria for PGPR attribute and heavy metal tolerance
148	Ms. Simran	Sri Guru Gobind Singh College, Chandigarh	M.Sc. Microbial biotechnology	3	Dr. Vivek Dogra	To be issued
149	Ms. Rubina Dhiman	Guru Nanak Dev University, Amritsar, Punjab	M.Sc. Human Genetics	3	Dr. Amitabha Acharya	Spectroscopy and microscopy characterization of anti-microbial nanoparticles and their efficacy evaluation
150	Ms. Kritika Saini	Shoolini University, Solan, Himachal Pradesh (Passout)	M.Sc. Biotechnology	4	Dr. Arun Kumar	Cloning, heterologous expression, and purification of a recombinant protein
151	Ms. Manisha Dhiman	GGDSD College, Rajpur, Palampur, Himachal Pradesh	B.Sc. Medical	6	Dr. Parlay Das	Hands-on training on extraction, isolation, quantitative analysis by UPLC and semi-synthesis of natural occurring compounds
152	Mr. Krishnaveer Singh Jhala	Mohanlal Sukhadia University, Udaipur, Rajasthan	M.Sc. Microbiology	6	Dr. Vidyashankar Srivatsan	Studies on the effect of abiotic stress in microalgae and their adaptive response

Sr. No.	Student Name	Affiliation	Course	Duration (Months)	Supervisor	Title of certificate
153	Ms. Deepti Gautam	Mohanlal Sukhadia University, Udaipur, Rajasthan	M.Sc. Microbiology	6	Dr. Mahesh Gupta	Evaluation of prebiotic potential, *in-vitro* gastrointestinal digestibility and shelf life stability of selected food products
154	Ms. Kritika Agrawal	Mohanlal Sukhadia University, Udaipur, Rajasthan	M.Sc. Microbiology	6	Dr. Kunal Singh	UPLC-MS based metabolite identification in three potato varieties against early blight disease
155	Ms. Kunika Sharma	Mohanlal Sukhadia University, Udaipur, Rajasthan	M.Sc. Microbiology	6	Dr. Kunal Singh	Antagonistic potential of endophytes isolated from *Crocus sativus*
156	Ms. Varsha Kumari	Mohanlal Sukhadia University, Udaipur, Rajasthan	M.Sc. Microbiology	6	Dr. Dharam Singh	Bacterial biomolecules production from pilot-scale fermentation
157	Mr. Rohan Pradhan	Guru Nanak Dev University, Amritsar, Punjab (Passout)	M.Sc. Microbiology	6	Dr. Rakshak Kumar	Basic microbiological techniques
158	Ms. Kavita Kumari	Shoolini Institute of Life Sciences & Business Management, Solan, Himachal Pradesh	M.Sc. Microbiology	1	Dr. Rakshak Kumar	Basic microbiological technique in handling bacterial culture, its maintenance and preservation
159	Ms. Anjali Thakur	Jaypee University of Information Technology, Solan, Himachal Pradesh	M.Sc. Biotechnology	3	Dr. Shiv Shanker Pandey	Training in basic microbiology and molecular biology techniques
160	Ms. Riya Gurung	Shoolini Institute of Life Sciences & Business Management, Solan, Himachal Pradesh	B. Tech. Biotechnology	1	Dr. Rakshak Kumar	Basic microbiological technique in handling bacterial culture, its maintenance and preservation
161	Ms. Aditi	Shoolini Institute of Life Sciences & Business Management, Solan, Himachal Pradesh	M.Sc. Biotechnology	1	Dr. Vivek Dogra	Basic techniques in molecular biology
162	Ms. Shilpa Devi	Chandigarh College of Pharmacy, Landran, Mohali, Punjab	M. Pharmacy	6	Dr. Damanpreet Singh	Investigating the neuroprotective potential of IHBT-TBF-01 in a Zebrafish model
163	Mr. Swarnabh Swarnam	Sam Higginbottom University of Agriculture, Technology and Sciences, Prayagraj, Uttar Pradesh	M. Sc. Forest biology and Tree Improvement	6	Dr. Ashish R. Warghat	Tissue culture and hydroponic cultivation of Mulberry (*Morus alba*)
164	Ms. Suhani Sinha	Lovely Professional University, Jalandhar, Punjab (Passout)	M. Sc. (Hons.) Biotechnology	3	Dr. Rohit Joshi	Micropropagation, nucleic acid isolation and genetic fidelity analysis of economically important plants
165	Ms. Riya Sood	Central University of Himachal Pradesh, Himachal Pradesh (Passout)	M. Sc. Bioinformatics	6	Dr. Vishal Acharya	Assessing the gut microbiome of individuals inhabiting the Himalayan region
166	Ms. Shruti Singh	University of Allahabad, Uttar Pradesh (Passout)	M. Sc. Bioinformatics	6	Dr. Ravi Shankar	Deep sequencing based transcriptome discovery on *Camellia sinensis* (Tea)
167	Mr. Shivam Chaudhary	Lovely Professional University, Jalandhar, Punjab (Passout)	M. Sc. (Hons.) Biotechnology	3	Dr. Rohit Joshi	Molecular biology and biotechnological analysis of *in-vitro* propagated high altitude medicinal plants

Sr. No.	Student Name	Affiliation	Course	Duration (Months)	Supervisor	Title of certificate
168	Mr. Kartikeya Dubey	Shoolini University, Solan, Himachal Pradesh (Passout)	M. Sc. (Hons.) Biotechnology	3	Dr. Gaurav Zinta	Molecular cloning of *AtLFG4* gene
169	Ms. Pankaj Kumar	Panjab University, Chandigarh (Passout)	M. Sc. Bioinformatics	3	Dr. Kunal Singh	Bioinformatics based identification and digital expression analysis of transcription factors from *Crocus sativus*
170	Ms. Deeksha Menia	Punjab Technical University, Jalandhar, Punjab (Passout)	M.Sc. Biotechnology	7	Dr. Rakshak Kumar	Isolation, screening and identification of bacteria producing hydrolytic enzymes from the landfill soil samples
171	Ms. Kajal Chauhan	Himachal Pradesh University, Shimla, Himachal Pradesh (Passout)	M. Sc. E.V.S	4	Dr. Amit Kumar	Hands-on training on basics and applications of remote sensing and GIS.
172	Mr. Pratham Jindal	Lovely Professional University, Jalandhar, Punjab (Passout)	B.Sc. (Hons.) Biotechnology	6	Dr. Vivek Dogra	Characterisation of foxtail millets (*S. italica*) germplasm and cloning of genes involved in plant photoprotection mechanism
173	Ms. Sayani Das	Shoolini Institute of Life Sciences & Business Management, Solan, Himachal Pradesh	M. Pharmacy	3	Dr. Upendra Sharma	Phytochemical investigation of *Neptunia oleracea*
174	Ms. Shilpa Ghosh	Shoolini Institute of Life Sciences & Business Management, Solan, Himachal Pradesh	M. Pharmacy	3	Dr. Upendra Sharma	Phytochemical investigation of *Callistemon citrinus*
175	Mr. Harnam Singh	Shoolini Institute of Life Sciences & Business Management, Solan, Himachal Pradesh	Animal House	14 days	Dr. Yogendra Padwad	Laboratory practices in Animal House, Animal Breeding and Housing Practices

START-UP AND INCUBATEES

Department of Industry, Himachal Pradesh signed an MoU on **23rd February, 2017** for implementation of H.P. state chief minister start-up incubation scheme at CSIR-IHBT, Palampur. Under this scheme, incubates shown interest to establish new start-up/enterprise in the state.

Total **56** start-up joined CSIR-IHBT, Palampur, since 2017. Presently, **40** startups already completed the startup tenure and developed their prototypes. Currently **16** startups are actively working in the area of process development, food processing, tissue culture, aeroponics, floriculture, aromatic crops and herbal products under the Himachal Pradesh CM Startup scheme. CSIR- IHBT has also demonstrated the incubation facilities in various events organized at state and national level for encouraging young potential incubators for new startups.

List of the start-ups joined during April 2022 to March 2023 at incubation facility at CSIR-IHBT, Palampur with their information as below:

S. No	Name of Start-up	Idea of Start-up and Start date	Name of Mentor
1	**Ranjiv Singh** C/O Joginder Singh, V.P.O. Raja ka Bagh, Teh Nurpur, Distt. Kangra. H.P – 176201 Cont. No. 7355471316 Email: ranjiv.parasram@gmail.com	Hydroponically growing Basil, Brahmi, lettuce and spinach **17th Aug 2022**	Name: Dr. Ashish Wargat Email: ashishwarght@ihbt.res.in
2	**Suveer Singh** H. No. 102, Block 1, Sanyard Tehsil Sadar Mandi, Himachal Pradesh 175001 Cont. No. 7018346165 Email: suveer.singh.07@gmail.com	Hydroponically growing exotic vegetables in Mandi region. **22nd Aug 2022**	Name: Dr. Ashish Wargat Email: ashishwarght@ihbt.res.in
3	**Shika Kalsi** Vill Khai, P.O. Bani, Teh Barsar, Distt. Hamirpur. H.P Cont. No. 7876792940,7807396307 Email: shikhakalsi30@gmail.com	Hydroponically growing high value herbs and medicinal plants **31st Aug 2022**	Name: Dr. Ashish Wargat Email: ashishwarght@ihbt.res.in
4	**Seema Kumari** V.P.O. Banuri, Tehsil Palampur, Distt Kangra. (Himachal Pradesh) pin code-176061 Cont. No. 7876506493 Email: patiyalsimran04@gmail.com	Value addition of flowers through dehydration technology and producing various products. **31st Aug 2022**	Name: Dr. Poonam Kumari Email: poonam@ihbt.res.in
5	**Yamini Sharma** House No- 372/11, V.P.O. Puranabazar, Teh Sundernagar, Distt. Mandi. H.P. Pin code- 175019 Cont. No. 09459970239, 8091107099 Email: sharmayamini208@gmail.com	Development of Ready to use beverage/ powder based on natural ingredients and herbs for health benefits. **15th Sep 2022**	Name: Dr. Vidyashankar Srivatsan Email: vshankar@ihbt.res.in
6	**Mona Singh** Yuktika Biotech and Nutraceuticals Private Limited Village - Bharmat, Tehsil - Palampur, District – Kangra. Himachal Pradesh (176061) Cont. No. 7650012340 Email: ybn@yuktika.in	Development of nutritive, tasty and healthy herbal cake for kids **06th Oct 2022**	Name: Dr. Vidyashankar Srivatsan Email: vshankar@ihbt.res.in

The Academy of Scientific and Innovative Research (AcSIR) was established in 2010 (by a resolution of the Government of India on July 17, 2010) and formalized by an Act of Parliament vide The Gazette of India (dated February 7, 2012). Later, it was notified as an Institution of National Importance with the mandate to undertake high-quality teaching and research in frontier areas of Science and Technology on 3rd April 2012. Consequent to this, CSIR-IHBT started its Ph.D. programme in January 2011 in the Biological and Chemical Sciences faculties under the banner of AcSIR.

To date, 383 students were registered for Ph.D. under AcSIR at CSIR-IHBT in the faculty of Biological Sciences and Chemical Sciences **(Fig. 1)** and 114 students have been awarded their doctoral degrees.

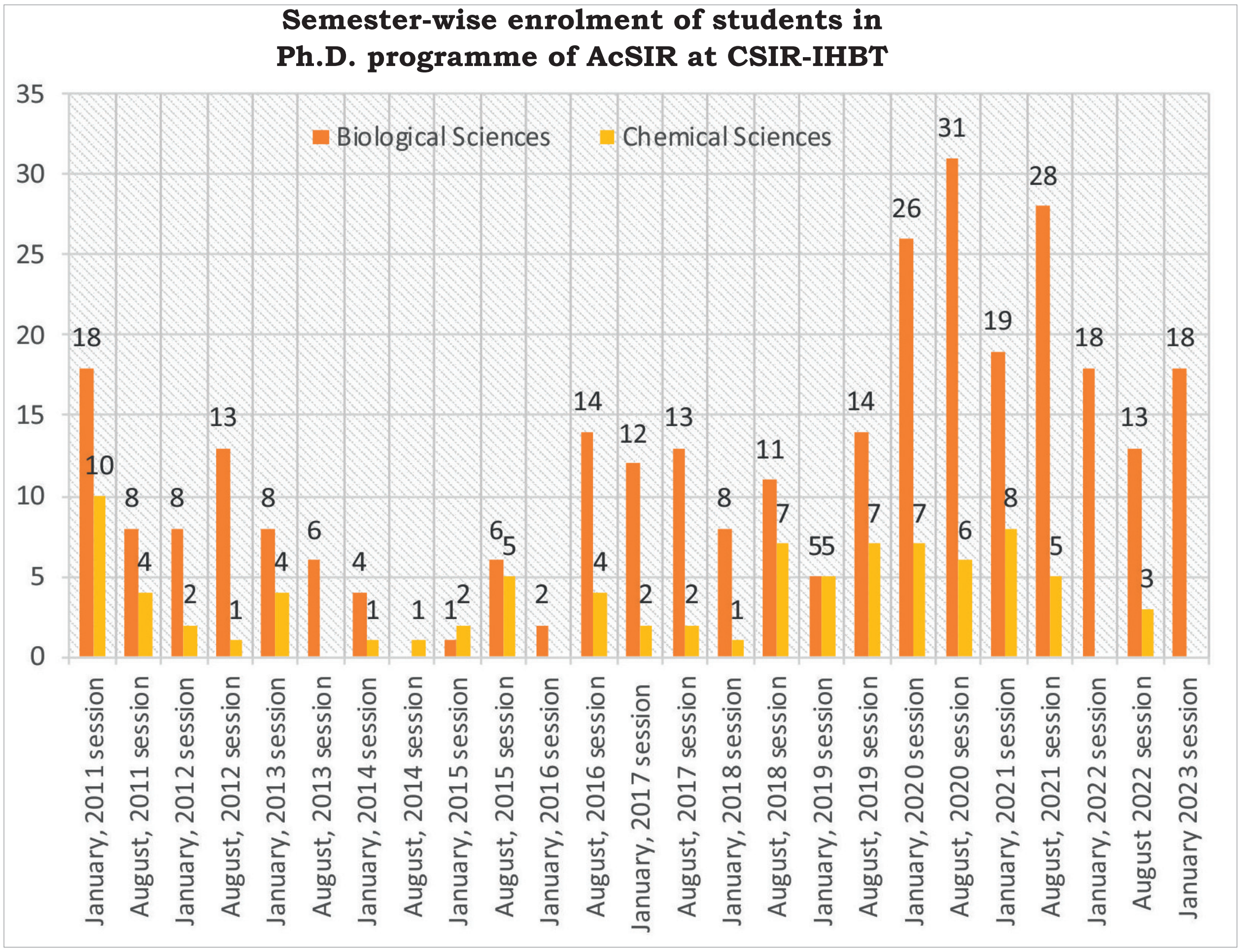


Fig. 1 Semester-wise enrolment of students in Ph.D. programme of AcSIR at CSIR- IHBT

From 1st April 2022 to 31st March 2023, total of 18 students successfully defended their thesis in their *viva voce* examinations and were awarded doctoral degree as per the following details:

SN	Registration No.	Name of the Student	Faculty	Supervisor
1.	10BB15A33005	Shudh Kirti Dolma	Biological Sciences	Dr. S. G. E. Reddy
2.	10BB16J33001	Namo Dubey	Biological Sciences	Dr. Kunal Singh
3.	10BB16A33006	Pallavi Sharma	Biological Sciences	Dr. Damanpreet Singh
4.	10BB16A33007	Vikas Dadwal	Biological Sciences	Dr. Mahesh Gupta
5.	10BB16A33009	Meetal Sharma	Biological Sciences	Dr. Vishal Acharya
6.	10BB16A33012	Ambika	Biological Sciences	Dr. Dharam Singh
7.	10BB16A33013	Neeraj Kumar	Biological Sciences	Dr. Vishal Acharya
8.	10CC16A33019	Amita Kumari	Chemical Sciences	Dr. S. K. Maurya
9.	10BB17J33005	Subhash Kumar	Biological Sciences	Dr. Dharam Singh
10.	10BB17J33006	Kajal Sinha	Biological Sciences	Dr. Y. S. Padwad
11.	10BB17J33009	Jyoti Chhimwal	Biological Sciences	Dr. Y. S. Padwad
12.	10BB17J33011	Jyoti Devi	Biological Sciences	Dr. Shashi Bhushan
13.	10BB17J33012	Shiv Rattan	Biological Sciences	Dr. Ashish R. Warghat
14.	10BB17A33011	Syed Murtuza Sayeed Abidi	Biological Sciences	Dr. Amitabha Acharya
15.	10BB17A33012	Chandni Sharma	Biological Sciences	Dr. Amitabha Acharya
16.	10BB17A33013	Ashish Kumar Shukla	Biological Sciences	Dr. Amitabha Acharya
17.	10BB18J33007	Vikas Thakur	Biological Sciences	Dr. Dharam Singh
18.	10CC19J33001	Rahul Upadhyay	Chemical Sciences	Dr. S. K. Maurya

Visit of Malaysian Delegation from Ministry of Science, Technology and Innovation (MOSTI), Secretary General

Malaysian delegation from Ministry of Science, Technology and Innovation (MOSTI), Secretary General and his team visited the institute on 04/04/2022 under the leadership of Prof. Anil K. Gupta, Founder Honeybee Network, SRISTI, GIAN & NIF.

Awareness Programme entitled Intellectual Property Rights (IPRs)

CSIR-IHBT in collaboration with Office of the Controller General of Patents, Designs & Trade Marks, Ministry of Commerce, GOI, New Delhi conducted awareness programme entitled "INTELLECTUAL PROPERTY RIGHTS (IPRs) under NATIONAL INTELLECTUAL PROPERTY AWARENESS MISSION (NIPAM)". Ms. Sumit Choudhary, NIPAM Officer and Examiner of Patents & Designs, O/o CGPDTM, New Delhi made an elaborated presentation on the subject, highlighting the fundamentals and importance of Patents, Designs, Trademarks, Copyrights, and Geographical Indications.

Swachhata Pakhwada Celebrations in CSIR-IHBT

Swachhata Pakhwada was celebrated in CSIR-IHBT from 1st to 15th May 2022. The Swachhata Pledge was administered by the Director of the Institute, Dr. Sanjay Kumar to the employees and research students of the Institute on 1st May through hybrid mode. Various programs like tree plantation, Drawing competitions, quiz, essay writing, Cleaning and sanitization of the institute campus, and a workshop on Domestic Waste Management was organized under Swachhata Pakhwada.

Dr. Sanjeev Khosla, Director, CSIR-IMTECH, Chandigarh visited CSIR-IHBT

Dr. Sanjeev Khosla, Director, CSIR-Institute of Microbial Technology, Chandigarh delivered an interesting talk on “Microbial interaction with the host epigenetic circuitry” on 04.05.2022 at CSIR-IHBT, Palampur. Dr. Khosla deliberated various issues related to mycobacterial proteins that interact with the host genome epigenetically.

National Technology Day

CSIR-IHBT, celebrated National Technology Day on 11th May, 2022. Chief guest of the function, Prof. Pulok Kumar Mukherjee, Director, IBSD, Imphal delivered a National Technology Day Lecture on the topic: “Ethnopharamacology-Integrating Shastra and Science from Tradition to Translation”. He emphasized on the importance of Indian traditional medicinal system, importance of its scientific validation, and highlighted the significance of the Himalayan Bioresources.

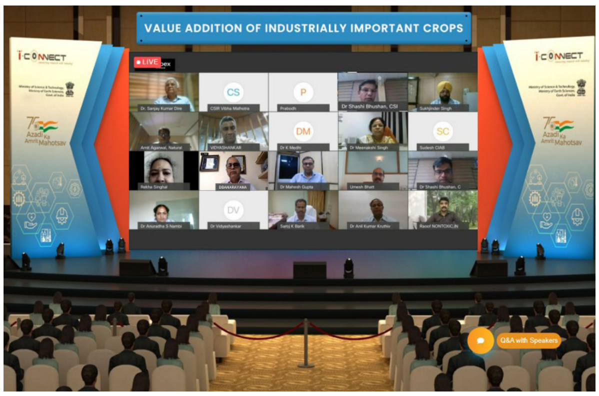
Dr. John All, Executive Director, American Climber Science Program visited CSIR-IHBT

Dr. John All, a distinguished researcher from United States and a visiting Fulbright Specialist at CSIR-IHBT, delivered a lecture on the theme “Glacier Retreat Monitoring.” By providing case studies from his research in the Andes mountains in Peru, the global issues of glacier retreat due to changing climate and other anthropogenic disturbances attributing to accumulation of dust in the glaciers were highlighted. He also emphasized in his presentation as how the diversity of macro-invertebrates in the streams helps to indicate water quality downstream in the valleys.

iConnect (iCEN-10) Event Value Addition of Industrially Important Crops

A series of iconic 75 Industry Connect (iConnect) events were organized from May to August 2022 under the aegis of the Ministry of Science & Technology, Government of India for celebrating the 75 years of Indian Independence.

In this context, CSIR-IHBT showcased the technologies developed by different CSIR, DST and DBT institutions for Value Addition of Industrially Important Crops under the Agri-Nutri-Biotech (ANB) Theme. Over 55 industries participated in the event including start-ups and new entrepreneurs. Besides the demonstration of technologies, there was a plenary session to discuss the Opportunities, Challenges and Way Forward in the area of plant-based Nutraceutical & Dietary Supplements and Alternative proteins.



CSIR Technologies for Rural Livelihood Showcasing CSIR-IHBT Technologies

CSIR-NIScPR, Unnat Bharat Abhiyan (UBA), and Vijnana Bharati (VIBHA) have jointly undertaken a major initiative for the dissemination of CSIR technologies to create livelihood opportunities in rural areas. In this context, CSIR-NIScPR, CSIR-IHBT, UBA, and VIBHA have jointly organized a Tow-day Technology Demonstration and Networking Meet on 29-30 June 2022, at CSIR-IHBT, Palampur. The key objective of this Meet was to showcase and demonstrate rural technologies developed by CSIR-IHBT that can help in farmers' livelihood creation and enhance their income through the development of the business opportunities.

CSIR-IHBT Foundation Day

CSIR-Himalayan Institute of Bioresource Technology, Palampur, Himachal Pradesh celebrated its 40th Foundation Day on 02 July 2022. On this occasion, Dr. T. Ramasami delivered a foundation day speech on "Towards Sustainable Bioeconomy Path of Himalayan Biosphere: IHBT as the Path Finder". While greeting the staff of the Institute on the 40th foundation day, he said that CSIR-IHBT is located in a fragile ecosystem and is mandated to emerge as a global leader on technologies for boosting bioeconomy through sustainable utilization of Himalayan bioresources". Apart from highlighting the contribution made by CSIR-IHBT in the service of the society over the last 40 years, Dr. Ramasami also suggested to focus upon developing technological solutions for sustainable bioeconomy. He is of the opinion that CSIR-IHBT has to play a crucial role of serving the nation as a path finder towards sustainable economy using resources available in Himalayan biosphere. He emphasized on three pillars for sustainable development i.e. Bearable, Equitable and Viable. He stressed upon innovation in the field of science, and value addition of bio-based products for the economical upliftment and called upon the institute to accept the challenges of the fragile Indian Himalayan ecosystem.

