SOUVENIR

National Seminar on

Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH)

November 27-28, 2023

Solan, Himachal Pradesh

Organizers

Co-organizers

Sponsors

National Seminar
on
Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH)

27-28 November 2023

SOUVENIR

Organized by

Indian Society of Plant Genetic Resources (ISPGR), New Delhi
Shoolini University (SU), Solan, Himachal Pradesh
ICAR- National Bureau of Plant Genetic Resources (NBPGR), New Delhi

Co-organized by

Protection of Plant Varieties and Farmers' Rights Authority (PPVFRA), New Delhi
Alliance for Bioversity International and CIAT, New Delhi
Trust for Advancement of Agricultural Sciences (TAAS), New Delhi
Chaudhury Sarwan Kumar Himachal Pradesh Krishi Vishwavidyalaya (CSKHPKV),Palampur
Dr YS Parmar University of Horticulture and Forestry (YSPUHF), Solan

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Messages

Shiv Pratap Shukla
Governor
Himachal Pradesh

सत्यमेव जयते

आज़ादी का अमृत महोत्सव

शिव प्रताप शुक्ल
राज्यपाल
हिमाचल प्रदेश

MESSAGE

I am happy to know that the Indian Society of Plam Genetic Resources (ISPGR) is organizing National Seminar onVlant Biodiversity for Food, Nutrition and Health Security in North-Western Himalayas (PBFSNWH)on 27-28 November. 2023 at Shoolini University Solan Himachal Pradesh in collaboration with ICAR-National Bureau of Plam Genelic Resources, Trust for Advancement of Agriculture Science. Alliance for Bioversity International and CIAT. and other partners.

Himalayas, including N-W Himalayan region is endowed with an array of genetic resources of crop plants, their wild relatives and a plethora of edible wild plants supporting 85% of the region's population on agriculture for their fond and daily needs. The region is very rich in species diversity of cereals, millets, pseudo cereals, pulses, oilseeds, vegetables, fruits, spices and condiments, fibers etc. There has to be a national action plan for further strengthening their collection, evaluation. conservation and sustainable utilisation of invaluable genetic resources.

I am sure that the outcome of this seminar would be usetul to develop a roadmap for further strengthening act ion-ori en ted framework, which would cater to the cause of our farming community in general and Himalayan people in particular.

I extend my good wishes to the organizers and participants and also wish the seminar all success.

(Shiv Pratap Shukla)

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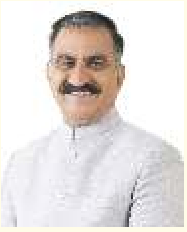

सुखविंदर सिंह सुक्खू
SUKHVINDER SINGH SUKHU

मुख्य मन्त्री
हिमाचल प्रदेश
CHIEF MINISTER
HIMACHAL PRADESH

Message

I am delighted to know that Shoolini University of Biotechnology and Management Sciences in association with Indian Society of Plant Genetic Resources (ISPGR) and ICAR-National Bureau of Plant Genetic Resources is organizing a National Seminar on the theme **'Plant** Biodiversity for Food, Nutrition and Health Security in North Western Himalayas' in Shoolini University on 27th and 28th November, 2023.

Plant biodiversity plays a crucial role in global food production, ensuring soil productivity and providing the genetic resources for crops. Investigating genetic potential is crucial for meeting the needs of a growing population, but sustaining biodiversity faces challenges like habitat loss, over-exploitation of resources, climate changes, pollution, invasive exotic species, diseases, hunting etc.

Himachal Pradesh, rich in horticulture diversity, holds the key to addressing challenges in food, nutrition and health security in the North-Western Himalayas. Although, progress has been made in calorie intake, malnutrition still remains a serious concern. Access to nutritious food is essential and exploring the region's plants species can contribute to health and nutritional security.

I wish the conference a grand success.

(Sukhvinder Singh Sukhu)

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Mukesh Agnihotri
Deputy Chief Minister
Himachal Pradesh
H.P. Secretariat, Shimla
Phone : 0177-262581, 2620530

मुकेश अग्निहोत्री
उप मुख्यमंत्री, हिमाचल प्रदेश
हिमाचल प्रदेश सचिवालय, शिमला
फोन : 0177.2621581, 2620530

Message

It is indeed a great pleasure for me to know that Shoolini University is organizing a National Seminar on "Plant Biodiversity for Food, Nutrition and Health Security in North Western Himalayas" on November 27-28, 2023.

Biodiversity contributes directly to food security, nutrition and well-being by providing a variety of plant and animal food from domesticated and wild sources. Biodiversity can also serve as a safety-net to vulnerable households during times of crisis, present income opportunities to the rural population, and sustain productive agriculture ecosystems, Exploring the hidden treasure of the North Western Himalayas will not only help us with the nutritional security but also the health security as the diverse plant population provides us with several medicinal benefits. The different crop varieties used in agriculture around the world are based on the world's genetic diversity. The age-old traditional values attached with the various medicinal plants have gained tremendous importance in the present century as the industries are increasingly using natural ingredients in their products. These natural ingredients inqlude extracts of many medicinal plants.

The seminar's cross-cutting initiative on biodiversity for food and nutrition aims to promote the sustainable use of biodiversity contributing to food security and improved human nutrition. Efforts to link biodiversity, food and nutrition issues are expected to contribute in achieving the Millennium Development Goals. This initiative will thereby raise awareness on the importance of biodiversity, its conservation and sustainable use. The seminar will be a splendid medium for accumulation and dissemination of valuable information about the genetic plant resources which can contribute towards food and nutritional security.

I wish the conference a grand success and congratulate all the organizers involved in the conference, for bringing it live on varied platforms.

(Mukesh Agnihotri)

mukeshagnihotri01@gmail.com Mukesh Agnihotri @Agnihotridycm agnihotridycm

प्रो. चन्द्र कुमार
Pro. Chander Kumar

कृषि एवं पशु पालन मन्त्री,
हिमाचल प्रदेश, शिमला-171002.
MINISTER OF AGRICULTURE & ANIMAL HUSBANDRY
HIMACHAL PRADESH, SHIMLA-171002

Message

It is a matter of great pleasure that Shoolini University is going to host the National Seminar on 'Plant Biodiversity for Food, Nutrition and Health Security in North Western Himalayas' on 27th and 28th November, 2023.

Biodiversity gives the answer to the several sustainable development challenges. The State Government has taken several steps to save and conserve biodiversity. Himachal Pradesh's diverse climate contributes to its enormous agro-biodiversity. Biodiversity at every level (genetic, species and ecosystem level) is the foundational pillar for food security nutrition and dietary quality.

Biodiversity can also serve as a safety-net to vulnerable households during times of crisis, provide income opportunities to the rural poor and sustain productive agricultural ecosystems. Moreover, an effective biodiversity framework in agriculture enhances ecosystem services, contributing to soil fertility and overall ecosystem health.

I hope the farmers, researchers and students would be benefitted by the deliberations of experienced delegates and also get an appropriate platform to exhibit their talent in research and other works.

I extend my best wishes for insightful discussions and impactful outcomes.

(Chander Kumar)

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Prabodh Saxena, IAS
Chief Secretary to the
Government of Himachal Pradesh

Ellerslie,
Shimla - 171 002

Shimla-2, the 14-11-2023

Message

I am pleased to know that Shoolini University is organizing a National Seminar on "Plant Biodiversity for Food, Nutrition and Health Security in North Western Himalayas" in its campus on November 27-28, 2023.

Food security is a serious concern all over the world. To cater the needs of the growing population efforts are required to explore the genetic potential of the existing crop plants. The existing plant biodiversity can be greatly utilized to ensure the food, nutrition and health security. Himachal Pradesh has a vast agro biodiversity due to the prevailing varied climatic conditions but it has become a challenge to sustain the biodiversity.

The state entails extensive diversity in cereals, millets, fruits, vegetable, spices, condiments, herbs and medicinal plants. Utilising the genetic potential of wild types and inculcating them into the agricultural and horticultural crops can help us achieve the goal of nutritional security. The existing plant diversity in the Himalayas is enriched with medicinal properties and can be utilized to attain health security.

I hope the seminar provides an excellent stage to bring along the farmers, researchers and students and concludes with some strategies for exploration, utilization and conservation of our plant biodiversity.

I extend my best wishes to the organizers for the success of the symposium and hope the discussions among the enlightened minds will definitely lead us to some solutions to mitigate the environmental and food security issues.

(Prabodh Saxena, IAS)

Message

Combatting hunger and ensuring food and nutritional security are the major challenges being faced world over. COVID-19 has further aggravated these challenges. To build resilience against future pandemics, plant biodiversity needs to be given a focused attention. UN Food Systems Summit held in 2022 highlighted the importance of local food systems for future food security.

More than 600 plant species have gone extinct in the past about 250 years due to over exploitation of genetic resources, global warming and habitat destruction. This trend need to be curbed on priority.

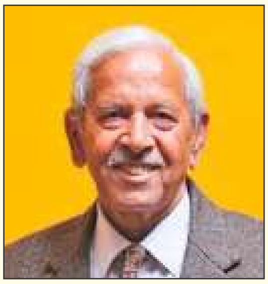
The Himalayas, recognised as one of the biodiversity hotspots, is endowed with a remarkable array of agrobiodiversity. In the light of habitat loss, existing climate change and diversity taking place in the food consumption patterns, it is imperative to have a comprehensive assessment of existing agrobiodiversity of the North-West Himalayans, including their production potential, the current status of research relating to genetic improvement and conservation practices followed, including evaluation and utilisation for food, nutritional and medicinal values, options available for value addition, marketing etc.

For long term sustainability and effective use of local food systems, there is an obvious need for enabling policy environment which help in both conservation and rational use for future food, nutrition and environmental security.

I am pleased that the Indian Society of Plant Genetic Resources (ISPGR), and the Shoolini University are organising a **National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in the North-Western Himalayas** in collaboration with Alliance of Bioversity International and CIAT, TAAS, and PPV&FRA to develop a Road Map for an efficient, long term and sustainable conservation through use of NW Himalayan plant diversity. I congratulate the organizers for this timely initiative and wish the National Seminar a great success.

R S Paroda
(Padma Bhushan Awardee)
Chairman, TAAs &
Former Secretary, DARE & DG, ICAR

Chancellor
Shoolini University, Solan



I am elated to know that the Shoolini University of Biotechnology and Management Sciences, Solan is organizing a National Seminar on the theme entitled "Plant Biodiversity for Food, Nutrition and Health Security in North West Himalayas" in collaboration with Indian Society of Plant Genetic Resources (ISPGR), New Delhi and ICAR-National Bureau of Plant genetics Resources (NBPGR), New Delhi, on 27th and 28th Nov., 2023. Shoolini University of Biotechnology and Management Sciences, Solan is a prestigious university that offers array of specialization in multiple streams like Agriculture, Botany and Environmental Sciences which are working towards the conservation of biodiversity.

Plant biodiversity for food and agriculture is the subset of biodiversity that contributes in one way or another to agriculture and food production. Biodiversity loss can exert significant human health impacts if ecosystem services are no longer adequate to meet social needs. Indirectly, changes in ecosystem services affect livelihoods, income, local migration and, on occasion, may even cause or exacerbate political conflict. Therefore, the cultivation, promotion, and implementation of underutilized crops can help to reduce malnutrition, assist in fighting poverty, and ensure food security for many people worldwide.

The sessions in the seminar will provide invaluable insights into various aspects of management of North-Western Himalayan (NWH) plant biodiversity, traits discovery, plant genomics and local food systems, the importance of preserving traditional practices in the face of environmental challenges. I extend my best wishes to the organizers and all the participants of the seminar.

(P. K. Khosla)

त्रिलोचन महापात्र
अध्यक्ष
पौधा किस्म और कृषक अधिकार संरक्षण प्राधिकरण
(संसद के अधिनियम द्वारा निर्मित सांविधिक निकाय)
कृषि एवं किसान कल्याण मंत्रालय
भारत सरकार

सत्यमेव जयते

Trilochan Mohapatra
Chairperson
Protection of Plant Varieties and Farmers' Rights Authority
(A Statutory body created by an Act of Parliament)
Ministry of Agriculture and Farmers Welfare
Government of India

Message

I am pleased to know that **National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas (PBFSNWH)** is being organized at Shoolini University, Solan during 27-28 November 2023, jointly by the Indian Society of Plant Genetic Resources (ISPGR), Shoolini University and ICAR-NBPGR in collaboration with TAAS, Alliance for Bioversity International and CIAT, and other partners. The North-Western Himalaya region is known to be rich in biodiversity particularly of crop species and their wild relatives; some of these being endemic. Given the importance of diverse germplasm resources in food and nutrition security under the changing climate, there is an urgent need to assess the status and develop strategy for conservation as well as sustainable utilization of biodiversity in this region. I am sure that the deliberations in the Seminar will be a step forward in generating new perspective for reorientation of plant biodiversity research and management in the North Western Himalayas.

I convey my best wishes for the success of the seminar.

(T. Mohapatra)

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कृषि वैज्ञानिक चयन मंडल

कृषि अनुसंधान और शिक्षा विभाग

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DEPARTMENT OF AGRICULTURAL RESEARCH & EDUCATION

Ministry of Agriculture & Farmers Welfare, Govt. of India

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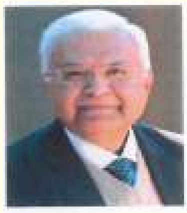
अध्यक्ष

Dr. Sanjay Kumar FNA, FNASc, FNAASc, FCISI

Chairman

Dated: 21st November, 2023



MESSAGE

I am pleased to learn that the Indian Plant Genetic Resources Society is organising a National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in Northwest Himalaya (PBFSNWH) from November 27-28, 2023 at Shoolini University, Solan. This event will be organised in collaboration with TAAS, Alliance for Bioversity International and CIAT, and other esteemed partners.

This timely and important event promises to bring together renowned academicians, scientists, professionals, and researchers to explore innovative approaches to improve agricultural technologies to meet the changing needs of farmers and society in the North-Western states of India.

I am confident that the deliberations at this seminar will yield valuable insights and pave the way for sustainable agricultural practices that will ensure food security, nutritional well-being, and overall health of the people in the region.

I extend my best wishes for the grand success of the seminar.

(Sanjay Kumar)

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Dr Gyanendra Pratap Singh
Director, ICAR-National Bureau of Plant Genetic Resources
Pusa Campus, New Delhi

10 November, 2023

Message

I am happy the National Seminar on Plant Biodiversity for Food, Nutrition, and Health Security in the North-Western Himalayas (PBFSNWH] is being organized at 27-28 November 2023, at Shoolini University, Solan, Himachal Pradesh. The seminar is being organized by ISPGR, Shoolini University and ICAR-NBPGR in collaboration with TAAS, Alliance for Bioversity International and CIAT, and other partners.

This initiative at the National level where the deliberations on management of plant biodiversity, nutrition and health security is highly appreciated. With the little time left to achieve the target of SDG goals and Aichi targets for food security in this challenging time, the deliberations in this seminar would be vital for the future course of action in plant biodiversity management.

NBPGR is the designated nodal agency for management of PGR in India, i.e import, export and national supply of seed and planting material for research purposes, undertaking their quarantine clearance and distribution of pest-free germplasm to users in India and abroad. Importantly, it houses the National Genebank (NGB), established during 1985-86 for *ex situ* conservation, which is the second largest Genebank in the world. India is currently, also contributing significantly to global PGR policy decisions and NBPGR is actively involved in the key decision-making process for many components within the 1TPGRFA.

The conference would strengthen the linkage of NBPGR with various stakeholders and help in dissemination of new knowledge and value-added germplasm of different agri-horticultural crops. Any shortcoming of the stakeholders would be deliberated on and the same would be taken for further refinement of value addition to germplasm.

1 wish all the delegates and the resource person to have a wonderful stay during the Seminar with warm hospitality from great team of organizers and to have fruitful deliberatiors.

10.11.2023

Gyanendra Pratap Singh

Alliance of Bioversity International and CIAT

I am happy that Alliance has joined hands with the Indian Society of Plant Genetic Resources and ICAR-National Bureau of Plant Genetic Resources in organizing **National Seminar on Plant Biodiversity for Food, Nutrition and Health Security in North-West Himalayas** during 27-28 November 2022 in Shoolini. I am sure the seminar will bring together various stakeholders working in the PGR management to achieve the common goal of nutrition security and environmental sustainability in the Himalayas. At the Alliance, we strive to make food and agriculture systems more sustainable, efficient and inclusive, through sustainably funded science, research-based solutions and inclusive knowledge generation. Our strategy sets out how we work and accelerate impact towards tackling four interconnected global crises: biodiversity, climate, environment and nutrition. Through our work on the ground with partners and beneficiaries, we are unlocking holistic, research-based solutions to these crises, spearheading initiatives at the nexus of agriculture, the environment and nutrition.

I wish the organizers and the participants a successful congregation.

Jai C. Rana
Country Representative, South Asia

Vice Chancellor
Shoolini University, Solan

It is indeed a matter of pride for us that Shoolini University of Biotechnology and Management Sciences, Solan is organizing a National Seminar on the theme entitled "Plant Biodiversity for Food, Nutrition and Health Security in North West Himalayas" on 27th and 28th Nov., 2023.

Plant biodiversity is the foundation of agriculture. It has enabled farming systems to evolve ever since agriculture was first developed over 10,000 years ago. Biodiversity is also the foundation of ecosystem services essential to sustain agriculture and human well-being. Indeed, sustainable agriculture both promotes and enhances biodiversity. In addition, biodiversity directly supports agriculture systems by helping to ensure soil fertility, pollination and pest control.

I commend the organizers for selecting the theme focusing on plant biodiversity in the North Western Himalayan region, its production potential, the status of genetic improvement research, conservation practices through utilization, their nutritional and medicinal value, options for value chains, socio-economic considerations and necessary policy support required to promote them as alternative sources of food, nutrition, and health security.

Distinguished scientists hailing from various regions across the nation will contribute to the seminar by sharing their research findings and experiences in the realm of sustainable agricultural technologies. This collaborative effort is poised to enhance our collective understanding. I am optimistic that the seminar will shed light on contemporary global challenges through insightful discussions and illuminating presentations.

(Atul Khosla)

Articles

Indian Society of Plant Genetic Resources– 35 Years of Contribution Towards Science and Policy in Plant Genetic Resources Management*

***Anuradha Agrawal*[1], *R.K. Tyagi*[2] *and Manjusha Verma*[3]**

[1]General Secretary, [2]Vice President, [3]Joint Secretary, Indian Society of Plant Genetic Resources (ISPGR), National Bureau of Plant Genetic Resources (NBPGR), Pusa Campus, New Delhi – 110 012

Introduction

The Indian Society of Plant Genetic Resources (ISPGR), New Delhi, came into existence in the year 1987, as a multidisciplinary scientific body dedicated to the area of plant genetic resources (PGR). The Society was established by the scientists at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, under the leadership of Dr R.S. Paroda, the then Director of NBPGR. The idea for creation of ISPGR was conceived during the 'National Symposium on Plant Genetic Resources' organized by NBPGR, on March 3-6, 1987 to commemorate completion of a decade of NBPGR's establishment. The symposium was attended by 300 scientists from India and 20 from abroad, including those from International Centres like International Rice Research Institute (IRRI), Philippines, International Maize and Wheat Improvement Centre (CIMMYT), Mexico and International Centre for Research in Semi-arid Tropics (ICRISAT), India. During the symposium, Dr R.S. Paroda proposed the creation of ISPGR, which was welcomed by all the delegates of the symposium. Therefater, suitable action was taken to draft a constitution of ISPGR and most of the NBPGR scientists became founder members.

