Indian Society of Plant Genetic Resources (ISPGR)

3rd Dr A.B. Joshi Memorial Lecture

on

"Plant Genetic Resources for Food and Nutritional Security"

by

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(Padma Shri Awardee)

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Dr B.P. Pal Auditorium

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Plant Genetic Resources for Food and Nutritional Security

Humans depend on rice, wheat and maize, out of about 300,000 species of plants on earth, for 60 per cent of their calorie intake. Even in these three species, only a fraction of the available genetic diversity is capitalized for commercial agriculture. The phenomenon of crop domestication and advent of agriculture about 8,000 to 10,000 years ago funnelled only a small portion of genetic diversity present in wild populations to the farmers' field. Millennia of existence as a crop under varying regimes of natural and human selection, however, recreated diversity in form of local landraces, within this initial endowment. Modern crop breeding practices tapped into this variation to pick the best variants, first as new varieties and then as parents of next cycles of varieties. The spread of pure lines and hybrids resulting from this process almost displaced the landraces. The advantage of productive new varieties was maximized through vast monocultures leading to rapid rise in agricultural productivity but loss of genetic diversity.

In deference to well-founded concerns about genetic erosion, a compact version of available genetic variation went into genebanks. More than 7.7 million accessions of plant genetic resources (PGR) have come to be conserved *ex situ* in around 1,750 genebanks worldwide with major holding in genebanks of the Consultative Group on International Agricultural Research (CGIAR). Besides cultivated varieties and landraces, these include primitive forms of cultivated plant species and related wild species. This uncoupling of farm productivity from evolutionary potential required for facing new biotic and abiotic challenges, caused genetic vulnerability and in some cases, epidemics. At the same time, PGR conservation in genebanks opened vast opportunities for non-local donor gene sourcing. Strategic utilisation of such gene resources was at the core of Green Revolution which made India self-sufficient in food.

Remarkable instances of commercial deployment of genes from distant germplasm are available in several crops. A single accession of wild rice *Oryza nivara*, identified after screening of more than 6,000 genebank accessions, has provided protection against grassy stunt virus disease in almost all tropical rice varieties in Asia for the last half a century. The 1B/1R translocation carrying a rye chromosome arm, in wheat varieties such as PBW 343 got deployed on millions of hectares as it conferred multiple disease resistance, better ability to withstand heat and drought stress and higher yield. A continual supply of rust resistance genes has served to keep wheat afloat as a major crop - about half of these genes have come from alien sources. The identification and transfer of hidden productivity conferring genes from low yielding but diverse donors or even wild relatives has been demonstrated in rice and tomato using 'Advanced Backcross-QTL' method. Without the use of genes from related species, particularly for incorporating resistance and winter hardiness in noble canes, sugar industry would not have been viable. Similarly improvement of total soluble solids in tomato, rust resistance in coffee, alien cytoplasm for hybrid seed production in various crops represent classical examples of utilization of PGR.

Presently, the genetic needs of our agricultural systems have increased in response to the emerging challenges. Improved varieties are expected to be resistant/tolerant to biotic and abiotic stresses, combine productivity with climate resilience and stability, provide better nutritional value, possess greater resource-use efficiency and carry a host of other traits. A sustainable food production system in this context would evidently be built on the foundation of PGR but with considerable strengthening through conceptual, technological advances as well as policy support.

In recent times, use of PGR has also been brought to bear on the need for nutritional security. Genetic improvements through biofortification have helped develop new varieties of staple food crops, containing higher content of key nutrients, *viz.*vitamin A, iron, and zinc. In wheat, varieties with high grain Zn have been released in a number of countries including India utilising the genetic variation from *Triticum dicoccum*. Using a wide spectrum of PGR, Harvest Plus has released more than 290 biofortified varieties of 12 crops such as wheat, rice, maize, sorghum, pearl millet, sweet potato, cassava and beans, in over 30 countries.A cloned, high grain protein gene *GpcB1,* identified from *T. dicoccoides*, has been transferred to elite backgrounds in a number of wheat improvement programmes including those in India.