Foundation stone laying ceremony of the "Food Processing Block

The Foundation stone laying ceremony of the "Food Processing Block" sponsored by Department of Science & Technology under Science and Heritage Research Initiative (SHRI) was held on 12th August 2022. The Chief Guest of the event was Dr. Srivari Chandrasekhar, Secretary, Department of Science & Technology, New Delhi was present online. The main aim of the upcoming food processing block is to develop and standardize food processing technologies focusing on traditional foods of Himalayas. The food processing block would house state of the art food processing machinery and in-house analytical laboratory.

Har Ghar Tiranga

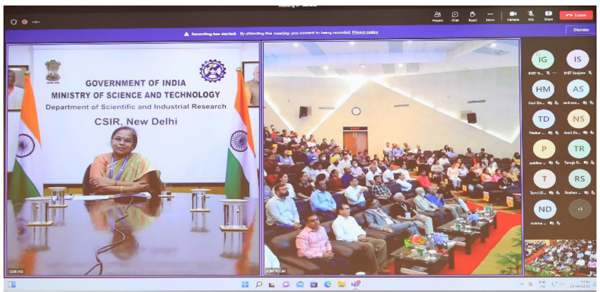
CSIR-IHBT Palampur celebrated "Har Ghar Tiranga"from 13-15, August 2022 to celebrate azaadi ka amrit mahotsav.

CSIR-IHBT celebrated 75 years of Indian Independence

CSIR-IHBT celebrated 75 years of Indian Independence by planting 75 trees, 25 each of Gulmohar (*Delonix regia* (Hook.) Raf.), *Champa* (*Plumeria* alba L.) and Kapoor (*Cinnamomum camphora* L.) to represent Tiranga. Gulmohar gives saffron-coloured flower while flowers of Champs are white in colour. Kapoor has green leaves throughout.

Student Seminar Series 2022-6th Edition

CSIR-IHBT Research Scholars organized "Student Seminar Series 2022-6th Edition" in Hybrid mode on the occasion of Teacher's Day to celebrate birth anniversary of Dr. Sarvepalli Radhakrishnan. The ceremony was presided over by Honorable DG & Secretary, DSIR, Dr. N. Kalaiselvi in the gracious presence of the Chief Guest Prof. S. P. Bansal, Hon'ble Vice Chancellor, Central University of Himachal Pradesh and Dr. Sanjay Kumar, the Director of the institute. Overwhelming response was received in the various events including Oral, Poster & e-Poster presentations, SWAR, Scientific Meme, Photography, and Videography. More than 500 participants including scientists, students, start-ups and entrepreneurs attended the event and benefitted from the deliberations.



हिंदी सप्ताह समारोह

सीएसआईआर–हिमालय जैवसंपदा प्रौद्योगिकी संस्थान, पालमपुर में हिंदी सप्ताह का मुख्य समारोह दिनांक 14 सितम्बर 2022 को बड़े हर्षोल्लास के साथ मनाया गया। समारोह के मुख्य अतिथि प्रो. अनिल कुमार त्रिपाठी, निदेशक, विज्ञान संस्थान एवं आचार्य, काशी हिंदू विश्वविद्यालय, बनारस ने 'विज्ञान की विकास यात्रा का भविष्यन्मुखी पुनरावलोकन' विषय पर अपना व्याख्यान दिया।

Fit India Freedom Run 3.0

CSIR-IHBT organised Fit India Freedom Run 3.0 under Azadi Ka Amrit Mahotsav on 02.10.2022. On the auspicious occasion of Gandhi Jayanti the event started with a Plog Run under the theme of "Azadi ke 75 saal, fitness rahe bemisaal." The run commenced from the Guest House and covered different areas of the CSIR-IHBT premises and was participated by scientific, technical, administrative staff and the research scholars. During the event cleanliness drive was also carried out to ensure a healthy workplace.

Dr. N. Kalaiselvi, Director General, CSIR and Secretary DSIR Visited CSIR-IHBT

Dr. N. Kalaiselvi, Honorable Director General, CSIR and Secretary DSIR addressed the scientists, staff, and researchers of CSIR-IHBT at its campus on 30 October 2022. DG CSIR was on a visit to the two-day CSIR Directors' Conference 2022: CSIR for Society and Industry at CSIR-IHBT Palmapur. Dr. Sanjay Kumar, Director CSIR-IHBT, warmly welcomed Dr. N. Kalaiselvi and introduced the institute.

Vigilance Awareness Week-2022

Vigilance Awareness Week-2022 was organized as per the guidelines of the Central Vigilance Commission, New Delhi, and the Chief Vigilance Officer, CSIR, New Delhi in CSIR-IHBT. On this occasion, an awareness Walkathon was organized in the institute on 3-11-2022. Many other activities viz., essay writing, slogan writing and quiz competition were organised for the scholars and CSIR IHBT staff. Contractors and suppliers meet was also organised as part of vigilance awareness week celebrations.

Directors Meet, October 28-29 2022

CSIR-IHBT, Palampur organised CSIR Director's Conference on 28-29 October, 2022 with the theme on "CSIR for Society and Industry". The Directors of various CSIR Institutes across India, distinguished as well as outstanding Scientists and Heads of different sections from CSIR Headquarters also participated in the conference.

CSIR Annual Finance & Accounts Meet

2-Days CSIR Annual Finance & Accounts Meet was conducted at CSIR-IHBT, Palampur from 4 to 5th November 2022. Dr. N. Kalaiselvi, DG CSIR and Secretary DSIR in her address expressed that Finance & Accounts, Store & Purchase and General Administration are strong pillars of the Labs and their synergism in functioning boosts the research outcomes of the CSIR labs. Shri Chetan Prakash Jain, JS & FA presented the overview of the achievements and issues to be addressed of the Finance & Accounts wing of CSIR. Shri Mahendra Kumar Gupta, Joint Secretary (Admin) also gave his opening remarks.

81st Foundation Day of CSIR

CSIR-IHBT celebrated 81st Foundation Day of CSIR on 15th November, 2022. Prof. Anupam Varma, Former President, the World Society for Virology, Former ICAR National Professor, INSA Emeritus Scientist, Advanced Center for Plant Virology, Indian Agriculture Research Institute, New Delhi was the Chief Guest. On this occasion, Padam Shri Prof. Sudhir K. Sopory, SERB Distinguished Fellow and Senior Emeritus Scientist at International Center for Genetics Engineering and Biotechnology New Delhi delivered the CSIR Foundation Day lecture on "Perception, Communication and Adaptation in Plants". During this event, IHBT honoured three entrepreneurs for adopting the technologies of the institute.

Inauguration of Facilities

Dr. N. Kalaiselvi, Director General, CSIR & Secretary DSIR inaugurated three new facilities in the institute on 13th February 2023, via online mode. She was pleased to inaugurate, Scholar's Hostel. Enzyme Bioprocessing Facility, and Dispensary.

Inauguration of CSIR- One Week One Lab Program

"One Week – One Laboratory" was organized at CSIR-IHBT, Palampur from February 20-25, 2023 to showcase its technological breakthroughs to the general public. The program was inaugurated by Shri Ashish Butail, Hon'ble Chief Parliamentary Secretary, Government of Himachal Pradesh. Dr. Girish Sahni, Bhatnagar Fellow and former Director General, CSIR emphasized on the need to change the ecosystem so that products based on technologies developed in the lab can reach to the market. The special guest, Dr. M. P. Gupta, Managing Director, Deccan Healthcare Ltd. Hyderabad also addressed the gathering and said that success is achieved only by overcoming challenges. Beside releasing a booklet on start-ups, the Hon'ble Chief Parliamentary Secretary also inaugurated the Plant Tissue Culture Unit and Flower Show at the institute. MoUs were also signed on the occasion for dissemination of technologies developed at CSIR-IHBT.

Conclusion of "One Week One Lab" Program

The "One Week One Lab" program at CSIR-IHBT, Palampur concluded on February 25, 2023. The theme of the event was "Strengthening Local Linkages". Mrs. Poonam Bali Mayor, Palampur Municipal Corporation was the guest of the ceremony. Dr. Pralay Das, Principal Scientist of the Institute while welcoming the participants highlighted the objective of the "One Week One Laboratory" programme. Institute's Scientist Er. Mohit Sharma gave information on Chemical Technology, Dr. Mahesh Gupta gave lecture on Challenges in Post-Harvest Management - Crispy Fruit and Fruit Technology, Dr. Poonam on Flower Value Addition Technology and Dr. Probir Kumar Paul on Agricultural Technology and Dr. Amit Kumar demonstrated drone based artificial intelligence technology in agriculture.

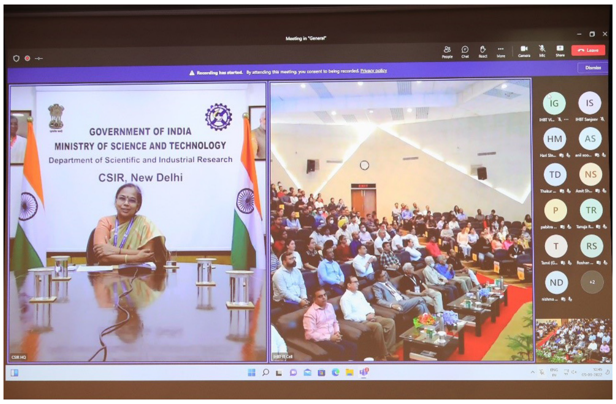
STUDENT SEMINAR SERIES

STUDENT SEMINAR SERIES

The research scholars of CSIR-IHBT organize a scientific program named as Student Seminar Series (SSS), wherein they share their research interests, ideas, and achievements to foster collaborations and enhance communication. The SSS was incepted in 2017 to celebrate Teachers' day (5^{th} September) scientifically.

In continuation to previous years, the 6^{th} edition of SSS was organized by the research scholars on 5^{th} September 2022 in a offline mode. The theme of 6^{th} edition was "*Vigyanam: Discover, Develop and Disseminate Science of Future Bioresources*". This year the SSS was organized in a symposium format where besides oral and poster presentations, events such scientific writing for articulating research (SWAR), scientific photography, and scientific meme, were included. As a result, SSS-2022 got a global attention, and besides the students of CSIR-IHBT, students from national and international institutions, including CSIR-IIIM, Jammu; Shoolini University, Solan; Department of Animal Husbandry, Himachal Pradesh; Chaudhary Bansilal University, Bhiwani; Panjab University, Chandigarh; Indian Institute of Science, Bangalore; National Institute of Plant Genome Research, New Delhi; Regional Centre for Biotechnology, Faridabad, Amity university, Noida; National Institute of Pharmaceutical Education and Research, Ahmedabad; Purdue School of Engineering and Technology, Indiana University-Purdue University, USA; Shanghai Center for Plant Stress Biology, China; Institute of Botany of the Czech Academy of Sciences, Czech participated and presented their work. In addition, this year, alumni of CSIR-IHBT were also invited, and three alumni gave invited talks to motivate the young generation. The program was presided over by the honorable Dr. Satprakash Bansal, Vice Chancellor, Central University of Himachal Pradesh, who delivered the keynote address.

The credit for the successful organization of SSS-2022 goes to young and dynamic scholars of CSIR-IHBT, wherein efforts from the student convenors, including Abhishek Goel, Abhisha Roy, Aman Kumar, Amit Kumar, Anil Kumar, Anish Tamang, Apoorva Prasad, Diksha Kalia, Dipanshu Ghosh, Himanshi Gangwar, Joel Jose Santhi, Jyoti Sharma, Mahima Chauhan, Pravesh Kundu, Ravi Thakur, Rishabh Kaundal, Shweta Sharma, Sumanta Mohapatra, Sumit Sharma, Vidhi Raturi, and Vijay Kumar Bharadwaj made this program a splendid occasion.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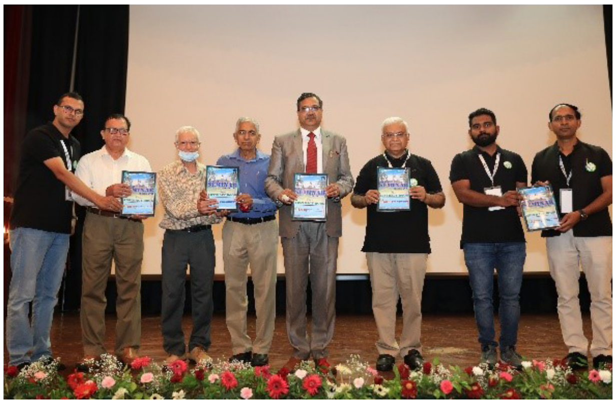
Department of Scientific and Industrial Research
CSIR, New Delhi




Optimized inhibitor screening and selection for human immunodeficiency virus (HIV) employing machine-intelligence driven framework

PATENTS / PUBLICATIONS

INTELLECTUAL PROPERTY

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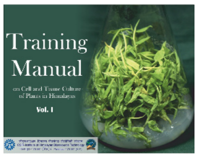

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Anil Kumar Rana (2022) Investigating the Efficacy of Selected Gsk-3 Pathway Modulators in Cerebral Stroke Model of Ovariectomized Rats. AcSIR program. Supervised by Dr. Damanpreet Singh.

Ankita Thakur (2022) Histological and molecular analysis of in vitro micropropagated plants of *Picrorhiza kurrooa*. School of Basic and Applied Sciences, Maharaja Agrasen University, Solan, Himachal Pradesh has completed her dissertation Supervised by Dr. Rohit Joshi (12-07-2022 to 01-09-2022).

Ashish Kumar Shukla (2023) Functional Carbon Nanomaterials and their Conjugates: Synthesis, Characterization and Biological Applications. Supervised by Dr. Amitabha Acharya.

Chandani Sharma (2023) Functional Fluorescent Nanomaterials: Synthesis, Characterization and Evaluation of their Imaging and Therapeutic Potential. Supervised by Dr. Amitabha Acharya.

Chaudhary S (2023) Molecular biology and biotechnological analysis of *in vitro* propagated high altitude medicinal plants. M.Sc. Biotechnology, Lovely Professional University, Phagwara, Punjab has completed his dissertation (21-12-2022 to 20-03-2023).

Deepika Nag (2022) Bioprospecting β-galactosidase producing microbes from dairy samples of indian trans-himalayas for applications in food industry. Supervised by Dr. Dharam Singh.

Devi P (2022) Effect of light intensity on in vitro proliferation and nucleic acid content of different bamboo species. M.Sc. Biotechnology, School of Basic and Applied Sciences, Maharaja Agrasen University, Solan, Himachal Pradesh has completed her dissertation (12-07-2022 to 01-09-2022).

Jumwal R (2022) To study the interaction of genotype, plant growth hormone and basal media composition on *in vitro* propagation of two *Dendrocalamus* species. M.Sc. Biotechnology, School of Basic and Applied Sciences, Maharaja Agrasen University, Solan, Himachal Pradesh has completed her dissertation (04-03-2022 to 07-05-2022).

Kaur S (2022) Micropropagation and transcript evaluation of an endangered high-altitude medicinal herb-*Nardostachys jatamansi* (D.Don) DC. under *in vitro* conditions.B.Sc. Biotechnology, Kanya Mahavidyalaya, Jalandhar, Punjab. has completed her dissertation (17-06-2022 to 15-07-2022).

Keshiha (2022) Analysis of transcript abundance in *in vitro* micropropagated plants of an endangered medicinal herb of alpine Himalayas: *Nardostachys jatamansi* (D.Don) DC. B.Sc Biotechnology, Kanya Mahavidyalaya, Jalandhar, Punjab has completed her dissertation (17-06-2022 to 15-07-2022).

Kumar A (2023) Exploration of microbial diversity and adaptational strategies from Himalayan glacier forefield. Supervised by Dr. Rakshak Kumar.

Meetal Sharma (2023) Computational assessment of oxidative stress in cancer interactome for potential therapeutics Supervised by Dr. Vishal Acharya.

Namo Dubey (2023) titled Exploration of TIR-NBS-LRR genes in potato against early blight caused by *Alternaria solani*. Supervised by Dr. Kunal Sngh.

Neeraj Kumar (2023) Advancement in virtual screening, drug repositioning approaches leveraging machine intelligence and deep learning frameworks. Supervised by Dr. Vishal Acharya.

Rahmani MA (2022) To optimize the factors affecting *in vitro* micropropagation and transformation in monk fruit (*Siraitia grosvernorii*). B.Tech. Biotechnology, Jaipur National University, Jaipur Rajasthan has completed his dissertation (01-03-2022 to 31-08-2022).

Shudh Kirti Dolma (2023) Insecticidal activities of *Triadica sebifera* (L.) Small against selected insect pests. AcSIR program. Supervised by Dr. S.G. Eswara Reddy.

Sinha S (2023) Micropropagation, nucleic acid isolation and genetic fidelity analysis of economically important plants.M.Sc. Biotechnology, Lovely Professional University, Phagwara, Punjab has completed her dissertation (21-12-2022 to 20-03-2023).

Subash Kumar (2022) Molecular characterization of L-asparaginase from *Pseudomonas* spp. of high-altitude niches in the western Himalaya. Supervised by Dr. Dharam Singh.

Suryavanshi VS (2022) Molecular dissection of the effect of gold nanoparticles in modulating morpho-physiological and biochemical changes in *Siraitia grosvernorii* under *in vitro* conditions. M.Tech (Integrated) Biotechnology, School of Biotechnology and Bioinformatics, D Y patil deemed to be University, Navi Mumbai, Maharastra has completed her dissertation (20-12-2021 to 13-06-2022).

Syed Murtuza Sayeed Abidi (2023) Isolation and characterization of plant based biomaterials and their use as nanocomposites for biological applications Supervised by Dr. Amitabha Acharya.

Tajpreet Kaur (2022) Investigation on the role of stevioside and umbelliferone against glycerol and sodium arsenite-induced nephrotoxicity nephrotoxicity in rats. Department of Pharmaceutical Sciences, Guru Nanak Dev University, Amritsar, Punjab. Co-Supervised by Dr. Damanpreet Singh.

Tanya R (2022) Assessment of callus induction and proliferation in *Nardostachys jatamansi* under different cytokinin concentrations.M.Sc. Biotechnology, School of Basic and Applied Sciences, Maharaja Agrasen University, Solan, Himachal Pradesh has completed her dissertation (04-03-2022 to 07-05-2022).

Thakur R (2022) Comparative histological analysis of *in vitro* and *ex vitro* bamboo species.M.Sc. Botany, Sardar Patel University, Mandi, Himachal Pradesh has completed her dissertation (28-07-2022 to 23-08-2022).

Vikas Dadwal (2022) Characterization and encapsulation of antioxidant active polyphenols from *Citrus* spp. and *Malus* spp. fruits for health benefits. PhD Under AcSIR program. Supervised by Dr. Mahesh Gupta.

Vikas Thakur (2022) Microbial and molecular studies for bioprospecting bacterial cellulolytic enzyme from Indian Himalayan niches. Supervised by Dr. Dharam Singh.

MSc./M. Pharma/B.Sc./B.Pharma/B.Tech

Shiwali Sharma (2022) Morphological and molecular marker based characterization of breeding lines of German chamomile. M.Sc. thesis supervised by Dr. Satbeer Singh.

Neha Dadwal (2022) Genetic variation for flower yield traits and molecular markers among the populations of German chamomile. M.Sc. thesis supervised by Dr. Satbeer Singh.

TRAININGS IMPARTED

Bidaliya V (2022) Efficacy testing and mechanistic insight of IHBT-FF01 in zebrafish model of haemorrhagic stroke. Supervised by Dr. Damanpreet Singh (20-12-2021 to 19-07-2022).

Atif A (2022) Isolation and screening of potential microorganisms for pectinase enzyme from cold desert region of Western Himalayas from Department of Life Sciences & Biotechnology, Graphic Era university (Deemed to be university), Dehradun, Uttarakhand. (22/02/2022 to 22/08/2022).

Thakur N (2022) Completed five months training entitled "Synthesis and Characterisation of Isoquinoline Derivatives". Feb-July.

Mandloi N (2022) Probiotic attributes of various microbes isolated from traditional fermented foods of Western Himalaya from School of Life Sciences, Devi Ahilya Vishwavidyalaya University, Indore. (01/07/2022-31/12/2022)

Shrama P (2022) In vitro studies on high glucose treated renal cell lines and histopathological analysis of rat tissues. Supervised by Dr. Vikram Patial (01-03-2022 to 31-07-2022).

Prakash Sirvi (2022) Understanding the protective effects of IHBT-01-V.P. in zebrafish model of convulsions. Supervised by Dr. Damanpreet Singh (25-03-2022 to 24-08-2022).

Dilkush (2022) Hepatoprotective ffect ofIHBT-VP10 against MCD-induced NAFLD in mice. Supervised by Dr. Vikram Patial (25-03-2022 to 24-09-2022).

Kaur S (2022) M.Sc. Student, Maharaja Agrasen University, Baddi, "In vitro propagation of rose (*Rosa* × *hybrida* var. Summer Snow)". (04.04.2022-27.05.2022).

Patial V (2022) Remote sensing tools and techniques from HIMCOSTE technician course. Supervised by Dr Amit Kumar (15.04.2022 to 15.05.2022).

Sharma V (2022) B.Sc. Biotechnology, Uttar Pradesh Pandit Deen Dayal Upadhyaya Pashu Chikitsa Vigyan Vishwavidyalaya Evam Go-Anusandhan Sansthan, (DUVASU) Mathura, U.P., "Micropropagation from nodal explant of rose (*Rosa* × *hybrida* L. var. Wedding Bells)". (12.04.2022 to 10.06.2022).

Rana S (2022) Completed one and half months training entitled "Phytochemical Investigation of Plants". June-August.

Sawhney VS (2022) Hands on training in histopathology and molecular techniques. Supervised by Dr. Vikram Patial (17-08-2022 to 16-09-2022).

kaur Nt (2022) Hands on training on in vitro and in vivo experimentation and molecular techniques. Supervised by Dr. Vikram Patial (17-08-2022 to 16-11-2022).

Ghaneera N (2022) Hands-on Training for various microbiological and biotechnological technique and characterization of fermented foods of Western Himalaya from Department of Microbiology, Shoolini Institute of Life Sciences and Business Management (SILB), Solan, Himachal Pradesh. (01/10/2022-30/12/2022)

Katoch S (2022) Hands on training for microbiological and biotechnological laboratory practices related to food technology from Department of Biotechnology, Himachal Pradesh University, Shimla, Himachal Pradesh. (01/10/2022-30/12/2022)

Chauhan K (2023) Hands-on training on basics and applications of remote sensing and GIS from Himachal Pradesh University, Summer Hills, Shimla, Himachal Pradesh, Supervised by Amit Kumar (09.11.2022 to 31.03.2023).