Objectives of ISPGR

The primary objective of the Society is to provide a forum to various workers in the field of PGR to express their views, publish their findings and interact with different stakeholders. The Society aims at the following:

1. To promote research in the field of PGR and related disciplines such as plant exploration/ collecting, characterization, evaluation, conservation, utilization, introduction and exchange, quarantine and data documentation and information management. Broadly, it will involve in an integrated way various disciplines, viz., Economic Botany, Ecology, Genetics, Plant Breeding, Ethnobotany, Taxonomy, Biosystematics, Biotechnology, Plant Physiology, Horticulture, Seed Science, Chemistry, Agronomy, Plant Pathology, Entomology, Nematology, Agricultural Statistics, Information Technology and allied disciplines.
2. To provide a forum to the scientists for expressing their critical views based on the scientific knowledge and rational thinking on important national policies and programmes related to PGR research and development.
3. To collect, collate and disseminate information on PGR.
4. To encourage and promote close association/collaboration among members belonging to various disciplines.
5. To work in association and collaboration with other national and international societies/ organizations having similar objectives.
6. To publish a journal at regular interval, as decided by the Executive Council (EC), as an official publication of the Society.

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*Adapted from 'Tyagi R.K. and A. Agrawal (2016) Indian Society of Plant Genetic Resources : Journey of three decades. *In*: Tyagi R.K. A. Agrawal, S. Archak, P.N. Mathur, Bhag Mal (eds). Souvinier. Ist International Agrobiodiversity Congress, Nov. 6-9, 2016, New Delhi, Indian Society of Plant Genetic Resources and Bioversity International, New Delhi, pp. 85-90.

Society Registration and Constitution

The Society was formally registered under the Indian Societies Act (1860) on November 3, 1987 with the Registrar of Societies, Delhi (Registration No. S/18336 of 1987). The Society is also registered under section 12A and 80G of the Income Tax Act of 1961, for tax exemption on any surplus funds of the ISPGR and for donor's tax exemption, respectively. Its headquarter is located in the NBPGR, Pusa Campus, New Delhi. The Constitution of ISPGR was drafted under which the General Body (GB) comprising all members of the Society was designated the supreme authority and elected an Executive Council (EC) biannually for management of all the activities. The Constitution was revised in 2007 and in 2017, under which EC tenure is three years. The GB determines the general policies and programmes of the Society in conformity with the constitution and bye-laws. The administration, direction and management of the activities/functions of the Society are carried out by the EC, which comprises President, two Vice-Presidents, one General Secretary, one Editor-in-Chief, one Joint Secretary, one Treasurer, and two Councillors from each zone demarcated by the EC. All Office Bearers are required to be members of the Society. Two Ex-Officio members of the Society are the immediate Past President, ISPGR and Director, ICAR-NBPGR.

The membership of the Society is open to any research worker/scientist or other person interested in PGR activities in India and abroad. The categories of members include life members, ordinary members, institutional members, student members and donor members.

Life Members are entitled to participate in all the seminars, symposia, conferences etc. organzied by ISPGR at subsidized rates, are entitled to apply for awards and become Fellows of ISPGR, as per guidelines, and receive copies (hard copy or PDF) of all issues of Indian Journal of Plant Genetic Resources (IJPGR). Annual/Life members can submit manuscripts for publication in IJPGR. Currently ISPGR has more than 900 members, both from within and outside India.

Notable Presidents

The EC of ISPGR is headed by President. Dr R.S. Paroda became the Founder President for two consecutive tenures (1987-88 and 1989-92) and later for another tenure during 1996-98. During 1993-95, Dr R.S. Rana, the then Director of NBPGR was the President, whilst in 1999- 2000, Dr Mangala Rai, the then DDG (Crop Science), Indian Council of Agricultural Research (ICAR), New Delhi, became President. Dr P.L. Gautam took charge as President in 2001-2002, when he was National Coordinator, National Agricultural Technology Project (NATP), ICAR. In the subsequent two tenures (2003-04 and 2005-06), Dr B.S Dhillon, the then Director, NBPGR, served as President. During 2007-09, Dr Bhag Mal from International Plant Genetic Resources Institute (IPGRI, later rechristened as Bioversity International), Sub-regional Office for South Asia was the President. Later Dr S.K. Datta, the then DDG (Crop Sciences), served as President for the period of 2010-2014. Since 2015 onwards, ISPGR is headed again by Dr R.S. Paroda as President, who is Chairman of Trust of Advancement in Agricultural Science (TAAS) also. Thus, over the years the Society has greatly benefitted by being led by scientists who have contributed immensely in the areas related to PGR including the policy matters at national and international level. Further, it has been blessed by patronage from luminaries like Dr M.S. Swaminathan and the late Dr A.B. Joshi, two doyens of Indian Agriculture.

Scientific Activities Undertaken

In the last 35 years of its existence, the ISPGR has organized several dialogues, conferences, symposia, meetings that have contributed directly and indirectly in formulation of international and national policies and action on agricultural biodiversity, especially PGR. A few important events organized by ISPGR are shown in Table 1.

Table 1. Major events organized by ISPGR.

	Title of Conference, Symposium, Workshop, Brainstorming etc.	Co-organizer(s)	Date and venue
1.	National Dialogue on *'Plant Genetic Resources in India - Developing National Policy Option'*	NBPGR	December1-2, 1993, New Delhi.
2.	National Dialogue on *'Issues in Management of Plant Genetic Resources'*	NBPGR	December1-2,1998, New Delhi

3.	Symposium on *'Plant Genetic Resources Management: Advances and Challenges'*	NBPGR	August 1-4, 2001, New Delhi.
4.	National Conference on *'Transgenics in Indian Agriculture'*	ICAR and NBPGR	March 9 -10, 2004, *New* Delhi
5.	International Symposium on *'Introduction Achievements and Opportunities in South Asia'*	NBPGR	February,15-17 2005, New Delhi.
6.	National Symposium on *'Recent Global Developments in the Management of Plant Genetic Resources '*	NBPGR	December 17-18 2009, New Delhi
7.	Brainstorming session on '*Access and Benefit Sharing (ABS)-Striking the Right Balance'*	NBPGR, NBA	October 22, 2016, New Delhi
8.	I[st] International Agrobiodiversity Congress Bioversity Science, Technology, Policy and Partnership	International,2016- ICAR, PPV&FRA, NBA,TAAS, NAAS, MSSRF, ISGPB. CIMMYT, ICRISAT, ICARDA, GCDT, CABI, GIZ, APAARI etc.	November 6-9, 2016, New Delhi
9.	Brainstorming		
10.	Satellite Symposium on *'Dry land Agrobiodiversity Bioversity International, for Adaptation to Climate Change'*	APAARI	Feb. 13, 2019 Jodhpur
11.	National Webinar on *'Implementation of Access Bioversity to Plant Genetic Resources and Benefit Sharing (ABS)'*	Alliance of International and CIAT, ICAR-NBPGR, NBA, PPV&FRA, TAAS	August 27, 2020 (virtual mode)
12.	Virtual Brainstorming on *'Digital Sequence Information and Germplasm Sharing'*.		March 2021 (virtual mode)
13.	National Consultation on *'Plant-based Local Food Systems for Nutrition and Health'*		Oct 22, 2021 (virtual mode)
14.	Peer Group Meeting on *'Biological Diversity (Amendment) Bill, 2021'*		Jan.22, 2022 (virtual mode)

Besides the above, ISPGR actively contributed as a coorgizers in following events:

1. Second 'Crop Science Congress' wherein a Satellite Symposium was organized by ISPGR, November, 1996, New Delhi
2. Society was a member of the confederation that jointly organized the 'International Conference on Managing Natural Resources in the 21st Century' held during 14-18 February, 2000, at New Delhi and organized a Session and Keynote Address on PGR/Agrobiodiversity.
3. In the first Indian Science Congress of the New Millennium (88th session), held in January, 2001, New Delhi, ISPGR made significant impact on the deliberations on household Food, Nutrition and Environmental Security.
4. ISPGR celebrated the Birth Centenary of Late Dr. B.P. Pal by joint organization of the Symposium on Search for New Genes held on September 1-3, 2006, at National Academy of Agricultural Science, New Delhi.
5. National Symposium on 'Crop Improvement for Inclusive Sustainable Development', organized by Indian Society of Genetics and Plant Breeding, ISPGR, Crop Improvement Society of India and MTAI, 17-18 December 2009.

6. National Seminar on 'Crop Breeding for Wider Adaptation' was organized by Ranchi Chapter of Indian Society of Genetics and Plant Breeding (ISGPB) in collaboration with ISGPB, New Delhi and ISPGR, New Delhi at Birsa Agricultural University (BAU) from Dec. 12-13, 2020.
7. 2nd International Agrobiodiversity Congress (IAC)' hosted by the Government of Italy and Alliance for Bioversity International & CIAT, Nov 15-18, 2021.
8. A National Symposium on "Food, Nutrition and Environmental Security: Towards Achieving SDGs" organized by TAAS, ICAR, NAAS and ISPGR in collaboration with BI & CIAT, ICRISAT, CIMMYT and IRRI, 29-30 August 2022, New Delhi.

All the above activities have led to great visibility of the ISPGR and its members. In the recent past, the IAC2016 initiated by ISPGR has become a rolling event at internatioal level, with the 2nd IAC held in Rome in 2021 and the next one expected to be held in China, with support from the Allaince of Bioversity International & CIAT. The 'Delhi Declaration on Agrobiodiversity', a visionary document developed for pathway and action points on the sustainable management and use of agrobiodiversity through interdisciplinary exchange of ideas and opinions among various stakeholders has been much appreciated. It provides a roadmap to enhance food, nutrition and health security by optimal utilization of agrobiodiversity while protecting agro- ecosystems and landscapes, and also mainstream agrobiodiversity related issues into global discussions to ensure fair access, benefit sharing and sustainable use.

Awards and Recognitions

The ISPGR annually bestows several awards and recognitions to its members to encourage and motivate dedicated researchers working in the area of PGR management. following awards are instituted:

1. Dr Harbhajan Singh Memorial Award: This prestigious award has been instituted by the ISPGR in the memory of Late Padma Shri Dr Harbhajan Singh, referred to as the Indian Vavilov and Father of PGR in India. It carries a sum of Rs 1,50,000 in cash, a citation and a plaque. The seed money was a contribution made by M/s Mahrashtra Hydrid Seeds Co., Jalna. The award is a lifetime achievement award, given biennially to eminent scientists who have made outstanding contribution in the field of PGR with specialreference to India.
2. Dr S.K. Vasal Award for Efficient Use of PGR : Dr Surinder Kumar Vasal, World Food Laureate (2000) and Distinguished Scientist (Retd) of International Maize and Wheat Improvement Center (CIMMYT), Mexico, contributed a corpus of Rs 10 lakhs to ISPGR fin 2021 for instituting an award to recognize those who have shown professional excellence in the utilization of PGR, including areas of pre-breeding, genetic enhancement, use of germplasm or crop wild relatives for breeding, widening genetic base of crops etc. The award is carries a sum of Rs 1,00,000, a citation and a plaque to be given annually to a scientist (or team of 2-4 scientists) who have dedicatedly used PGR for developing advanced materials, that have impacted agricultural growth/ sustainability.
3. Dr B.R. Barwale Award for Application/ Excellence in PGR was instituted by ISPGR in 2017 to recognize the work of scientists/researchers who have significantly contributed in any area of PGR science or application, including collecting, characterization, evaluation, conservation, use (e.g. development of varieties) and other matters for its management. The award is supported by generous contribution made by the family of late Dr B.R. Barwale. It carries a sum of Rs 1,00,000, a citation and a plaque to be given annually to mid-level scientists working in the PGR domain.
4. Dr R.S. Paroda Young Scientist Award: Dr R.S. Paroda, an outstanding scientist, administrator and policy maker, donated the cash prize received by him in 2001 on account of Dr Harbhajan Singh Memorial Award and some corpus fund to ISPGR. The award is carries a sum of 50,000, citation and plaque and is given annually to recognize the outstanding contributions of young scientists in area of PGR.
5. Dr R.K. Arora Best Paper Award. This award has been instituted in 2008 by the ISPGR out of the cash prize donated by the late Dr R.K. Arora to ISPGR on account of Dr H.B. Singh Memorial award of 1998-99. The award carries a cash prize of Rs 10,000 and a plaque. This award is given annually to author(s) who contribute(s) best work in the form of publication in Indian Journal of Plant Genetic Resources.
6. Dr K.L. Mehra Memorial Award for the Best PGR Student: Dr K.L. Mehra was the first Director of NBPGR. Mrs Mehra donated seed money to institute an award in name of Dr Mehra in the year 2009. This award is given annually to best M.Sc. PGR student of IARI Post-Graduate School to motivate and encourage PGR students to excel in area of PGR. It carries Rs 20,000 cash prize and a plaque of honor.

7. Fellows' of ISPGR. The process was initiated in 2007 wherein 52 Founder Fellows were selected. Five fellows are selected each year, and so far the Society has recognized valuable contributions of more than 75 Fellows in the areas of PGR research. In addition six Honorary Fellows include Prof M.S. Swaminathan, Late Dr A.B. Joshi, Prof G.S. Khush, late Prof. S Rajaram, Prof. R.B. Singh, Dr H.D. Upadhyaya, Prof. Emile Frison, Late Prof H.Y. Mohan Ram, Dr S.K. Dutta, Dr R.R. Hanchinal, Dr J.S. Sandhu, late Dr K.S. Gill, Dr S.K. Vasal and Prof. Kamal Bawa.

Publications by ISPGR

In accordance with objectives of the Society, a triennial journal, 'Indian Journal of Plant Genetic Resources (IJPGR, ISSN 0971-8184), is being regularly published to disseminate/update knowledge on PGR activities. The IJPGR comprises full-length papers or short communications of original scientific research in the field of PGR. Review articles summarizing the existing state of knowledge in topics related to PGR are also published. In addition, it also notifies the trait- specific germplasm/genetic stock 'registered' by the ICAR. The current NAAS rating of IJPGR is5.54 (2022) while Indian Citation Index – Research Impact Indicator is 0.096. The PDF copies of all issues from 1988 till date are available at http://www.indianjournals.com/. Efforts are underway to make IJPGR a fully open access journal, to increase its visibility. The latest issue of IJPGR (Vol 35 issue no 3, 2022) is special issue commemrating the 80th birth anniversary of the founder and current President of ISPGR, Dr R.S. Paroda. The issue consists of 80 articles by eminent experts in agrobiodiversity, on achievements and way forward in variuos facets of genetic resource management. The articles can be accessed from the link http://ispgr.nbpgr. ernet.in/80.html

Besides the IJPGR, the Society publishes books, proceedings and other information leaflets related to its activities. The details can be accessed from the ISPGR website (http://ispgr.nbpgr. ernet.in/Default1.aspx)

Miscellanous Activites

The ISPGR hosts lectures and meetings on relevant topics under the series of 'Dr A.B. Joshi Memorial Lecture', Dr Dilbagh Singh Athwal Memorial Lecture', which normally coincide with the annual award function of the Society. Further, need-based technical inputs are provided on policy matters to ICAR, NAAS, and Ministries etc. Regular meetings of GB and EC are held and elections of Society are conducted as per rules, every three years.

Conclusion

ISPGR has been serving the PGR research community for the last 35 years in various ways. Under the able guidance of past and current Presidents and EC, Society has been serving its purpose very effectively. However, the emerging issues related to PGR are enormous, which need the attention of researchers, teachers, policy makers and farmers time to time. It is the endeavour of ISPGR to provide a platform for open discussion and provide the way forward for sustiable management of agriculture through effective use of agrobiodiverity.

Plant Diversity for Food, Nutrition and Health security in North-West Himalayas

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The North-Western Himalayas (NWH), also known as the Western Himalayas, is a region of great environmental significance located in the northern part of the Indian subcontinent. It is characterized by its stunning landscape, rugged terrain, and diverse flora and fauna. The region is home to a vast array of plant species, many of which have immense importance in terms of food, health, and nutrition security for the local communities. The North-Western Himalayas boasts a rich and diverse plant biodiversity due to its unique geographical location and climatic conditions. The region is situated at an altitude of 2,500-5,500 meters above sea level and experiences a wide range of climatic variations throughout the year. This creates an ideal environment for the growth of diverse plant species.

The plant biodiversity in the region is represented by various vegetation zones, including alpine meadows, coniferous forests, subalpine forests, and mixed broadleaf forests. These vegetation zones harbor a plethora of plant species, ranging from medicinal herbs and aromatic plants to fruit-bearing trees. The North-Western Himalayas play a crucial role in ensuring food security for the local communities residing in the region. The unique plant biodiversity provides a wide range of food options that are not only nutritious but also adapted to thrive in the harsh mountainous conditions. One of the key crops in the region is barley, which is well-suited to the high altitudes and colder temperatures. Barley is a staple food for the local communities and is used to make a variety of traditional dishes, such as barley bread and barley porridge. Another important crop is rice, which is grown in the lower altitudes and provides a significant source of carbohydrates for the people. Apart from staple crops, the region is also home to a variety of fruits, including apples, apricots, cherries, and walnuts. These fruits not only contribute to the nutrition security of the people but also serve as an important source of income through commercial cultivation and trade.

The plant biodiversity in the North-Western Himalayas plays a crucial role in ensuring the health and nutrition security of the local communities (Fig. 1). The region is known for its rich tradition of traditional medicine, which extensively utilizes the medicinal properties of various plants. Many medicinal herbs and plants, such as *Rhodiola*, Turmeric, and Aloe Vera, have been used for centuries in traditional healthcare practices. These plants are believed to possess a wide range of health benefits, including immune-boosting properties, anti-inflammatory effects, and wound-healing abilities. Furthermore, the diverse plant species provide a wide range of nutrients that contribute to the overall nutrition security of the people. Traditional dishes made from locally available plants often include a mix of ingredients that offer a balanced combination of macronutrients and micronutrients necessary for a healthy diet. Despite the immense importance of the North-Western Himalayas' plant biodiversity for food, health, and nutrition security, the region faces numerous conservation challenges. These challenges include habitat destruction due to unsustainable agricultural practices, deforestation, and overexploitation of medicinal plants. Climate change also poses a significant threat to the delicate ecosystem of the Himalayan region. As the temperatures rise and precipitation patterns change, it can lead to the loss of plant species adapted to specific climatic conditions, resulting in a decline in biodiversity and a potential decrease in food and health security.