A major future role of PGR is likely to be in the context of climate change. Crop diversity will be the key for adapting to climate change and thus help mitigate the possible negative impact of climatic fluctuations. Scouting genetic variation from landraces and crop wild relatives can provide resilience against temperature and moisture extremes, erratic rains and sudden shift in temperature. In wheat, *Aegilops speltoides* and *Ae. tauschii* have been identified as potential sources of heat tolerance and genes for stability under heat stress are being introgressed into cultivated lines. In rice, submergence tolerance gene *Sub1A*, from an Indian landrace has been introgressed in Swarna and a number of varieties grown in flood prone areas.It can provide tolerance for upto 2-weeks of submergence. Climate resilience in crop germplasm remains poorly demarcated in terms of physiological mechanisms and genes. In light of variations in production environment, the concept of phenotypic plasticity and its genetic and physiological underpinnings need to be developed further. Global climate shifts would warrant biome based germplasm introductions, which the international regulations need to facilitate and promote.

Large scale characterization of the genebank accessions in the target environment for multiple traits of interest can fuel wider use of PGR in crop breeding programmes. But it is a challenging task as many traits of interest have quantitative inheritance and are governed by multiple genes, have low heritability and strong genotype x environment interactions. Advances in sequencing technologies including whole genome resequencing and high throughput genotyping platforms provide unprecedented avenues of germplasm characterization at molecular level. These allow efficient and rapid assessment of genetic diversity, discovery of new alleles, removal of duplicate accessions, identification of core collections and targeted introgression of the desired genes in elite backgrounds. In case of distant donors, molecular tools can facilitate a full-fledged pre-breeding phase including the development of introgression libraries and their genome wide mapping. Once donor genes of interest are tagged with molecular markers, their marker assisted mobilisation in breeders' crossing block can lead to precise and rapid transfers along with gene pyramiding. For gene introgression from distant sources, advances such as speed breeding in combination with molecular markers can help reduce time taken for multiple cycles of backcrossing and selection.

To fully harness the potential of PGR for the crop improvement programmes in India, we need to integrate pre-breeding, biotechnology and conventional plant breeding. Further, to work as a team, it is time to institute an All India Coordinated Research Programme on Pre-breeding with focus on all major field, fruit and vegetable crops. Biotechnological tools such as cis-genesis (*vis-a-vis* conventional transgenesis) need to be facilitated through policy and utilised for transfer of genes from cultivated/wild donors in form of multigene cassette, thus creating multiple, linkage drag free transfers in a short time. Replica of alleles from distant germplasm can be created in the elite genetic backgrounds through base pair editing, a specialised genome editing technology. Research and policy environment should aim at harnessing the power of this technology. High throughput geno typing and pheno typing, combined with internationally accessible informatics platforms are already proving to be useful in this regard.

It is a privilege to deliver this lecture in the memory Dr A.B. Joshi, whose contributions to Indian agriculture are legion. He played a pivotal role in creation of National Bureau of Plant Genetic Resources, breeding of cotton, wheat and other crops, and initiation of All India Coordinated Research Project in wheat.

About the Speaker

Professor Baldev Singh Dhillon, currently the Vice Chancellor (VC) of Punjab Agricultural University (PAU), Ludhiana, is an internationally acclaimed scientist in the field of Plant Breeding and Genetic Resources. He served PAU as Director of Research, Director (Seeds) and Maize Breeder, the Indian Council of Agricultural Research (ICAR) as Assistant Director General, and Director, ICAR-National Bureau of Plant Genetic Resources (NBPGR), New Delhi and Guru Nanak Dev University, Amritsar as Director of Research. Prior to holding the reigns of PAU as VC, he was working in the University of Hohenheim, Stuttgart, Germany. Earlier, he has served CIMMYT, Mexico as Associate Scientist.