Das S (2023) Completed three months training entitled "Phytochemical Investigation of *Neptunia oleracea*". Jan-March.

Ghosh S (2023) Completed three months training entitled "Phytochemical Investigation of *Callistemon citrinus*". Jan-March.

Agarwal K (2023) UPLC-MS based metabolite identification in three potato varieties against early blight disease Supervised by Dr. Kunal Singh.

Sharma K (2023) Antagonistic potential of endophytes isolated from *Crocus sativus*. Supervised by Dr. Kunal Singh.

CONFERENCES/TRAINING/WORKSHOP/ SYMPOSIUM PRESENTATIONS

Randhawa S and Acharya A (2022) "Development of engineered gold nanoparticles for selective targeting of aggregation prone peptide sequences to combat neurogenerative diseases" 3rd Student IPS Symposium 2022 on Peptides: Therapeutics, Biomaterials and Beyond, organized by Department of Chemistry, Indian Institute of Technology Bombay, Powai. March 31-April 01.

Kumari A, Dar AI and Joshi R (2022) Insight into the potential application of gold nanoparticles in enhancing biomass production in bamboo. 43rd Annual Meeting of Plant Tissue Culture Association–India (PTCA-I) & International Symposium On "Advances in Plant Biotechnology and Nutritional Security- APBNS-2022", NIPB, New Delhi. April 28-30. p. 266.

Kumar A and Singh S (2022) Essential oil variations among the selected breeding lines of aromatic marigold (*Tagetes minuta* L.). International conference on, "Sustainable use of high altitude medicinal and aromatic plants for the socio-economic development" at Uttarakhand Ayurved University, Rishikul, Haridwar, Uttarakhand organized by National Medicinal Plants Board (Ministry of Ayush, Govt. Of India) May 7- 8.

Kumar S, Rana R, Singh S, Agnihotri V K and Joshi R (2022) Contributions of CSIR-IHBT to Essential Oil Industry using Himalayan Bioresources. International Congress & Expo-2022 at Indore organized by the Essential Oil Association of India May 26-28.

Bishnoi J, Kumar P, Kumar A, Singh S, Gehlot A, and Kumar A (2022) Protocol Standardization for Flow-Cytometry study in *Heeng* (*Ferula assa-foetida*). 6th Student seminar series organized at CSIR-IHBT, Palampur, pp-62, September 05.

Kumar A, Singh S, Singh S, Chauhan R and Kumar S (2022) Introduction of *Heeng* (*Ferula assa-foetida*) plant to cold deserts of Indian Himalayas. 4th International Conference on "Global Efforts on Agriculture, Forestry, Environment and Food Security (Theme: Climate Change and Its Impact) (GAFEF-2022)" organized at Pokhra, Nepal. Pp-290. ISBN: 978-93-5659-453-1, September 17-19.

Kumar P, Kumar A, Gautum R D, Kumar R, Singh S and Kumar A (2022) Morphological characterization of palmarosa (*Cymopogon martini*) for essential oil content. 4th International Conference on "Global Efforts on Agriculture, Forestry, Environment and Food Security (Theme: Climate Change and Its Impact) (GAFEF-2022)" organized at Pokhra, Nepal. Pp-266. ISBN: 978-93-5659-453-1, September 17-19.

Bishnoi J, Kumar P, Kumar A, Singh S, Gehlot A and Kumar A (2022) Flow-cytometry protocol standardization for genome size estimation in *Heeng* (*Ferula assa-foetida*). 4th International Conference on "Global Efforts on Agriculture, Forestry, Environment and Food Security (Theme: Climate Change and Its Impact) (GAFEF-2022)" organized at Pokhra, Nepal. Pp-557. ISBN: 978-93-5659-453-1, September 17-19.

Urvashi, Chauha N and Reddy SGE (2022) Chemical composition, insecticidal, persistence and detoxification enzyme inhibition activities of essential oil of Artemisia maritima against pulse beetle. pp.87-88. National Conference on Role of Science and Technology in Environmental Conservation and sustainable Development. Organized by Himachal Pradesh University, Shimla, September 23-24.

Bishnoi J, Kumar P, Kumar A, Singh S, Gehlot A and Kumar A (2022) Protocol Standardization for Flow-Cytometry study in *Heeng* (*Ferula assa-foetida*). International Conference on Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security (AAVASILES-2022) organized at University of Kashmir, pp-414, September 28-30.

Kumar P, Kumar A, Gautum R D, Kumar R, Singh S and Kumar A (2022) Diversity assessment of palmarosa (*Cymopogon martini)* for essential oil concentration. International Conference on Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security (AAVASILES-2022) organized at University of Kashmir, pp-416, September 28-30.

Patial M, Suryavanshi V, Dar AI, Devi K, Pal PK and Joshi R (2022) Investigation of effect of gold nanoparticles on the morpho-physiological and photosynthesis related traits of *Siraitia grosvenorii* under *in vitro* conditions. International conference on "Physiological and Molecular Mechanisms for Abiotic Stress Tolerance in Plants", Department of Botany, University of Calicut, Kerala. October 26-28.

Chaudhari AA, Kumar P, Patial D, Rani N, Chauhan R, Singh S, Singh S and Kumar A (2022) Exploring genetic diversity of *Artimisia maritima* germplasm for essential oil content and its contributing traits. 1st National conference on plant genetic resource and management (NCPGRM-2022) organized by Indian Society of Plant Genetic Resources (ISPGR) at National Agricultural Science Centre, Pusa campus, New Delhi, pp-160-161, November 22-24.

Kumar A, Singh S, Singh S, Chauhan R, Sharma RK and Kumar S (2022) Introduction and morphological characterization of *Heeng* (*Ferula assa-foetida*) accessions in cold deserts of Indian Himalayas. 1st National conference on plant genetic resource and management (NCPGRM-2022) organized by Indian Society of Plant Genetic Resources (ISPGR) at National Agricultural Science Centre, Pusa campus, New Delhi, pp-85-86, November 22-24

Yadav N, Kumar R, Kumar A, Chauhan R, Singh S, Sharma S, Dalal N, Kumar P and Singh S (2022) Effect of different soil media mixtures on seedling survival and growth of *Ferula assa-foetida* accessions introduced in India. 1st National conference on plant genetic resource and management (NCPGRM-2022) organized by Indian Society of Plant Genetic Resources (ISPGR) at National Agricultural Science Centre, Pusa campus, New Delhi, pp-167-168, November 22-24.

Kumar R, Kumar P, Yadav S, Joshi R, Kumar D, Singh S, Chauhan R, Singh S and Kumar A (2022) Effect of plant growth regulators in overcoming the *Heeng* (*Ferula assa-foetida*) seed dormancy and improvement in seed germination. 14th International conference on agriculture, horticulture and food sciences organized by The society of tropical Agriculture, New Delhi India, December 17-18.

Tirpude N (2022) Invited lecture 'Nutraceuticals for respiratory health.' for Hands-on training program on development of nutraceutical based formulations and their characterization Karyashala at CSIR – IHBT, Palampur. November 25.

Verma M and Acharya A (2022) "Fabrication of biomolecule conjugated biogenic silica nanoparticle and its biological efficacy evaluation" BIO-Remedi 2022 (International conference on Biomaterials, Regenerative Medicine and Devices) organised by Society for Tissue Engineering and Regenerative Medicine India (STERMI) in association with The Society for Biomaterials & Artificial Organs India (SBAOI) at IIT Guwahati. December 15-18.

Randhawa S and Acharya A (2022) "Development of Engineered Gold Nanoparticles for Selective Targeting of Aggregation Prone Peptide Sequences to Combat Neurodegenerative Diseases" Bio-Remedi 2022, International Conference on Biomaterials, Regenerative Medicine and Devices, organised by Society for Tissue Engineering and Regenerative Medicine India (STERMI) in association with The Society for Biomaterials & Artificial Organs India (SBAOI) at IIT Guwahati, India. December 15-18.

Chauhan R, Singh S, Kumar A and Singh S (2022) Introducing true cinnamon (*Cinnamomum verum*) in non-traditional areas of Himachal Pradesh. 1st National Conference on Plant Genetic Resources Management. Indian Society of Plant Genetic Resources, New Delhi. p. 89.

Kumar A, Singh S, Singh S, Chauhan R, Sharma RK and Kumar S (2022) Introduction and morphological characterization of Heeng (*Ferula assa-foetida*) accessionsin cold deserts of Indian Himalayas. 1st National Confrence on Plant Genetic Resources Management. New Delhi: Indian Society of Plant Genetic Resources, New Delhi. p. 85–86.

Yadav N, Kumar R, Kumar A, Chauhan R, Singh S, Sharma S, Dalal N, Kumar P and Singh S (2022) Effect of different soil media mixtures on seedling survival and growth of *Ferula assaz foetida* accessions introduced in India. 1st National Confrence on Plant Genetic Resources Management. New Delhi: Indian Society of Plant Genetic Resources, New Delhi. p. 167–168.

Chaudhari AA, Kumar P, Patial D, Rani N, Chauhan R, Singh S, Singh S and Kumar A (2022) Exploring genetic diversity of *Artemisia maritima* germplasm for essential oil content and its contributing traits. 1st National Confrence on Plant Genetic Resources Management. New Delhi: Indian Society of Plant Genetic Resources, New Delhi. p. 160–162.

Kumar R, Chauhan R, Singh S, Kumar D, Singh S and Kumar A (2023) Variation in essential oil composition among the different accession of *Ferula assa-foetida* L. International conference on food and nutritional security (iFANS-2023) organized by National Agri-Food Biotechnology Institute (NABI) and Centre of Innovative and Applied Bioprocessing (CIAB), Mohali, January 6-9, Pp-240.

Kumar D (2023) Delivered a lecture during 28 days training and skill internship on "Application of medicinal plants in aquaculture industry for growth and control of fish diseases., organized by Department of fisheries, Dr GC Negi College of Veterinary and animal sciences, CSKHPKV, Palampur. January 04-31.

Chaudhary A, Thakur R, Kumari A and Singh K (2023) Differentially expressed transcription factor regulate the transition from dormant to flowering stage in *Crocus sativus* L, presented by Anjali Chaudhary at International symposium on Biology of Development and Disease combined with 45th All India Cell Biology Conference-2023' at Banaras Hindu University, Varanasi. January 20-22.

Kumari A, Dar AI and Joshi R (2023) Transcriptome analysis reveals the synergistic effect of gold nanoparticles with plant growth regulators on *in vitro* proliferation of bamboo species. International conference on food and nutritional security and 5th International Plant Physiology Congress and 44th Annual Meeting of Plant Tissue Culture Association–India (PTCA-I), NABI, Mohali, India January 6-9. p. 244.

Patial M, Joshi R, Devi K, Kumar A, Singh S and Kumar S (2023) Establishment of an *in vitro* protocol for indirect shoot regeneration and plantlet generation in *Ferula assafoetida* (Hing). International conference on food and nutritional security and 5th International Plant Physiology Congress and 44th Annual Meeting of Plant Tissue Culture Association–India (PTCA-I), NABI, Mohali. January 6-9. p. 249.

Joshi S, Dar AI and Joshi R (2023) Next generation sequencing (NGS) provide insight into the role of gold nanoparticles in eliciting *in vitro* micropropagation of *Nardostachys jatamansi*. International conference on food and nutritional security and 5th International Plant Physiology Congress and 44th Annual Meeting of Plant Tissue Culture Association–India (PTCA-I), NABI, Mohali. January 6-9. p. 243.

Anwar K, Joshi R, Bahuguna RN, Govindjee G, Singla-Pareek SL and Pareek A (2023) Comprehending the individual, combined and sequential abiotic stresses in rice under natural conditions. International conference on food and nutritional security and 5th International Plant Physiology Congress and 44th Annual Meeting of Plant Tissue Culture Association–India (PTCA-I), NABI, Mohali. January 6-9. p. 10.

Mishra M, Rathore RS, Joshi R, Pareek A and Singla-Pareek SL (2023) Overexpression of *DTH8* induces early flowering, boosts yield and improves stress recovery in rice. International conference on food and nutritional security and 5th International Plant Physiology Congress and 44th Annual Meeting of Plant Tissue Culture Association–India (PTCA-I), NABI, Mohali. January 6-9. p. 97.

Anwar K, Joshi R, Bahuguna R, Singla-Pareek SL and Pareek A (2022) The multi-scale interplay of morphological and physiological traits shapes phenotypic diversity among rice genotypes to improve the rice yield. Newton Bhabha Fund Researcher Link Workshop on "Sustainable food production under environmental stress", NABI, Mohali. January 18-21.

Bishnoi J, Kumar P, Singh S, Gehlot A, and Kumar A (2023) Genome size estimation of *Ferula assa-foetida* (*Heeng*) through flow-cytometry analysis. International Conference on Climate Resilient Agriculture for Food Security and Sustainability organized by CCS Haryana Agricultural University, Hisar pp-158, ISBN: 978-93-5786-023-9, February 17-19.

Yadav N, Bishnoi J and Kumar A (2023) Effect of plant growth regulator on survival and growth after root distressing in different accessions of *Ferula assa-foetida*. International Conference on Climate Resilient Agriculture for Food Security and Sustainability organized by CCS Haryana Agricultural University, Hisar pp-319, ISBN: 978-93-5786-023-9, February 17-19.

Kumar A, Singh S, Singh S, Chauhan R and Kumar S (2023) Introduction and cultivation of *Heeng* (*Ferula assa-foetida*) in cold desert of Indian Himalayan- A new approach. International Conference on Climate Resilient Agriculture for Food Security and Sustainability organized by CCS Haryana Agricultural University, Hisar pp-836, ISBN: 978-93-5786-023-9, February 17-19.

Mishra A, Yadav P and Singh K (2023) Transcriptome-wide identification of miRNA(s) under stress conditions in *Crocus sativus* L. presented as poster at International Conference on "Current Trends and Future Prospects of Plant Biology", School of Life Sciences, University of Hyderabad, Hyderabad. February 23-25.

Yadav P, Yadav K, Mishra A, Neha and Singh K (2023) Exploring the potential of endophytic fungi isolated from *in-vitro* grown saffron corms presented as poster at International Conference on "Current Trends and Future Prospects of Plant Biology" School of Life Sciences, University of Hyderabad, Hyderabad. February 23-25.

Dhiman D, Vishvamitera S, Singh S and Chauhan R (2023) Attaining higher yield of *Salvia sclarea* with application of mulch and nitrogen levels in Western Himalayan region. International conference on climate resilient agriculture for food security and sustainability. Chaudhary Charan Singh Haryana Agricultural University, Hisar. p. 298.

Vishvamitera S, Dhiman D, Singh S and Chauhan R (2023) Comparative assessment of NPK levels for sustainable cultivation of *Saussurea costus* in cold desert region of North-Western Himalayas. International conference on climate resilient agriculture for food security and sustainability. Chaudhary Charan Singh Haryana Agricultural University, Hisar. p. 298–299.

Sharan H, Chauhan R and Singh S (2023) Molecular characterization of climate resilient selections of Lavender (*Lavandula angustifolia*). International conference on climate resilient agriculture for food security and sustainability. Chaudhary Charan Singh Haryana Agricultural University, Hisar. p. 65.

CONFERENCES/TRAINING/WORKSHOP/MEETING/WEBINAR ATTENDED

Patial V (2022) IP Awareness/Training program under: National Intellectual Property Awareness Mission" organized by Intellectual Property Office, India. April 22.

Joshi R (2022) Attended 43rd Annual Meeting of Plant Tissue Culture Association–India (PTCA-I) & International Symposium On "Advances in Plant Biotechnology and Nutritional Security- APBNS-2022". April 28-30.

Goel K, Kundu P and Zinta G (2022) Investigating heat sensitivity of underutilized C4 grain Amaranth (*A. hypochondriacus*). Conference Abstract (Student Oral Presentation) 43rd Annual Meeting of Plant Tissue Culture Association – India (PTCA-I) & International Symposium on "Advances in Plant Biotechnology and Nutritional Security (APBNS-2022). April 28-30.

Choudhary D, Gehlot A, Sarkar S, Dhrek MS, Kumar D and Bhushan S (2022) *In vitro* adventitious roots of *Valeriana jatamansi*: A sustainable source of Valerianic acid derivatives. In 43rd Annual meeting of PTCA (1& International Symposium on "Advances in Plant Biotechnology and Nutritional security" APBNS) (Online). April 28-30.

Das P (2022) A invited lecture "Lignocellulosic bio-mass conversion to furan compounds and their applications for high valued chemicals synthesis" delivered in Chemical Sciences Symposium (23-24 May,2022)" organized by Indian Institute of Technology, Mandi. May 24.

Das P (2022) A invited Keynote Speaker for the One Day National Webinar on "Recent Advances in Chemistry" held at Department of Chemistry, Govt Postgraduate College, Ambala Cantt. May 26.

Das P (2022) A invited Speaker for the International Webinar series on "Reimagine Enthopharmacology" held at Institute of Bioresources & Sustainable Development (IBSD), Imphal. May 28.

Agnihotri VK (2022) International Congress & Expo 2022 – Exploring Excellence in Essential Oils" organized by Essential Oil Associations of India (EOAI) Indore. May 26-28.

Patial V (2022) 10th International conference of LASA India: Animal models for one health programme: challenges and future perspectives, jointly organized by NIAB, Hyderabad and ICMR-NARFBR, Hyderabad in association with LASA, India at NAARM, Hyderabad. June 03-04.

Joshi R (2022) Attended Bioingene International webinar on "Translational genomics in soybean: How genomic information can be made relevant to breeders" by Prof Francois Belzile, Plant Science Department, University of Laval, Quebec, Canada. June 27.

Das P (2022) A invited Bronze Medal Lecture in the 29th CRSI National Symposium in Chemistry & CRSI-ACS Symposium Series in Chemistry (7-9th July, 2022) held at IISER, Mohali. July 07.

Joshi R (2022) Attended webinar on "Impact of climate change factor on crops and role of climate smart practices to enhance productivity, nutrition and resilience" by Prof. P.V. Vara Prasad, Kansas State University at NABI, Mohali. July 18.

Joshi R (2022) Attended webinar on "Tissue culture of tree/woody plants (Bamboo and Teak): Significance, best practices and way forward", organized by APAARI, BCIL & APCoAB for popularizing Plant Tissue Culture in Asia Pacific Region and African Countries towards realizing its potential. July 29.

Joshi R (2022) Attended Webinar on "Tissue Culture of Ornamental Plants: Significance, Best Practices and Way Forward" organized by Biotech Consortium India Limited, Anuvrat Bhawan, New Delhi. August 26.

Bishnoi J, Kumar P, Kumar A, Singh S, Gehlot A, and Kumar A (2022) Protocol Standardization for Flow-Cytometry study in *Heeng* (*Ferula assa-foetida*). 6th Student seminar series, organized at CSIR-IHBT, Palampur, pp-62, September 05.

Kapoor K (2022) Participated in oral presentation in National conference "Recent Trends in Plant Biology" (RTPB) held at SKICC, Srinagar, J&K. September 5-7.

Joshi R (2022) Participated in National symposium on "Emerging Innovations in Plant Molecules for Achieving Food and Nutritional Security", organized by Department of Plant Molecular Biology and Division of Biochemistry, ICAR and Society for Plant Biochemistry and Biotechnology, IARI, Pusa Campus, New Delhi ACHF, NAU, Navsari. September 22-23.

Joshi R (2022) Attended online "ConSept22: Harnessing Plant Physiology to improve productivity and nutritional value of crops", KSK-MUK Memorial Lecture by Prof. Paul Struik, Center for Crop System Analysis, WUR, Netherlands, at GKVK, Bangalore. September 24.

Kumar S (2022) Participated in poster presentation in National conference "Recent Trends in Plant Biology" (RTPB) held at SKICC, Srinagar, J&K. September 5-7.

Joshi R (2022) Attended Plant Physiology Focus Issue Webinar: Evolution of Plant Structure and Function. September 16.

Kumar A, Singh S, Singh S, Chauhan R and Kumar S (2022) Introduction of *Heeng* (*Ferula assa-foetida*) plant to cold deserts of Indian Himalayas. 4th International Conference on Global Efforts on Agriculture, Forestry, Environment and Food Security (Theme: Climate Change and Its Impact) (GAFEF-2022), organized at Pokhra, Nepal. Pp-290. ISBN: 978-93-5659-453-1, September 17-19.

Kumar P, Kumar A, Gautum R D, Kumar R, Singh S and Kumar A (2022) Morphological characterization of palmarosa (*Cymopogon martini*) for essential oil content. 4th International Conference on Global Efforts on Agriculture, Forestry, Environment and Food Security (Theme: Climate Change and Its Impact) (GAFEF-2022), organized at Pokhra, Nepal. Pp-266. ISBN: 978-93-5659-453-1, September 17-19.

Bishnoi J, Kumar P, Kumar A, Singh S, Gehlot A, and Kumar A (2022) Flow-cytometry protocol standardization for genome size estimation in *Heeng* (*Ferula assa-foetida*). 4th International Conference on Global Efforts on Agriculture, Forestry, Environment and Food Security (Theme: Climate Change and Its Impact) (GAFEF-2022), organized at Pokhra, Nepal. Pp-557. ISBN: 978-93-5659-453-1, September 17-19.

Joshi R (2022) Attended Bioingene International Live interactive webinar on "Climate resilient rice using biodiverse resources", by Dr Zeba Seraj, Bangladesh. September 27.

Bishnoi J, Kumar P, Kumar A, Singh S, Gehlot A, and Kumar A (2022) Protocol Standardization for Flow-Cytometry study in *Heeng* (*Ferula assa-foetida*). International Conference on Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security (AAVASILES-2022), organized at University of Kashmir, pp-414, September 28-30.

Kumar P, Kumar A, Gautum R D, Kumar R, Singh S and Kumar A (2022) Diversity assessment of palmarosa (*Cymopogon martini)* for essential oil concentration. International Conference on Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security (AAVASILES-2022), organized by University of Kashmir, pp-416, September 28-30.

Tamang A (2022) Participated in workshop on Deep-dive on 16S-based metagenomics and functional profiling, conducted by T-CAG life sciences in collaboration with research boulevard technologies (Ghaziabad). September 27- 1 October.

Joshi R (2022) Attended Bioingene Webinar by Prof Jonathan Lynch, Penn State College of Agricultural Sciences, USA on "Roots to the second green revolution". October 11.

Joshi R (2022) Attended virtual roundtable session on "International Partnership for food and nutritional security in the developing world", organized by Food Futures Institute, Murdoch University, Australia. This session was a part of the 2022 Norman E. Borlaug International Dialogue- Feeding a Fragile World, World Food Prize Foundation, USA. October 20.