To ensure the availability of food to the growing population, strategies are needed to be adopted. With the dependence of population on plants for food whether directly or indirectly, emphasis should be on utilizing maximum potential from the available diverse plant resources. Thus, this seminar aims to focus on the existing plant biodiversity, its exploration, utilization, and conservation. The seminar will cover the following themes:

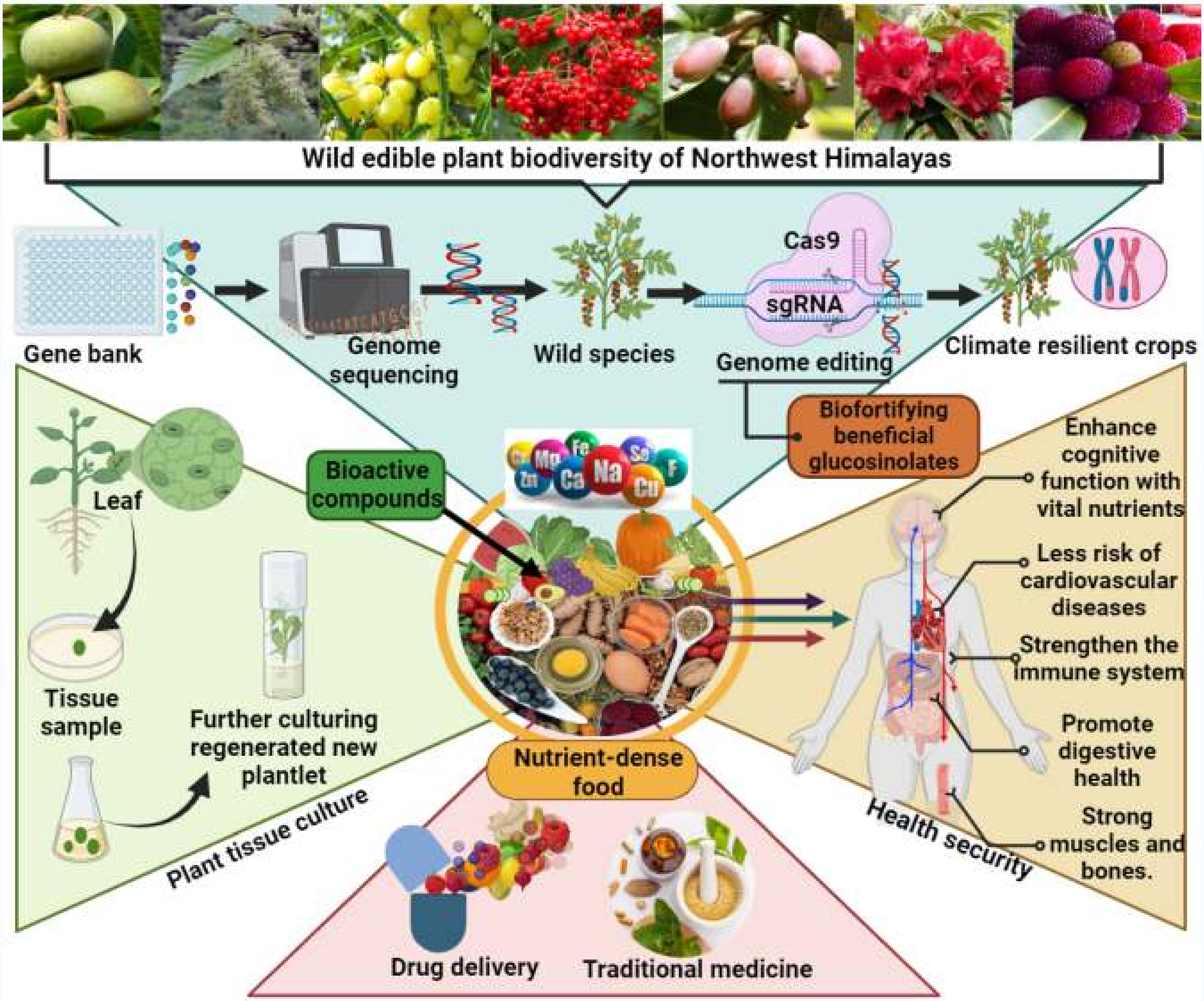

Fig. 1: Conceptual framework showing Plant Diversity for Food, Nutrition, and Health security in North-Western Himalayan perspectives.

Theme 1: Current status and management of North-Western Himalayan (NWH) plant Biodiversity

The current status of North-Western Himalayan plant biodiversity is relatively stable, but there are growing concerns about the impact of climate change, habitat loss, and overexploitation. The region is known for its rich and diverse flora, with over 6,000 species of flowering plants and numerous endemic species. However, climate change is causing shifts in temperature and precipitation patterns, leading to changes in the distribution of plant species. Many plants are moving upslope to higher elevations to find suitable habitats, but there is a limit to how far they can go before they run out of space. Habitat loss due to agriculture, urbanization, infrastructure development, and illegal logging is another major threat to plant biodiversity in the North-Western Himalayas. The conversion of forests and grasslands into agricultural lands and settlements disrupts the natural habitat of many plant species, leading to their decline or extinction. Overexploitation of plants, particularly for medicinal purposes, is also a concern. For several decades, biodiversity loss has been a part of the international policy agenda, and this loss has not halted, we continue to face many issues in terms of biodiversity conservation. As mentioned earlier, that North-Western Himalayas are known for the presence of valuable medicinal plants, therefore, their indiscriminate harvesting for commercial purposes can lead to population decline and ecosystem disruption.

To address these challenges, the management of North-Western Himalayan plant biodiversity requires a combination of conservation efforts, sustainable land use practices, and community participation. Protected areas, such as national parks and wildlife sanctuaries, play a crucial role in conserving plant diversity by providing legal protection and habitat restoration. Local communities need to be involved in conservation efforts through awareness campaigns, capacity building, and sustainable use of resources. Community-managed forests and agroforestry systems can help protect plant biodiversity while providing livelihood opportunities to the local people (Oh and Lu, 2023). Additionally, research and monitoring programs are important for understanding the changes in plant biodiversity and developing effective conservation strategies. This includes the assessment of species distribution, population dynamics, and the identification of threatened and endemic species.

The NWH unique ecosystem supports a wide range of plant species, which are not only important for their ecological roles but also for their contribution to the local food systems. The diverse range of plant species supports the overall ecosystem health and provides habitat and food for various animals and insects. The Himalayas are considered a treasure trove of medicinal plants, with a significant portion of the plant species having medicinal properties. Local communities in the region have been traditionally using these plants for curing various ailments and preparing traditional medicines (Dar and Ahmad, 2016). The region is also home to several wild edible plants, which are an essential part of the local food systems. These plants are rich in nutrients and provide an additional source of food for local communities, especially during times of scarcity.

NWH plant biodiversity is declining despite its critical relevance in ecosystem maintenance, as the worth of ecosystems for the welfare of humans is still undervalued. Several natural and anthropogenic (man-made) processes contribute to biodiversity loss. Natural factors rarely cause biodiversity loss, but increased human interventions in mountain forests have a direct correlation with loss of biodiversity. Changes in the demography and exploitation of plant products and resources of forest have hastened the deterioration of this region's native flora and fauna. Because NWH region contains numerous sites for tourism and adventure that may lead to disruptions in the region. Several development projects, such as road, dam, tunnel, and hydropower projects, also cause significant disruptions (Kala, 2000). For several decades, biodiversity loss has been a part of the international policy agenda, and this loss has not halted, we continue to face many issues in terms of biodiversity conservation.

The success of biodiversity management actions varies substantially depending on the paradigms represented by diverse conservation specialists, as well as the political, social, and cultural setting. In addition to fragmentation, degradation of natural habitat, and hunting, other challenges to biodiversity protection in protected areas are invasive species, changes in climatic conditions, and the interactions between them also adversely affect biodiversity. Biodiversity management is critical for preserving the planet's ecological balance. Plant biodiversity is one of the most important constituents that sustain humanity by providing fodder, food, fuel, and fiber. As a result, the necessity for biodiversity management should be jointly acknowledged. The objectives of conservation should be well-defined and alternative methods for management should be used.

2. Trait Discovery and genomics in plants of NWH

Predictions of exponential population growth and climate change call for a rethinking of attempts to fulfill the demand for world food safety. The availability of genetic diversity which serves as the basis for crop breeding is critical in crop improvement. Crop wild relatives, landraces, and elite varieties are valuable sources of variation that can be obtained from prevailing gene banks or gene pools. Conserving genetic diversity in gene banks, gene pools, and wild relatives is critical for reducing the loss of diversity for future breeding efforts. Furthermore, the Green and Industrial Revolutions fashioned how these products are handled for adeptness and commercialization. The next revolution will not only need to curb hunger but also focus on sustainability keeping in view the escalating climate change. Crop yields are predicted to increase by 70-110% to feed the estimated 9 billion people by 2050 (Lieder and Schröter-Schlaack, 2021).

Trait discovery and genomics are two important areas of research in understanding the genetic makeup and characteristics of plants in the North-Western Himalayas. Trait discovery involves identifying and characterizing specific traits or characteristics of plants, such as drought tolerance, disease resistance, or high yield potential. By studying the genetic basis of these traits, researchers can gain insights into which genes are responsible for specific traits and how they can be manipulated or transferred to other plant species. Genomics, on the other hand, focuses on studying the entire genetic material, or genomes, of plants. This includes analyzing DNA sequences, gene expression patterns, and variations in the genome. Advancements in genomics technologies, such as next-generation sequencing, have enabled researchers to efficiently analyze plant genomes (Pretty et al., 2018). They can compare and analyze the DNA sequences of different plants to identify genetic markers associated with specific traits. This information can be further utilized for crop improvement, conservation, and breeding programs. Genomic studies help in understanding the evolutionary history of plants, their adaptation to different environments, and the genetic diversity within and between populations. In the context of the North-Western Himalayas, trait discovery and genomics can provide valuable information for conservation efforts, crop improvement, and sustainable agriculture. By identifying plant traits that confer adaptation to specific environmental conditions, researchers can target these traits for conservation and restoration efforts in the face of climate change.

Furthermore, understanding the genetic diversity and population structure of plant species in the region can aid in conservation planning and management strategies. It can help in identifying rare or endangered plant species and designing effective conservation measures to protect their genetic resources. In terms of crop improvement, trait discovery and genomics can facilitate the development of improved varieties that are better adapted to the local environment and have desirable traits such as disease resistance, high yield, and nutritional value. This can enhance agricultural productivity in the region and contribute to food security. However, despite these conservation efforts, there are still challenges to effectively manage the plant biodiversity in the North-Western Himalayas. Insufficient funds, lack of adequate enforcement, inadequate research and monitoring infrastructure, and limited community participation are some of the key challenges that need to be addressed for long-term conservation success (Paul and Kundu, 2023).

3. *In*-situ/on-farm ex situ conservation, access and benefit sharing

In-situ conservation refers to the conservation of biodiversity within its natural habitat, while on-farm conservation involves maintaining biodiversity by integrating it with farming practices. Ex-situ conservation, on the other hand, involves the conservation of biodiversity outside of its natural habitat, such as in gene banks or botanical gardens. In the north-western Himalayas, there is a rich diversity of plant and animal species that are unique to the region. These species face various threats, including habitat loss, deforestation, climate change, and unsustainable agricultural practices. In-situ and on-farm conservation play a crucial role in preserving the biodiversity of the region.

In-situ conservation in the north-western Himalayas involves the establishment and management of protected areas, such as national parks and wildlife sanctuaries. These protected areas provide a safe haven for endangered species and help maintain the ecological balance of the region. Local communities and indigenous people are actively involved in the management of these areas, ensuring that their traditional knowledge and practices are integrated into conservation efforts. On-farm conservation in the north-western Himalayas focuses on sustainable agricultural practices that promote biodiversity. Farmers are encouraged to use traditional and indigenous farming methods that are suitable for the local environment. This includes the cultivation of traditional crop varieties and the preservation of traditional farming practices that have co-evolved with the local biodiversity (Oh and Lu, 2023).

Access and benefit sharing (ABS) is an important aspect of conservation efforts in the north western Himalayas. ABS refers to the fair and equitable sharing of benefits arising from the utilization of biodiversity. This includes sharing benefits with local communities and indigenous people who have traditional knowledge and practices associated with biodiversity conservation. In the north-western Himalayas, ABS ensures that local communities and indigenous people are involved in decision-making processes related to conservation and benefit from the sustainable use of biodiversity. This can include the sharing of monetary benefits, access to genetic resources, and the protection of traditional knowledge.

Theme 4: Plant Biodiversity and Local Food Systems

Plant biodiversity plays a crucial role in local food systems by supporting the availability and accessibility of diverse, nutritious, and culturally relevant foods. When local food systems rely on a limited number of plant varieties, there is a higher risk of crop failure due to disease, pests, or environmental changes. In contrast, diverse plant varieties can provide resilience against these risks, ensuring a more stable and sustainable food supply. Here are some ways plant biodiversity is connected to local food systems: a) crop resilience: by cultivating a wide range of plant species and varieties, communities can increase their resilience to pests, diseases, and climate change. Different plant varieties have different tolerances and resistance to various environmental stresses, making it more likely that at least some crops will survive and thrive; b) nutritional diversity: Plant biodiversity allows for a greater variety of nutrients in the local food supply. Different plants contain different combinations of vitamins, minerals, and phytochemicals, contributing to a more balanced and nutritious diet. This is particularly important in combating malnutrition and ensuring optimal health outcomes; c) cultural preservation: Local and indigenous communities often have traditional knowledge and cultural practices related to specific plant species. By maintaining plant biodiversity, these communities can continue to preserve their cultural traditions, including traditional recipes, medicinal uses, and rituals (Noor et al., 2022). Plant diversity is a vital component of cultural identity and heritage; d) pollination and ecosystem services: Biodiverse plant communities support a range of pollinators, including bees, butterflies, birds, and bats. These pollinators play a crucial role in the reproduction of many food crops. Without diverse plant communities, pollinators may not have enough food sources and habitats to thrive, leading to a decline in crop yields; e) Seed sovereignty and farmer autonomy: Plant biodiversity allows farmers to save and exchange seeds, maintaining seed sovereignty and reducing dependence on commercially produced seeds. This promotes farmer autonomy and resilience in the face of market uncertainties and restrictive intellectual property rights; f) Local economy and market diversification: A diverse range of plant species and varieties can support the development of local food markets by providing a wide array of products, such as fruits, vegetables, grains, and herbs. This diversification can enhance economic opportunities for small-scale farmers and create a more resilient local food economy (Dar and Ahmad, 2016).

The food system is made up of many sub-systems (such as the farming system, input supply system, and waste management system) and is interconnected with other essential systems (such as the energy system, health system, trade system, and so on). A sustainable food system (SFS) is one that provides nourishment and ensures the security of food for all while preserving the environmental, social, and economic base for the coming generations. They provide profitability, social sustainability, and environmental sustainability. However, plant biodiversity in local food systems is under threat due to factors such as industrial agriculture, land degradation, habitat loss, and the spread of monoculture farming (Kala, 2000). Protecting and promoting plant biodiversity requires sustainable agricultural practices, conservation efforts, seed saving initiatives, and the support of local farmers and communities (Table 1). Adopting a local food system as a part of community ownership project creates jobs in the area in which it is situated. Expenditure by the regional people on the local food system keeps the money in the community itself. Local food systems refer to the production, dispersion, and uptake of food within a certain geographic region. This results in an economic upturn, which leads to improved education, training, shops, open spaces, and other leisure facilities in that particular region.

Table 1. Comprehensive overview of sustainable innovations addressing challenges and perspectives of plant biodiversity, food, nutrition and health security

Sustainable thematic innovations	Techniques	Benefits	Challenges
Health security	CRISPR-Cas9 gene editing for genetic disorders	· High accuracy: Enhanced precision in targeting specific genomic locations, minimizing off-target effects. · Easy handling: Simplified design and manipulation of guide RNA sequences, increasing accessibility and efficiency in laboratory settings · Relatively low cost: Cost-effective in terms of time and resources, providing economic advantages over other technologies.	· Non target mutations and side effects · Cost considerations. · Genetic mosaicism and gene drifts · Bioethical issues, including ecological imbalance · Patenting concerns. · Animal welfare and dignity · Potential threats to human identity and dignity
	Messenger RNA (mRNA) vaccines	· Precision: mRNA technology selectively expresses specific antigens, ensuring a precise immune response. · Immune response: Induces	· Issues related to vaccine thermostability, cell targeting, delivery efficiency, materials safety and the route of

		both humoral and cellular immune responses for comprehensive immune activation. · Innate immune system: Triggers responses from the innate immune system. · Alternative to traditional vaccines: Offers an attractive alternative to conventional and DNA vaccines.	administration.
	Nanomedicine	Nano therapeutics advantages: · Low toxicity · Improved bioavailability · Enhanced pharmacokinetics · Increased therapeutic effectiveness · Overcoming conventional drug limitations: · Surpassing obstacles inherent in conventional drugs · Future market potential: · Addressing anticipated demands for advanced disease treatments	· Clinical translation efficiency remains suboptimal. · Safety concerns persist. · Biological challenges, including bio distribution complexities, require attention. · Achieving scale-up while managing costs poses a significant obstacle. · Regulatory considerations add another layer of complexity.
Agricultural innovations and plant biodiversity	Precision agriculture	· Precision agriculture aims to provide decision-making systems that take into account numerous crop factors such as humidity, soil nutrients, wind speed, water level, temperature, sunshine intensity and chlorophyll content.	· Data management · Weather variations · Secure and rapid data transfer · Hardware cost · Limitations of resources and education
	Biological pest control	· Alternative to pesticides: · Mitigates environmental damage and health risks associated with pesticide use. · Conservation Biological Control: · Involves interventions like managing vegetation patterns to support natural enemies. · Offers benefits beyond pest control, such as pollination and carbon sequestration. · Integrated Pest Management (IPM): 5-40% increases in crop yields and reduces pesticide use by 30-70%.	· Flexible strategies are needed to adapt to changes in pest distributions and food-web structures. · The approach must address multiple ecosystem services to be effective.
	Vertical farming and hydroponics	· Space-efficient cultivation · Potential for hyper-localized production · Shortening food supply chains · Year-round availability to fresh and nutritious local foods	· Obstacles to the widespread adoption of vertical farming.

	Smart farming (SF)	· Precision application methods, utilizing mapping and sensing, can decrease fertilizer and pesticide use, offering environmental advantages.	· Technological barriers · High investment costs · Lack of knowledge among farmers
Food and Nutritional security	Alternative proteins	· Mitigates environmental damage and addresses climate change. · Provides essential macro and micronutrients, including high-quality proteins. · Promotes healthy diets and aids in preventing various diseases.	· Proteins resistant to digestion can affect health positively or negatively. · Modifications may alter nutritional value and lead to toxic peptide formation. · Contamination with harmful chemicals during modifications poses health risks.
	Insect-based protein	· Insect protein offer high nutritional value and are easily digestible · Environment friendly sourcing of insect proteins (insect farming often involves sustainable practices)	· Incorporating insects into food production faces challenges beyond acceptability, economics, environmental impact and processing · Concerns include addressing biological and chemical hazards. · Allergies associated with insect consumption represent a significant safety consideration.

With the growth in these areas, tourists can be attracted leading to the increased source of income. As a result, people may be more inclined to reside in and invest in the neighbourhood. Finally, when a community's food economy is more self-sufficient, people more likely want to get involved and contribute to a system that benefits everyone locally. They are even more inclined to embrace healthy eating habits because they believe it will benefit their personal, environmental, and communal health. Local food systems also have substantial environmental benefits, including reducing the usage of transportation. Many farmers that sell local food use more environmentally friendly farming methods, such as organic farming.

Plant biodiversity, on the other hand, refers to a number and variety of plant species found in a given ecosystem. Native crop varieties are typically promoted for production and consumption in local food systems. They help to preserve traditional farming techniques and crop genetic diversity by doing so. This helps to preserve a diverse range of plant species, which supports biodiversity and food security (Fig. 2). These strategies seek to reduce the distance travelled by food from farm to plate. These technologies help to reduce the emission of greenhouse gases and consumption of energy related to long-distance food transportation by shortening transportation routes. Natural habitats are thereby safeguarded, and the negative impact on biodiversity is mitigated. Small-scale farmers who adopt sustainable agricultural practices are typically supported by local food networks. These farmers are more likely to embrace biodiversity-friendly agricultural techniques such as agroforestry, crop rotation, and organic farming because they have a stronger connection to the land. Local food systems indirectly enhance biodiversity protection by assisting these producers (Singh and Hajra, 1996).