As a Vice Chancellor since 2011 and Director of Research (2005-07), Prof. Dhillon took numerous initiatives that catapulted PAU to greater heights. As a result of overall development in research, teaching and extension programmes carried out under his leadership PAU has (i) won the 'Sardar Patel Outstanding ICAR Institution Award (2017)' based on achievements during previous 5 years and their impact; (ii) been identified as 'Institute of Excellence' in agriculture with research output of national and global prominence, by the Empowered Expert Committee constituted by MHRD/UGC under 'Institute of Eminence' project; (iii) occupied the top position for research publications and citations among all State Universities as per CII-India Citation Index Report, 2017.

Prof. Dhillon's constant guidance, encouragement and motivation to the faculty led to the development of outstanding crop varieties and their production-protection technologies. As a result, the state achieved the highest productivity (>12 t/ha) of its most important crop rotation, i.e. *parmal* (paddy) and wheat during 2017-18. Early maturing, high yielding varieties of paddy having less biomass developed by PAU are now most popular among farmers and are instrumental in water and pesticide saving, and are also helpful in paddy straw management. PAU led the nation in the development of biofortified wheat (Zn rich), *Bt* cotton (bollworm resistant) and less seeded kinnow and vegetable hybrids/varieties to promote nutritional security, diversification and value addition. New farm machines and implements have been developed to address the issues of paddy straw management, spraying of pesticides and drying of produce. Prof. Dhillon led the Joint Inter-State Campaign (Punjab, Haryana and Rajasthan) that successfully managed the white fly in cotton resulting in bumper crop with record productivity of 756 and 750 kg/ha of lint (compared to 197 kg/ha during 2015) and during 2016 and 2017, respectively, accompanied by saving of pesticides worth Rs 2,600 to 2,800 per ha. He is among those who very rigorously led the campaign against paddy straw burning during 2018.

Since 2011, the PAU has also made outstanding research contributions for sustainable progress in agriculture, making rational use of natural resources (e.g. laser leveller, drip irrigation and fertigation schedule for saving water), integrated nutrient management (need based application of nutrients based on soil testing, leaf colour chart and green seeker for nitrogen requirement), integrated pest management (pesticide application as a last resort and that too based on economic threshold level), integration of food technology with processing and nutrition, plant biotechnology with field and horticultural crops improvement (to transfer genes from wild to cultivated species for meeting the challenge of climate change), cultivation of new crops and protected cultivation of vegetables. Under his leadership, PAU has developed/strengthened linkages with industry particularly that of seed, food processing and farm machinery and created IPR and Technology Commercialization Cell which had significant effect on commercialization of technologies.

As a maize breeder, Prof. Dhillon worked in the maize improvement team, and developed 16 varieties/hybrids including '*Paras*', the first single cross hybrid in India (1995), and thereby, gave a new direction to maize breeding in the country. His pioneering work on maize cultivation during non-traditional winter/spring season has led to the emergence of spring maize as an important crop in NW India. He has developed new methods of plant breeding and techniques of quantitative genetic analysis which have been included in the text books.

During his tenure as a Director at ICAR-NBPGR (2000-2005), germplasm evaluation network was developed and comprehensive evaluation in rice, wheat, chickpea and pigeonpea was started and database on introduced and indigenous collections was created. Further, the strategies for targeted collection/introduction of indigenous/exotic germplasm were prepared and implemented and the National Containment Facility was developed. The accessions in National Genebank increased from 0.196 to 0.303 million. He started Ph.D. programme in Plant Genetic Resources at NBPGR. At PAU and NBPGR, he guided several M.Sc. and Ph.D. students.

Born on June 27, 1947 at village Doburji, in the erstwhile Tarn Taran tehsil of Amritsar district, Prof. Dhillon has outstanding academic credentials. He obtained his Doctorate from Indian Agricultural

Research Institute, New Delhi, M.Sc. from PAU, Ludhiana and B.Sc. from Khalsa College, Amritsar. He has bagged many prestigious scholarships/ fellowships that included post-doctoral fellowships namely German Academic Exchange Service (DAAD) Fellowship, Alexander von Humboldt Fellowship; University of Hohenheim fellowship to work at University of Hohenheim in Germany and Alexander von Humboldt Europe Fellowship to work at University of Birmingham, UK.