Patial M (2022) Participated in Workshop on "Physiological and Molecular Markers for Abiotic Stress Tolerance in Plants", organized by Department of Botany, University of Calicut, Kerala & South Zone-Indian Society for Plant Physiology (ISPP). October 31-November 04.

Singh S, Bhatt P and Bhandari P (2022) Natural colors as clean labelled ingredients for global food industry. National conference on frontiers in chemical sciences at central University, Dharmshala organized by Indian Society of Analytical Scientists and Central University of Himachal Pradesh. November 04-05.

Kumar R (2022) Agro-technonogical interventions in North East India for livelihood generation and enhancement of farmers' income. Paper presented in National Conference on Northeast sustainable and inclusive development at Kaziranga University, Jorhart, Assam, November 16-18.

Kumar A (2022) International workshop on leveraging innovations for infrastructure development and sustainable industrialisation organised by Centre for science and technology of the non-aligned and other developing countries (NAM S&T Centre), Zimbabwe. November 17-18. (attended in virtual mode)

Sendri N, Swati, Katoch S, Patial V and Bhandari P (2022) Anthocyanins from *Rhododendron arboretum*: stabilization using red cabbage waste derived biopolymer and their hepatoprotective effects. 6th world congress on drug discovery and development organized by Arjyopa healthcare at Bangalore. November19-20.

Joshi S and Kumari A (2022) Successfully completed workshop entitled "RNASEQ data analysis" with T-CAG Lifesciences Pvt. Ltd., Ghaziabad. November 21-24.

Chaudhari AA, Kumar P, Patial D, Rani N, Chauhan R, Singh S, Singh S and Kumar A (2022) Exploring genetic diversity of *Artimisia maritima* germplasm for essential oil content and its contributing traits. 1st National conference on plant genetic resource and management (NCPGRM-2022), organized by Indian Society of Plant Genetic Resources (ISPGR) at National Agricultural Science Centre, Pusa campus, New Delhi, pp-160-161, November 22-24.

Kumar A, Singh S, Singh S, Chauhan R, Sharma RK and Kumar S (2022) Introduction and morphological characterization of *Heeng* (*Ferula assa-foetida*) accessions in cold deserts of Indian Himalayas. 1st National conference on plant genetic resource and management (NCPGRM-2022), organized by Indian Society of Plant Genetic Resources (ISPGR) at National Agricultural Science Centre, Pusa campus, New Delhi, pp-85-86, November 22-24.

Yadav N, Kumar R, Kumar A, Chauhan R, Singh S, Sharma S, Dalal N, Kumar P and Singh S (2022) Effect of different soil media mixtures on seedling survival and growth of *Ferula assa-foetida* accessions introduced in India. 1st National conference on plant genetic resource and management (NCPGRM-2022), organized by Indian Society of Plant Genetic Resources (ISPGR) at National Agricultural Science Centre, Pusa campus, New Delhi, pp-167-168, November 22-24.

S Singh (2022) 1st National Conference on Plant Genetic Resources Management organized by Indian Society of Plant Genetic Resources at NASC complex, New Delhi. November 22-24.

Patial V (2022) Interactive meet with Veterinarians: 133rd foundation day of ICAR-IVRI organized by ICAR-IVRI regional station, Palampur. December 09.

Kumar R, Kumar P, Yadav S, Joshi R, Kumar D, Singh S, Chauhan R, Singh SS and Kumar A (2022) Effect of plant growth regulators in overcoming the *Heeng* (*Ferula assa-foetida*) seed dormancy and improvement in seed germination. 14th International conference on agriculture, horticulture and food sciences, organized by The society of tropical Agriculture, New Delhi India, December 17-18.

Singh A (2023) 'Ex-situ conservation and development of gene bank of commercially important threatened medicinal plants in the high altitude areas, Himachal Pradesh' In 6th Monitoring & Evaluation Workshop-2023" at Wildlife Institute of India, Dehradun, Uttarakhand. January 06-07.

Goel K, Kundu P, Kaachra A, Singh S and Zinta G (2023) Physiological, transcriptional and metabolic analysis delineates the effect of heat stress on *Chenopodium quinoa*" in International Conference on Food and Nutritional Security & 5th International Plant Physiology Congress & 44th Annual Meeting of Plant Tissue Culture Association (India) at NABI-CIAB, Mohali. January 06-09.

Kundu P, Goel K, Kumar A, Chandora R, Singh S and Zinta G (2023) "Investigations on the role of triterpenoids saponins in Plant development and abiotic stress responses in *Chenopodium quinoa*" in International Conference on Food and Nutritional Security & 5th International Plant Physiology Congress & 44th Annual Meeting of Plant Tissue Culture Association (India) at NABI-CIAB, Mohali. January 6-9.

Kumar R, Chauhan R, Singh S, Kumar D, Singh S and Kumar A (2023) Variation in essential oil composition among the different accession of *Ferula assa-foetida* L, along with 5th International Plant Physiology congress and 44th annual meeting on Plant Tissue Culture Association organized by National Agri-Food Biotechnology Institute (NABI) and Centre of Innovative and Applied Bioprocessing (CIAB), Mohali, pp-240, January 06-09.

Zinta G, Goel K, Kundu P, Kaachra A and Singh S (2023) "Disentangling the effects of daytime and night-time heating on *Chenopodium quinoa*" in International Conference on Food and Nutritional Security & 5th International Plant Physiology Congress & 44th Annual Meeting of Plant Tissue Culture Association (India) at NABI-CIAB, Mohali. January 6-9.

Dutta M, Raturi V, Goel K, Kumar R, Kundu P, Mali S, Sharma P, Swarankar M, Gupta VK, Sood S, Acharya V and Zinta G (2023) "Multi-omics analyses shed light on thermotolerance mechanism in potato (*Solanum tuberosum*)" in International Conference on Food and Nutritional Security & 5th International Plant Physiology Congress & 44th Annual Meeting of Plant Tissue Culture Association (India) at NABI-CIAB, Mohali, January 6-9.

Raturi V, Dutta M, Kumar R, Jadhav R, Swarnkar M, Acharya V and Zinta G (2023) "Transcriptional dynamics during heat stress and recovery in *Arabidopsis thaliana*" in International Conference on Food and Nutritional Security & 5th International Plant Physiology Congress & 44th Annual Meeting of Plant Tissue Culture Association (India) at NABI-CIAB, Mohali. January 6-9.

Mali S, Dutta M. Goel K, Kumar R, Acharya V, Gupta VK, Sood S and Zinta G (2023) "Genome-wide identification and expression profiling of JmjC domain-containing histone demethylase gene family in potato (*Solanum tuberosum* L.)" in International Conference on Food and Nutritional Security & 5th International Plant Physiology Congress & 44th Annual Meeting of Plant Tissue. January 6-9.

Joshi R (2022) Participated in International conference on food and nutritional security and 5th International Plant Physiology Congress and 44th Annual Meeting of Plant Tissue Culture Association–India (PTCA-I), at NABI. January 6-9.

Bishnoi J, Kumar P, Singh S, Gehlot A and Kumar A (2023) Genome size estimation of *Ferula assa-foetida* (*Heeng*) through flow-cytometry analysis, International Conference on Climate Resilient Agriculture for Food Security and Sustainability, organized by CCS Haryana Agricultural University, Hisar pp-158, ISBN: 978-93-5786-023-9, February 17-19.

Yadav N, Bishnoi J and Kumar A (2023) Effect of plant growth regulator on survival and growth after root distressing in different accessions of *Ferula assa-foetida*. International Conference on Climate Resilient Agriculture for Food Security and Sustainability, organized by CCS Haryana Agricultural University, Hisar pp-319, ISBN: 978-93-5786-023-9, February 17-19.

Kumar A, Singh S, Singh S, Chauhan R and Kumar S (2023) Introduction and cultivation of *Heeng* (*Ferula assa-foetida*) in cold desert of Indian Himalayan- A new approach. International Conference on Climate Resilient Agriculture for Food Security and Sustainability, organized by CCS Haryana Agricultural University, Hisar pp-836, ISBN: 978-93-5786-023-9, February 17-19.

Kumar R and Thakur P (2023) Reimagine Ethnopharmacology - Globalization of Traditional Medicine, organized by the Institute of Bioresources and Sustainable Development (IBSD), and the Society for Ethnopharmacology, City Convention Centre, Imphal, Manipur, February 24-26.

Sharan H, Chauhan R and Singh S (2023) Molecular characterization of climate resilient selections of Lavender (*Lavandula angustifolia*). International conference on climate resilient agriculture for food security and sustainability. Chaudhary Charan Singh Haryana Agricultural University, Hisar. pp. 65.

Dhiman D, Vishvamitera S, Singh S and Chauhan R (2023) Attaining higher yield of *Salvia sclarea* with application of mulch and nitrogen levels in Western Himalayan region. International conference on climate resilient agriculture for food security and sustainability. Chaudhary Charan Singh Haryana Agricultural University Hisar. pp. 298.

Vishvamitera S, Dhiman D, Singh S and Chauhan R (2023) Comparative assessment of NPK levels for sustainable cultivation of *Saussurea costus* in cold desert region of North-Western Himalayas. International conference on climate resilient agriculture for food security and sustainability. Chaudhary Charan Singh Haryana Agricultural University Hisar. pp. 298–299.

Chauhan R, Singh S, Kumar A and Singh S (2022) Introducing true cinnamon (*Cinnamomum verum*) in non-traditional areas of Himachal Pradesh. 1st National Confrence on Plant Genetic Resources Management. Indian Society of Plant Genetic Resources, New Delhi. pp. 89.

Kumar A, Singh S, Singh S, Chauhan R, Sharma R K and Kumar S (2022) Introduction and morphological characterization of Heeng (*Ferula assa-foetida*) accessionsin cold deserts of Indian Himalayas. 1st National Confrence on Plant Genetic Resources Management. Indian Society of Plant Genetic Resources New Delhi. pp. 85–86.

Yadav N, Kumar R, Kumar A, Chauhan R, Singh S, Sharma S, Dalal N, Kumar P and Singh S (2022) Effect of different soil media mixtures on seedling survival and growth of *Ferula assa-foetida* accessions introduced in India. 1st National Confrence on Plant Genetic Resources Management. Indian Society of Plant Genetic Resources New Delhi. pp. 167–168.

Chaudhari AA, Kumar P, Patial D, Rani N, Chauhan R, Singh S, Singh S and Kumar A (2022) Exploring genetic diversity of *Artemisia maritima* germplasm for essential oil content and its contributing traits. 1st National Confrence on Plant Genetic Resources Management. Indian Society of Plant Genetic Resources New Delhi. pp. 160–162.

CONFERENCES/TRAINING/WORKSHOP/ MEETING ORGANIZED

Devi S (2022) organized Intellectual Property Awareness program under National Intellectual Property Awareness Mission on with Intellectual Property Office, India. April 22.

Sharma M (2022) One-day training cum demonstration imparted of processing of essential oil distillation was given to 46 officers of Horticulture Department of H.P. May 10.

Kumar R (2022) Two days' workshop for the officers of Horticulture Department, Govt. of HP on Cultivation processing marketing of aromatic and floriculture crops at CSIR-IHBT Palampur, May 9-10.

Sharma M (2022) Organised three days training cum demonstration of extraction of colouring compounds from *Arnebia* spp. had been given to company representatives of M/s Nanotech Chemical Brothers, Chandigarh. May 25-27.

Kumar R (2022) Organized oneday workshop on "Smart Farming" In association with Agro Industry, Govt. of HP at Dharamshala, Distt. Kangra, HP, July 13.

Kumar R (2022) Organized oneday workshop on "Smart Farming" In association with Agro Industry, Govt. of HP at Vill. Dhwali, Dharampur, Distt. Mandi, HP, July 23.

Kumar R (2022) Organized "Capacity Building of Agriculture Officers, Department of Agriculture, HP on Production Technology of Saffron and Heeng at CSIR-IHBT Palampur, September 6-10.

Kumar A (2022) Organized a training on 3rd Capacity building program on *Heeng* cultivation at CSIR-IHBT, Palampur, September 6-10.

Kumar R (2022) Organized interaction meet of Aroma farmers and Research Council team members of CSIR-IHBT at Village Talla of aspirational district Chamba, December 18.

Soni V and Bhavya B (2022) Organized a training program on "cultivation of flower crops" at Leh, Ladakh (UT), April 19-20.

Singh S (2022) Organized a training program on Agro-Ecological Practices of Farming and Successful Income Generation Model for HPSRLM-Mandi (H.P.), September 21-22.

Singh S (2022) Organized a training program on Agro-Ecological Practices of Farming and Successful Income Generation Model for HPSRLM-Shimla (H.P.), November 1-2.

Singh S (2022) Organized a training program on Crop Diversification (Medicinal, aromatic, floriculture, spice crops etc.) Priyadarshini Indira Mahila Block Society, Janipur, Reasi, Jammu & Kashmir. December 12-13.

Singh S (2023) Organized a training program on Agro-Ecological Practices of Farming and Successful Income Generation Model for HPSRLM-Hamirpur (H.P.), January 23-24.

Singh S (2023) Organized a training program on Agro-Ecological Practices of Farming and Successful Income Generation Model for HPSRLM-Una (H.P.), January 30-31.

Singh S (2023) Organized a training program on Agro-Ecological Practices of Farming and Successful Income Generation Model for HPSRLM-Bilaspur (H.P.), February 06-07.

Singh S (2023) Organized a training program on Agro-Ecological Practices of Farming and Successful Income Generation Model for HPSRLM-Chamba (H.P.), February 09-10.

Singh S (2023) Organized a training program on Cultivation and Post-Harvest Management of Aromatic plants for the farmers associated with HP Horticulture Department Distt. Mandi, February 19-23.

Singh S (2023) Organized a training program on Agro-Ecological Practices of Farming and Successful Income Generation Model for HPSRLM-Kangra (H.P.), February 20-21.

Singh S (2023) Organized a training program on Agro-Ecological Practices of Farming and Successful Income Generation Model for HPSRLM-Shimla (H.P.), February 23-24.

Singh S (2023) Organized a training program on Agro-Ecological Practices of Farming and Successful Income Generation Model for HPSRLM-Solan and Kullu (H.P.), March 2-3.

Singh S (2023) Organized a training program on Agro-Ecological Practices of Farming and Successful Income Generation Model for HPSRLM-Kinnaur (H.P.), March13-14.

Singh S (2023) Organized a training program on Cultivation and Post-Harvest Management of Aromatic plants for the farmers associated with HP Horticulture Department Distt. Kangra. March 13-17.

Singh S (2023) Organized a training program on Agro-Ecological Practices of Farming and Successful Income Generation Model for HPSRLM-Lahaul & Spiti (H.P.), March 6-17.

Singh S (2023) Organized a training program on Cultivation and Post-Harvest Management of Aromatic plants for the farmers associated with HP Agriculture Department, Panchrukhi, Distt. Kangra. March 21.

Gupta M (2022) Organize one day workshop on POSHAN MAITREE–A programme for way forward in combating protein and micronutrient malnutrition at CSIR-IHBT, Palampur. April 25.

Agnihotri VK (2022) Worked as a Rapporteurs in International Congress & Expo 2022 "Exploring Excellence in Essential Oils" 2022, organized by "Essential Oil Association of India". May 26-28.

Chawla A (2022) An i-Connect event (iCEN 58) entitled "Climate change and its impact on various sectors and ecosystems" was organised in association with Indian Institute of Tropical Meteorology, Pune, in online mode. In this event eminent persons from Industry, Academia and Research Institutes took part and deliberated on the issues concerning climate change impacts on various sectors and the steps required to be taken for its mitigation. July 22.

Gupta M (2022) Organize three days workshop cum training programme on Food Processing & Value Addition of Agri-horti produces for the 22 entrepreneurs from UT of Ladakh at CSIR-IHBT, Palampur. August 25-27.

Dogra V (2022) Organized 6th Student's Seminar Series 2022 at CSIR-IHBT. September 05.

Sharma M (2022) Organised training on processing of aromatic crops and value added products was imparted to thirty women participants of Distt. Sirmaur (H.P.) during an exposure visit of Farm Livelihood Community Resource Persons (Krishi and Pashu Sakhi) and Mahila Kisan under Deendayal Antyodaya Yojana - National Rural Livelihoods Mission (DAY-NRLM). September 14-15.

Singh A and State Horticulture Department Keylong (2022) Organized one-day farmers training cum exposure visit program on "लाहौल एवं स्पीति जिले मे मौजूद दुर्लभ औषधीय पादपों व अन्य उपयोगी वनस्पतियों से संबंधित जागरूकता, कृषिकरण कर कवालियों की आर्थिकी सुधारने का एक प्रयास" at CeHAB. September 16.

Singh A, Chawla A et al. (2022) organized a one-day meeting program entitled "Heeng, Kesar, Pushp Ropan Smagri va Compost Booster Vitran Karyakram" venue at Centre for High Altitude Biology Ribling, Lahaul & Spiti (HP) of CSIR-IHBT (Chief Guests of the function were Honorable Minister of Technical Education Himachal Pradesh Dr. Ram Lal Markanda, and Dr. Sanjay Kumar Director CSIR-IHBT Palampur). September 19.

Sharma M (2022) Organised training on processing of aromatic crops was imparted during an exposure visit of Farm Livelihood Community Resource Persons (Krishi and Pashu Sakhi) and Mahila Kisan under Deendayal Antyodaya Yojana - National Rural Livelihoods Mission (DAY-NRLM. September 21-22.

Sharma M (2022) Organised one-day training cum demonstration on processing of *Tagetes minuta* for essential oil was given to 15 farmers of Dodra Kwar, Shimla on 1200 kg/ batch capacity improved distillation unit established by CSIR-IHBT under Mission aroma phase-II. October 18.

Sharma M (2022) Organised one-day training cum demonstration of *Tagetes minuta* essential oil distillation was given to 80 farmers Khari Bahi (Dharamshala) by running Mobile Essential Oil Distillation Unit. October 27.

Sharma M (2022) Organised training on processing of aromatic crops was imparted during a training-cum-exposure visit of Himachal Pradesh State Rural Livelihood Mission Staff on "Agro-ecological Practices of Farming and Successful Income Generation Model". November 01-02.

Saneja A (2022) Organized Hands on Training Program on Development of Nutraceutical Based Formulations and Their Characterization funded by SERB. November 22-28.

Agnihotri VK (2022) Organized and co-ordinated a training program entitled "Quality Control, Standardization and Botanical Studies of Electrohomeopathic Drugs". Thirteen Electrohomeopathic doctors participated in this program. December 21-22.

Sharma M (2022) Organised training on processing of aromatic crops and value added products was imparted to twenty-five farmers of Distt. Reasi, Jammu & Kashmir during a training-cum-exposure visit program on "Crop diversification (medicinal, aromatic, floriculture, spice crops etc.)". December 12-13.

Sharma M (2022) Organised one-day training cum demonstration on processing of *Tagetes minuta* was given to 30 farmers of Ghumarwin (Bilaspur). on 1200 kg/ batch capacity distillation unit established by CSIR- IHBT under Mission Aroma. December 14.

Sharma M (2023) Organised training on processing of aromatic crops was imparted during a training-cum-exposure visit of Farm Livelihood Community Resource Persons (Krishi and Pashu Sakhi) and Mahila Kisan under Deendayal Antyodaya Yojana - National Rural Livelihoods Mission (DAY-NRLM). January 23-24.

Sharma M (2023) Organised training on processing of aromatic crops was imparted to around thirty (30) women participants of Distt. Una, Bilaspur, Chamba and Kangra in Four (04) batches during training-cum-Exposure Visit Programs (2 days each) of Farm Livelihood Community Resource Persons and Mahila Kisan under Deendayal Antyodaya Yojana - National Rural Livelihoods Mission (DAY-NRLM) conducted at CSIR-IHBT. January 30-31, February 06-07, 09-10, 20-21.

Soni V and Bhargava B (2023) Organized a training program on "cultivation of flower crops" at IHBT Palampur. January 30-February 02.

Sharma M (2023) Organised training on processing of aromatic crops was imparted to around fifty farmers of Distt. Mandi (H.P.) during a training program under MEHAK scheme being organized at CSIR-IHBT, Palampur on "Cultivation and Post-Harvest Management of Aromatic plants". February 19-23.

Sharma M (2023) Organised training on processing of aromatic crops was imparted to around thirty (30) women participants of Distt. Shimla during a two days Training-cum-Exposure Visit Programs for Farm Livelihood Community Resource Persons and Mahila Kisan under Deendayal Antyodaya Yojana- National Rural Livelihoods Mission (DAY-NRLM) organized at CSIR-IHBT. February 23-24.

Sharma M (2023) Organised training on processing of aromatic crops was imparted to around Thirty (30) women participants per batch (total four batches) from Distt. Kullu, Solan, Kinnaur and Lahaul & Spiti during training-cum-exposure visit programs of Farm Livelihood Community Resource Persons and Mahila Kisan under Deendayal Antyodaya Yojana - National Rural Livelihoods Mission (DAY-NRLM) at Pilot Plant Chemical Technology division, CSIR-IHBT. February 27-28, March 02-03, 13-14, 16-17.

Kumar A (2023) Online training program organized on *Heeng* cultivation at CSIR-IHBT, Palampur and Department of Agriculture, Chamba for the farmers of district Chamba, February 14.

Kumar R and Pal PK (2023) Organized interaction meet of Aroma farmers with NITI Aayog members and district administration of aspirational district Chamba at village Talla, Chamba, February 15.

Singh D (2023) Conducted five days Advanced Entrepreneurship Skill Development Programme (Advanced-ESDP, a MSME sponsored project) on Enzyme Bioprocessing. twenty participants from all over India and fifteen guest's faculty from Academia, Research Institutes and Industry were invited to deliver an expert talk. March 13-17.

Sharma M (2023) Organised Training on processing of aromatic crops was imparted to around thirty farmers of Distt. Kangra (H.P.) during a five days training program organized at CSIR-IHBT, Palampur on "Cultivation and Post-Harvest Management of Aromatic plants". March 13-17.

Sharma M (2023) Organised one-day training cum demonstration of processing of damask rose for essential oil distillation was given to 10 farmers of Barnala (Punjab) on mini distillation unit, 10 kg capacity established at the site. March 14.

Kumar R (2023) Organized Cultivation technology of saffron in non-traditional areas of HP at Baga Sarahan Kullu, March 14.

LECTURES INVITED/DELIVERED

Dr Acharya Vishal (2022) Delivered a lecture and Workshop titled "National workshop on Genome Informatics" organized at Punjab University, Chandigarh. March 21.

Dr Rakesh Kumar (2022) Delivered an invited talk on the topic entitled "Crop Diversification through Medicinal, Aromatic and Industrial Crops" (virtual Mode) for the faculty and Students of Agriculture College, Galgotia University, Noida, India. April 2.

Dr Upender Sharma (2022) Delivered a lecture in Webinar on Role of Natural Products in Drug Discovery and Development, NIPER, Ahmedabad, Gujrat, April 29.