Local food systems also emphasize the relevance of ecosystem services in agricultural productivity, such as pollination, soil fertility, and insect control. As a result, local food production will be more sustainable in the long run. These systems usually prioritize education and awareness-raising campaigns to help maintain biodiversity (Kashyap et al., 2014). Through farmer training programs, community workshops, and public outreach, these systems help to increase understanding of the significance of biodiversity and its role in maintaining a resilient and sustainable food system. Local food systems are important for biodiversity conservation. These strategies contribute to biodiversity conservation by preserving native crop varieties, reducing food miles, assisting small-scale farmers, maintaining ecosystem services, and raising awareness. Any effort that involves direct collaboration with local agricultural and indigenous communities in India can help restore biodiversity-rich farming and locally controlled food systems.

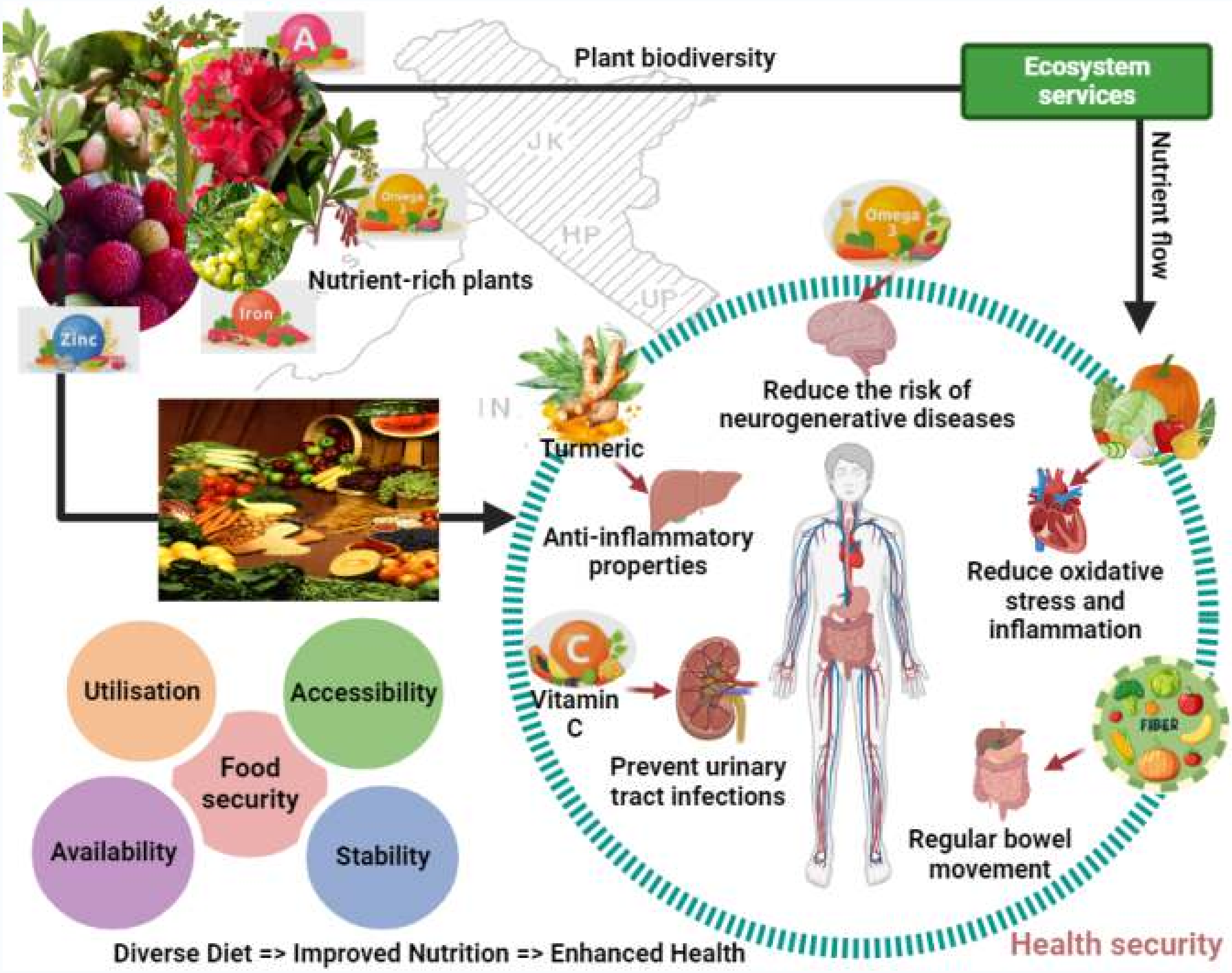

Fig. 2. A schematic showing a holistic nexus among plant biodiversity, food, nutrition and health security

Theme 5: Entrepreneurship and value chains- role of youth and women

Entrepreneurship and value chains play a crucial role in economic development and poverty reduction. They create opportunities for economic growth, generate employment, and increase incomes. In recent years, there has been a growing recognition of the importance of incorporating youth and women into these value chains to maximize their impact and promote inclusive economic development. Youth, particularly those in the age group of 15-24, represent a significant proportion of the global population. However, they often face challenges in accessing decent employment and career opportunities. By engaging youth in entrepreneurship and value chains, they can contribute to economic growth and innovation. Entrepreneurship provides avenues for young people to develop their skills, creativity, and business acumen (Muthuraman and Kasianantham, 2023). Moreover, by actively participating in value chains, they can access markets, networks, and resources, which are essential for their businesses' success.

Women, on the other hand, make up half of the global population but face various barriers in economic participation. Engaging women in entrepreneurship and value chains not only addresses gender inequality but also enhances economic productivity by harnessing their untapped potential. Women entrepreneurs often bring unique perspectives, innovative solutions, and efficient management practices to the table. By incorporating women into value chains, there is a potential to increase productivity, improve supply chain efficiency, and enhance competitiveness. To involve youth and women effectively in entrepreneurship and value chains, several actions should be taken: a) providing access to entrepreneurship training, mentorship, and business development services can equip youth and women with the necessary skills and knowledge to succeed as entrepreneurs. It is important to tailor these programs to address specific challenges faced by these groups; b) lack of access to finance is a significant barrier for youth and women entrepreneurs. Creating financial inclusion mechanisms and establishing targeted funding schemes can empower these entrepreneurs to invest in their businesses and expand their operations; c) networking and mentorship: Establishing networks and platforms that connect young and women entrepreneurs with established business leaders and industry experts can facilitate knowledge exchange; provide guidance, and open doors to new opportunities. Efforts should be made to challenge and eliminate gender biases and barriers that hinder women's participation in value chains. This can include policy changes, promoting gender equality in education and training, and creating inclusive business environments that encourage the participation of women. Governments and policymakers should develop supportive policies and strategies that prioritize youth and women entrepreneurship, recognize their contributions, and provide an enabling environment for their engagement in value chains.

Plants are a complete package of gifts from nature to mankind. Every single part of the plant of the varied plant biodiversity has some or other use. The roots, flowers, stems, twigs, leaves, seeds, and fruits have some nutritional or medicinal benefits. Several species of plants can be a source of income for the local farmers such as flowers of *Rhododendron arboreum* for the production of squash, berries of sea buckthorn for medicinal purposes, rhizome part of *T. govanianum* for pharmaceutical purposes, and many others. Some of the plants are so specific to particular regions that they are provided as Geographical indications tags such as saffron (Kashmir), Kangra Tea, Black Cumin, Basmati rice and wild apricot oil (Himachal Pradesh) and Cinnamon (Uttarakhand). They are a good source of income for the locals and enterprises based on natural products, crafts, and medicines from plants, fetching good prices in the market. More than 95% of the plants used for medicinal purposes by several industries are obtained from the wild forests. The use of the value chain concept will provide better prices for the product in the market. Timber from forest is used for multiple purposes while non-timber forest products also play a vital role in providing bread and butter to the rural poor by satisfying their economic needs.

With majority of the people in Himalayan regions migrating towards cities for better education, health facilities, and job opportunities, the women of the household are still residing in their native places and greatly contributing towards several micro, small, and medium enterprises. Women possess brilliant skills in planning, organizing, directing, and coordinating. Support from the government by providing subsidies, training, and workshops can encourage the participation of rural youth and women in starting their own enterprises. Youth plays a vital role in transforming rural areas and agri-food systems. Drawing the attention of the youth towards exploration of the existing plant biodiversity can revitalize the rural economy. Their awareness of the policies and the ease to access technologies can be a boon for entrepreneurial success. Rural women and youth in alignment with government organizations can work in harmony for the exploration, utilization, and conservation of plant biodiversity.

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Management of PGR in India: Role of ICAR-NBPGR

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The National Bureau of Plant Genetic Resources (ICAR-NBPGR) was established by the Indian Council of Agricultural Research (ICAR) in 1976 with its headquarters at New Delhi. The chronology of events leading to the present day ICAR-NBPGR dates back to 1905 when Botany Division was established under the then Imperial Agricultural Research Institute. ICAR-NBPGR has been given the mandate to act as a nodal institute at the national level for acquisition and management of indigenous and exotic plant genetic resources (PGR) for agriculture, and to carry out related research and human resources development for sustainable growth of agriculture. The Bureau is also vested with the authority to issue Import Permit and Phytosanitary Certificate and conduct quarantine checks in seed material and vegetative propagules (including transgenic material) introduced from abroad or exported for research purposes. Besides having a 40 ha experimental farm at Issapur village (about 45 km west of Pusa Campus), the Bureau has a strong national network comprising Regional Stations/ Base Centres and ICAR Institutes/ SAUs that provide access to representative agro-ecological situations in the country.

Mandate: The mandate includes management and promote sustainable use of plant genetic and genomic resources of agri-horticultural crops and carry out related research; coordination of capacity building in PGR management and policy issues governing access and benefit sharing of their use, and molecular profiling of varieties of agri-horticultural crops and GM detection technology research.

ICAR-NBPGR has its headquarters in New Delhi that hosts the second largest genebank in the world. The operations are administered by Divisions of Plant Exploration and Germplasm Collection, Germplasm Evaluation, Germplasm Conservation, Genomic Resources and Plant Quarantine in addition to the Units of Germplasm Exchange and Agricultural Knowledge Management. ICAR-NBPGR has the network of 10 Regional Stations covering different agro-climatic zones to carry out PGR activities including collection, characterization, evaluation and maintenance of various crops as mentioned below:

1. ***Shimla (Himachal Pradesh):*** Established in 1960 for temperate crops.
2. ***Jodhpur (Rajasthan):*** Established in 1965 for agri-horticultural crops germplasm of arid and semi-arid zones.
3. ***Thrissur (Kerala):*** Established in 1977 for agri-horticultural crops germplasm of southern peninsular region with particular emphasis on spices and plantation crops.
4. ***Akola (Maharashtra):*** Established in 1977 for agri-horticultural crops germplasm of central India and Deccan Plateau.
5. ***Shillong (Meghalaya):*** Established in 1978 for agri-horticultural crops germplasm of north-eastern region including Sikkim and parts of north Bengal.
6. ***Bhowali (Uttarakhand):*** Established in 1985 for agri-horticultural crops germplasm of sub-temperate region.
7. ***Cuttack (Odisha):*** Established in 1985 for agri-horticultural crops germplasm of eastern peninsular region with main emphasis on rice germplasm.
8. ***Hyderabad (Telangana):*** Established in 1985 for quarantine clearance of agri-horticultural crops germplasm of Telangana, Andhra Pradesh and adjoining areas.
9. ***Ranchi (Jharkhand):*** Established in 1988 for germplasm of tropical fruits and other field crops of Bihar, eastern Uttar Pradesh, Jharkhand and West Bengal.
10. ***Srinagar (Jammu & Kashmir):*** Established in 1988 for agri-horticultural germplasm of temperate crops.

PGR are conserved in the form of seeds, vegetative propagules, tissue/ cell cultures, embryos, gametes, etc. in the Genebank. The National Genebank facility commissioned in 1997 has 12 long term storage modules, each with a storage capacity of 50,000 to 76,000 samples depending upon the size of seeds. Its cryopreservation facility contains six liquid nitrogen storage tanks (cryo-tanks), each having a capacity to hold 1,000 litres of liquid nitrogen. These six cryo-tanks have a total capacity to store 0.25 million samples. Thus, the National Genebank has a total capacity to store 0.85 to 1.25 million samples. This is one of the most modern Genebanks of the world.

The Bureau not only conserves PGR safely to meet the needs of future generations, but also provides these to the nation's crop improvement programmes to sustain continued advances in agricultural productivity and stabilize production. The Bureau works in close collaboration with several international institutes/ organizations through memoranda/ work plans developed under bilateral/ multilateral agreements. It exchanges plant germplasm with over 100 countries. The Bureau is gradually developing and strengthening the national plant genetic resources system by linking up the National Base Collection (kept under long-term storage at ICAR-NBPGR with National Active Germplasm Sites (NAGS) responsible for different crops where germplasm collections are evaluated and multiplied under field conditions backed by medium-term storage facilities. The various activities and achievement of the Bureau are presented here, briefly.

PGR Exploration and Collection

- To develop new varieties in various agri-horticultural crops for farmers suitable to different agro-climatic conditions, new germplasm/ parent material with desired traits or genes is a continuous requirement of the plant breeders. Therefore, periodically such germplasm is collected by ICAR-NBPGR Scientists in collaboration with crop-based institutes of ICAR. Also, the trait-specific germplasm of various crops has been collected from diversity-rich spots (including the difficult unreached areas in different parts of the country).
- The institute has so far undertaken 2864 explorations and collected about 2.83 lakhs accessions of crop species and their wild relatives.
- **Focus on North-East and rescue missions**: In total, 165 explorations undertaken and a total of 9,698 accessions (cultivated- 6,622, wild- 3,076) collected. 45 exploration trips to North-Eastern Hill Region and five rescue missions to natural calamity affected areas of Uttarakhand were undertaken. Systematic explorations have been conducted in the remotest parts of the country including Mon district of Nagaland; Anjaw, Changlang and Tirap districts of Arunachal Pradesh; and Great Nicobar. Disturbed/insurgency-prone areas such as Bastar region in Chhatttisgarh; Gadchiroli in Maharashtra; and West Medinipur in West Bengal resulting in collection of 858 landraces of different agri-horticultural crops. Gap analysis, geo-referencing and diversity distribution mapping completed in nine crops.
- **Priority was given to the crop wild relatives (CWR)** which resulted in collection of 576 unique accessions which resulted in a significant increase in the share of wild species (32%) in the total collection. In year (2019-20) 159 accessions were collected in an exploration undertaken in A&N Islands. In one exploration in North Andaman conducted for 25 days, 44 CWR species including rare first-time collections like *Oryza indandamanensis, Sorghum nitidum, Garcinia dulcis, Phoenix andamanensis* etc. 18 species were collected for the first time.

PGR Exchange

- ICAR-NBPGR is the nodal agency for import and export of all PGR for research purpose, adhering to guidelines of National Biodiversity Act, 2002.
- ICAR-NBPGR is instrumental in introduction of several new crops in India such as soybean, sunflower, kiwi, tree tomato, oil palm, jojoba, guayule, hops etc. and aromatic plants like rose geranium which are getting popular in Himalayan states, Uttarakhand and HP.
- More than 10, 000 accessions of indigenous and introduced germplasm are supplied annually to the researchers throughout the country.
- Exchange carried out with >130 countries and CGIAR institutes under bi-or multi-lateral agreements. Annually, ~25,000 accessions of PGR and ~75,000 samples of trial material (primarily from CG Institutes) are introduced into India for use in crop improvement programmes. Till date, about 6.5 lakh germplasm accessions of various crops including the transgenic planting material have been introduced/ imported into the country. This is now facilitated through online application for import permit (Germplasm Exchange & Quarantine - Login (ernet.in)). These introductions

have been used both for direct release as varieties and in crossing programme as parents. Hundreds of such examples are available of use of exotic germplasm in varietal development.

- Not only the exotic germplasm introduced from other countries has helped in growth of Indian agriculture but several germplasm lines of Indian origin have helped in saving crops in other countries.

Plant Quarantine

- Introduction of planting material, including transgenics from other countries carries risk of entry of the associated pests (fungi, bacteria, viruses, insects, nematodes and weeds etc.). Hence, all genetic resources acquired from foreign countries are tested using plant quarantine measures (legislative measures) to prevent the entry of exotic pests and to avoid their spread to the fields.
- ICAR-NBPGR has been empowered under the Plant Quarantine (Regulation of Import into India) Order 2003 of the Government of India to carry out quarantine checks on the germplasm being exchanged meant for research purposes, including transgenics. It undertakes quarantine processing of germplasm meant for export and issues the Phytosanitary Certificate for the material meant for export.
- The quarantine has resulted in the interception of several pests of high economic significance including (>75) those not yet reported from the country. Such interception signifies the success of quarantine as otherwise these pests could have entered the country and played havoc with the plant biodiversity and Agriculture.
- So far > 50 lakh samples of various crops have been processed for quarantine clearance
- Infestation/ infection/ contamination detected in > 2 lakh samples of which 99.95% were salvaged and 78 exotic pests intercepted.
- Any inadvertent introduction of any pest not present in the country could lead to serious economic losses to farmers and the country. NBPGR has also undertaken an exercise to estimate losses that could occur, if any of the diseases/weeds was introduced in the country

PGR Conservation

Seed Conservation: The Indian National Genebank (NGB) was established at ICAR-NBPGR to conserve the PGR for posterity in the form of seeds, vegetative propagules, *in vitro* cultures, budwoods, embryos/embryonic axes, genomic resources and pollen. The NGB has four kinds of facilities, namely, Seed Genebank (-18°C), Cryogenebank (-170°C to -196°C), *In vitro* Genebank (25°C), and Field Genebank, to cater to long-term as well as medium-term conservation.

The NGB with a capacity to conserve about one million germplasm in the form of seeds is currently conserving about 0.46 million accessions (Table 1) belonging to over 1,800 species. Over 12,500 samples of seed, dormant buds, and pollen are cryopreserved (Table 3) and over 1,970 accessions are conserved in the *in vitro* genebank (Table 2). The NGB is supported by active partnership of other intuitions designated as the NAGS. The NAGS are responsible for maintaining, evaluating and distributing germplasm from their active collections to NGB and other user scientists.

***In-vitro* conservation:** Conservation of cells, tissues, and organs in glass or plastic containers under aseptic conditions. Such conservation is based on the slowed growth of cultures in highly controlled *in-vitro* conditions.

Table 1. Accessions conserved in the base collection (-18°C) at National Genebank (Seeds)

Crop group	Status as on March 31, 2023
Cereals	175119
Millets	60270
Forages	7497
Pseudocereals	8143
Legumes	68588
Oilseeds	63384
Fibre	16943
Vegetables	29000
Fruits & Nuts	300
M&AP	9361
Ornamental	739
Spices, Condiments and Flavour	3669
Agroforestry	1699
Duplicate safety Samples (Lentil, Pigeonpea)	10235
Trial Material (Wheat, Barley)	10771
Total	**465718**

The NGB also maintains 1927 accessions belonging to more than 158 vegetatively-propagated plant species under *in-vitro* conditions.

Cryopreservation: Conservation of cultures (tissues, pollen, cultures, or seed in liquid nitrogen. Around 11,936 accessions belonging to 720 species have been cryopreserved at optimum moisture contents of 5-8% in vapour phase of liquid nitrogen at a temperature of –150 to –196^{0}C.