He has a strong flair for scientific writings and has published ~ 400 research and policy papers, besides authoring/editing 13 scientific books. He has been associated as Member, Editorial Board with international scientific journals, namely Theoretical and Applied Genetics, Germany; Maydica, Italy; Journal of Crop Improvement, USA; Rice Genetics Newsletter, Japan; and as a Regional Secretary of the Society for the Advancement of Breeding Researches in Asia and Oceania. He has also worked as a member of Editorial Board of many national journals and served/serving as a member of high level national and state level committees. He participated in the negotiations on International Treaty on Plant Genetic Resources for Food and Agriculture (2001-2002).

For his outstanding contributions, Prof. Dhillon has been bestowed with several awards such as: Rafi Ahmed Kidwai Memorial Prize by ICAR; Dr BP Pal Memorial Award (the apex award) and Recognition Award by NAAS; Om Parkash Bhasin Award for Science and Technology; Lifetime Achievement Award by Punjab Academy of Sciences; Sardar Bishan Singh Samundri Memorial Lectureship Award by Guru Nanak Dev University, Amritsar; Dr. HB Singh Award by ISPGR; Dr Joginder Singh Memorial Award by Indian Society of Genetics and Plant Breeding (ISGPB); Appreciation Certificate by Punjab State Council for Science and Technology, and Gold Medal by ICAR-IARI. He has also been conferred with Asian Maize Champion Award by CIMMYT. He is Fellow of several academies, the important ones being Indian National Science Academy, National Academy of Agricultural Sciences; National Academy of Sciences, India; Punjab Academy of Sciences. He is also J.C. Bose National Fellow. He served as President and Secretary of ISPGR, New Delhi; and President of ISGPB, New Delhi; Maize Technologists Association of India, New Delhi and Crop Improvement Society of India, Ludhiana.

Based on his immense contributions to science and society, Professor Dhillon has been conferred with prestigious 'Padma Shri Award' in 2019 by the President of India.

About ISPGR

The Indian Society of Plant Genetic Resources (ISPGR) was founded in 1987 as a multidisciplinary scientific body involved in the various issues of plant genetic resources (PGR) and related fields. It currently has more than 750 members, nearly 700 of them being life members. The genesis of the society was from the initiative taken by the scientists at the National Bureau of Plant Genetic Resources (NBPGR), New Delhi, under the leadership of Dr R.S. Paroda, who was then Director of NBPGR and is also currently the President of ISPGR (2019-21). The ISPGR 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 ISPGR is also registered under section 12A and 80G of Income Tax Act 1961, for tax exception on any surplus funds of the ISPGR and for donor's tax exception, respectively. Membership is open to all persons interested in the field of PGR, in India and abroad.

Objectives

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 especially in germplasm exploration and collecting, conservation, evaluation and characterization, introduction and exchange, quarantine and related activities.
2. To encourage the management of PGR in an integrated fashion involving different disciplines such as Economic Botany, Ecology, Ethnobotany, Biosystematics, Biotechnology, Physiology, Horticulture, Seed Science, Agronomy, Pathology, Entomology, Nematology, Chemistry & Biochemistry, Computer Science and Informatics.
3. To provide a forum to the scientists for expressing their critical views based on scientific knowledge, rational thinking on policies related to PGR.
4. To collect, collate and disseminate information on PGR programmes.
5. To encourage and promote close association and collaboration among members belonging to various disciplines.
6. To provide recognition to persons having made significant contribution in furthering the science of PGR.
7. To work in association with international organizations and other societies with similar interests.
8. To publish research journal at periodical intervals.

Executive Council (2019-2021) of ISPGR