Dr Upender Sharma (2022) Delivered a lecture on BioX Annual Conference, IIT, Mandi, Himachal Pradesh, May 13-14. May 13.

Dr Upender Sharma (2022) Delivered a lecture on Chemical Science Symposium, IIT, Mandi, Himachal Pradesh, May 23-24. May 23.

Dr Poonam Kumari (2022) Delivered online guest lecture on "Prospects of Gladiolus and Rose Cultivation in India" for B.Sc. students in School of Agricultural Innovations and Advanced Learning (VAIAL) Vellore Institute of Technology, Vellore. June 02.

Dr Probir Kumar Pal, Mitali Mahajan and Babit Kumar Thakur (2022) Oral Presentation at 10th World Convention on Stevia: Recent agronomic development on stevia towards higher productivity. June 03.

Dr Upender Sharma (2022) Delivered a lecture on Two-week Intensive Training Program, NIPER, Mohali, Punjab, June 08-17. June 14.

Dr Mahesh Gupta (2022) Delivered a talk on "Traditional Foods" as lead speaker at 15th & 16th UCOST Science Congress held in Dehradun (Uttarakhand). June 22-24.

Dr Upender Sharma (2022) Delivered a lecture on Webinar on Innovation in Organic Synthesis in India – presented by SynOpen and SoS, July 14.

Dr Damanpreet Singh (2022) Delivered a talk on "Integrative Multi-Omics Network Approaches for Target Identification in Chronic Noncommunicable Diseases: A Special Reference to Epilepsy" in a Faculty Development Program on "Exploring multidisciplinary avenues in pharmaceutical education and research" at GHG, Khalsa College, Ludhiana, Punjab. August 09

Dr Upender Sharma (2022) Delivered a lecture on DST-STUTI "Recent Approached and Techniques in Drug Design and Drug Discovery" Organised by ICT, Mumbai at Shoolini University, 22-28. August 24.

Dr Rakesh Kumar (2022) Delivered an invited talk on the topic entitled "Crop Diversification through Medicinal, Aromatic and Industrial Crops" (virtual Mode) in International Webinar Series Session 75 Reimagine Ethnopharmacology, India, organized by Institute of Bioresources & Sustainable Development, DBT, Govt. of India as invited speaker. September 10.

Dr Sukhjinder Singh (2022) Delivered lecture for 'Business Development for Medicinal and Aromatic Plants and its Value Addition' during "Comprehensive training on sustainable harvesting, processing and sustainable cultivation of Medicinal Plants" (sponsored by SECURE Himalaya Project through Forest Department, Lahaul Forest Division) at KVK Kukumseri during on 28th Sep 2022.

Dr Acharya Vishal (2022) Invited lecture at Delhi Pharmaceutical Sciences and Research University (DPSRU) at Centre for Precision Medicine and Pharmacy (DCPMP), October11.

Dr Acharya Vishal (2022) Delivered a lecture at Delhi Pharmaceutical Sciences and Research University (DPSRU) at Centre for Precision Medicine and Pharmacy (DCPMP). October11.

Dr Rakesh Kumar (2022) Delivered an invited talk on the topic entitled "Agro-technonogical interventions in North East India for livelihood generation and enhancement of farmers' income" in the National Conference on Northeast sustainable and inclusive development held at Kaziranga University, Jorhart, Assam. November 16-18.

Dr Ankit Saneja (2022) Delivered invited talk on "Polymeric Conjugation Based Approaches for Augmenting the Therapeutic Efficacy of Natural Products" in Symposium on Advances in the Natural Products Research, at National Institute of Pharmaceutical Education & Research (NIPER), Hyderabad. November 19.

Dr Pamita Bhandari (2022) Delivered an invited talk on "Chemical Exploration of Himalayan Medicinal Plants for Bioactive Molecules" in 6th world congress on drug discovery and development organized by Arjyopa healthcare at Bangalore. November 19-20.

Dr Pamita Bhandari (2022) Delivered an invited talk on "Bioprospection of bioactive molecules from Indian Medicinal Plants" in Hands-on Training Program on the Development of Nutraceutical Based Formulations and Their Characterization. November 22-28.

Dr Sukhjinder Singh (2022) Delivered lecture on CSIR-IHBT technologies Assam State Conclave on "Sustainable Livelihood through Science, Technology and Innovation Capabilities" at Guwahati, and interacted with the participants (Panchayat officials, MSMEs, NGOs, and Entrepreneurs) to promote CSIR-IHBT Technologies for Bioeconomy generation in North Eastern States of the Country. November 26.

Dr Mahesh Gupta (2022) Deliver a talk on "Startup and incubation opportunities at CSIR – IHBT in nutraceuticals" in Hands on Training Program on "Development of Nutraceutical Based Formulations and Their Characterization" (Under Accelerate Vigyan Scheme). November 25.

Dr Damanpreet (2022) Delivered a lecture Zebrafish as an Experimental Model to Establish PoC in Nutraceuticals Development in SERB Funded Training program on "Development of Nutraceutical Formulations and Their Characterization", at CSIR-IHBT, India. November 25.

Dr Damanpreet Singh (2022) Delivered a lecture entitled "Current research based on Zebrafish" in a workshop on "Zebrafish as an alternative model" organized by Sri Lanka Association for Laboratory Animal Science (SLALAS) in collaboration with Society of Alternative to Animal Testing (SAAT-SL), Sri Lanka and Medical Research Institute (MRI), Sri Lanka via online mode. November 25.

Dr Vijai Kant Agnihotri (2022) Delivered a lecture on Development of Nutraceutical Based Formulation and Their Characterization (Under Accelerate Vigyan Scheme) in training programme: Edible in essential oils: Extraction and Standardization from 22nd to 28th November, 2022 organized by Dr. Ankit Sneja, Scientist, CSIR-IHBT, Palampur. Venue: J.C. Bose Conference Hall, CSIR-IHBT, Palampur. November 26.

Dr Vivek Dogra (2022) Delivered an invited talk on "Utility of Confocal Microscope" at "Hands-on Training Program on Development of Nutraceutical based Formulations and their Characterization" organized under accelerated Vigyan Scheme by CSIR-IHBT, Palampur, H.P, on November 26.

Dr Upender Sharma (2022) Delivered a lecture on Regional Level Science Congress at Palampur Science Center, Palampur, Himachal, December 05-09. December 6.

Er Mohit Sharma (2022) Delivered invited lecture on "Processing of aromatic plants: essential oil" during Regional Level Science Congress-2022, NVS, Chandigarh Region at Palampur Science Centre (A unit of National Council of Science Museums), Ministry of Culture, GOI. December 06.

Dr Vikram Patial (2022) Delivered a lecture on "Burn and firearm injuries in animals" as a resource person in a refresher course of veterinary officers on "Post-mortem diagnosis with emphasis on veterolegal investigations" at department of Veterinary Pathology, CSKHPKV, Palampur. December 9.

Dr Upender Sharma (2022) Delivered a lecture on CME Training Programme for Ayurvedic Medical Officers Organized by Research institute in Indian system of Medicine Joginder Nagar, Distt. Mandi, Himachal on December 12-17, 2022. December14.

Dr Vikram Patial (2022) Delivered a lecture on "Introduction to in-vitro and in-vivo toxicity and safety evaluation of plant-based drugs" as an invited speaker in a training programme on "Quality control, standardization and botanical studies of electrohomeopathic drugs" at CSIR-IHBT, Palampur. December 21.

Dr Vijai Kant Agnihotri (2022) Delivered a lecture on Theoretical background of instruments used for analytical works (GC, GC-MS, HPLC, AAS etc) in training programme on "Quality Control, Standardization and Botanical Studies of Electrohomeopathic Drugs" from 21st - 22nd December 2022. Organized at Venue: J.C. Bose Conference Hall, CSIR-IHBT, Palampur. December 22.

Dr Upender Sharma (2022) Delivered a lecture on DST-Under Accelerate Vigyan Scheme "Hands on Training Program on Development of Nutraceutical Based Formulations and Their Characterization" Organised by CSIR-IHBT, Palampur, November 22-28. December 23.

Dr Dinesh Kumar (2023) Delivered a lecture in International Bioresource conclave & Ethnopharmacology Congress (ISESFEC-2023) at City Convention centre Imphal-795005, Manipur, February 24-26. February 25.

Dr Mahesh Gupta (2023) Delivered a talk on GI vision of CSIR-IHBT Palampur during workshop on Geographical Indications (GIS) Of North-Western Himalayas at SKAUST, Jammu. January 4-5.

Dr Upender Sharma (2023) Delivered a lecture on Advanced E-SDP on Entrepreneurship Skill Development on Enzyme Bioprocessing" Organised by CSIR-IHBT and Sponsored by DC (MSME). March 13-17, 2023, Govt. of India, New Delhi. March 15.

Dr Acharya Vishal (2023) Invited lecture and Workshop titled "National workshop on Genome Informatics" organized at Punjab University, Chandigarh, March 21.

Dr Vivek Dogra (2023) Delivered an invited talk titled 'Chloroplast generates retrograde phytoelicitors to induce growth inhibition and programmed cell death upon sensing stress factors' at International Conference on Food and Nutritional Security (IFANS-2023), 5th International Plant Physiology Congress & 44th Annual Meeting of Plant Tissue Culture Association, India. January 6-9.

Dr Poonam Kumari (2023) Delivered online guest lecture on 'Importance, scope, status and challenges of floriculture in India' for B.Sc, second year students in School of Agriculture, Lovely Professional University, Jalandhar. February 08.

Dr Poonam Kumari (2023) Delivered online guest lecture on Cultivation of rose and gladiolus in GSSS, Jaree, District Kullu. HP. February 09.

Dr Vivek Dogra (2023) Delivered an invited talk titled 'Deciphering chloroplast oxi-proteome for engineering oxidative stress resilient chloroplasts in plants' 15th Young Investigators Meeting (YIM)-2023 organized by India Bioscience (in the category of exceptional young scientists) at IIT Gandhinagar. February 13-17.

Dr Sarita Devi (2023) Delivered a lecture (offline mode) on "Microbial enzymes and their industrial applications" on 'International Women's Day', CSIR-IHBT, Palampur. March 6.

Dr Sarita (2023) Delivered a lecture on "Microbial enzymes and their industrial applications" on 'International Women's Day' at CSIR-IHBT, Palampur. March 06.

Dr Vivek Dogra (2023) Delivered an invited talk titled 'Fundamentals of Photosynthesis and Stress Sensing' at Plant Genome Engineering for Sustainable Development Symposium and Hands-on Training Workshop, Goswami Ganesh Dutt Sanatan Dharam (GGDSD) College Rajpur. March 13-14.

Dr Amitabha Acharya (2023) Delivered a talk on "Nanozymes: Recent Development and Biomedical Applications" at Advanced E-SDP on Entrepreneurship Skill Development on Enzyme Bioprocessing (Sponsored by DC (MSME), Govt. of India, New Delhi) Organized by CSIR-IHBT, Palampur. March 14.

Dr Vikram Patial (2023) Delivered a lecture on "Nanotechnology in drug development: Safety and toxicity concerns" as a resource person in National CME on Role of Nanotechnology in Health Care organized by AIIMS Raipur, Chhattisgarh. March 28.

Dr Amitabha Acharya (2023) Delivered a talk on "In Search of Functional Nanomaterials for Biomedical Applications: Our journey at CSIR-IHBT" at National CME on Role of Nanotechnology in Health Care Organized by AIIMS, Raipur. March 28.

Dr Vivek Dogra (2023) Invited to attend 15th Young Investigators Meeting (YIM)-2023 organized by India Bioscience (in the category of exceptional young scientists) at IIT Gandhinagar. February 13-17.

Dr Sukhjinder Singh (2023) Delivered lecture for 'Business Strategies for Aromatic Crops' during training program (under MEHAK Scheme) entitled as "Cultivation and Post-Harvest Management of Aromatic plants" at CSIR-IHBT, Palampur. March 13.

Dr Sukhjinder Singh (2023) Delivered lecture (online mode), "CSIR-IHBT technology intervention in aromatic/ herbal plants" during entrepreneurship development programme organized by Sampada Institute for Social Awareness Samiti, Bhopal (Sponsored by DST, Govt. of India). March 23.

Dr Damanpreet Singh (2023) Delivered a lecture "Zebrafish as a potential model in Nano Science and Technology" in National CME on Role of Nanotechnology in Health Care organized by AIIMS, Raipur. March 28.

VISITED ABROAD

Dr. Mahesh Gupta (2022) Participated in 21st IUFoST - World Food Congress at Singapore and presented my work on "study the effect of soluble dietary fiber incorporated in pea protein on physicochemical, textural and rheological properties of gel matrix". October 31-November 3.

Dr. Bhavya Bhargava (2022) Visited to attend International Floriculture Trade Fair (IFTF) in Harlemmermeer, Amsterdam, The Netherlands, November 9-15.

ONLINE TALK

Gupta M (2022) Deliver an online talk on MS team. खाद्य प्रसंस्करण में इंजीनियरिंग का अनुप्रयोग during webinar "राष्ट्र निर्माण हेतु इलेक्ट्रॉनिक्स इंजीनियरिंग के क्षेत्र में नवीनतम प्रगति" organized by CSIR-IHBT. July 22.

Bhargava B (2022) Delivered an online talk on the topic entitled "Improving the livelihood of farmers through CSIR Floriculture Mission" on Zoom meeting organized by Plant Lover's Association. 11:30 AM, November 19.

RADIO/TELEVISION TALK

Bhargava B (2022) Cultivation of Floriculture Plants under CSIR-Floriculture Mission project on DD Kisan. August 31.

EXHIBITIONS

Dr Mahesh Gupta (2022) Participate and demonstrate the food processing technologies of CSIR-IHBT in TECHBHARAT 2022 - A flagship program of IMS Foundation & Laghu Udyog Bharati at CSIR-CFTRI Campus, Mysore. May 19-21.

Dr Satbeer Singh (2022) Participated in Government Achievements and Scheme Expo - 2022, at Pragati maidan, New Delhi. June 17-19.

Dr Amit Chawla, Singh A, Devi K et al. (2022) Organized display of the institutional activities at the Tribal Fair Keylong (Chief guest: Dr. Ram Lal Markanda, Honorable Minister for Information Technology and Tribal Development; District Administration Lahaul & Spiti, HP). 14.8.2022 to 16.8.2022.

Dr Satbeer Singh (2023) Participated in India International Science Festival – 2022, at MANIT, Bhopal. January 21-24.

Dr Satbeer Singh (2023) Science Conclave and Agro-Tech Expo-2023, at Gurugram University, Gurugram. March 15-16.

Dr Mahesh Gupta (2023) Participated in the "Science Conclave and Agro Tech Expo 2023" jointly organized by CSIR-NIScPR and Gurugram University, at Gurugram University and demonstrated the CSIR-IHBT technologies & products. March15-16.

ABSTRACT PRESENTED

Kumar R, Kumar P, Yadav S, Joshi R, Kumar D, Singh S, Chauhan R, Singh S and Kumar A (2022) Effect of plant growth regulators in overcoming the *Heeng* (*Ferula assa-foetida*) seed dormancy and improvement in seed germination. 14th "International conference on agriculture, horticulture and food sciences", The society of tropical Agriculture, New Delhi India, December 17-18.

AWARD RECOGNITIONS

Sharma V (2022) Awarded best poster award in SFEC-2022, International Congress of Society of Ethnopharmacology for *"Swertia purpurascens* Wall extract prevented the progression of liver fibrosis via inhibition of TGFβ/SMAD/NFκB signaling in rats" at JSS college of Pharmacy, Mysuru. April 22-24.

Katoch S (2022) Awarded best poster award in SFEC-2022, International Congress of Society of Ethnopharmacology for *Tinospora cordifolia* mitigates glomerular and tubular cell injury by activation of PPARγ pathway in diabetic at JSS college of Pharmacy, Mysuru. April 22-24.

Saini SK, Rana AK, Sharma S and Singh D (2022) Awarded best poster award "Quercetin attenuates intracerebral hemorrhagic stroke in a zebrafish model" at 9th International Congress of the Society for Ethnopharmacology, Mysore. April 24

Devi K, Patial M, Kumari K, Kumar A, Singh S, Joshi R and Kumar S (2022) Awarded best poster presentation Optimization of micropropagation protocol for *Ferula assafoetida* using leaf explant-A historic step towards self-sustainability in India. 43rd Annual Meeting of Plant Tissue Culture Association–India (PTCA-I) & International Symposium On "Advances in Plant Biotechnology and Nutritional Security- APBNS-2022", NIPB, New Delhi. April 28-30, p. 270-271.

Kalia D, Jose-Santhi J, Kumar R and Singh RK (2022) Awarded best poster presentation 'Molecular cloning and characterization of *PEPB* genes and their putative roles in flowering regulation in saffron (*Crocus sativus*)' at the 43rd Annual Meeting of Plant Tissue Culture Association (India) & International Symposium on Advances in Plant Biotechnology and Nutritional Security, (APBNS-2022). April 28-30.

Gorakh Mal, Singh B, Agnihotri VK, Jairath G, Sharma R, Devi G and Dhar JB (2022) Won best poster Presentation award on the research article entitled "Goat milk protein hydrolysates with improved bioactive potential" during SVAHE National Conference-2022 organized by Dept. of Vety &A.H. Extension Education DGCN College of Veterinary & Animal Sciences, CSKHPKV Palampur (H.P.) I collaboration with Society for Veterinary and Animal Husbandry Extension (SVAHE). May 06-08.

Agnihotri VK (2022) Member of the Technical Program Committee of EOAI International Congress and Expo 2022 on the topic "Exploring Excellence in Essential Oils" held. May 26-28. Pp. 26.

Singh S (2022) Certificate of participation in International Workshop on, "Role of Science, Technology and Innovation (STI) in Achieving Sustainable Development Goals- 2023" a virtual event organized by NAM S&T Centre, New Delhi and Indian Ocean Rim Association (IORA), Ebene (Mauritius). May 24-25.

Chander R and Agnihotri VK (2022) *In vitro* α-amylase and α-glucosidase activity of *Dracocephalum heterophyllum* Benth. essential oil from North-western Himalayas India received the best poster award, 1st prize in International Congress & Expo 2022 "Exploring Excellence in Essential Oils" organized by Essential Oil Associations of India (EOAI) Indore. May 26-28.

Das P (2022) A invited Bronze Medal Lecture in the 29th CRSI National Symposium in Chemistry & CRSI-ACS Symposium Series in Chemistry (7-9th July, 2022) IISER, Mohali. July 07.

Das P (2022) Received the CRSI Bronze Medal for his "Notable contributions in the area of Organic Synthesis" in 29th CRSI-National Symposium in Chemistry & CRSI-ACS Symposium at IISER-Mohali held on July 07.

Singh S (2022) Received Best Paper Award Poster Presentation Award 2022 on the occasion of Regional Conference on "Speciality Agriculture in the Context of Farm Economy of Himalayan Region" organized by Division of Agril. Economics and Agribusiness Management, SKAUST, Jammu in collaboration with Indian Society of Agril. Economics, Mumbai. September 21-22.

Dhiman V and Kumar A (2022) Awarded best poster award in the "GeoSmart India 2022" - a national symposium of 'Indian Society of Remote Sensing (ISRS)' and 'Indian Society of Geomatics (ISG)' Hyderabad, Telangana, India, entitled "High-resolution remote sensing for precise biomass estimation of Himalayan forests. November 17.

Bhandari P (2022) Awarded as best researcher in the Alexander Fleming Memorial Award in 6th world congress on drug discovery and development organized by Arjyopa healthcare at Bangalore. November19-20.

Sendri N (2022) Awarded for best poster the Young Researcher Award in 6th world congress on drug discovery and development organized by Arjyopa healthcare at Bangalore. November19-20.

S Singh (2022) Received Best-Poster Award for "Introducing true cinnamon in its non-traditional areas of Himachal Pradesh" at 1st national conference on Plant Genetic Resource Management organized by Indian Society of Plant Genetic Resources at NASC complex. November 22-24.

Kumar A et al., (2022) Awarded the Best oral presentation award in the 1st national conference on plant genetic resource management (NCPGRM-2022) organized by Indian society of plant genetic resource (ISPGR), New Delhi. November 22-24.

Kumar R, Kumar P, Yadav S, Joshi R, Kumar D, Singh S, Chauhan R, Singh SS and Kumar A (2022) Awarded best poster award in the 14th International conference on agriculture, horticulture and food sciences at New Delhi India, December 17-18.

Kalia D, Jose-Santhi J and Singh RK (2023) Awarded best poster presentation Transcriptional network underlying flowering regulation in Saffron (*Crocus sativus* L.)' at the international conference on Food and Nutritional Security, (APBNS-2022), NABI, Mohali, Punjab. January 6-9.

Sheikh FR, Jose-Santhi J, Kalia D, and Singh RK (2023) Awarded best poster presentation sugar metabolism mediates temperature-dependent flowering induction in saffron (*Crocus sativus* L.) at the International Conference on Food and nutritional NABI, Mohali, Punjab. January 6-9.

Chauhan R, et al. (2023) Awarded best poster award in international conference on climate resilient agriculture for food security and sustainability for "Comparative assessment of NPK levels for sustainable cultivation of *Saussurea costus* in cold desert region of North-Western Himalayas" at organized by CCS Haryana Agricultural University, Hisar, Haryana. February 17-19.

Kumari P (2022) Awarded Kanwar Virender Singh Memorial All India Best Publication Award by SADHNA (Society for Advancement of Human and Nature) Dr YS Parmar University of Horticulture and Forestry Nauni, Solan, Himachal Pradesh for publication (Edible rose flowers: a doorway to gastronomic and neutraceutical research. Food Research International). Hegde AS, Gupta S, Sharma S, Srivatsan V and Kumari P. 162(A): 111977; doi: 10.1016/j.foodres.2022.111977.

Bhargava B (2022) Got recognition in field of Hindi communication in science field by CSIR-IHBT during the year 2021-2022.

Kumar A (2022) Nominated as a Life member of Indian Society of Geomatics (ISG) (ISG-L-2331).

Singh A (2022) Reviewer of the National Mission on Himalayan Studies.

Agnihotri VK (2022) Official Nominator for VinFuture prize and three additional special prizes.

Sharma U (2022) Became Fellow of Royal Society of Chemistry (FRSC), London, UK.

Sharma U (2022) Become a Life member of Chemical Research Society of India (CRSI).

Das P (2022) Selected as Fellow of the Royal Society of Chemistry (FRSC), London

Dogra V (2023) Invited to join Plant Physiology Reports as Associate Editor.

Dogra V (2023) Awarded ISPP-ASPB Young Scientist Award of the Indian Society of Plant Physiology (ISPP) at the 5th International Plant Physiology Congress (iFANS-2023).

Dogra V (2023) Selected as a Member of the Indian National Young Academy of Sciences (INYAS), INSA. 2023.