Table 2: Status of Accessions conserved *In Vitro* Genebank at ICAR-NBPGR (Tissue Cultures)

Crop / Crop Group	Accessions as on March 31, 2023
***In vitro* bank**	
Tropical fruits	449
Temperate and minor tropical fruits	390
Tuber crops	527
Bulbous crops	178
Medicinal & aromatic plants	211
Spices and industrial crops	230
TOTAL	**1,984**

Table 3: Status of accessions status at Cryogenebank (-196 Degree Celsius) at ICAR-NBPGR

Crop / Crop Group	Accessions as on March 31, 2023
Cryobank	
Recalcitrant	0
Intermediate	7784
Orthodox	3,962
Dormant bud	389
Pollen	655
TOTAL	**12,790**

PGR Characterization and Evaluation

The utilization of PGR in crop improvement programs rests on identification of promising accessions. The collected or introduced germplasm is characterized and evaluated to assess its potential, by recording data on agronomic traits such as yield, quality, and tolerance to biotic and abiotic stresses. The germplasm is also evaluated for new traits using molecular tools to identify the genes to develop new varieties as per requirement of the farmers. Salient achievements are as:

- Approximately 10,000 accessions are characterized/ evaluated every year at ICAR-NBPGR and its regional stations. So far, more than 3.0 lakhs accessions of different agri-horticultural crops have been characterized and evaluated and passport data is available**.**
- Core sets have been developed in crops viz., okra, mungbean, sesame, brinjal, cowpea, and wheat to facilitate the enhanced utilization of germplasm.
- Genetic diversity in large collection has been determined using morphological and DNA fingerprinting markers in crops like rice, mungbean, banana, cashew, mango, oilseeds, brassicas, tomato, sesame, cucumber and cotton.
- Mega programme on characterization and evaluation under the National Initiative for climate Resilient Agriculture (NICRA) executed in collaboration with SAUs for 21,822 accessions of wheat and 18,775 of chickpea.

DNA Fingerprinting and development of Genomic Resources

- About 2,300 varieties in more than 35 crops have been fingerprinted so far (Table 1.6)**.** Also, the new varieties are being DNA fingerprinted to avoid any biopiracy by any unauthorized person or country.
- Established the National Genomic Resources Repository to collect, generate, conserve and distribute genomic resources for agricultural research in the country. The aim is to promote deposition, sharing and utilization of enormous amount of genomic resources generated in the country and elsewhere.
- All forms of genomic resources including clones, gene constructs, large DNA fragment libraries as well as genomic sequence information in soft copy form can be deposited in this repository.
- All depositions or requests are to be made along with material transfer agreements in order to protect the interest of the depositor and the sovereignty of the Nation over the genetic resources. The IP rights (if any) shall remain with the depositor.
- Newly identified genes (952) are also conserved in the form of DNA libraries, etc.

ICAR-NBPGR also has the mandate to carry out molecular profiling of varieties of agri-horticultural crops. This involves generation and utilization of molecular markers for molecular characterization of these crops. Although a lot of dominant multi-locus marker systems such as RAPD (Random Amplified Polymorphic DNA), AFLP (Amplified Fragment Length Polymorphism) etc. have been used, the preferred markers for molecular characterization are SSR (Simple Sequence Repeat) and SNP (Single nucleotide Polymorphism) markers owing to their codominant nature. Whereas a lot of molecular markers are available in crops like rice, wheat, maize, potato, cotton, soybean etc. there are others which despite being important contributors to the food basket are less worked at the genomics front.

Generation, validation and utilization of genomic resources is one of the major objective of ICAR-NBPGR. These resources are utilized for value addition to the plant germplasm resources harboured in the genebank and for generating molecular profiles varieties of agri-horticultural crops. The advent of next generation sequencing with improved chemistries and lower input costs have resulted high throughput data that can be mined for generating SSR and SNP markers.

- Genomic SSRs have been generated and validated at NBPGR in crops like okra, snake gourd and moth bean using NGS technologies in house. SSRs from transcriptome sequencing have been mined and validated in finger millet, kodo millet, little millet and sponge gourd
- A novel gene targeted marker technique CBDP (CAAT Box-Derived Polymorphism) has been developed that can be used for various genotyping applications in plants. The technique exploits conserved CCAAT motif in the CAAT box region of promoter region of plant genes to generate markers. The concept has been validated in three different crops (Jute, cotton, linseed) representing five different species (*Corchorus capsularis, C. olitorius, Gossypium hirsutum, Gossypium orboratum*) and linseed (*Linum usitatissimum*).
- A draft genome assembly of 480 Mb of black pepper (*Piper nigrum*) genome has been generated at NBPGR under the ICAR funded Consortium Research Platform on Genomics. A large number of genomic resources in the form of genomic and genic SSRs have been generated.
- A rice core consisting of 701 accessions has been developed from 6,984 accessions of North-Eastern region of India. This core was further characterized with 50K SNP chip of Rice for development of mini-core. Cluster analysis based on 50K SNP markers grouped 192 accessions of core into seven clusters. This analysis shows that the core developed from NE rice collection is very diverse and has captured maximum diversity present.
- DNA Barcoding loci rbcL, matK, trnH-psbA and ITS region alone and/combination of two loci identified 21 genomic species in *Oryza* and were used for establishing correct genetic identity of mis-labeled species. Two combined loci DNA barcodes (rbcL + ITS) gave better species delineation and proper barcode gaps for species identification in genus Luffa.
- DNA profiling services were rendered to various public and private sector organizations. A total of 558varieties belonging to 33 crops have been profiled in the last four years itself.
- Discovery of non-Kranz C4 photosynthesis in two cell layers (cross- and tube-cells) of pericarp in developing wheat grains. Named it as "Bose anatomy" in honour of his earliest works on C4 in Hydrilla reported in 1924 when C3 itself was not known.
- Technology has been developed for Identification of SRAP Markers Linked to the Single Dominant Resistance Gene against Tomato Leaf Curl New Delhi Virus in *Luffa cylindrica* Roem: Two sequence-related amplified polymorphism (SRAP) markers closely-linked to the ToLCNDV-susceptible gene in the susceptible parent and in a susceptible bulk population; and two SRAP markers closely-linked to the resistance gene in the resistant parent and in a resistant bulk population were found. These can be used for large-scale screening of genotypes of *L. cylindrica* for resistance against ToLCNDV at the seedling stage, and to accelerate the breeding of high yielding, ToLCNDV resistant varieties and hybrids.
- Qualitative and quantitative PCR and real-time PCR assays have been developed/ validated for detection of more than 50 events of 14 GM crops (brinjal, cabbage, cauliflower, cotton, maize, mustard, oilseed rape, okra, papaya, potato, rice, soybean, tomato, wheat).
- Rapid and cost-efficient assays have been developed for screening of GM crops employing a) visual and Real-time Loop-mediated Isothermal Amplification (LAMP) for rapid on-site detection; b)

GMO Screening Matrix as decision support system, and c) ready-to-use TaqMan® Real-time PCR based multi-target system.

- GM-free Conservation of Germplasm in National Genebank: Bt cotton has been commercially cultivated in India since 2002 and other GM events of cotton, brinjal, okra and maize were under field trials, hence, to ensure GM-free conservation of germplasm in the National Genebank, the adventitious presence of transgenes was monitored in ex situ collection including cotton (200 accns.), brinjal (150 accns.), okra (50 accns,), maize (100 accns) using PCR/real-time PCR-based markers. None of the accessions screened so far showed adventitious presence of transgenes based on tests conducted.

Germplasm Utilization

The Bureau has supplied germplasm, collected indigenously or from exotic sources, to the breeders and other researchers in the country. The germplasm supplied by ICAR-NBPGR to various breeders have been used in varietal development. Several indigenously supplied germplasm accessions have helped to develop improved varieties in various national programmes. These include rice variety (Maruteru sannalu), sorghum variety (Parbhani Moti), red okra (Aruna), Chinese potato (Nidhi), coriander variety (Sudha), and yam variety (Indu) a few to name.

The NBPGR is involved in the release of about 100 varieties in the past in different agri-horticultural crops either through direct introduction or by selection from the introduced germplasm and popularized several such introductions for commercial cultivation. Also, many temperate fruits including kiwi, hops and several medicinal and aromatic plants like rose geranium are getting increasingly popular in Himalayan states, Uttarakhand and HP.

PGR Documentation

A PGR Portal has been hosted on NBPGR website, which is a gateway to information on plant genetic resources conserved. The Portal contains information on about 0.4 million accessions belonging to about 1800 species. The PGR documentation is done in various forms including printing of books, crop catalogues, inventories, research papers, popular articles, pamphlets etc. In addition, NBPGR has developed mobile apps Genebank and PGR map in PGR Informatics which can accessed through NBPGR web pages, genebank.nbpgr.ernet.in and http://pgrinformatics.nbpgr.ernet.in/pgrmap/

- Two mobile apps "Genebank" and "PGR Map" have been developed to enhance access to PGR information with an easy user interface. The apps have been hosted on Google Play and App Store.
- "Genebank App" provides a dashboard view of indigenous collections (state-wise), exotic collections (country-wise), addition of accessions to genebank, etc. The app also helps generate routine genebank reports. The app uses databases live on the backend and hence always gives updated information.
- "PGR Map App" offers three benefits: "*What's around me*" helps user to obtain quickly the accessions that have been collected and conserved in the genebank from a particular location in India where the user is located at the moment; *"Search the map"* helps user to list the accessions that have been collected and conserved in the genebank from any selected location in India; *"Search for species"* helps user to map the collection sites of a crop species.
- Establishment of geo-informatics portal in PGR: A study to link germplasm to changing climatic regimes was earlier carried out with the funding of the CGIAR Research Program on Climate Change, Agriculture and Food Security (CCAFS). A web interface named PGR CLiM was also developed to access information *(www.nbpgr.ernet.in:8080/climate)*.

Germplasm Registration

Recognizing the importance of PGR with novel, unique, distinct and high heritability traits of value that could be used in crop improvement, and to facilitate flow of germplasm to users. ICAR-NBPGR plays a vital role in germplasm registration. More than 2000 potentially valuable germplasm of over 120 species of various crops registered so far. To facilitate smooth registration process, a fully online system of filing registration applications, their scrutiny, review and communications at every stage has been developed (http://www.nbpgr.ernet.in:8080/registration/). Details of the registered germplasm could be accessed at http://www.nbpgr.ernet.in:8080/ircg/index.htm.

All India Coordinated Network Project Potential Crops

This network programme is located at ICAR-NBPGR, New Delhi and has 13 main centers in different parts of the country. The major functions are introduction, evaluation, conservation, and popularization of new potential and useful plant species for acclimatization to local condition. Grain amaranth, buckwheat, ricebean, jatropha and simarouba have been developed and popularized under this project.

Grain amaranth (*Amaranthus* spp.), normally grown in the hilly region, was tested for cultivation in the plains after the inception of the network in mid 1980s in Gujarat. The crop of grain amaranth acclimatized well and was found suitable for cultivation during rabi season. Three varieties, namely, GA-1, GA-2 and GA-3 were released for cultivation in north Gujarat.

Likewise, germplasm for some other potential crops like quinoa (*Chenopodium quinoa),* Faba beans (*Vicia faba*), etc, have been introduced and distributed to farmers.

Human Resources Development

- NBPGR faculty conducts M.Sc and Ph.D. courses in PGR under the Post-graduate School of Indian Agriculture Research Institute (IARI), New Delhi.
- National and international training programmes conducted routinely on various aspects of PGR management.
- NBPGR is designated as the Centre of Excellence since 2006 by ICAR and Bioversity International to impart training on *in vitro* conservation and cryopreservation of PGR and more than seven trainings conducted. So far, more than 120 researchers from 40 countries have benefitted from this training course.

National and International Linkages

- Close collaborations with Bioversity International, ICARDA, IRRI, CIMMYT and other countries on genetic resources management and utilization
- Collaborations with all ICAR institute, state agricultural universities, CSIR institute, DBT, DST, DRDO etc. for germplasm trait-specific evaluation and utilization
- Memorandum of Understanding (MoU) was signed between the Indian Council of Agricultural Research (ICAR) and the Royal Botanic Gardens (RBG), Kew, UK to enhance capacities of both the institutions in research on conservation biology.
- ICAR-National Bureau of Plant Genetic Resources and Forest Research Institute, Dehradun had signed a MoU for the conservation of seed-bearing trees species of forestry importance.
- MoU of ICAR-NBPGR with CPCRI, Kasaragod and NRC Orchids has been operationalized for cryo-conservation of coconut and orchids germplasm, respectively, at the National Cryogenebank, NBPGR.

ICAR-NBPGR for Safeguarding Nation's Future Food and Nutritional Security: Safety Duplicates: ICAR has taken a step forward in securing its crop genetic diversity by depositing 25 accessions of pigeonpea in the Svalbard Global Seed Vault. This was the first such deposit by India as safety duplicates in the global genebank which is jointly maintained and managed by Norway's Department of Agriculture and the Global Crop Diversity Trust under the ITPGRFA. A second deposit of 100 samples each of rice and sorghum was sent to Svalbard Global Seed Vault (SGSV) for safety duplication in 2016. In October, 2022 India further added to its safety duplicate tally with the deposition of wheat (2,180 accessions) and chickpea (887 accessions), which represented the core sets in the respective crops. This contribution to the global conservation endeavor is a major milestone in NBPGR's PGR management mandate.

GM Detection Research Facility (GDRF)—Accredited as per international standards ISO:IEC 17025:2017 by the National Accreditation Board for Testing and Calibration Laboratories (NABL), a Constituent Board of Quality Council of India. It was designated as the National Referral Laboratory to detect the presence or absence of LMOs and GMOs under sub-section (1) of Section 4 of the Seeds Act, 1966 in the Gazette of India Notification (DAC&FW, MoA&FW, Govt. of India) dated 15 November 2017. GDRF is coordinating the Network of GMO Testing Laboratories (NGTL) of India http://gmolabs.nbpgr.ernet.in:9090

New Initiatives by ICAR-NBPGR for PGR Management

- Modernization of genebank
- Large scale characterization, evaluation and core set development including pre-breeding activities
- Generation of genomic resources for tolerance to abiotic and biotic stresses and nutritional quality
- Genomics assisted traits discovery using GWAS tools
- Development of G-DIRT (Germplasm Duplicate Identification and Removal Tool)
- Conservation and cryo-banking of selected vegetatively propagated species.
- Digitization of all herbarium specimens
- Launching of Chip based technology for Real-time and RFID passive monitoring of field genebank and agroforestry species
- Remote phenotyping of tree Germplasm by using Hyperspectral, Multi-spectral and RGB camera on a Drone under ICAR-NBPGR, IARI and ICRAF Collaboration
- Development of eco-friendly salvaging treatments for imported germplasm

Future Thrusts

Germplasm management is a gigantic task, particularly in the context of the richness of genetic resources and agro-ecological diversity in the country. Some important thrust areas of the research include the following:

- Rationalization of the National Genebank collection and harnessing natural environment for cost effective conservation.
- Collection in partnership mode, trait-specific germplasm for tolerance to biotic and abiotic stresses and quality characteristics.
- Harmonizing multitude stakeholders including private seed sector, farming community, NGOs and international agriculture research centres to enhance conservation and utilization
- Taxonomic and biosystematic studies of Indian taxa using morphological and molecular tools.
- Comprehensive evaluation of conserved germplasm, establishment of core/ mini-core/reference set of large germplasm collection, identification of potential donor germplasm for agronomic, stress-related and quality traits for genomics assisted trait discovery and enhanced utilization.
- Strengthening of the National Genomic Resources Repository, genomic resource generation and conservation.
- Adoption of all the forthcoming technologies to maximize accuracy, coverage and efficiency of germplasm collection, economize and rationalize germplasm conservation, identify trait-specific germplasm and promote utilization, add value to germplasm based on genomic and geographical information, develop decision support system to manage PGR
- Develop and implement strategies to comply with international and national legal requirements ensuring easy access and fair benefit sharing
- Develop human resource in PGR and attract researchers to PGR science

Awards and recognitions— Recently ICAR-NBPGR has been ranked 2nd among the 93 ICAR institutes for the years 2019-20 and 2020-21. The Bureau has the distinction of receiving “Best Institute of ICAR” award for the year 1997 in recognition of its dedicated and meritorious service to the nation in the field of PGR augmentation, exchange, quarantine, characterization, utilization, distribution and conservation, and developing a network for efficient management of PGR in the country.

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Overview of Agri-biodiversity across Indian Himalayas

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The Himalaya was formed as an enfoldment of earth crust under the Tethys sea resulting from collusion of Indian (peninsular) plate with the Asian continental plate some 15 million years ago. It is 2500 Kms long occupying a geographical area of about 236000 square kilometres in India. Its width ranges from 240 to 340 km and has a rise of over 8000 m from the Indian plains. It has been great attraction for spiritual aspirants, trekkers, explorers etc. it is earnestly termed as Devbhumi. Because of its vast diversity in soil, slope aspects, altitudes and ecological conditions, it hosts a large variety of plant life on rocks, rivers and forests as well as in agriculture. This is also true for human ethnic races and wild life. Agro-biodiversity, which forms the basis of existence of human life on the earth planet, is amply rich resource in the Himalayan Mountains and plain valleys. Agro-biodiversity broadly covers all forms of life that has a link with agricultural production systems that exist among the various farming communities. The various components of agro-biodiversity may include crop plants, weeds, soil micro-organisms, domesticated and wild animals that has bearing on agriculture, pathogens, insect pests, agroforestry plant species etc. This paper however, deal with the diversity in crop plants that are found across the Indian Himalaya.

Physiography of the Indian Himalaya

The Indian Himalaya starts in the west from Nanga Parbat and extends to Arunachal Pradesh. The Arunachal Pradesh portion of the eastern Himalaya further extends in northeasterly direction covering all norths–eastern states. It includes Indian states such as Jammu & Kashmir, Himachal Pradesh, Uttaranchal, hills of West Bengal, Sikkim and Arunachal Pradesh. Vertically it extends from Indian plains to Tibet high lands and has four parallel ranges from south to north. These are:

(i) **Shivalik hills or outer Himalaya:** are low hills with altitude below 1000 m.

(ii) **Middle or lesser Himalaya:** is about 60 to 80 km width and has an altitude averaging 3500 m above msl.

(iii) **Inner or greater Himalaya ranges:** are high mountain ranges about 120 to 140 km in width.

(iv) **Trans-Himalayan region:** is about 40 km wide and includes arid, temperate areas of Ladakh, Lahual–Spiti, Pangi (Chamba).

The Indian Himalaya are mainly constituted of

(a) **N-W Himalaya:** comprising of Jammu & Kashmir and Himachal Pradesh

(b) **Central Himalaya:** which include the newly formed state of Uttaranchal (Kumaon and Garhwal hills)

(c) **Eastern Himalaya:** is comprised of state of Sikkim and Arunachal Pradesh.

(d) **North-Eastern Himalaya:** is the extension of the eastern flank encompassing states of Assam, Tripura, Manipur, Nagaland, and Mizoram.

The western or North-Western ranges are drier, gets snowfall beyond 2000 m during winters and as it advances towards east direction the elevation for snowfall rises and rainfall increases and the vegetation becomes very rich. The Himalayas are mainly characterised by Boreal and Paleo-tropical or Indo-Malayan type bio-geographical zones. Out of 6000 endemic plant species, 2532 species occur in the Himalaya.