Kumar R (2023) Joined as life member of Essential Oil Association of India (EOAI).

Certificate of Appreciation 2023

Bishnoi J, Kumar P, Singh S, Gehlot A, and Kumar A (2023) Poster entitled "Genome size estimation of *Ferula assa-foetida* (*Heeng*) through flow-cytometry analysis" authored by won third prize in International Conference on Climate Resilient Agriculture for Food Security and Sustainability.

POSTER PRESENTED

Verma V, Kumar A, Chaudhary P, Chauhan S, Goel K and Bhargava B (2022) Melatonin application ameliorates salt stress impact on growth and photosynthesis of *Tagetes erecta* L. 43rd Annual Meeting of Plant Tissue Culture Association – India (PTCA-I) &International Symposium on "Advances in Plant Biotechnology and Nutritional Security" (APBNS-2022). ICAR-National Institute for Plant Biotechnology New Delhi-110012, India April 28-30.

Sharma V, Raj D, Upadhyaya A, Kumar N, Joshi R, Acharya V, Kumar D and Patial V (2022) *Swertia purpurascens* Wall extract prevented the progression of liver fibrosis via inhibition of

TGFβ/SMAD/NFκB signaling in rats. SFEC-2022, International Congress of Society of Ethnopharmacology, held at JSS college of Pharmacy, Mysuru. April 22-24.

Katoch S, Chhimwal J, Singh P P, Shivprasad P, Suresh, Padwad Y and Patial V (2022) *Tinospora cordifolia* mitigates glomerular and tubular cell injury by activation of PPARγ pathway in diabetic rats. SFEC-2022, International Congress of Society of Ethnopharmacology, held at JSS college of Pharmacy, Mysuru. April 22-24.

Katoch S, Chhimwal J, Singh P P, Shivprasad P, Suresh, Padwad Y and Patial V (2022) *Tinospora cordifolia* mitigates glomerular and tubular cell injury by activation of PPARγ pathway in diabetic rats. SFEC-2022, International Congress of Society of Ethnopharmacology, held at JSS college of Pharmacy, Mysuru. April 22-24.

Kalia D, Jose-Santhi J, Kumar R and Singh RK (2022) Awarded best poster presentation 'Molecular cloning and characterization of *PEPB* genes and their putative roles in flowering regulation in saffron (*Crocus sativus*)' at the 43rd Annual Meeting of Plant Tissue Culture Association (India) & International Symposium on Advances in Plant Biotechnology and Nutritional Security, (APBNS-2022). April 28-30.

Kumar A and Singh S (2022) Essential oil variations among the selected breeding lines of aromatic marigold (*Tagetes minuta* L.). International conference on, "Sustainable use of high altitude medicinal and aromatic plants for the socio-economic development" at Uttarakhand Ayurved University, Rishikul, Haridwar, Uttarakhand organized by National Medicinal Plants Board (Ministry of Ayush, Govt. Of India). May 7- 8.

Anmol and Sharma U (2022) Phytochemical investigation of *Aconitum heterophyllum* Wall. ex Royle to validate its traditionally claimed antiplasmodial potential. International Conference on Conservation, Cultivation and Sustainable Use of High Altitude Medcicinal and Aromatic Plants for the Socio-economic Development, Uttarakhand Ayurveda University, Dehradun. May 07-08.

Kumar S, Rana R, Singh S, Agnihotri V K and Joshi R (2022) Contributions of CSIR-IHBT to Essential Oil Industry using Himalayan Bioresources. International Congress & Expo-2022 at Indore organized by the Essential Oil Association of India. May 26-28.

Thakur BK, Shivani and Pal PK (2022) Temporal dynamic of essential oil accumulation and its composition of *Valeriana jatamansi* from the western Himalaya. International Congress & Expo 2022. Exploring Excellence in Essential Oils. Essential Oil Association of India. May 26-28

Shivani, Thakur BK and Pal PK (2022) Post-harvesting drying conditions alter the concentration and composition of essential oil of *Valeriana jatamansi*. International Congress & Expo 2022. Exploring Excellence in Essential Oils. Essential Oil Association of India. May 26-08

Rathore S and Kumar R (2022) Sowing time and salicylic acid variability enhanced the growth and yield of German chamomile (*Matricaria chamomilla* L.) in the western Himalaya. International Congress and Expo: 2022 organized by Essential oil Association of India, Indore, Madhya Pradesh, India. May 26–28.

Rathore S and Kumar R (2022) Sulphur and seaweed extract enhances the flower yield and essential oil composition of German chamomile (*Matricaria chamomilla* L.)". International Congress and Expo: 2022 organized by Essential oil Association of India, Indore, Madhya Pradesh, India. May 26–28.

Agnihotri VK (2022) In vitro α-amylase and α-glucosidase activity of *Dracocephalum heterophyllum* Benth. essential oil from North-western Himalayas India. International Congress & Expo 2022 – Exploring Excellence in Essential Oils" organized by Essential Oil Associations of India (EOAI) Indore. May 26-28.

Bishnoi J, Kumar P, Kumar A, Singh S, Gehlot A, and Kumar A (2022) Protocol Standardization for Flow-Cytometry study in *Heeng* (*Ferula assa-foetida*). 6th Student seminar series. September 05.

Kumar A, Singh S, Singh S, Chauhan R and Kumar S (2022) Introduction of *Heeng* (*Ferula assa-foetida*) plant to cold deserts of Indian Himalayas. 4th International Conference on Global Efforts on Agriculture, Forestry, Environment and Food Security (Theme: Climate Change and Its Impact) (GAFEF-2022). September, 17-19.

Kumar P, Kumar A, Gautum RD, Kumar R, Singh S and Kumar A (2022) Morphological characterization of palmarosa (*Cymopogon martini*) for essential oil content. 4th International Conference on Global Efforts on Agriculture, Forestry, Environment and Food Security (Theme: Climate Change and Its Impact) (GAFEF-2022). September, 17-19.

Bishnoi J, Kumar P, Kumar A, Singh S, Gehlot A, and Kumar A (2022) Flow-cytometry protocol standardization for genome size estimation in *Heeng* (*Ferula assa-foetida*). 4th International Conference on Global Efforts on Agriculture, Forestry, Environment and Food Security (Theme: Climate Change and Its Impact) (GAFEF-2022). September, 17-19.

Bishnoi J, Kumar P, Kumar A, Singh S, Gehlot A, and Kumar A (2022) Protocol Standardization for Flow-Cytometry study in *Heeng* (*Ferula assa-foetida*). International Conference on Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security (AAVASILES-2022). September 28-30.

Kumar P, Kumar A, Gautum RD, Kumar R, Singh S and Kumar A (2022) Diversity assessment of palmarosa (*Cymopogon martini)* for essential oil concentration. International Conference on Advances in Agricultural, Veterinary and Allied Sciences for Improving Livelihood and Environmental Security (AAVASILES-2022). September 28-30.

Anmol and Sharma U (2022) Exploration of antiplasmodial potential of *Aconitum heterophyllum* Wall. ex Royle and development of UHPLC-DAD based quality assessment method. National Conference on Fornteir in Chemical Sciences (NCFCS), Central University of Himachal Pradesh, Dharamshala. November 04-05.

Kumar A, Singh S, Singh S, Chauhan R, Sharma RK and Kumar S (2022) Introduction and morphological characterization of *Heeng* (*Ferula assa-foetida*) accessions in cold deserts of Indian Himalayas. 1st National conference on plant genetic resource and management (NCPGRM-2022). November 22-24.

Chaudhari AA, Kumar P, Patial D, Rani N, Chauhan R, Singh S, Singh S and Kumar A (2022) Exploring genetic diversity of *Artimisia maritima* germplasm for essential oil content and its contributing traits. 1st National conference on plant genetic resource and management (NCPGRM-2022). Nov. 22-24.

Kumari S, and Sharma U (2022) Phytochemical investigation of *Cissampelos pareira* for validation of traditionally claimed antiplasmodial potential. National Conference on Fornteir in Chemical Sciences (NCFCS), Central University of Himachal Pradesh, Dharamshala. November 04-05.

Yadav N, Kumar R, Kumar A, Chauhan R, Singh S, Sharma S, Dalal N, Kumar P and Singh SS (2022) Effect of different soil media mixtures on seedling survival and growth of *Ferula assa-foetida* accessions introduced in India. 1st National conference on plant genetic resource and management (NCPGRM-2022). November 22-24.

Singh S (2022) Received Best-Poster Award for "Introducing true cinnamon in its non-traditional areas of Himachal Pradesh" at 1st national conference on Plant Genetic Resource Management organized by Indian Society of Plant Genetic Resources at NASC complex. November 22-24.

Kumar R, Chauhan R, Singh S, Kumar D, Singh S and Kumar A (2023) Variation in essential oil composition among the different accession of *Ferula assa-foetida* L. International conference on food and nutritional security (iFANS-2023). January 06-09.

Kalia D, Jose-Santhi J and Singh RK (2023) Awarded best poster presentation Transcriptional network underlying flowering regulation in Saffron (*Crocus sativus* L.)' at the international conference on Food and Nutritional Security, (APBNS-2022), NABI, Mohali, Punjab. January 06-09.

Sheikh FR, Jose-Santhi J, Kalia D, and Singh RK (2023) Awarded best poster presentation sugar metabolism mediates temperature-dependent flowering induction in saffron (*Crocus sativus* L.) at the International Conference on Food and nutritional NABI, Mohali, Punjab. January 06-09.

Sharma A, Joshi R, Patial V and Nadda G (2023) *Ophiocordyceps* from treeline areas of Indian Western Himalaya-A Goldmine for Nutraceuticals. 63rd Annual International Conference of Association of Microbiologists of India (AMI) held at Maharshi Dayanand University, Rohtak. February 02-04.

Ranout AS, Sharma A, Kumar R, Kaur R and Nadda G (2023) Isolation, identification and acaricidal potential of two entomopathogenic fungi from *Ophiocordyceps* of Indian Western Himalayas. 63rd Annual International Conference of Association of Microbiologist of India (AMI) held at Maharshi Dayanand University, Rohtak February 02-04.

Bishnoi J, Kumar P, Singh S, Gehlot A and Kumar A (2023) Genome size estimation of *Ferula assa-foetida* (*Heeng*) through flow-cytometry analysis. International Conference on Climate Resilient Agriculture for Food Security and Sustainability. February 17-19.

Yadav N, Bishnoi J and Kumar A (2023) Effect of plant growth regulator on survival and growth after root distressing in different accessions of *Ferula assa-foetida*. International Conference on Climate Resilient Agriculture for Food Security and Sustainability. February 17-19.

Kumar A, Singh S, Singh S, Chauhan R and Kumar S (2023) Introduction and cultivation of *Heeng* (*Ferula assa-foetida*) in cold desert of Indian Himalayan- A new approach. International Conference on Climate Resilient Agriculture for Food Security and Sustainability. February 17-19.

Sharma A, Krishnan A, Thakur A, P Naveen, Chanu LD, Sharma N, Bhardwaj PK and Pal PK (2023) Organic production technology of *Mentha piperita*: a silver lining to increase farmer's income in the Himalayan region. International Bioresource Conclave & Ethanopharmocology Congress. 22nd International Congress of International Society for Ethnopharmacology (ISE) & 10th International Congress of the Society for Ethnopharmacology (SFE), India (ISE- SFEC 2023). Feb 24-26.

Kumar R, Thakur P, Raj Y, Saini KS, Hallan V and Kumar S (2023) Introduction of low chilling varieties of apple (*Malus domestica* Borkh.) in North east India. International Bioresource Conclave & Ethnopharmacology Congress. February 24-26. Pp 242-243

LINKAGES

International Linkages:

- MoU for development of new drugs for the treatment of neglected tropical and viral diseases with Drugs for Neglected Diseases initiative (DNDi) 15, chemin Camille-Vidart, 1202, Geneva, Switzerland on 08.04.2022.
- MTA for resorcinol derivatives for evaluation and testing purposes with Colgate-Palmolive Company, 300 Park Avenue, New York, New York 10022 on 18.10.2022.

STAFF

STAFF

Director
Dr. Sanjay Kumar (till 28.02.2023)
Dr. Prabodh Kumar Trivedi

Chief Scientist
Dr.(Mrs.) Aparna Maitra Pati

Sr. Principal Scientist
Dr. Vipin Hallan
Dr. Sanjay Kumar Uniyal
Dr. Ram Kumar Sharma
Dr. Amit Kumar
Dr. Rakesh Kumar
Dr. Sanatsujat Singh
Dr. Shashi Bhushan
Dr. Pralay Das

Principal Scientist
Dr. Vijai Kant Agnihotri
Dr. Ravi Shankar
Dr. Probir Kumar Pal
Dr. Gireesh Nadda
Dr. Mahesh Gupta
Dr. Rituraj Purohit
Er. Mohit Sharma
Dr. Amit Chawla
Dr. Ashok Kumar
Dr. S.G.E. Reddy
Dr. Dharam Singh
Dr. Y.S. Padwad
Dr. Upendra Sharma
Dr. Pamita Bhandari
Dr. Amitabha Acharya
Dr. Dinesh Kumar
Dr. Vikram Patial
Dr. Damanpreet Singh

Senior Scientist
Dr. Vishal Acharya
Dr. Ashok Singh
Dr. Bhavya Bhargava
Dr. Kunal Singh
Dr. Sukhjinder Singh
Dr. Jeremy Dkhar
Dr. Rohit Joshi
Dr. Shiv Shankar Pandey
Dr. Ashish Rambhau Warghat
Dr. Rajiv Kumar
Dr. Narender Vijay Tirpude
Dr. Arun Kumar
Dr. Vivek Dogra
Dr. Gaurav Zinta
Dr. Rajesh Kumar Singh
Dr. Rakshak Kumar
Dr. Vidyashankar Srivatsan

Scientist
Dr. Ankit Saneja
Dr. Poonam Kumari
Dr. Vandana Jaiswal
Er. Amit Kumari
Dr. Satbeer Singh
Dr. Ramesh
Dr. Vikas Kumar
Dr. Sarita Devi

Senior Technical Officer (3)
Dr. Robin Joshi
Dr. Kiran Devi
Sh. Vikrant Gautam
Dr. Avnesh Kumari

Senior Technical Officer (2)
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
Sh. Ramjeelal Meena
Sh. Vivesh Sood
Sh. Mahesh S.
Sh. Bijan Bihari Garnayak
Dr. Vipul Gupta [Sr. Medical Officer (2)]

Senior Technical Officer (1)
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
Dr. Arvind Kumar Verma
Smt. Meenakshi
Sh. Anil Chaudhary

Technical Officer
Sh. Pawan Kumar
Dr. Rimpy Diman
Sh. Virat Abhishek
Sh. Saurabh Sharma

Technical Assistant
Sh. Rajeev Kumar Koundal
Sh. Vikas Soni

Senior Technician (2)
Sh. Karandeep Sood

Senior Technician (1)
Sh. Ramesh Kumar
Sh. Kuldip Singh
Sh. Sanjay Kumar
Sh. Avinash Chander Rana
Sh. Sandeep Sood
Sh. Ranjeet Singh
Sh. Ajay Kumar
Sh. Arvind Kant

Technician (2)
Sh. Surjeet Singh
Smt. Jasveer Kaur
Sh. Vikas Kumar

Technician (1)
Sh. Sanjeev
Sh. Sanjeet Kumar
Sh. Monu Kumar
Sh. Ishwar Dass

Lab. Assistant
Mrs. Anupama Saini
Sh. Shamsher Singh

Lab. Attendant (2)
Sh. Uttam Chand
Sh. Balak Ram
Sh. Kuldeep Singh
Sh. Balwant Raj
Sh. Girja Nand
Sh. Deepak Sood

Administration Officer
Sh. Virender Lamba

Finance & Accounts Officer
Sh. S. K. Narad

Store and Purchase Officer
Sh. Sanjay Rawat

Hindi Officer
Sh. Sanjay Kumar

Private Secretary
Sh. Didar Singh

Section Officer (Gen.)
Sh. Constan Kujur
Sh. Prajwal Rai
Sh. Ranjeet Kumar Gupta

Section Officer (F&A)
Sh. Mahabir Singh

Section Officer (S&P)
Sh. Ravinder Singh

Assistant Section Officer (G.)
Sh. Parveen Singh
Smt. Santosh Kumari
Sh. Baldev
Sh. Kiran Kumar
Smt. Pooja Awasthi

Assistant Section Officer (F&A)
Smt. Aruna Kumari

Assistant Section Officer (S&P)
Sh. Rajeev Sood

Sr. Stenographer
Sh. Boni Kumar

Senior Secretariat Assistant (G.)
Sh. Praveen Kumar
Sh. Sandeep Kumar
Sh. Mukul Sharma
Sh. Ajay Singh Kaundal

Senior Secretariat Assistant (S&P)
Sh. Rajinder Singh

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 Gurung

MTS
Sh. Baleshwar Prasad
Sh. Thaman Bahadur
Smt. Rujala Devi

Joined CSIR-IHBT between 01.04.2022-31.03.2023

Sr. No.	Name	Designation	Date of Joining
1.	Sh. S.K. Narad	Finance & Accounts Officer	22.12.2022
2.	Sh. Ranjeet Kumar Gupta	Section Officer (Gen.)	17.03.2023
3.	Dr. Vipul Gupta	Sr. Medical Officer (2)	21.03.2023
4.	Sh. Virender Lamba	Administrative Officer	09.01.2023

Staff Superannuated


Sh. Parveen Kumar
Sr. Technician (1): 31.05.2022


Sh. Mukhtiar Singh
Principal Technical Officer: 30.06.2022


Sh. Trilok Nath
Security Assistant: 30.09.2022


Dr. Rakesh Kumar Sud
Chief Scientist: 30.11.2022


Sh. Rakesh Chand
Lab Assistant: 31.12.2022


Dr. Sanjay Kumar
Director: 28.02.2023


Sh. Dharuv Kumar
Sr. Technician (2): 31.03.2023


Sh. Devender Singh
Multi Tasking Staff: 31.03.2023

Staff Resigned: Dr. Sushil Kumar Maurya, Pri. Scientist on 28-10-2022

Transferred to other CSIR Labs/Institutes between 01.04.2022 - 31.03.2023.

1. Sh. Yash Pal, FAO, CSIR-IMT, Chandigarh : 26-12-2022
2. Sh. Ram Gopal Meena, PPS, CSIR, Hqrs., New Delhi : 12-12-2022
3. Sh. B.P. Saw, AO, CSIR-CMERI, Durgapur : 12-01-2023
4. Sh. Ved Prakash, SO(G.) 4PI, Bangaluru : 06.03-2023

Emeritus Scientist
Dr. Bikram Singh
Dr. Surender Kumar Vats

INSPIRE Faculty
Dr. Nishma Dahal
Dr. Vijay Gehlot

RAMANUJAN Fellow
Dr. Satish Singh

Young Scientist
Dr. Virender Kumar
Dr. Vijay Kumar
Dr. Prakriti Kashyap
Ms. Tanvi Sharma

Senior Research Associate (Pool)
Dr. Paromik Bhattacharya

Women Scientist
Ms. Ujala
Ms. Mamta
Dr. Vidya Rajendran
Ms. Nitisha Sendri

NPDF
Dr. Rahul Jain
Dr. Sapna Thakur
Dr. Aasim Majeed
Dr. Asha Kiran

ISWP
Ms. Abhisha Roy
Mr. Ammu V.V.V. Ravi Kiran

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Dr. Sharad Thakur
Dr. Varun Chauhan
Dr. Surender Kumar
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Dr. Rahul Michael

RA
Dr. Deepali Katoch
Dr. Heena Gupta
Mr. Vinod Kumar
Dr. Ashish Gupta
Dr. Jyoti Chhimwal
Dr. Shagun Bali
Dr. Girija Kaushal

Principal Project Associate
Dr. Vipasha Verma
Dr. Anand Mishra
Dr. Narender Kumar

Senior Project Associate
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Dr. Vishal Sharma
Dr. Romit Seth
Mr. Vinod Kumar
Ms. Niketa Yadav
Dr. Kumari Sita
Ms. Meenakshi Thakur
Dr. Raghawendra Kumar
Mr. Ankush Arun Bajad
Dr. Pawan Kumar
Ms. Namo Dubey
Mr. Neeraj Kumar
Dr. Vasundhara Thakur
Mr. Patil Shivprasad Suresh
Ms. Deepika Singh
Ms. Swati Walia
Dr. Mohammed Saba Rahim
Mr. Manish Kumar Gupta
Ms. Poonam Pal
Dr. Shailika Sharma
Mr. Mahinder Partap
Ms. S. Borkar Shruti Digamber
Ms. Usha Kumari Rattan
Dr. Subhash Kumar
Dr. Sandhya Yadav
Mr. Prince Anand
Ms. Aishwarya Singh

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Mr. Dinesh Kumar
Ms. Surekha Kumari
Mr. Rahul Kumar
Mr. Shubham Neelkanth Rahmatkar
Mr. Ashish Kumar
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Ms. Tsering Dolma
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Ms. Vandana Kumari
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Ms. Poonam Sharma
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Ms. Ruchika
Mr. Joel Jose S
Ms. Komal Goel
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Mr. Rajender Kumar
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Mr. Rakesh Kumar Dhritlahre
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Ms. Krishma Devi
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Ms. Sonia Sharma
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Mr. Sarvpreet Singh
Ms. Avantika
Ms. Anuradha
Km. Srishti Awasthi
Ms. Pallavi Sharma
Dr. Abhilash Verma
Dr. Neha Bharti
Mr. Amit Kumar
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Ms. Amanpreet Kaur
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Mr. Veerbhan Kesarwani
Ms. Diksha Thakur
Mr. Mukul Rana
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Mr. Rohan Pradhan
Mr. Ravi Raj
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Mr. Neeraj Kumar
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Ms. Anjana
Mr. Rahul Rana
Ms. Saizal Jamwal
Ms. Kanchan Kundlas
Mr. Mathan L.
Mr. Vivek Kumar Awasthi
Mr. Sahil Sharma
Ms. Rupali Katoch
Ms. Babita Kaundal
Mr. Randhir Singh
Ms. Ravina
Dr. Anjali Thakur

Field Assistant
Mr. Arvind Sharma
Mr. Aman Jamwal

Field Investigator
Mr. Jagdeep Singh
Mr. Bunesh Kumar
Mr. Ramesh

Field worker
Mr. Kishan Kharka
Mr. Abhishek Bhatt
Mr. Kalyan Yadav
Ms. Isha Kumari

Field Worker/Scientific Administrative Assistant
Mr. Narender Kumar
Mr. Amit

Student Intern
Mr. Prakash Sirvi
Ms. Anjali Dhiman

CSIR - IHBT in Print and Electronic Media

सीएसआईआर–आईएचबीटी में राष्ट्रीय प्रौद्योगिकी दिवस समारोह

पोखरण में सफलतापूर्वक किए गये परमाणु परीक्षण तथा विश्व का छठा परमाणु देश बनने पर मनाया जाता है। संस्थान के निदेशक डा. संजय कुमार ने छात्रों, अध्यापकों और अन्य उपस्थित जन का स्वागत करते हुए प्रौद्योगिकी दिवस की शुभकामनाएं दी। अपने संबोधन में उन्होंने बताया कि कैसे डिजीटल प्रौद्योगिकी ने हमारे जीवन में परिवर्तन लाया है। इससे ज्ञान के प्रसार को गति मिली है। संस्थान अपने मिशन मोड परियोजनाओं के माध्यम से समुदायों के ...

... की सगंध फसलों को उगाने एवं इसके प्रसंस्करण द्वारा उनकी आय बढ़ाने में सक्रिय भूमिका निभा रहा है जिससे किसान परम्परागत फसलों की अपेक्षा अधिक आय प्राप्त करके आत्मनिर्भता की ओर बढ़ रहे हैं। अपने संबोधन में उन्होंने वैज्ञानिक अभिरुचि को बढ़ाने के लिए छात्रों का मार्गदर्शन किया। उन्होंने देश की महत्वपूर्ण प्रौद्योगिक उपलब्धियों तथा विभिन्न वैज्ञानिक उपलब्धि यों पर चर्चा की जिसके कारण आज देश आत्मनिर्भर बना है। समारोह के मुख्य अतिथि प्रो. पुलोक कुमार ...

लाहौल घाटी के किसानों को सशक्त बना रहा सीएसआईआर-आईएचबीटी

छात्रों ने जानी वैज्ञानिक शोध गतिविधियां

89 विद्यार्थियों ने सीएसआईआर पालमपुर का किया दौरा

हिमाचल दस्तक ■ बैजनाथ

राजकीय वरिष्ठ माध्यमिक पाठशाला कृष्णानगर के व्यावसायिक शिक्षा पाठ्यक्रम के 89 विद्यार्थियों ने सीएसआईआर/आईएचबीटी पालमपुर का एक दिवसीय दौरा किया।

इसमें विद्यार्थियों ने प्रोजेक्ट कार्यक्रम के अंतर्गत अनेक वैज्ञानिक शोध गतिविधियों का निरीक्षण किया और जानकारी ली। स्कूल के प्रवक्ता अनुज कुमार आचार्य ने बताया कि आईएचबीटी/सीएसआईआर के ट्रेनिंग सेल के एचओडी प्रो. गिरीश नड्डा और डॉ. अरुण बरवाल के मार्गदर्शन में विद्यार्थियों ने टिशु कल्चर, बंबू म्यूजियम, पायलट प्लांट्स, बायो टेक्नोलॉजी लैब और केमिस्ट्री लैब का दौरा कर इस शोध संस्थान में चल रही विभिन्न वैज्ञानिक और अनुसंधान गतिविधियों के बारे में महत्वपूर्ण जानकारी प्राप्त की।

संस्थान के ट्रेनिंग सेल के एचओडी गिरीश नड्डा का कहना है कि जिज्ञासा प्रोजेक्ट के अंतर्गत स्कूल विद्यार्थियों को लैब के भीतर चल रही साइंटिफिक एक्टिविटीज का एक्सपोजर दिया जाता है तो वहीं कृष्ण नगर स्कूल के विद्यार्थी रहे और वर्तमान में संस्थान की बायो टेक्नोलॉजी लैब के वरिष्ठ वैज्ञानिक डॉ. अरुण बरवाल ने प्लांट ब्रीडिंग, एडीबल प्रोडक्ट, फ्लोरीकल्चर मिशन के अंतर्गत ओर्नमेंटल प्लांट्स, ट्यूलिप पुष्प उत्पादन और विभिन्न जड़ी-बूटियों से निर्मित स्वास्थ्यवर्धक उत्पादों के निर्माण की जानकारी दी। पलक, संजना, मुस्कान, एंजल, मनु, कुनाल, कृष रांगड़ा और निखिल आदि विद्यार्थियों ने इस शैक्षणिक भ्रमण को बेहद उपयोगी एवं जानकारी से परिपूर्ण बताया। इस मौके पर अध्यापक आकांक्षा सूद, बबिता शर्मा, कैप्टन सुरेश डोगरा एवं प्रवक्ता अनुज आचार्य ने विद्यार्थियों का मार्गदर्शन किया।

IHBT HOLDS CAMP ON HEENG, KESAR CULTIVATION

DHARAMSHALA : Council of Scientific and Industrial Research's (CSIR) Institute of Bioresource Technology (IHBT), Palampur, organised a one-day programme for the empowerment of the farmers at its Centre for High Altitude Biology, Ribling, Lahaul and Spiti on Monday, September 19. The theme of the programme was "Heeng, Kesar and Floriculture Crops along with Compost Booster".

Technical education minister, Ram Lal Markanda was the chief guest at the event attended by several tribal farmers, women, and unemployed youth of Tandi Panchayat. In addition, Pradhan and Mahila Mandals of Marble

सीएसआईआर-आईएचबीटी में लद्दाख के उद्यमियों को किया जा रहा प्रशिक्षित

सवेरा न्यूज / जसवंत कठियाल

पालमपुर 26 अगस्त : सीएसआईआर-आईएचबीटी ने केंद्र शासित प्रदेश लद्दाख के उद्यमियों के लिए 25 - 27 अगस्त 2022 के दौरान खाद्य प्रसंस्करण और कृषि-बागवानी उत्पादों के मूल्यवर्धन पर तीन दिवसीय प्रशिक्षण कार्यक्रम का आयोजन किया है। सीएसआईआर-आईएचबीटी के सहयोग से इस प्रशिक्षण कार्यक्रम को उद्योग और वाणिज्य विभाग, लद्दाख प्रशासन द्वारा प्रायोजित किया गया है। कार्यक्रम में खाद्य प्रसंस्करण के विभिन्न पहलुओं जैसे निर्जलीकरण, मूल्य वर्धित उत्पादों की तैयारी, खाद्य लेबलिंग और पैकेजिंग और अच्छी

अब ट्यूलिप नगरी से मशहूर होने लगा पालमपुर

गार्डन खुलने से सिर्फ दो हफ्तों में 40000 से ज्यादा लोग गार्डन का ले चुके हैं आनंद

राकेश सूद - पालमपुर

गार्डन
■ अंतरराष्ट्रीय बाजार में ट्यूलिप फूलों की उच्च मांग

... है। पड़ोसी राज्य पंजाब से भी काफी संख्या में पर्यटक ट्यूलिप गार्डन का नजारा देखने के लिए लोग भारी संख्या में ...

केसर व हींग की खेती का संकल्प दोहराया

संवाद सहयोगी, पालमपुर : सीएचआइआर-आइएचबीटी पालमपुर के निदेशक डा. संजय कुमार ने कहा कि संस्थान राज्य सरकार द्वारा वित्त पोषित परियोजनाओं को कृषि से संपदा योजना के तहत कृषि विभाग के सहयोग से केसर और हींग की खेती का विस्तार कर रहा है। ...

सीएसआइआर-आइएचबीटी ने मनाया अंतरराष्ट्रीय महिला दिवस

प्रदेश को केसर, हींग का प्रमुख उत्पादक राज्य बनाने की तैयारी

कार्यालय संवाददाता, पालमपुर

सीएसआईआर–आईएचबीटी ने केसर व हींग की उत्पादन तकनीक पर कृषि विभाग, हिमाचल प्रदेश के कृषि अधिकारियों हेतु पांच दिवसीय क्षमता विन्यास कार्यक्रम संपन्न हुआ। कार्यक्रम में चंबा, कांगड़ा, किन्नौर, कुल्लू, ... के क्षेत्रों एवं सीएसआईआर–आईएचबीटी में प्रशिक्षण शिविर का आयोजन किया जा रहा है। उन्होंने हिमाचल प्रदेश को केसर एवं हींग का प्रमुख उत्पादक राज्य बनाने के अपने संकल्प को भी दोहराया। उन्होंने कृषि अधिकारियों को केसर एवं हींग की खेती के प्रत्येक क्षेत्र में संस्थान की टीम ...

ग्रामीण आजीविका के लिए सीएसआईआर की प्रौद्योगिकियां हो रही सहायक साबित

Palampur institute reviews floriculture mission in D'sala

CSIR-IHBT Research Council members have a look at a bo[x of] carnations and gerberas in Palampur on Tuesday. TRIBUNE [PHOTO]

PALAMPUR, DECEMBER 20

The Council of Scientific and Industrial Research-Institute of Himalayan Bio-resource Technology (CSIR-IHBT) reviewed the activities undertaken under the CSIR-Floriculture Mission at Tang Narwana, Dharamsala, today.

Members of the CSIR-IHBT Research Council along with the director and scientists of ... floriculture ...eneurs and ...Dharamsala ...with 50 pro...s and dis... of the flori... the region. ...hapatra, for... partment of ...earch and ...with Dr San...ctor, CSIR-...harma; Dr ...endra; Prof Uma Ramakrishnan; and Dr Meenakshi Singh; monitored the activities and progress of the floriculture mission.

Under the CSIR-Floriculture Mission, Dr N Kalaiselvi, DG, CSIR and Secretary, DSIR, had flagged off the refrigerated van at the CSIR-IHBT in November.

Dr Mohapatra toda[y] ... the first cold-chain ... boxes containing fre[sh carna]tions and gerberas ... the van. He apprec[iated the] efforts of the Palam[pur insti]tute to support fl[oriculture] farmers of the region ...

विज्ञान एवं प्रौद्योगिकी से देश को बहुत उम्मीद : डॉ. टी रामास्वामी

संवाद न्यूज एजेंसी

सीएसआईआर पालमपुर ने मनाया स्थापना दिवस

पालमपुर (कांगड़ा)। सीएसआईआर-हिमालय जैव संपदा प्रौद्योगिकी संस्थान पालमपुर ने 40वां स्थापना दिवस मनाया। कार्यक्रम की शुरुआत में संस्थान के निदेशक डॉ. संजय कुमार ने मुख्यातिथि पद्मश्री, पद्म-विभूषण एवं शांति स्वरूप भटनागर पुरस्कार से सम्मानित डॉ. टी रामास्वामी का स्वागत किया। डॉ. टी रामास्वामी ने सीएसआईआर-आईएचबीटी को संस्थान के स्थापना दिवस की शुभकामनाएं देते हुए उन्होंने इस संस्थान के नामकरण के बारे में बताया कि ... देश को बहुत अधिक उम्मीद है, अत हमारा दायित्व है कि राष्ट्र एवं विश्व की अपेक्षाओं को पूरा करने की दिशा में प्रयास करें। उन्होंने जैव आर्थिकी को बढ़ावा देने ... में हमारी क्या ताकत है तथा इस क्षेत्र में क्या संभावनाएं हैं, इस बारे में विस्तार से बताया। इससे पूर्व संस्थान के निदेशक डॉ. संजय कुमार ने संस्थान के वर्ष 2021-22 के वार्षिक प्रतिवेदन को प्रस्तुत किया। उन्होंने बताया कि अरोमा मिशन चरण-11 के ...

सीएसआईआर-आईएचबीटी में अंतरराष्ट्रीय महिला दिवस पर महिलाओं को दी बधाई

फूलों की महक से सराबोर टंग नरवाणा

सीएसआईआर-आईएचबीटी की टीम ने किसानों को दी उपयोगी जानकारी

... की। संस्थान के निदेशक डॉ. संजय कुमार ने किसानों को बताया कि कैसे कूल-चेन सुविधा की स्थापना से फसल कटाई के बाद होने वाले नुकसान को कम किया जा सकता है।

हवाई अड्डों और घरेलू बाजारों सहित व्यापार बिंदुओं पर ताजे कटे फूलों के परिवहन के लिए हितधारकों को रेफ्रिजरेटेड वैन सुविधा उपलब्ध कराई जाएगी।

जमीन की बात | चंबा जिला के प्रगतिशील किसान कर रहे सीएसआईआर अरोमा मिशन के तहत कमाल

तल्ला गांव की फिजाओं में फूलों की खुशबू

कार्यालय संवाददाता- पालमपुर

चंबा की सिहुंता तहसील के तल्ला गांव के किसान सीएसआईआर अरोमा मिशन के तहत सुगन्धित फसलों से लाभ उठा रहे हैं। ... बनाया और अपने खेतों में सगंधित गेंदा की खेती करने लगे। गांव के किसानों से अनुसंधान परिषद, सीएसआईआर-आईएचबीटी तथा संस्थान के निदेशक और वैज्ञानिकों ने ... हैदराबाद विश्वविद्यालय), डॉ उमा रामकृष्णन (प्रोफेसर, नेशनल सेंटर फॉर बायोलॉजिकल साइंसेज, बेंगलुरु), डा. मीनाक्षी सिंह (मुख्य वैज्ञानिक, सीएसआईआर मुख्यालय, नई ...

40th foundation day of IHBT celebrated

OUR CORRESPONDENT

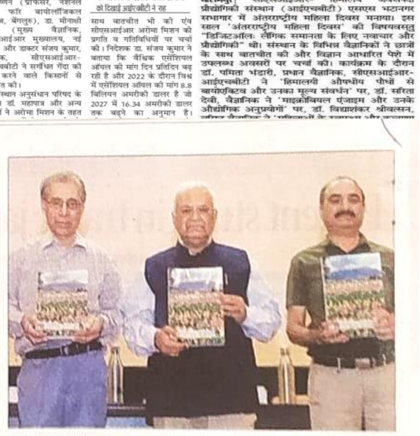
PALAMPUR, JULY 2

The 40th foundation day of the CSIR-Institute of Himalayan Bioresource Technology (CSIR-IHBT), Palampur, was celebrated here on Saturday.

Dr T Ramasami, former secretary, Department of Science and Technology, Government of India, delivered a speech on "Towards sustainable bioeconomy path of Himalayan biosphere". Apart from highlighting the contributions made by CSIR-IHBT in society over the last 40 years, Dr Ramasami also suggested to focus upon developing technological solutions for sustainable bioeconomy. He is of the opinion that CSIR-IHBT has to play a crucial role of serving the nation as a path ?nder towards sustainable economy using resources available in Himalayan biosphere. He emphasised on three pillars for sustainable development i.e. bearable, equitable and viable.

Earlier, the director of the institute, Dr Sanjay Kumar presented an annual report of the institute for 2021-22. He said under the Phase II of the Aroma Mission, the institute covered an area of 1,398 hectares under aromatic crops and expanded its cultivation in 12 states and two Union Territories. During the year, Himachal Pradesh has maintained its position as the top producer of marigold oil in the country with a production of 7.3 tonne of oil with institutional efforts.

Under the Floriculture Mission, the area was expanded to 350 hectares, benefiting 1,004 farmers.



A book on IHBT achievements is released in Palampur. TRIBUNE PHOTO

European GI tag for Kangra tea likely

TRIBUNE NEWS SERVICE

SHIMLA, APRIL 6

Kangra tea is likely to be awarded the Geographical Indication Tag (GI tag) for the European Union, a spokesperson of the Agriculture Department said here today.

He said that the subject of Tea Cultivation and Development was transferred from the Industries Department to the Agriculture Department in April, 1999. Since then, various steps have been taken to improve tea cultivation in the state, particularly in Kangra.

Kangra Tea was accorded the GI tag in India in 2005.

The spokesperson said that at present, the development and cultivation of Kangra Tea is being promoted and looked after by four departments, namely Tea Board of India Regional office Palampur, cooperative & agriculture department ... CSIR IHBT Palampur and Chaudhary Sarwan Kumar Agriculture University, Palampur.

He said that more than one lakh plants were provided to tea growers in the financial year 2021-22 and an area of 5.6 hectares was brought under fresh plantation. The department is providing the tea plants to growers both for the existing gardens and also for fresh plantations.

'The department is also organising the awareness programmes to impart the latest technical know-how being developed by the research institutes in the field of tea cultivation ...

गुड न्यूज चाय की गुणवत्ता में निरंतर हो रहा सुधार, भौगोलिक संकेतक मिलने की संभावना

कांगड़ा चाय को शीघ्र मिलेगा यूरोपीय संघ का जीआई टैग!

हिमाचल दस्तक ■ शिमला

कृषि विभाग के एक प्रवक्ता ने बताया कि सभी संबद्ध विभागों के सामूहिक प्रयासों से कांगड़ा चाय की गुणवत्ता में निरंतर सुधार हो रहा है और शीघ्र ही कांगड़ा चाय को यूरोपीय संघ के जीआई टैग (भौगोलिक संकेतक) मिलने की संभावना है।

उन्होंने कहा कि चाय की खेती और विकास का विषय अप्रैल 1999 में उद्योग विभाग से कृषि विभाग को स्थानांतरित किया गया था। इसके उपरांत प्रदेश में और विशेष तौर पर कांगड़ा चाय की खेती में सुधार लाने के लिए अनेक कदम उठाए गए हैं। विभाग के अथक प्रयासों के परिणामस्वरूप वर्ष 2005 में कांगड़ा चाय को भारत में जीआई टैग मिला था। प्रवक्ता ने बताया कि वर्तमान में 4 विभागों टी बोर्ड ऑफ इंडिया के क्षेत्रीय कार्यालय पालमपुर, राज्य के सहकारी और कृषि विभाग, सीएसआईआर-आईएचबीटी पालमपुर और चौधरी सरवण कुमार कृषि विश्वविद्यालय पालमपुर कांगड़ा चाय की खेती को बढ़ावा देने के लिए प्रयास कर रहे हैं।

उन्होंने कहा कि वित्तीय वर्ष 2021-22 में चाय उत्पादकों को एक लाख से अधिक पौधे प्रदान किए गए और 5.6 हेक्टेयर नए क्षेत्र में चाय की पौध लगाई गई है। विभाग चाय उत्पादन को बढ़ावा देने के लिए सामान्य वर्ग के किसानों को 2 रुपये प्रति पौधा तथा अनुसूचित जाति वर्ग के किसानों को 1 रुपये प्रति पौधा उनके घरद्वार पर उपलब्ध करवा रहा है।

आईएचबीटी पालमपुर में किया था टी-फेयर का आयोजन

विभाग भारतीय टी बोर्ड और चौधरी सरवण कुमार कृषि विश्वविद्यालय के चाय विभाग के वैज्ञानिकों के संयुक्त तत्वावधान में जागरूकता एवं प्रशिक्षण कार्यक्रम आयोजित कर रहा है, जिससे अनुसंधान संस्थानों द्वारा विकसित की जा रही नई तकनीकों का प्रशिक्षण प्रदान कर चाय की खेती को बढ़ावा दिया जा सके। 14 दिसंबर, 2021 को आईएचबीटी पालमपुर द्वारा टी-फेयर का आयोजन किया गया था, जिसमें बड़े चाय बागानों, छोटे उद्यमियों और स्वयं सहायता समूहों व चाय उत्पादकों ने भाग लिया था।

कांगड़ा में भी शुरू हुई जायका परियोजना

वरिष्ठ संवाददाता ■ शिमला

हिमाचल में 800 करोड़ की जापान अंतरराष्ट्रीय सहयोग एजेंसी (जायका) परियोजना में कांगड़ा जिला को भी जोड़ लिया गया है। कांगड़ा जिला के अंतर्गत धर्मशाला वन वृत के तीनों वन मंडलों (नूरपुर, धर्मशाला व पालमपुर) तथा हमीरपुर वन वृत के एक वन मंडल (देहरा) के 11 वन परिक्षेत्रों को शामिल किया गया है। जिसका कार्यान्वयन वित्तीय वर्ष 2022-23 से शुरू कर दिया गया है।

ऐसे में अब यह परियोजना प्रदेश के 7 जिलों के अंतर्गत 22 वनमंडलों, जिसमें 20 क्षेत्रीय व 2 वन्य प्राणी वनमंडल शामिल हैं। ऐसे में 72 वन परिक्षेत्रों, जिसमें 67 क्षेत्रीय एवं 5 वन्य प्राणी परिक्षेत्र

■ **अब प्रदेश के 7 जिलों में चल रही परियोजना**

शामिल हैं। यहां पर यह परियोजना चल रही है। गौरतलब है कि कोविड-19 महामारी से पूरे विश्व के साथ-2 भारतवर्ष समेत प्रदेश भी ग्रसित रहा। इसके कारण जनजीवन की वित्तीय स्थिति दयनीय हुई है। इस महामारी के कारण हिमाचल प्रदेश के आबादी के लिहाज से सबसे बैंडे जिला कांगड़ा के लोगों के जीवन स्तर पर भी बहुत बुरा असर पड़ा है। इस बात को ध्यान में रखते हुए वन, युवा सेवाएं एवं खेल मंत्री राकेश पठानिया की ओर से कांगड़ा जिले को परियोजना में शामिल करने के लिए हिमाचल सरकार ने भारत सरकार को एक प्रस्ताव भेजा था।

पहल जिला चंबा के चुराह के किसान संजय जरयाल ने क्षेत्र के 25 युवाओं को रोजगार से जोड़ा

अंतरराष्ट्रीय बाजार में बढ़ी लैवेंडर तेल की मांग

सुभाष कुमार अग्निहोत्री

चंबा। अंतरराष्ट्रीय बाजार में लैवेंडर तेल की मांग बढ़ गई है। इससे चुराह क्षेत्र के किसान खुश हैं। विदेश-देश से लैवेंडर तेल और फूलों की बढ़ती मांग को पूरा करना उनके लिए चुनौती बन गया है।

उत्तराखंड से दो लाख लैवेंडर फूलों की स्टिक की मांग को पूरा करने के लिए उन्हें जम्मू-कश्मीर से भी लैवेंडर फूल मंगवाने पड़े। किसान संजय जरयाल लैवेंडर फूलों की खेती कर क्षेत्र के 25 युवाओं को रोजगार के साथ जोड़ने में अहम भूमिका निभा रहे हैं। संजय जरयाल ...

देश-विदेश से आ रहे ऑर्डर, उत्तराखंड में स्टिक की मांग पूरा करने के लिए जम्मू-कश्मीर से मंगवाने पड़े लैवेंडर फूल

चंबा के चुराह क्षेत्र में लैवेंडर की खेती करने में जुटे किसान। संवाद

की चाह में अन्य किसानों के लिए प्रेरणास्त्रोत बन गए हैं। चुराह विधानसभा क्षेत्र का सेईकोठी इलाका ... उपयुक्त साबित हो रहा है। लैवेंडर फूलों से तेल निकालने के बाद इसे भारतीय और अंतरराष्ट्रीय बाजार में भेजा जा रहा है। ...

संजय जरयाल ने बताया कि वह 15 वर्षों से लैवेंडर फूलों की खेती कर रहे हैं। लैवेंडर की विशेषता यह है कि फूल, स्टिक समेत पौधे की भी ...