Agro-Biodiversity Across the Indian Himalayas

The Indian Himalayas are a rich reservoir of crop agro-biodiversity. The whole range of species diversity under various crop groups could be classified as:

(1) **Cereal Crops:** which includes wheat (*Triticum aestivum*), maize (*Zea mays*), rice (*Oryza sativa*), barley (*Hardeum vulgare*), Jau (*H. himalayense O*ujau)

(2) **Millet Crops:** Jowar (*Sorghum bicolour*), Bajra (*Pennesetum typhiodes)*, Chena (*Panicum miliaceum*), Kodo or Kodra (*Paspalum scrobiculatum*), Kaoni (*Setaria itatica*), Mandira or Jhangera (*Echinochloa frumentacea*), Mandua (*Eleusine coracana*), Sanwa, Kutki (*Panicum sumatrense*).

(3) **Pseudocereals:** Buckwheat Ogal (*Fagopyrum esculentum*), Phaphar (*Fagopyrum tataricum*), Pigweed, Bathua (*Chenopodium album*), Chauli (*Amaranthus caudatus, A. hypochondriacus, A. cruentus*)

(4) **Less Known Cereals:** Job's tear (*Coix lachryma jobi*), Small millet, Raishan, (*Digitaria cruciata var. esculenta*.).

(5) **Pulse or Legume Crops:** Black gram, Urd (*Vigna mungo*), Mung or Green gram (*V. radiata*), Rains or Adjuki bean (*V. angularis*), Bharinga or Moth bean (*V. aconitifolia*), Rongi, sonta or Cowpea (*V. unguiculata*), Ricebean or Bhotiya (*V. umbellate*), Matar (*Pasum sativum*), Rajmah (*Phaseolus vulgaris*), Bhatta (*Glycine soja*), Kala Bhatta (*Glycine spp.*), Soybean (*Glycine max*), Chana, Gram (*Cicer arietinum*), Masar, lentil (*Lens esculenta*), Kultha, Gahat or horse gam (*Macrotyloma uniflorum*), Mattari, Khesari (*Lathyrus sativus*), Vakla (*Vicia faba*), Sudu (*V. sativa var. angustifolia*), Tur, Arhar (*Cajanus cajan*).

(6) **Edible Oil Yielding Plant Species:** Sarson, Toria (*Brassica campestris*), Banarsi Rai (*Brassica nigra*), Rai Sarson (*B. juncea*), Taramira, Rocket (*Eruca sativa*), Tisi, Alsi, Flax (*Linum usitatissimum*), Sesame, Til (*Sesamum indicum*), Bhanjira, Neileh (*Perilla frutescens*), Chiura (*Aesandra butyracea = Bassia butyracea*), Chuli (*Prunus armeniaca*), Bhekal (*Princepia utilis*), Erand, Castor (*Ricinus communis*), Akhrot, Walnut (*Juglans regia*).

(7) **Vegetable Crop Plant Species:** It is very large group of plant species, which may be cultivated or even collected from natural habitats. The cultivated vegetables include followings;

(a) **Crucifer Vegetables**: Band Gobhi, Cabbage (*Brassica oleracea var. capitata*), Phulgobhi, Cauliflower (*B. oleracea var. botrytis*), Shaljam turnip (*B. campestris var. rapa*), Muli, Radish (*Raphanus sativus*).

(b) **Cucurbitaceous Vegetables:** Pumpkin (*cucurbita moschata, C. maxima*), cucumber (*Cucumis sativus*), Cho-cho (*Sechium edule*), Bottle gourd, Ghiya, Lauki (*Lagenaria siceraria*), Ridge gourd (*Luffa acutangula*), Sponge gourd (*Luffa cylindrica*), Bitter gourd (*Momerdica charantia*), Parval (*Trichosanthes dioica*), Snake gourd (*Trichosanthes anguina*), Bhat Karela (*Momordica cochinensis*), Kakral, Kakora (*Momordica dioica*), Kundru (*Cephalandra indica*), Petha, Ash gourd (*Benincasa hispida*).

(c) **Leafy Vegetables:** Palak (*Beta vulgaris var. bengalensis*), Vilayati Palak (*Spinacia oleracea*), Methi (*Trigonella foenumgraecum*), Kasuri Methi (*T. corniculata*), Lai Patta (*Brassica campestris var. cuneifolia*), Lohi patta (*B. campestris var. rugosa*), Karam Sag (*B. oleracea var. acephala*), new Zealand Spinach (*Tetragona expansa*), Bathua (*Chenopodium album*), Khatta Palak (*Rumex vesicarius*), Chaulai (*Amaranthus blitum, A. dubius, A. hypochondriacus, A. caudatus*), Jirag (*Phytolacca acinosa*), *Perilla frutescens.*

(d) **Leguminosus Vegetables:** Pea, Matar (*Pisum sativum*), Frans bean (*Phaseolus vulgaris*), Bakla (*Vicia faba*), Rongi, Asparagus bean or Yard long bean (*Vigna sinensis var. sesquipedalis*), Lima bean (*Phaseolus lanatus*), *Cabavalia ensiformis, C. gladiata, Dolichos lablab, Mucuna pruriens, Psophocarpus tetragonolobus.*

(e) **Root and Tuber Crops:** Alu (*Solanum tuberosum*), Ratalu, Yam (*Dioscorea alata, D. esculenta, D. bulbifera*), Tapioca Yuca or Cassava (*Manihat esculenta*), Suran, Zamikand (*Amorphophallus campanulatus*), Arvi (*Colocasia esculenta*), Sakarkand (*Ipomoea batatas*), Mankand (*Alocasia indica, A. macrorhiza*), Tannia (*Xanthosoma sp.*).

(f) **Solanaceous Vegetables:** Tamatar, Tomato (*Lycopersicon esculentum, L. pimpinellifolium*), Baingan, Brinjal (*Solanum melangena var. esculentum, Serpentum depressum, S. macrocarpon*), Bitter brinjal (*Solanum gilo*), Tree Tomato (*Cyphomandra batacea*), Shimla mirch (*Capsicum annum*), Chilli, Lal mirch (*C. frutescens*), *Solanum torvum*.

(g) **Others:** Bhindi, ladies finger (*Abelmoschus esculentus*), Gajar, Carrot (*Daucus carota*).

(8) **Starchy-tuber Foods:** *Moghania vestita, Vigna vexillata, Bunium persicum, Pachyrhizus tuberosus, Maranta arundinacea.*

(9) **Spices and Condiments:** A*llium cepa, Carum carvi, Coriandrum sativum, Cinnamomum tamala, Curcuma domestica, Zingiber officinale, Amomum subulatum, Allium sativum, Capsicum frutescens* Shallot (*Allium cepa var. aggregatum*), Bara lahsun (*Allium ampeloprasum var. porrum*), Chives (*Allium schoenoprasum*), *Allium fistulosum.*

(10) **Fibre Crop Plants:** *Boehmeria nivea, Cannabis sativa, Grewia optiva, Hibiscus cannabinus, Gossypium hirsutum, G. barbadens, Corchorus oletorius.*

The above list of crop plant species under cultivation across the Himalayas includes over 139 crop species. The total crop species in India may be around 166 species (Arora, 1991), which is about 84 per cent of predominant species under cultivation.

Crop and Varietal Diversity in N-W Himalaya

In the N-W Himalaya, 135 crop plant species are being cultivated which is about 38 % of total crop diversity in Indian agriculture. The varietal or genetic diversity has been narrowed down to few improved varieties from 60 landraces in rice, 29 landraces in wheat and 13 landraces in maize. The cultivation of millets and pseudo-cereals is almost on negligible area. Due to the use of high doses of fertilisers harming natural rhizobium soil cultures, the pulses such as Moong, Mash, Gram and Kulth has been reduced to negligible acreage. Temperate fruit and nuts diversity is also narrow and because of expansion of area under these fruits has resulted in replacement of traditional crop species such as grain amaranth, chenopods and buckwheat.

Crop and Varietal Diversity in Central Himalaya

The total crop plant diversity in the central Himalaya is 119, which is about 33 per cent of the total crop agro-biodiversity in the country. The central Himalaya is constituted of Uttaranchal. The loss of genetic materials have been comparatively slow. But as the communication will improve the replacement of landraces and some traditional crops will increase. These will be replaced by few improved high yielding varieties and major crops will replace some of the famine food crops such as millets and pseudo-cereals. The genetic diversity in crops like rice, maize and wheat has been to the tune of 49, 5 and 10 respectively.

Crop and Varietal Diversity in the Eastern and N-E Himalaya

The eastern and N-E Himalayas region receives heavy rains and is a rich reservoir of crop plant species as well as genetic diversity. The total crop diversity found in this region is 167 species, which is about 47 per cent of the total agricultural crop diversity in the country. There has been large varietal diversity in crops like rice (8003 landraces) and in maize ten races with 799 landraces has been identified. A large number of vegetables (65) are grown and consumed in the region. Another important feature is the cultivation of 12 plant species of energy rich crop plants. These are *Manihot esculenta, Saccharum officnarum, S. sinense, Pachyrhizus erosus, Maranta arundinacea, Dioscorea alata, Dioscorea esculenta, Helianthus tuberosus, Ipomoea batas, Maghania vestita, Vigna vexillata, Alocassia indica, Dioscorea bulbifera.*

Diversity of Agro-Ecosystems in the Himalaya

An agro-ecosystem is essentially constituted of land, crops, agroforestry, forests, domestic animals and water resources. It is a man and nature made ecosystem which is aimed at meeting basic human food, fodder, fuel, manure, fibre, timber, commodity crops and also income generation crops or plants. Out of 21 agro-ecosystems identified, five agro-ecosystems fall in the Himalaya. The state of Himachal Pradesh has been divided into five major physio-graphic regions namely the Greater Himalayas, the Lesser Himalayas, the outer Himalayas or Siwaliks, Piedmont plains and flood Plains. These are further subdivided into ten agro-ecological zones on the basis of rainfall, potential evapo-transpiration actual evapo-transpiration, length of growing period, soils and physiography. This illustrates the diversity in agro-ecological zones or agro-ecosystems that occurs in the length and breadth of the Himalayas. Implicit in this is the proper choice of crop species so as to develop suitable cropping patterns and provides scope for on-farm conservation of traditional crops and landraces. In each of the agro-ecosystem traditional farmers generally grow ten to twelve or even more crop species to meet all their food requirements all through the year.

Conservation of Himalayan Agro-Biodiversity of Traditional Agro-Ecosystems

The crop diversity in traditional agro ecosystems is basic to stability in food production as it minimises crop losses due to diseases, insect pests and weather odds, conserves soil fertility, protects from soil erosion and increases productivity per unit area due to maximum utilisation of production resources. In order to conserve traditional crops and to ensure long term stability of agro ecosystems there is need to lay emphasis on traditional uses of crops and new value-added consumption uses should be found out. Moreover, maintenance and conservation of traditional agro-ecosystems in their entirety is the only sensible way to preserve *in situ* repositories of crop germplasm. The issue of on-farm conservation has recently attracted the attention of many scientists but the question as to how to promote it still remains obscure. The mechanisms of compensating the traditional growers for losses accruing on not adoption of modern agricultural techniques are still a debatable issue.

Genetic Erosion of Agro-Biodiversity

The state and central Governments have undertaken massive efforts to modernise agriculture laying much emphasis on introduction of high yielding varieties. These varieties have replaced the landraces of wheat, maize and rice at a very fast rate. The landraces could only be found only in remote, landlocked areas, which had difficult means of communication. This is especially true in Himachal Pradesh. However, situation is not so bad in Jammu and Kashmir hills, Uttaranchal, Sikkim, arunachal Pradesh and other N-E states. In respect of crop diversity also some of the species either have become rare or completely lost from the cultivation. In Meghalaya, a local cereal *Digitaria cruciata var. esculenta* has become rare. Similarly in Himachal Pradesh, crops like black gram (*Vigna mungo*), green gram (*Vigna radiata*), Kultha (*Macrotyloma uniflorum*), Gram (*Cicer arietinum*), velvet bean (*Mucuna utilis*), Mandua (*Eleusine coracana*), Cheena (*Panicum miliaceum*), Kodo (*Paspalum scrobiculatum*), have become either rare or extinct. In Tripura, landraces of rice had been reduced to 32 from 105 in 1975. The major causes which are responsible for this genetic erosion in traditional agro ecosystem are (i) developmental activities (ii) shift in consumption patterns (iii) greed to earn more and more to modern living needs.

Scope and Potential: Increasing or even maintaining food production to meet expected demand will require greater use of genetic resources. We need to incorporate a broader range of crops and exploitation of naturally occurring and/or under-utilized crop species and related wild taxa to make better use of marginal lands and changing environments for the self-reliance of agro-ecosystems. Unfortunately, the speciality high value crop plant species which is a monopoly of the Himalayan region have still not been exploited to their full potential. These include saffron, kala zeera, wild Allium species, chilgoza, sea buckthorn, walnuts, hazelnuts, dry apricots, local maize, naked barley, and aromatic strains of rice. Besides, there are large number of wild edible plant genetic resources, medicinal & aromatic plants, and cottage industrial plants, which need to be bio-prospect in order to make them an economic resource for earning livelihoods by the rural people of Himalayan region. To promote and utilize the concept of eco-tourism, the indigenous communities must exploit the local plant genetic resources for earning economic gains. This is possible by way of serving local food dishes with modern refinement, developing scented herbal cold and hot drinks, a score of handicrafts and using wild edibles. Unless these vast biodiversity resources are utilized more and more, they cannot be saved.

The use of off–season cultivation must involve an array of crops or varieties in order to keep intact the concept of sustainability through diversity. Thus, inclusion of local resources in the existing cropping patterns will be highly desirable. However, this requires a well established multi-disciplinary research backup. Enhanced competitiveness, documentation, information, public awareness, value added research, better policies and legislations, and farmers oriented marketing network are some of the areas that needs to be addressed to harness the full potential of locally available plant genetic resources for enhancing farm incomes of hill farmers. Further as climate change continues to change the geography of agriculture, we have to mimic natural systems ourselves and use a diversity of approaches to ensure that farmers and breeders have the ability to get hold of and make use of as much diversity as possible and in that way, we might stand a chance of creating secure food systems

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Moving Towards Food and Nutritional Sustainability in the N-W Himalayas

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Himalayas constituted of three distinct regions, the north-western Himalaya, the central Himaya, which have distinct features of vegetation pattern, geological formation, climatic condition and social and cultural life. Among these broad categories the north-western Himalayas are characterized by rich alpine gymnosperm flora and host about 5000 species of angiosperms, and about 800 endemic species (Nikita, 2018). The region extends from Jammu and Kashmir, Ladakh, Himachal Pradesh and Uttarakhand up to the border of Nepal. This region also hosts 135 species of crop plants and 125 species of wild relatives of crop plants and several species of unexploited minor fruits (Sharma, 2009).

The traditional agriculture in the north-western hills has in general been sustainable in nature and usually did not have any commercial trend. The sustainable agriculture produces even if, small quantities, yet it has been meeting all the minimum needs of a farmer family for food, fiber, fodder, fuel and medicines without any dependence on any externa sources. This could not have been possible by adopting various strategies designed for ensuring sustainable supply of food and nutrition through traditional agriculture. These are mentioned below.

Mixed Farming: This has been one of the remarkable strategies and the most important feature of traditional farming practices not only in the mountains but also elsewhere in the country. The mixed farming combines crop husbandry with animal husbandry, rearing of goats and sheep, poultry birds, apiculture, sericulture, pisciculture etc. Milch cattle rearing was a regular practice of every family. A pair of bullocks was used for ploughing the fields and was a practice of using renewable energy. Agro-forestry formed a permanent feature which served the purpose of meeting the fodder requirements during scarcity months and to get fuel wood and timber wood. The farm produce included milk, meat, eggs, honey, raw silk fibre, honey, fish etc. The excess of produce was sold locally to earn cash income to meet other needs of the family.

Mixed Cropping: Mixed cropping had multi-benefits such as symbiotic relationship, competition between cop species, the best utilization of Sun energy, soil and water natural resources. This practice involved growing two or more crop species together in the same piece of land. The most common crop mixtures included wheat with gram, wheat with oil seed brassica, wheat with pea, maize with beans, maze with black gram or green gram or horse gram. Traditionally, in hills farmers of Uttarakhand used to grow 12-20 crops per year to meet the food and nutrition requirement of 8-10 family members.

Crop Species Diversity: Crop diversity is necessary to meet the challenges of adversities of climate and pest epidemics. It is also important to utilize the locally available natural resources o land, water, sunlight, soil fertility etc. Besides main crops (wheat, maize, rice), coarse millets, small millets, oil seed crops, legumes and pulses, condiments and spices fiber and cotton are included in cultivation plan.

Varietal or Genetic Diversity: This had been the significant strategy of faming communities to counteract the odd conditions that may arise suddenly to cause substantial damage to the growing crops. This contributes major share for sustainability in production and productivity of various food crops especially the cereal foods. This also ensures production under abiotic and biotic stresses. In Uttarakhand, a single farming family has a tradition to maintain 10 to 14 landraces/varieties of a single crop.

Use of Subsidiary Food Plants: These are the foods which people in remote and difficult terrains of Himalayas consumed as their staple diet in times of scarcity. Such food species included yams, elephant foot yam, Colocasia, tubers of Pueraria tuberosa, cucurbits, aloe vera flesh, fruits of Ficus species, flower buds and young fruits of Bombax ceiba, Flower buds of Bauhinia variegate, fruits of Pyrus pasha and P.lanata. Nasturtium aquatica in recent research has been found to be a super vegetable but this is a common plant which grows abundantly in running stream waters. In Uttarakhand, a millet, Jhangora (Echinochloa frumentacea) Is grown near rice fields and is used as supplement of rice food.

Diversification of Traditional diets by wild Fruits and wild edible Plants: This practice had immense health benefits to the rural communities because of the fact the wild fruits and wild edible plants are rich sources of several minerals, vitamins and at times they are high in some of them as well as contain some health-benefitting phyto-constituents. There were large number of wild fruits and wild edible plants used as cooked vegetables, which were in use some 50 years back. An interesting case is that of Nasturtium officinale (Water Cress or Chchucchcha) which in recent research has been declared as super vegetable by the FDA in U.S.A. Important wild fruits and vegetables include Eurale ferox, Grewia asiatica, Hippophae rhamnoides, Corylus jacquimontii, Ficus palmata, Prunus cornuta, Pinus gerardiana, Nelumbo nucifera, Aegle marmelos, Syzygium cuminii, Deeringia amaranthoides, Myrica esculenta, Pyrus pashia, Ficus auriculata, Species of Viburnum, Rubus, Sorbus etc.

Pseudocereals and Wild Mushrooms: In the Himalayan mountains pseudocereals are the main food and nutrition cops. Sometimes they are supplemented with barley both non-husked and husked, and winter wheat. Pseudocereals include grain amaranths *(Amaranthus tricolor, Amaranthus caudatus, Amaranthus cruents), Chenopodium album* (grain chenopod), buck wheat *(Fagopyrum esculentum, Fagopyrum tataricum)*. Himalayan mountains are also rich repository of edible fungi-mushrooms. Among them, edible mushrooms are about 76 species. The most important species are belonging to the genus Morchella. Morchella has seven species and the most popular among them are Morchell esculenta and Morchella deliciosa. In recent years several mushroom growers have their earnings from large to small growing enterprises.

The most important strategic consideration is to pay full attention to preserve and conserve the natural resources of forests eco-zones and agro-ecological zones. Agro-ecological (9) zones must be duly managed and developed for delivering various goods and services. These steps will help to ensure supply of food and nutrition to all inhabiting the difficult terrains of N-W Himalayas.

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Plant genetic resources for improvement of wheat (*Triticum aestivum* L.) against biotic stresses in North-Western Himalaya

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Wheat is an important winter cereal of Himalayan Region (Jammu and Kashmir, Himachal Pradesh, Uttarakhand, hilly regions of West Bengal, and North-Eastern states) occupying 1.39 million hectares (mha) area (Gupta and Kant, 2012). The average productivity of wheat in this region is low as compared to Indo-Gangetic plains. Low productivity is primarily due to rain fed cultivation and losses due to biotic stresses. Among biotic stresses, stripe rust, leaf rust, stem rust, powdery mildew, karnal bunt and loose smut are important diseases affecting the productivity of wheat. Leaf rust or brown rust has its impact on the wheat crop grown in 30 mha area of India, Pakistan, Bengladesh and Nepal (Huerta-Espino *et al.,* 2011), whereas stripe rust or yellow rust affecting the productivity of wheat crop grown in 10-12 mha area of Northern India (Bhardwaj and Singh, 2019).

Plant genetic resources have been playing a pivotal role for improving wheat against biotic stresses. Wheat varieties having 1RS.1BS translocation carrying *Yr9/Lr26/Sr31/Pm8* gene complex, provided protection against leaf and stripe rusts in India till 1995. However, the emergence of new pathotypes and shift in virulence patterns rendered most of the resistant wheat varieties susceptible. The prevalence of *Yr9, Yr2,* and *Yr27* virulences and recently identified five new pathotypes *viz*., 46S117, 110S119, 238S119, 110S247, and 110S84 which rendered *Yr11, Yr12,* and *Yr24* susceptible (Gangwar *et al.,* 2015) is of grave concern in North-Western Himalaya. Therefore, it is imperative to develop rust resistant plant genetic resources effective against newly evolved virulent pathotypes of rusts to minimize the yield losses. In this direction, we have developed rust resistant genetic resources, shared among wheat breeders for developing rust resistant wheat varieties in the country. Salient features of some of the recent genetic stocks developed at ICAR-Indian Agricultural Research Institute, Regional Station, Shimla are summarized as under:

HS628: The wheat variety HS240 has been a popular variety among the hill farmers of North-Western Himalayan Region for timely sown, rainfed production conditions due to its broad- adaptability, drought tolerance, grain luster, good chapatti and bread making qualities. However, over the years it has become susceptible to rusts. HS628 carrying rust resistance genes *Lr19/Sr25* and *Yr15* along with genome of HS240 is developed from a cross (HS240*2/FLW20//HS240*2/FLW13) through back crossing followed by bulk-pedigree method of breeding. The genotypes FLW13 and FLW20 were used as gene donors for transferring *Yr15* and *Lr19/Sr25*, respectively. HS628 has been validated to carry *Lr19/Sr25* using molecular markers scs265, wmc221 and presence of *Yr15* was validated through barc8 and gwm11 markers (Pal *et al.,* 2020). HS628 has shown resistance to all the pathotypes of yellow rust, black rust and brown rust except 77-8 at seedling stage. It has also shown adult plant resistance under epiphytotic conditions to brown rust (AC1=0.1 to 0.6). The field population of *Puccinia triticina* pathotypes in Northern India, lacks virulence for *Lr19* (Bhardwaj and Singh, 2019), hence rust resistance gene pool present in HS628 would prove useful gene source for developing potential rust resistant genotypes and/ or serve as potent donor for creating new usable variability against wheat rusts in India (Pal *et al.,* 2018). HS628 has been registered with NBPGR, New Delhi vide INGR#20013 for its availability to the wheat breeders.

HS661: Among wheat varieties HS295 has been a favorable choice of the hill farmers of North-Western Himalayan Region for late sown and rainfed production conditions due to its early maturity, broad adaptability, drought tolerance, good chapatti and bread making qualities. However, over the years it has become low yielding and highly susceptible to yellow rust. To build up rust resistance in genetic background of HS295, a rust resistant wheat germplasm HS661, was developed from a cross 'HS295*2/FLW20// HS295*2/FLW13' through back crossing followed by Bulk-Pedigree method of breeding. HS661 has been found resistant against all the pathotypes of yellow rust under seedling resistance test. Besides, it has shown seedling resistance to all pathotypes of brown rust and stem rust. It has also adult plant resistance (APR) to yellow rust. HS661 was confirmed to possess *Yr15* using molecular marker gwm11 (Pal *et al.,* 2019), also confirmed the presence of *Sr25/Lr19* using STS marker Gb. HS661 possesses good agronomic features viz., semi-erect growth habit, waxy flag leaf sheath, tapering ear shape, 88cm of plant height, white ear with white awns, attitude of awns is spreading, the grains are semi-hard and ovate shaped, amber in colour with thousand grain weight of 39g. The rust resistance genes *Yr15* and *Sr25/Lr19* rendering broad spectrum resistance against wide array of pathotypes of all the three rusts along with good agronomic features present in HS661 could be a desirable choice for breeding rust resistant wheat varieties in India. HS661 has been registered with NBPGR, New Delhi vide INGR#21181 for its availability to the wheat breeders.

HS545: Rust resistance gene complex *Lr24/Sr24* derived from *Agropyron elongatum*, located on 3DL, confer resistance to all the currently prevalent pathotypes of brown rust in the Indian Sub-continent (Bhardwaj *et al.,* 2021). HS545 developed from a cross "HD2819/HS435" following bulk-pedigree method of breeding. It has shown resistance against all the pathotypes of brown rust under seedling resistance test (SRT). HS545 has been validated for presence of *Lr24/Sr24* using molecular marker *Sr24#12*. HS545 possess agronomic features *viz*., semi-erect growth habit, green foliage, waxy flag leaf sheath, waxy peduncle with bent attitude, tapering ear shape, 94cm plant height, brown ear with brown medium awns, matures in 157 days, the grains are semi-hard and ovate shaped, amber in colour with thousand grain weight of 40g. Broad spectrum resistance present in HS545 along with good agronomic features would serve as desirable choice for breeding brown rust resistant wheat varieties in India. HS545 has been registered with NBPGR, New Delhi vide INGR#23027 for its availability to the wheat breeders.

DH-1: Doubled haploid genetic stock registered vide INGR# 21119 with NBPGR, New Delhi is developed from a cross (HS542/China 84-40022) following *Imperata cylindrica* mediated chromosomal elimination technique. It has shown resistance to all the prevailing pathotypes of stripe rust and leaf rust at seedling stage except for pathotype 77-5 (Patial *et al.,* 2021).

T/W7-4 and T/W17-5: Triticale has long been used as a bridge species to transfer useful genes from rye (*Secale cereale*) into wheat. Among several useful translocations, 1RS.1BS translocation has been proved useful for improving wheat with resistance to biotic and abiotic stresses, consequently large number of wheat varieties have been released word wide. Powdery mildew caused by fungus *Blumeria graminis* is an important disease impacting wheat crop grown in North-Western Himalayan region. Keeping in view the importance of powdery mildew in North-Western Himalaya, a RIL population consisting of 112 genotypes was developed from a cross 'TL2942/HS562'. All the genotypes were evaluated for powdery mildew resistance according to Browder (1972) and Leath and Heun (1990) under green house conditions. Among 112 genotypes, 25 were recorded as resistant to powdery mildew at adult plant stage. A unique recombinant inbred line 'T/W7-4' is identified as resistant to Shimla isolate to powdery mildew under seedling and adult plant stage. This genotype possesses pubescent peduncle (hairy neck) controlled by the gene '*Hp*' known to present on $5R^L$ (Kattermann, 1937; O'Mara, 1946; Smith, 1963), indicating that 'T/W7-4' carry rye chromatin introgressed through *Triticale* variety TL2942 into wheat. Another triticale x wheat derivative 'T/W17-5' was identified to carry seedling resistance to 77-5 and 77-9 pathotypes of leaf rust, considered as most virulent in Northern India.

Germplasm with multiple genes for rust resistance: Among 36 genotypes, IND393 and WBM3934 were identified to carry *Lr19/Sr25*, *Lr24/Sr24*, *Lr34/Yr18/Pm38/Sr57* and *Lr24/Sr24*, *Lr34/Yr18/Pm38/Sr57*, *Lr46/Yr29/ Pm39* gene combinations, respectively using SRT and molecular markers. These multiple gene sources of resistance would prove useful for improving wheat in North-Western Himalaya (Pal *et al.,* 2022).

Rust resistant gene pools in wheat varieties released for North-Western Himalaya: Breeding work for the improvement of wheat for North-Western Himalaya was started in India at Shimla in 1934. Wheat varieties developed and released from IARI Regional Station, Shimla during post green revolution era are summarized in Table 1. The cultivation of wheat varieties as illustrated in Table1 has provided suitable genetic barriers to avoid rust epidemics not only in North-Western Himalaya but also in Indo-Gangetic plains.

Conclusions:

The choice of germplasm not only providing the opportunities to the plant breeders for incorporating viable genes into the elite genetic backgrounds of wheat but also permit the system to release cultivars carrying diverse rust resistance genes. Durable resistance in wheat is rarely found, and the basis for the most durable resistance to wheat rust has been combination of different genes (Samborski, 1985). Of the genes described for adult plant resistance, *Lr34* has been found to be partially effective against leaf rust in India (Sawhney and Sharma, 1990). Resistance gene *Lr*34 involved in gene combinations conferring durable resistance to leaf rust and expresses enhanced resistance in combinations with other resistance genes (German and Kolmer, 1992). It can be deduced that the mosaic of rust resistance gene combinations *viz*., *Lr1+10+13+23+26+34, Yr2+2ks+9+18* and *Sr2+5+8a+9b+11+31* as deployed in the Himalayas has been proved effective for protecting the wheat crop grown in Northern Hills Zone and the adjoining plains of North-Western India from epidemics of wheat rusts (Pal and Patial, 2017).

Table1. Wheat varieties possessing rust resistant genes recommended for cultivation during post green revolution era in North-Western Himalaya.

Variety	Rust resistance gene combination
HS 86	*Lr13+Yr2+Sr11*
HS 207	*Lr26+34+1+ Yr9+18+ Sr2+5+31*
HS 240	*Lr26+34+1+ Yr 9+18+ Sr2+31+*
HS 277	*Lr26+34+ Yr9+18+ Sr5+31*
HS 295	*Lr23+34+Yr2ks+18+ Sr2+8b+11*
HS 365	*Lr26+1+ Yr9+Sr5+31+*
HS 375	*Lr26+34+1+ Yr 9+18+ Sr2+5+31*
HS 420	*Lr13+10+34+Yr18*
HS 490	*Lr23+ Sr2+9b+*
HS 507	*Lr26+1+ Yr9+Sr31+*
HS 542	*Lr13+10+ Yr2+ Sr5+8a+9b+11+*
HS562	*Lr23+YrA+Sr8a+9b+2+*

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Mushroom crops: a boon to health and prosperity

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Introduction

Out of 15 lakhs estimated fungi on the earth, only 3000 are prime edible mushrooms and 200 are experimentally cultivated. Most of them belong to the basidiomycetes, and only a few belong to the ascomycetes. Mushrooms are divided into three categories, viz., decomposers, endophytic, and mycorrhizic. Decomposers include edible, medicinal, toxic, and poisonous mushrooms. They are considered as the best solutions to our nationalized problems, such as limited land and water resources, unemployment, inadequate quality food supply, diminishing quality of health, and increasing environmental deterioration. Reasons for this are their limited requirement for land and water, high protein content, use of vertical space and bioconversion of agro-waste. For instance, only 25 liters of water is required to produce 1kg of mushrooms, which is too low in comparison to crops like paddy, which require 2500 liters of water to harvest 1 kg of paddy. These qualities make it a perfect option for small-scale or urban farming. Mushroom is a low-maintenance crop, requiring minimal inputs and labour. Based on temperature and humidity requirements mushroom can be cultivated all-round the year without use of energy ensuring its round the year availability. Moreover, the left over substrate can be utilized in a sustainable manner for biogas, organic manure or animal feed. Value addition of mushroom is playing an important role in popularization of mushroom by making it accessible to the distant markets.

Historical development

Before domestication, mushrooms were only collected from the wild and consumed for various purposes such as foods and medicines. Humans attracted towards mushroom values long back in 1600 B.C with the collection of truffles from wild habitats. Auricularia polytricha (Ear fungus), was first cultivated mushroom in ancient China around 600 AD. Lentinus edodes (Shiitake) was also originally cultured in China about 1100 AD. Systematic cultivation of button mushrooms was first recorded in Paris, France, around 1630 using horse dung manure. The original color of button mushroom is brown and the first white variant of button mushroom was developed in USA in 1926. Research focuses on domestication of mushroom results into successful cultivation of Pleurotus ostreatus (Dhingri) in 1917. Grain spawn was first introduced by the Pennsylvania State University in 1932 which played an important role in commercialization of various mushroom crops. The scientists devoted much time on mushrooms after world war second with a target to identify nutritionally rich food. In India, paddy straw mushroom (Volvariella volvacea) was the first cultivated mushroom which was introduced at Coimbatore in Tamil Nadu in 1943. Sinden and Hauser (1950) developed a “Short Method of composting” in 1950 to solve the problem of diseases and competitor moulds and low crop yield by using unpasteurized compost was used. In 1974, milky mushroom (Calocybe indica) was identified as first indigenous mushroom of India. In 1961, button mushroom was introduced in the state Himachal Pradesh at Solan by HP government and ICAR. However the growing and research facilities were later on strengthened under the guidance of FAO Experts and E F K Mantel.

Nutraceutical values

Mushrooms are very rich in carbohydrates, proteins, vitamins and minerals (Gonzalez et al, 2020; Salemi et al, 2021). All the essential amino acids are present in mushrooms with high digestibility of more than 90%. Selenium is a powerful mineral that is essential for the proper functioning of your body. Oyster Mushroom is a source of Lovastatin that helpful in preventing cardiovascular disease. Shiitake contains Lentinan which has anti-tumor and anti-cancer activity NG and Yap (2002). They are well known for curing stress, cancer, cholesterol reduction, allergies, insomnia, asthma, and diabetes (Bahl, 1983). They improve the immunity and protect human beings from various illnesses. They are poor in starch and cholesterol which make them suitable for diabetic and heart patients. Most of the iron content in mushroom is present in available form. Bio active compounds of many mushrooms have antifungal, antibacterial, antioxidant and antiviral properties and are used as pesticides as well. Polysaccharides from Morchella esculenta fruit bodies have several medicinal properties, including anti-tumor effects, immunoregulatory properties, fatigue resistance, and antiviral effects (Lakhanpal and Rana, 2005). Polysaccharide-K (PSK) and Polysaccharide Peptide (PSP) are two proteoglycan extracts from the Turkey tail mushroom (Trametes versicolor). These compounds have immune-boosting properties and effective against cancer like diseases (Lindequist et al., 1998; Mitomi et al., 1992).

Production and Export status

World has witnessed rapid growth in mushroom production from < 5MT in 1970 to 44.21MT in 2020 with compound annual growth rate (CAGR) of 9.6% since 1970. As per the continent-wise total world mushroom production in 2021, Asia accounting for 82.8% in total world mushroom production followed by Europe (12%), America (4.5%), Oceania (0.4%) and Africa (0.3%). China, USA, Netherlands, Poland, Spain, France, Italy, Ireland, Canada and UK are the top mushroom producing countries of the world. In China, 60 types of mushrooms are cultivated commercially. In the early 1960s, button mushroom was contributing maximum share in the total world production i.e. 78% however later on that came down to 11% in 2022 due to increase in the share of other mushrooms such as Shiitake (26%), wood ear (21%), oyster (21%), Flammulina (7%), Paddy straw (1%) and others (13%). Presently India contributes about 3.08 metric tons of mushrooms. Mushroom production increased from 1.29 lakh tonnes to 3.08 tonnes during 2016- 22. Button mushroom is accounting for maximum share in the total production of the country (70%), followed by oyster (17%), paddy straw (9%), milky (3%) and others (1%). A total of 7.7 lakh tons agro-waste was utilized and 15.4 lakh tonnes of spent substrate generated. The Per capita mushroom consumption in India is too low (0.22kg) as compared to world (5-6kg). Odisha is the mushroom producing state of India with 34.1% share followed by Maharastra (32.9%) and Bihar (32.15%). Mushrooms are consumed as health food, dietary supplement and medicine. Edible mushrooms are accounting for maximum share (59%) in total world trade followed by medicinal (31%) and wild mushroom (10%).

Spawn availability

Initially few strains like S11, S 310 were in use in button mushroom. Later U3 and U1 became popular. In the late eighties, Sylvan from USA marketed spawn in India later other spawn companies also started marketing spawn in India. A dozen species of Pleurotus are available for cultivation under different climatic zones. After 2014 different strains bred at ICAR-DMR were released in button, shiitake, oyster, milky and paddy straw mushroom. ICAR-DMR played prime role in strengthening the spawn facilities of the country. Since inception of the Directorate, free consultancy is given to the entrepreneurs on producing the quality spawn in their laboratories. Techno Economic Feasibility Reports (TEFRs) are prepared by the Directorate for the farmers which are accepted across the country. Presently, ICAR-DMR along with its AICRP centers is supplying 220T spawn/annum to the farmers.

Crop improvement and cultivation

In 2023, Indian Council of Agricultural Research (ICAR) has release 7 high yielding varieties of mushrooms bred by ICAR- DMR, Solan. Molecular markers (RAPDs, RFLPs, repetitive DNA sequences, ITS, SSR, ISSR and AFLP) have played an important role to develop genetically improved high yielding strains (Yadav, 2004).Five mushrooms namely white button mushroom (Agaricus bisporus), oyster mushroom (Pleurotus spp.), milky mushroom (Calocybe indica), paddy straw mushroom (Volvariella volvacea) and shiitake (Lentinula edodes) are commercially cultivated in India. Cultivation is done in low cost huts (seasonal huts) and in environmentally controlled units. Saprophytic mushrooms like button are cultivated on selective composted substrate prepared using long method, short method and indoor method. Whereas other mushrooms like oyster require simple wet substrate for their cultivation. In India many large modern mushroom farms are there such as Tirupati Balaji Agro-Products, Weikfield Mushrooms etc whose turnovers are in crores. Mushrooms are grown on lignocellulosic agro-wastes (Chang and Miles, 1992) which are available in abundance in our country (750 m tonnes). However, only less than 1% available agro-residue is utilized in mushroom cultivation. Use of computer applications in mushroom production technology has revolutionized the mushroom cultivation by reducing the labour cost and in optimization of resource utilization.

Mushroom Marketing channels

In mushroom industry there are four major marketing channels. In Channel-1 produce is directly sold to the consumers. In Channel-2 produce is first procured from the growers and then sell the Local/Distant Markets/Exports. In third channel Cooperative/Farm organization collect the produce and further sale to the Local/Distant Markets/ Exports. Under fourth channel, farmers go Auction/Bidding of their produce and further marketing is done on the basis advice of Mushroom specialist traders. All these channels are helpful in maximizing the profit as per the convenience of the producers and buyers.

Conclusion

It is true that the challenges in the agriculture sector are multidimensional and conventional approaches alone are not enough to obtain the desirable results. Exploiting the best of modern indigenous technologies is the only way to provide us with breakthrough solutions. Mushrooms require negligible land, can be cultivated in varied climatic conditions and require very few resources compared to other forms of agriculture. Considering the changing food habits of our peoples, urge for nutritional security and new business opportunities in agriculture sector, mushroom is one of the most viable options.