गरीब व्यक्तियों के जीवन को बेहतर बनाने के लिए करें काम

आई.एच.बी.टी. पालमपुर में सी.एस.आई.आर. निदेशकों का सम्मेलन

सीएसआइआर की परियोजनाओं की प्रगति की समीक्षा

संवाद सहयोगी, पालमपुर : सीएसआइआर निदेशकों का सम्मेलन-2022 सीएसआइआर हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पालमपुर में शुरू हुआ है। सम्मेलन का विषय 'समाज और उद्योग के लिए सीएसआइआर' है। ...

विज्ञान के क्षेत्र में सीएसआइआर का सराहनीय कार्य

संवाद सहयोगी, पालमपुर : सीएसआइआर की महानिदेशक डा. एन कलैसेल्वी ने रविवार को हिमालय जैव प्रौद्योगिकी संस्थान सीएसआइआर-आइएचबीटी ...

- सीएसआइआर की महानिदेशक ने सीएसआइआर आइएचबीटी पालमपुर में शोधार्थी प्रोत्साहित किए
- कुशल नेतृत्व व टीम भावना के माध्यम से सब कुछ हो रहा साकार : डा. एन कलैसेल्वी

देश में दालचीनी के उत्पादन का 'ध्वजवाहक' बनेगा हिमाचल

चीन व वियतनाम जैसे देशों से प्रतिवर्ष लगभग 1000 करोड़ रुपए की 45 हजार टन दालचीनी का आयात करता है भारत

पालमपुर, 2 अप्रैल (भृगु): अपने ही देश के पौधे को बड़े स्तर पर लगाए जाने का ध्वजवाहक हिमाचल बनेगा। प्रदेश में बड़े स्तर पर दालचीनी का उत्पादन किया जाएगा। प्रदेश सरकार ने भी बजट में दालचीनी का प्रदेश में उत्पादन किए जाने की घोषणा की है। वहीं हिमालय जैवसंपदा प्रौद्योगिकी संस्थान पहले ही इस दिशा में कार्य आरंभ कर चुका है जिसके परिणाम आशातीत सफल रहे हैं।

प्रदेश के निचले क्षेत्रों की जलवायु दालचीनी के उत्पादन के लिए उपयुक्त

हिमालय जैवसंपदा प्रौद्योगिकी संस्थान के वैज्ञानिकों ने भौतिक व पर्यावरणीय परिस्थितियों के आधार पर मॉडल का अध्ययन कर इस बात को सुनिश्चित बनाने का प्रयास किया है कि प्रदेश में किन-किन स्थानों पर दालचीनी का सफलतापूर्वक उत्पादन किया जा सकता है। इस अध्ययन में यह तथ्य सामने आया है कि प्रदेश के निचले क्षेत्रों बिलासपुर, हमीरपुर,

ऊना, कांगड़ा के निचले क्षेत्रों तथा पौंग डैम के आसपास के क्षेत्रों की जलवायु दालचीनी के उत्पादन के लिए उपयुक्त पाई गई है। ऐसे में संस्थान ने पायलट प्रोजैक्ट के अंतर्गत कुछ हजार पौधे दालचीनी के लगाए जिनके परिणाम आशातीत सफल रहे हैं। ऐसे में अब बड़े स्तर पर दालचीनी के उत्पादन को लेकर संस्थान प्रदेश सरकार के साथ आगे बढ़ने को तैयार है।

"संस्थान ने ऐसी फसलों पर अपना शोध तथा अध्ययन केंद्रित किया है जो दूसरे देशों से आयात की जाती हैं। दालचीन भी इनमें से एक है। दालचीनी का आयात बड़े स्तर पर विदेशों से किया जाता है। ऐसे में अब प्रदेश में दालचीनी की पैदावार बड़े स्तर पर हो सके इसके लिए संस्थान प्रदेश सरकार के साथ मिलकर कार्य करेगा। प्रदेश सरकार ने भी बजट में प्रदेश में दालचीनी के उत्पादन को बढ़ावा देने का निर्णय लिया है, जो सुखद है।
–डा. संजय कुमार, निदेशक हिमालय जैवसंपदा प्रौद्योगिकी संस्थान

Farmers and members of co-operative societies at CSIR.

Experts inspire farmers to grow aromatic marigold

OUR CORRESPONDENT

PALAMPUR, MAY 25

The CSIR-IHBT, Palampur, organised aromatic marigold day — the harbinger of golden revolution ... ing, practical demonstration and interaction with progressive farmers of aromatic marigold from different villages of Himachal Pradesh.

Dr Sanjay Kumar, Director, CSIR-IHBT, Palampur said ...

हिमाचल सवेरा

सीएसआईआर-आईएचबीटी में पोषण मैत्री अभियान पर कार्यक्रम सम्पन्न

● बच्चों एवं महिलाएं सामान्य से कम वजन, स्टंटिंग या एनीमिया से है कुपोषित

सीएसआईआर–आईएचबीटी पालमपुर में आयुर्वेद दिवस का आयोजन

कार्यालय संवाददाता-पालमपुर

सीएसआईआर–आईएचबीटी पालमपुर में 7वां आयुर्वेद दिवस आयोजित किया गया। इसका आयोजन आयुष मंत्रालय द्वारा हर ... अपने संबोधन में आयुर्वेद आधारित मानव प्रकृति पर अपने व्याख्यान में कफ, पित्त एवं वात प्रकृति के अनुसार उपचार एवं आहार संबंधी जानकारी प्रदान की। यही ही नहीं, इस अवसर पर ...

सीएसआईआर आईएचबीटी में 7 वां आयुर्वेद दिवस आयोजित

सवेरा न्यूज / ... पालमपुर 17 अक्तूबर सीएसआईआर-आईएचबीटी पालमपुर में 7वां आयुर्वेद दिवस 14 अक्तूबर 2022 को आयोजित किया गया। ...

कार्यक्रम में उपस्थित लोग।

सीएसआईआर–आईएचबीटी के प्रयास सराहे

केंद्रीय मंत्री साध्वी निरंजन ने हिमालयी जैव संपदा प्रौद्योगिकी संस्थान का किया दौरा

कार्यालय संवाददाता- पालमपुर

केंद्रीय राज्य मंत्री, ग्रामीण विकास मंत्रालय, उपभोक्ता मामले, खाद्य और सार्वजनिक वितरण मंत्रालय साध्वी निरंजन ज्योति ने सीएसआईआर–हिमालयी जैव संपदा प्रौद्योगिकी संस्थान का दौरा किया। साध्वी निरंजन ज्योति ने उच्च शोध आधारित प्रौद्योगिकियों के विकास और ग्रामीण अर्थव्यवस्था को बढ़ावा देने के लिए उनकी तैनाती के माध्यम से संस्थान द्वारा किए गए योगदान की सराहना की । उन्होंने अरोमा ए फूलों की खेती और बांस मिशन जैसे अपने कार्यक्रमों के माध्यम से किसान और ग्रामीण समुदायों का समर्थन करने के लिए संस्थान के प्रयासों की प्रशंसा की ए जो किसानों ए बेरोजगार युवाओं और उद्यमिता विकास के बीच क्षमता निर्माण में मदद करते हैं । हींग,

केसर, मॉक फल और दालचीनी की खेती के अलावा, उन्होंने सुगंधित गेंदे के तेल के उत्पादन के लिए प्रदेश को भारत में नंबर एक राज्य बनाने के लिए सीएसआईआर–आईएचबीटी के प्रयासों की सराहा । इस अवसर पर माननीय मंत्री जी ने संस्थान की प्रदर्शनी एवं सुविधाओं का भी अवलोकन किया। डा. संजय कुमार ए निदेशक ए सीएसआईआर–आईएचबीटी ने मंत्री को संस्थान की प्रमुख उपलब्धियों और अनुसंधान गतिविधियों के बारे में जानकारी दी । उन्होंने कहा कि संस्थान गेंदा ए डैमस्क गुलाब, लेमन ग्रास आदि सुगंधित फसलों के प्रसंस्करण के माध्यम से महत्वपूर्ण भूमिका निभा रहा है जिससे किसान आत्मनिर्भर हो रहे हैं और पारंपरिक फसलों की तुलना में अधिक आय प्राप्त कर रहे हैं । डा. कुमार ने बताया कि सीएसआईआर–आईएचबीटी ग्रामीण समुदायों को प्रशिक्षण ए कौशल विकास और उद्यमिता विकास में सहयोग देने के लिए अथक प्रयास कर रहा है ।

Himachal's Palampur on way to becoming 'tulip city' of country

Yudhvir.Rana@timesgroup.com

Palampur: Encouraged by the public response and success of growing tulips in Palampur, the Council of Scientific and Industrial Research (CSIR)-Institute of Himalayan Bioresource Technology (IHBT) here has planted over 40,000 tulip bulbs of various colours in an effort to promote Palampur as "tulip city" of India.

"Last year, we had planted around 28,000 bulbs, but this year we have planted over 40,000 bulbs, which were grown by around two dozen farmers of Lahaul and Spiti

Tulips were a temperate crop and the bulbs require a cold temperature regime for flower initiation. Tulips grown in hills require a day temperature of 20-26°C and a night temperature of 5-12°C during the growth period.

"Open places that receive maximum sunlight for most part of the day are most suitable for its cultivation. Plants can be grown outdoors and under greenhouse conditions. It can grow in pots, containers, prepared beds, borders, basins of the other orchards like apple, cherry, etc. which are best for its cultivation," said Bhargava

सीएसआईआर-आईएचबीटी द्वारा स्कूलों में चलाया गया पौधारोपण अभियान

स्कूलों के छात्र पौधारोपण के उपरांत उपस्थित सामूहिक चित्र में।

सवेरा न्यूज / जसवंत कठियाल(पालमपुर): सीएसआईआर हिमालय आईएचबीटी पालमपुर संस्थान द्वारा फ्लोरिकल्चर मिशन के उपशीर्ष अर्बन फ्लोरिकल्चर अंतर्गत पिछले सप्ताह पालमपुर ब्लॉक, जलि कांगड़ा, हि.प्र. के 6 सरकारी विद्यालयों में उद्यान विकसित करवाने हेतु विभिन्न प्रकार के लगभग 650 पौधे लगवाए गए। जिनमें राजकीय वरिष्ठ माध्यमिक पाठशाला, लाहला व डाढ; शहीद राके

Liquorice (*mulethi*) plants bloom in Palampur. TRIBUNE PHOTO

A first: Commercial cultivation of liquorice begins in Palampur

OUR CORRESPONDENT

PALAMPUR FEBRUARY 20

For the first time in the state, the commercial cultivation of liquorice (*mulethi*) has been started by the CSIR-Institute of Himalayan Bioresource

heart diseases, coughs, low blood pressure, liver toxicity and pancreatic disorders.

Liquorice is grown mainly in Afghanistan, while minor producing countries include Pakistan, China, Nepal and India. India imports 8,047 tonnes of

ट्यूलिप के फूलों की विभिन्न रंगों और आकृतियों के खूबसूरत फूलों के कारण अंतरराष्ट्रीय बाजार में अच्छी मांग

सीएसआईआर आईएचबीटी पालमपुर में खिले ट्यूलिप, फूल दिला रहे कश्मीर का अहसास

सवेरा न्यूज/जसवंत कठियाल

पालमपुर, 26 फरवरी : कश्मीर ही नहीं अब हिमाचल प्रदेश के पालमपुर

फूलों की खेती, कृषि प्रौद्योगिकी विभाग, सीएसआईआर-आईएचबीटी पालमपुर ने बताया कि यहां

डा. प्रबोध त्रिवेदी ने संभाला आई.एच.बी.टी. के निदेशक का अतिरिक्त प्रभार

पालमपुर : आई.एच.बी.टी. के नए निदेशक डा. त्रिवेदी साथ सेवानिवृत्त निदेशक डा. संजय। (भृगु)

पालमपुर, 2 मार्च (भृगु): वैज्ञानिक और औद्योगिक अनुसंधान परिषद नई दिल्ली द्वारा एक अंतरिम व्यवस्था के रूप में डा. प्रबोध कुमार त्रिवेदी को

पालमपुर का ट्यूलिप गार्डन बना सैल्फी प्वाइंट

गार्डन की सुंदरता को निहारने के लिए बड़ी संख्या में आगंतुक पहुंचने लगे

पालमपुर, 26 फरवरी (भृगु): रंग-बिरंगी होली की आहट के मध्य पालमपुर का ट्यूलिप गार्डन लोगों को आकर्षित करने लगा है। हिमालय जैव संपदा प्रौद्योगिकी संस्थान में को देखने के लिए किसी प्रकार का शुल्क निर्धारित नहीं किया गया है तथा लोग बड़ी संख्या में सन पर पहुंच कर न केवल ट्यूलिप पोस्ट की रंग-बिरंगी छटा का आनंद ले रहे हैं अपितु यह एक बड़ा सैल्फी प्वाइंट भी बनकर उभरा है।

पालमपुर में विकसित इस ट्यूलिप गार्डन में पुष्पन का समय फरवरी के अंत तथा मार्च का महीना माना जाता है जबकि श्रीनगर में ट्यूलिप गार्डन में पुष्पन का समय अप्रैल माह है।

1000 वर्ग मीटर में विकसित है ट्यूलिप गार्डन

लगभग 1000 वर्ग मीटर में विकसित इस ट्यूलिप गार्डन में 30,000 ट्यूलिप की पौध लगाई गई है तथा वैज्ञानिकों के अनुसार ट्यूलिप का एक फूल 15 दिन तक पूरी तरह से खिला रहता है। यह विश्व में सबसे अधिक खरीदे जाने वाले फूलों में से एक है तथा ट्यूलिप विश्व का ऐसा तीसरा फूल है जिसकी सबसे अधिक खरीद होती है। अपने मनमोहक लाल, पीले व श्वेत तथा गुलाबी चटक रंगों के कारण यह फूल आकर्षण का केंद्र रहता है। भारत में प्रतिवर्ष विदेशों से 50 करोड़ के ट्यूलिप का आयात किया जाता है।

कार्यशाला | सीएसआईआर-आईएचबीटीए पालमपुर में महिला सशक्तिकरण पर कार्यशाला का किया आयोजन

गंदर्भा राठौर ने दिया महिलाओं को मंत्र

कार्यालय संवाददाता-पालमपुर

सीएसआईआर-आईएचबीटीए पालमपुर में एक सप्ताह एक विकसित प्रौद्योगिकियों को अपनाने पर बल दिया, ताकि वे अपनी आर्थिकी को सुधार कर सक्षम बन सकें। इस समारोह में संस्थान की मुख्य वैज्ञानिक डा. अपर्णा मैत्रा ने मुख्यातिथि एवं

Prabodh Trivedi new Director of CSIR-IHBT

PALAMPUR, MARCH 2

Prabodh Kumar Trivedi today took charge as the Director of the CSIR-Institute of Himalayan Bioresource Technologies (IHBT), Palampur. At present, Trivedi is the Director of the CSIR-Central Institute of Medicinal and Aromatic Plants (CIMAP), Lucknow.

It is an interim arrangement made by the Council of Scien-

Sanjay Kumar had served the CSIR-IHBT for over 33 years on different positions; he was the Director of the institute for almost eight years.

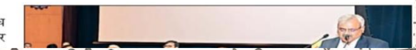
Trivedi appreciated Sanjay Kumar's commendable contribution and assured him that he would carry forward initiatives taken by him with full commitment.

The heads of different departments

डा. प्रबोध त्रिवेदी ने सम्भाला सीएसआईआर-आईएचबीटी के निदेशक का अतिरिक्त प्रभार

सवेरा न्यूज/जसवंत कठियाल

पालमपुर, 2 मार्च : डा. प्रबोध कुमार त्रिवेदी को वैज्ञानिक और



प्रदेश के किसानों की आर्थिकी मजबूत करेगी फूलों की खेती

सीएसआईआर-आईएचबीटी संस्थान पालमपुर में ट्यूलिप गार्डन का सफल परीक्षण, इस साल से लद्दाख में भी तैयार होगा ट्यूलिप गार्डन

संवाद न्यूज एजेंसी

पालमपुर (कांगड़ा)। सीएसआईआर-आईएचबीटी संस्थान पालमपुर में इन दिनों लोगों के आकर्षण का केंद्र बना ट्यूलिप गार्डन आने वाले दिनों में किसानों की आर्थिकी को काफी मजबूत करेगा। सीएसआईआर में इस समय ट्यूलिप गार्डन में लगे फूलों को देखने लोग देश समेत विदेशों से भी आ रहे हैं। अभी तक करीब 60 हजार से अधिक लोग ट्यूलिप गार्डन को देख चुके हैं।

हॉलैंड से आयात फूलों का बीज किया जा रहा विकसित

अमर उजाला एक्सक्लूसिव

दिनों में आर्थिकी मजबूत करने के लिए सीएसआईआर की ओर से तीन हजार कन्द (फूलों का बीज) भेजा दिए हैं। इससे लद्दाख में भी अब फूलों की खेती होगी। जबकि लाहौल स्पीति में पहले ही सफल ट्रायल किया जा चुका है।

पालमपुर में सीएसआईआर का ट्यूलिप गार्डन। संवाद

विदेशों से आयात होने वाले बीज होंगे उपलब्ध

सीएसआईआर के अतिरिक्त कार्यभार देख रहे निदेशक डॉ. प्रबोध कुमार त्रिवेदी ने कहा कि अभी तक यह कन्द हॉलैंड से मंगाया जाता है। इसका कन्द लोगों को 30 से 35 रुपये में मिलता है। अब सीएसआईआर पालमपुर अपने स्तर पर इसका बीज पैदा करने लगा है। जिस पर काफी शोध हुआ है। आने वाले दिनों में किसानों को यहां से 15 से 20 रुपये में एक कन्द मिल जाएगा। इससे जल्द ही किसानों के खेतों में फूलों की खेती लहराएगी और आर्थिकी मजबूत होगी।

सकते हैं। इससे प्रदेश के किसानों की आर्थिक मजबूत होगी। अच्छी तरह से तैयार होने वाले इस फूल की कीमत 30 से 35 रुपये किसान को मिलेगी।

सीएसआईआर संस्थान पालमपुर ने इस साल करीब 45 हजार अलग-

काफी खुश है। ट्यूलिप गार्डन का जिम्मा संभाले सीएसआईआर के वरिष्ठ वैज्ञानिक डॉ. भव्य भार्गव का कहना है कि पालमपुर में इसका ट्रायल सफल रहा है।

इस बार यह ट्यूलिप गार्डन लद्दाख में भी तैयार होगा। कहा कि

सीएसआईआर-आईएचबीटी 'एंजाइम बायोप्रोसैसिंग' पर कौशल विकास के माध्यम से युवाओं को कर रहा प्रोत्साहित

सवेरा न्यूज/जसवंत कठियाल

पालमपुर, 13 मार्च : सीएसआईआर हिमालय जैवसंपदा प्रौद्योगिकी संस्थान (आईएचबीटी), पालमपुर में एंजाइम बायोप्रोसेसिंग पर 5 दिवसीय उद्यमिता कौशल विकास कार्यक्रम (ई-एसडीपी) की सोमवार से शुरूआत हुई। यह कार्यशाला, भारत सरकार के सूक्ष्म, लघु और मध्यम उद्यम मंत्रालय (एमएसएमई) द्वारा वित्त पोषित है। यह प्रोग्राम 13-17 मार्च, 2023 तक जारी रहेगा और प्रतिभागियों को एंजाइम बायोप्रोसैसिंग में नवीनतम प्रगति की व्यापक समझ प्रदान करेगा। कार्यशाला का मुख्य उद्देश्य विभिन्न

कार्यशाला में भाग ले रहे प्रतिभागी छात्र व अन्य।

क्षेत्रों में एंजाइम बायोप्रोसैसिंग के अवसरों और क्षमता के बारे में युवा उद्यमियों और छात्रों के कौशल को बढ़ाना और जागरूकता पैदा करना है। इसके अलावा, इस प्रोग्राम में एंजाइम उत्पादन, शुद्धिकरण और लक्षण वर्णन जैसे विभिन्न पहलुओं में व्यावहारिक प्रशिक्षण भी प्रदान किया जाएगा। कार्यशाला को एंजाइम बायोप्रोसैसिंग में रुचि रखने वाले छात्रों, शोधकर्ताओं, उद्यमियों और उद्योग के पेशेवरों की जरूरतों को पूरा करने के लिए डिजाइन किया गया है। डा. प्रबोध कुमार त्रिवेदी, निदेशक, सीएसआईआर-आईएचबीटी ने कार्यशाला का उद्घाटन किया और प्रतिभागियों को संबोधित किया। उन्होंने युवाओं में उद्यमिता विकसित करने और भारत को एंजाइम उत्पादन में आत्मनिर्भर बनाने के लिए ऐसे कार्यक्रम की आवश्यकता पर बल दिया। डा. त्रिवेदी ने प्रतिभागियों को सीएसआईआर-आईएचबीटी में स्थापित एंजाइम बायोप्रोसैसिंग सुविधा का पूरा उपयोग करने और उनके भविष्य के प्रयासों में संस्थागत सहयोग सुनिश्चित करने के लिए भी आश्वासन दिया। प्रोफेसर रूप लाल, वरिष्ठ वैज्ञानिक भारतीय राष्ट्रीय विज्ञान अकादमी, दिल्ली विश्वविद्यालय ने इरिकामाइसिन बी एनालॉग्स के बायोप्रोसेस विकासइ पर मुख्य भाषण दिया।

हमारे दैनिक जीवन में सूक्ष्मजीवों के महत्व पर प्रकाश डाला। इस कार्यक्रम में, डॉ. संजय कुमार, पूर्व निदेशक, सीएसआईआर-आईएचबीटी ने अपने व्याख्यान में औद्योगिक क्षेत्रों से एंजाइम बायोप्रोसैसिंग में गुंजाइश, अवसरों और चुनौतियों के बारे में चर्चा की। इससे पूर्व, इस कार्यक्रम के समन्वयक, डा. धर्म सिंह, प्रधान वैज्ञानिक ने प्रतिभागियों को कार्यशाला के लक्ष्य एवं उद्देश्य के बारे में जानकारी दी। कहा कि सीएसआईआर-आईएचबीटी में स्थापित एंजाइम बायोप्रोसैसिंग सुविधा स्टार्ट-अप और इन्क्यूबेटरों को बड़े पैमाने पर उत्पादन, शुद्धिकरण और औद्योगिक स्तर पर नए प्रोटीन और एंजाइम के अप-स्केलिंग के लिए एक महत्वपूर्ण प्लेटफार्म है। समग्र रूप से, पूरे भारत के विभिन्न संस्थानों (आईआईटी, केंद्रीय विश्वविद्यालयों, निजी और राज्य विश्वविद्यालयों/संस्थानों, आईसीजीईबी, सीएसआईआर, और डीबीटी संस्थानों) से बीस (20) प्रतिभागी इस कार्यशाला में भाग ले रहे हैं।

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Innovation Hub for Better Tomorrow

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

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

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

वार्षिक प्रतिवेदन 2022 - 23 Annual Report