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Underutilized Temperate Fruit Species in The Western Himalayas - Scope for Enhancing Rural Livelihoods and Improving Food Security

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The identification of new species, their characterization, conservation and sustainable utilization is the key to improving agricultural productivity and sustainability, therefore contributing to national development, food security and poverty alleviation. Variation in climatic conditions and short term abrasions in weather parameters has raised levels of uncertainty, vulnerability and risk of investments in horticulture. In the face of warmer temperatures due to climate change, winter chill requirements will become harder to meet in many important temperate-fruit and nut-producing areas. Different agro ecological /phytogeographical regions of Western Himalayan Regions hold rich diversity in both the cultivated, underutilized and the wild temperate horticultural crops. Due to this a wide range of natural population has been built up both at species and genotypic level in the region. In the present context of climate change, the diversification of temperate fruit with various underutilized horticultural crops is one of the possible solutions to this major challenge as their cultivation can bridge the gap between increasing demands and supply of food.

Prospects of underutilized temperate fruit and nut crops in India

In western Himalayas (WH), 80% people depend upon agriculture and allied activities. Geographically, Jammu and Kashmir, Himachal Pradesh and Uttarakhand which comprises the western Himalayas are located at Latitude 28 43-37 06 N and Longitude 73 26 – 81 02 E, and altitude varies from 300 to 7800 m MSL and is known for greater diversity of species of *Malus, Pyrus, Prunes, Vitis, Ribes, Rubus, Fragaria,* etc. In North West Himalayan region, most of the area consists of difficult hilly terrain of different types (low, mid and high) which are unfit for cultivation of high input demanding crops. Such lands can easily be put to use for growing with low input in order to diversify the present day horticulture, and to meet the demands of increasing population, nutritional security and fast depletion of natural resources as well as the growing and changing human needs in the region. These untapped fruits are nature's wonderful gift to the mankind; indeed, they are life-enhancing medicines packed with vitamins, minerals, anti-oxidants and many phyto-nutrients (Plant derived micronutrients). Therefore it becomes possible to exploit the untapped potential of the region through location specific horticulture and subsequently expanding the area under lesser known horticultural crops through adoption of modern scientific viable technologies. Under exploited horticultural crops have a vast potential for production of value added products' with high therapeutic, medicinal values and antioxidant properties have high export potential.

Underutilized exotic temperate fruit and nut crops

Kiwi fruit (*Actinidia chinensis***)**

Kiwi fruit, also known as *Chinese gooseberry,* is one of the delicious fruits with full of promising health promoting phyto-chemicals, vitamins and minerals. This widely recognized, wonderfully unique fruit is native to eastern Chinese "Shaanxi" province. Kiwifruit plant is a semitropical, deciduous, large woody vine belonging to the family of *Actinidiaceae* in the Genus, *Actinidia*. During each season which lasts from September until November, the kiwi vine bears numerous oval shaped, fuzzy, brown colored fruits. Each kiwi berry weighs up to 125 g. internally; its flesh is soft, juicy, emerald green with rows of tiny, black, edible seeds. Fruit texture is similar to strawberry or sapodilla, and the flavor resembles a blend of strawberry and pineapple fruits. "Gold Kiwifruit," developed by hybrid technique by agricultural research department in New Zealand, has a smooth, sparse hairs, bronze skin, a pointed cap at one end and distinctive golden-yellow flesh with less tart and more tropical flavor than green-kiwifruit.

Berries

Berries are considered soft fruit and are used as desserts as well as in processing. They are canned, frozen or made into jams, jellies or preserves. The juices are used in beverages and ice cream.

The most important vitamin in berries is vitamin C. Berries are also regarded as good source of β-carotene, thiamin, riboflavin and nicotinic acid. Anthocyanin is a major pigment in berries. Different botanical types:

- Blackberries (*Rubus fruticosus)*
- Black currants (*Ribes nigrum*)
- Raspberry (*Rubus idaeus*)
- Strawberries (*Fragaria X ananassa)*.
- Blueberries (*Vaccinium sps.)*
- Cranberries (*Vaccinium macrocarpon*).
- Gooseberries (*Ribes uva-crispa* L.)

Persimmon (*Diospyros virginiana*)**.**

Persimmon fruit is a golden yellow, round or oval, flavorful, smooth textured delicacy from far East Asian origin. Its sweet, delicious flesh is packed with several health promoting nutrients such as vitamins, minerals, and anti-oxidants vital for optimum health. Botanically, persimmons belong to the family of *Ebenaceae*, in the genus: *Diospyros*. This delicate fruit is native to China. Persimmons are either multi-trunked or single-stemmed deciduous trees, which may grow up to 25 ft in height. Persimmon trees classified broadly into two general categories: those that bear "astringent fruit" (whilst unripe) and those that bear "non-astringent" fruits. An astringent cultivar, which is commonly cultivated in Japan known as *"Hachiya,"* is high in *tannins* and must be allowed to ripen fully until it attains jelly-soft consistency before being fit to eat. A non-astringent persimmon, on the other hand, contains less tannin and can be eaten while it is crispy, as in apples.

Pecan nut (*Carya illinoensis* Koch)

These are classified in family Jugalandaceae is called as 'Queen of nuts'. It has native to southern east USA. Fruit mature in September –October. Alternate fruit bearing is more pronounced in pecan nuts. Fruit is rich in fiber, proteins as well as minerals like calcium, phosphorus, potash, iron, manganese and vitamin A.

Processing and product diversification

Kiwi, and other untapped and underutilized temperate fruit crops are used as desserts as well as in processing. They are canned, frozen or made into jams, jellies or preserves. The juices are used in beverages and ice-cream.

Future fruits and nutraceuticals

The term nutraceuticals, is derived from the words "nutrition" and "pharmaceutical", is a food or food product that provides health and medical benefits, including the prevention and treatment of disease. Nutraceuticals have physiological benefits and provide protection against chronic diseases. Their bioactive ingredients, the phytochemicals, sustain or promote health and occur at the intersection of food and pharmaceutical industries. They play a crucial role in maintaining optimal immune response, such that deficient or excessive intakes can have negative impact on health. Phytochemicals, are non-nutritive plant chemicals that have either defensive or disease protective properties. These phytochemicals, either alone and/or in combination, have tremendous therapeutic potential in curing various ailments. Phytochemicals with nutraceutical properties present in food are of enormous significance due to their beneficial effects on human health since they offer protection against numerous diseases or disorders such as cancers, coronary heart disease, diabetes, high blood pressure, inflammation, microbial, viral and parasitic infections, psychotic diseases, spasmodic conditions, ulcers, osteoporosis and associated disorders. Majority of untapped fruits of future importance contain phytochemicals of nutraceutical importance.

Prospects for strengthening genetic biodiversity

1. Systematic planning for explorations for minor temperate fruit including wild texa particularly crops whose economic importance is known for commercial exploitation.
2. Need-based introduction of new crops, new varieties with specific traits.
3. Mostly minor temperate fruit crops are hardy and resilient, once established in field gene bank, agronomic practices should be developed considering suitable climate conditions.

4. Priority should be to conserve the material in field gene bank and protocol should also be developed for *in vitro* conservation and cryopreservation.

5. *In situ* conversation by the various government agencies and policy planners to protect the ecological niches, where large variability is existing e. g. hazelnut in Ladakh & Himachal, Chilgoza in Kinnuar , and walnut in Himachal, J&K and Uttrakhand.

6. Molecular characterization of underutilized temperate fruits will provide information on identification of useful genes and other molecular markers, which will help in genetic improvement work.

7. There is need to investigate value addition useful for products and processing, neutraceutical, ornamental and other potential applications.

Research and resources are needed in developing suitable protocols for cultivation of these underutilized fruit crops. Therefore, identification of new species, their characterization, conservation, and sustainable utilization is the key to improve agricultural productivity and sustainability, thereby contributing to national development, food security and poverty alleviation. The strategies for conservation, improvement and innovation shall be discussed in detail in general and kiwi fruit in particular given its high commercial potential in the Himalayan region.

Role of Potato in Entrepreneurship Developments (Seed Production Technologies)

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The availability of virus-free planting material is a prerequisite for micropropagation and seed production of the clonally propagated potato crop. The Government of India is committed to ensuring the timely availability of certified seeds to the farmers cultivating different crops. However, for high-volume high-seed rate crops like potatoes, the production and supply of good quality certified seeds is a challenge. Annually India requires 5.4 million tons of potato tubers as seeds. The challenge becomes even more complex as the vegetative mode of propagation makes the seed vulnerable to several pathogens in its multiplication process and the seed multiplication ratio (SMR) of 1:6 is very low. Farmers, especially marginal and small farmers, rarely store their harvests as seeds for the next growing season. Often, they buy seed potatoes every season, making the seed replacement rate (SRR) almost 100%. However, there is no institutional mechanism to monitor the quality of seed potatoes. Most often, degenerated produce is sold as seed, especially to small and marginal farmers who lack finances. The seed alone comprises over one-third of the total cost of production of potatoes. There is a huge gap between the requirement and supply of certified seed potatoes in India. The Central Potato Research Institute of the Indian Council of Agricultural Research produces about 3,000 tons of nucleus and breeder seed every year and supplies 80% of it to the states and other agencies for its multiplication. If this stock were to multiply in three stages, i.e., Foundation 1, Foundation 2, and Certified grades, we can produce only about 0.5 million tons of certified seed. On the assumption of 100% SRR, it meets only 10% of the total seed requirement, leaving a deficit of about 4.9 million tons. It is virtually impossible to produce such a huge quantity of certified seeds using traditional methods. Besides its low rate of multiplication in a longer span of 7-8 years, the traditional seed production system suffers from several other constraints like (i) the requirement of a huge number of disease-free propagules in the initial stage, (ii) the slower process of generating 100% healthy seed stock from the infected material, (iii) progressive accumulation of degenerative viral diseases in each field exposure, and (iv) field multiplications of initial disease-free material. It is further complicated by the fact that Breeder Seed supplied by ICAR-CPRI is seldom multiplied in all three generations by the State Seed Certification Agencies maintaining the recommended procedures. About 1.2 million tons of potato seed is sold by private seed producers, especially those from Punjab, western Uttar Pradesh, West Bengal and Haryana, though there are no mechanisms and infrastructures for monitoring seed quality. It is, therefore, imperative to evolve a seed production system, encompassing innovative techniques to improve the quality of seed and to reduce field exposure, along with a robust system of certification and quality assurance of the seed produced and supplied by the private seed growers.

Role of ICAR-CPRI for the development of the entrepreneurship in seed production: Of the key technologies developed by the institute, the tissue culture-based hi-tech seed system developed has led to the opening of > 30 labs across the country and has allowed the supply of healthy mother stock (in vitro plants) to different seed-producing organizations/agencies for seed production in the country. One *in vitro* tube with 2-3 plants, sub-cultured at least ten (2^{10}) times will generate 2048 plants. During 2010-2020, ~1296 culture tubes were supplied to 64 firms which have generated 2654208 healthy microplants. These plants have cover 8 ha area under G0 crop followed by 40 ha G1, 200 ha G2, 1000 ha G3, 50000 ha G4 and 25000 ha G5 area respectively thereby producing 6250000 q of certified seed. This has resulted in covering the 12.5% of the total potato area of the country resulting in total monetary gain of Rs. 1250 crores, assuming that seed potatoes were sold @ Rs. 20000/ton. Further, aeroponics has been commercialized to 17 firms. Each firm was licensed to produce one million minitubers. If these firms operate at its capacity, it might have covered 1.47 million ha area with 352050.9 thousand tonnes of certified seed. This has led to a total monetary gain of Rs.70412 million crores to the agricultural GDP. The combination of seed production technology advancement and the availability of varieties in the Indian market has resulted in tremendous development in the seed industry in the recent past. There is an excellent transformation in the overall potato portfolio across the sectors in the country and farmers need to rationalize their production as per the requirement of various categories of potatoes.

Genomics of medicinal plants: Status and Prospects

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Abstract

Medicinal plants being a repository of enormous bioactive secondary metabolites are used to cure a variety of human ailments since aeons. It is estimated that plant-based components are extensively (> 90%) used in modern medical system, and traditionally more than 75% of the global population relies on them as a primary treatment regime. Therefore, the demand for medicinal plants increased by 50%, while their accessibility decreased by 26%, indicating a significant gap between demand and supply of raw materials. This has also resulted into fast declining of biodiversity genetic resources categorizing approximately 35,500 species under threat of extinction. In-spite of its broad spectrum health benefits, the molecular aspects and cultivation of medicinal plants are not well explored. Thus, the current situations indicated that we are likely to lose a significant portion of traditional wealth of medicinal plants and therefore, conservation and management of biodiversity is a priority of concern. Moreover, the traditional medicinal system also requires the scientific validation of their safety, efficacy and quality. Hence, genetic improvement of medicinal plant genetic resources requires better comprehension of genomics. Interestingly, paradigm shift in sequencing technology with availability of multiple cost effective and high-throughput next/ third generation sequencing platforms have contributed enormously for creation of cost effective genomic resources and greatly assisted fundamental understanding of key regulatory mechanisms and biosynthetic pathways irrespective of model and non-models. Recent advances in plant genomics integrated multi-omics approaches pave the way for elucidation of secondary metabolite biosynthesis pathways, key genes, and genetic improvement of medicinal plant genetic resources. Genomic interventions in medicinal plants will surely be hastening the creation of sustainable cultivation and conservation efforts by development of germplasm bank, genetic diversity and population structure analysis. Development of elite varieties, genetic diversity assessment, proliferation and overproduction of secondary metabolite would be beneficial for sustainable cultivation of medicinal genetic resources. Furthermore, iintegration of emerging technologies including single cell genomics would be helpful to illuminate the cellular heterogeneity and metagenomics reveals the associated microflora in metabolite production represents a fascinating frontier for future investigation. Our ongoing efforts on collection and characterization of genetic diversity and population structure resulted into successful identification of core genotypes/ populations for implementation of conservation strategies in the targeted MAPS. Furthermore, successful efforts for creation of tissue-specific genomic resources enabled us for fundamental understating of specialised metabolism and identification of functionally relevant molecular markers. Genome-wide inferences using next generation genomics will be useful for developing conservation strategies and implantation of breeding programs for sustainable cultivation of endangered Himalayan MAPs.

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अम्बुजा सीमेंट फाउण्डेशन ने सामाजिक कार्यो के माध्यम से आसपास के क्षेत्र में अपनी एक अनूठी और प्रभावशाली पहचान बनाई है। अम्बुजा सीमेंट फाउण्डेशन ने विकास कार्यों को जन-जन तक पहुंचाया है। इन विकास कार्यों के फलस्वरूप अम्बुजा फाउण्डेशन से जुड़ा प्रत्येक व्यक्ति उच्च जीवन स्तर यापन कर रहा है। अम्बुजा सीमेंट फाउण्डेशन आसपास के क्षेत्र में विभिन्न तरह के कार्यो को क्रियान्वित कर रहा है। जिसका विवरण निम्न है।

जलागम परियोजना :- अम्बुजा सीमेंट फाउण्डेशन द्वारा दाड़लाघाट व आसपास के क्षेत्रों में भूमिगत जल स्तर को बढ़ाने के लिए विभिन्न जलागम परियोजनाओं का क्रियान्वयन किया जा रहा है। जिसके अर्न्तगत लगभग 12,515 हेक्टेयर भूमि पर तरह तरह के कार्य जैसे मेढ़बदीं, ट्रेंचिग, पौधारोपण, पानी के भण्डारण टैंक, खाल, कुहल व चैकडेम आदि के कार्य किये जा रहे है।

स्वास्थय :- स्वास्थय के क्षेत्र में अम्बुजा सीमेंट फाउण्डेशन द्वारा आस पास के 42 गांव में स्वास्थ्य सखियो क्षरा मुख्य रूप से मातृत्व एवं शिशु स्वास्थ्य, गैर संचारित से नियंत्रण, संचारित रोग नियंत्रण, तम्बाकु मुक्त स्वस्थ विद्यालय आदि कार्यक्रमो पर लोगों को जानकारी एवं स्वास्थ्य लाभ उपलब्ध करवाया जा रहा है। साथ ही अम्बुजा सीमेंट फाउण्डेशन द्वारा समय-समय पर विभिन्न गावो में बड़े स्तर पर स्वास्थय शिविरों के माध्यम से लोगों को स्वास्थय लाभ दिया जा रहा है। इसके अलावा अम्बुजा डायगनोस्टिक सेंटर द्वारा विभिन्न प्रकार की जांच सेवाएं, न्युनतम् दरों पर प्रदान की जा रही है।

शिक्षा :- शिक्षा के क्षेत्र में गुणवता लाने तथा बच्चों के सर्वागीण विकास हेतु 31 राजकीय प्राथमिक और 18 माध्यमिक विद्यालयों को सहयोग प्रदान किया जा रहा है। जिसमे शिक्षा विभाग के साथ मिलकर विद्यार्थियों को खेलकूद को बढावा देने के साथ साथ जल एवं स्वच्छता कार्यक्रम, पठ्न अभ्यास व विज्ञान की गतिधियों को बढावा देने का कार्य के अर्न्तगत लगभग 2795 बच्चों को लाभान्वित किया जा रहा है।

कौशल उद्यमिता संस्थान :- दाड़लाघाट व आसपास के क्षेत्रों के युवाओं को आजीविका उपलब्ध कराने हेतु अम्बुजा सीमेंन्ट फाउण्डेशन के कौशल उद्यमिता संस्थान में विभिन्न प्रकार के कौशल पाठ्यक्रम प्रदान किये जा रहे है। जिसमे प्रतिवर्ष लगभग 300 प्रशिक्षार्थिओं को उनकी योग्यता के आधार पर प्रत्यक्ष व अप्रत्यक्ष रूप से रोजगार प्रदान किया जाता है।

महिला सशक्तीकरण :- अम्बुजा सीमेंन्ट फाउण्डेशन दाडलाघाट द्वारा आस पास के क्षेत्रों में लगभग 235 स्वयं सहायता समुहो का गठन किया गया है। जिसमें 2705 महिलाओं को संगठित किया गया है। इन स्वयं सहायता समुहो की महिलाओं को आय वृद्धि के विभिन्न प्रकार के प्रशिक्षणों द्वारा सामाजिक व आर्थिक रूप से सुदृढ किया जा रहा है। इसके अलावा महिलाओं ने एक फपीओ का गठन करके दुग्ध संयत्र स्थापित किया है। जहां आसपास के किसानो द्वारा दुग्ध एकत्रित करके उचित मुल्य पर विक्रय किया जाता है।

कृषि :- कृषि के क्षेत्र में अम्बुजा सीमेंट फाउण्डेशन लगभग 4710 किसानों के साथ कार्य कर रही है। किसानों को और अधिक प्रतिशील बनाने के लिए नवीनतम प्रशिक्षण एंव संसाधनों को किसानों तक पहुंचाने का कार्य किया है। इन किसानो के संगठन ने अपना एक हल्दी संयत्र स्थापित किया है जिसे पहाडी हल्दी के नाम से विक्रय किया जा रहा है। साथ ही किसानो को प्राकृतिक खेती के बारे में जागरूक किया जा रहा है। इसके अलावा कृषि गतिविधियों को और अधिक सुदृढ करने के लिए चार किसान उत्पादक संगठनो का गठन किया गया हैं जिसमे किसानो के उत्पादों को बाजार उपलब्ध करवाया जा रहा है।


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