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Use of Plant Genetic Resources for Food and Nutritional Security

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Plant genetic resources (PGR) have been extensively used to develop new cultivars for meeting the emerging challenges and needs of the society. These have played a pivotal role in assuring food and nutritional security of the humankind. Our National Agricultural Research System, particularly the National Bureau of Plant Genetic Resources, has made dedicated efforts to collect indigenous germplasm and introduce exotic germplasm and conserve the same. Indigenous germplasm has been used to develop crop varieties and even now traditional varieties/landraces act as rich source of genes of economic importance (submergence tolerance in FR13A rice, salinity tolerance in Pokkali rice and Kharchia wheat). Exotic germplasm has been used to develop several landmark varieties including IR 8 rice; Kalyansona and Sonalika wheats, the cultivation of which resulted in Green Revolution. Hybridization of indigenous and exotic germplasm to combine their desirable traits has led to remarkable achievements in enhancing crop productivity coupled with adaptation to prevalent agro-ecologies. The overdependence on improved cultivars of few crops (to ensure food security of increasing human population) for human diet markedly changed the food consumption pattern causing hidden hunger, and also making these crops more vulnerable to biotic and abiotic (climate change) stresses. In view of these developments, research on nutritional security and adaptation to changes in agro-ecologies has been getting greater attention in recent past with appreciable successes. In these research programmes, unadapted germplasm of same crop species and wild relatives are being increasingly used. More focussed efforts are needed on acquisition, characterization and conservation of PGR as well as their use. The International Treaty on Plant Genetic Resources for Food and Agriculture needs to be implemented in letter and spirit and pre-breeding research on wild relatives be strengthened to develop usable PGR and be strongly linked with cultivar development.

Introduction

Plant genetic resources (PGR) are the genetic material of plants having value as a resource for present and future generations. PGR include land races and primitive cultivars, modern varieties, parental lines of hybrids, genetic stocks with known desirable attributes and wild and weedy relatives of crop plants. Being the building blocks of improved crop varieties, the availability of PGR is pivotal requirement in cultivar development programmes. Earlier there was sufficiently wide food basket that ensured balanced nutrition of human beings. As civilization progressed, the ever-increasing population and changes in lifestyle necessitated research programmes for productivity enhancement. Commendable achievements of these programmes in some crops led to overdependence on wheat, rice, maize, potato and cassava which meet 75% caloric requirement of our society. The narrowed food basket resulted in nutritional deficiencies. The spread of improved varieties also narrowed on-farm diversity accentuating the damage due to insect-pests and diseases. Recently, the climate change and volatility have added further dimensions. For addressing these problems, the focus has been greatly enhanced on search, development and use of PGR for traits like tolerance to temperature and moisture extremes, high protein, zinc and iron concentration, and even traits like low glycemic index and low gluten concentration to tackle the increasing incidence of diabetes and gluten intolerance.

Indian centre is one of the eight centres of origin and one of the 12 mega gene centres of the world. Many crops, including important ones, namely rice, chickpea, pigeonpea, mungbean, urdbean, sugarcane, *desi* cotton, jute, eggplant, cucumber, mango, citrus, banana have originated in this centre. India is enormously rich in plant wealth and lot of variability for these crops has been collected, conserved and utilized.

Collection of Indigenous Germplasm and its Use

In India, initial sporadic collection of indigenous germplasm were made in wheat (Howard and Howard, 1906-10, D Milne), jute (Burkill and Finlow, 1907),

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legumes (Shaw *et al*., 1931-33, rice (Govindaswamy, 1955-60, RH Richharia, 1965, 1977-79; SD Sharma and SVS Sastry, 1967-1972) and sugarcane (Thuljaram Rao, 1968). Systematic and elaborate work on collection and maintenance of germplasm was started in 1946 in IARI, New Delhi by Dr. Harbhajan Singh and co-workers. The National Bureau of Plant Genetic Resources (NBPGR), New Delhi, established in 1976 is the nodal agency for PGR management in the country.

The systematic plant breeding work in India started with collection, classification and purification of local landraces leading to release of wheat varieties T9 and 8A in the 2nd decade followed by rice varieties *Jhona* 349 and *Basmati* 370 in 3rd decade of 20th century. Selection from local landraces continues to yield new varieties with specific traits like aromatic rice variety Kalanamak from Nepal/India, low glycemic index variety Chhattisgarh Madhuraj Paddy-55 developed by refinement of local cultivar Chaptigurmatiya and Sona Moti variety of native wheat (*T. sphaerococcum*). Traditional varieties/landraces are proving to be rich sources of genes/QTLs for traits of economic importance, e.g., in rice, the *sub1* gene from FR13A landrace from Ghaghara Ghat of Uttar Pradesh, salinity tolerance from *Pokkali* of Kerala, the *Pup1* locus for phosphorous deficiency tolerance in *aus* type rice variety Kasalath. Many improved rice varieties like Swarna sub1 have been developed by utilizing these resources.

Germplasm Exchange

Export of Indian Germplasm

The rich wealth of PGR in India attracted collectors from across the globe. The scientists from India and foreign countries conducted joint explorations to collect germplasm of rice, wild rice, wheat, barley, wild barley, tropical forages, *Brassica* spp., wild crucifers, minor millets, sesame, cucumber, melons, banana, etc. William Farrer introduced Indian wheats in Australia in 1890 for imparting earliness, drought tolerance and rust resistance in the Australian wheats. Wheat variety C591 with excellent grain quality was used in Canadian wheat breeding programme. Wheat variety PBW 65 has been used extensively in breeding programme by International Maize and Wheat Improvement Center, Mexico as a source of resistance to Karnal bunt and loose smut. Chickpea variety C 235 was released in Australia (as Tyson) and USA (as Farha). Maize composite Vijay was released in Nepal (as Rampur Yellow) and in Pakistan (as J1).

Introduction of Exotic Germplasm

Germplasm exchange, facilitated by human migration, cross-border trade, foreign invaders as well as domestic requirements, has been happening since long. Some important crops like wheat, maize, American cotton, sunflower, etc. were introduced**.** There are several examples of successful deployment of introduced hallmark germplasm (global elite varieties) as cultivars namely, wheat Sonora 64, Lerma Rojo 64, and rice IR 8, etc. Mungbean variety SML 668, identified from the material received from Asian Vegetable Research Development Centre, Taiwan, revolutionized mung production during spring season in North India.

Secondary Introductions – Selections from Introduced Material

These have made a major impact as exemplified by development of wheat varieties PV18, Kalyansona, Sonalika during late 60s through selections in introduced germplasm, the adoption of which resulted in Green Revolution. Such selections have continued to revolutionize crop production (wheat mega-varieties PBW 343, DBW 187). Selected from germplasm introduced from International Rice Research Institute, Philippines (IRRI), rice variety PR 106 released in Punjab in 1976 ruled the state for three decades. Rice variety PR126 released in 2017, is high yielding, short duration variety. It fits well in the multiple cropping system and has become the most sought-after variety in North-west India. *Gobhi sarson* (*Brassica napus*) was introduced during early 1980s and owing to its higher productivity, oil content, and resistance to white rust, it became an important crop in North-west India. Tomato varieties Punjab Tropic and Punjab Varkha Bahar 4 were developed through selection from segregating material received from the USA and Taiwan, respectively. Chilli varieties Punjab Surkh and Punjab Guchhedar were selections from germplasm received from Indonesia.

Hybridization of Indigenous and Exotic Germplasm

The breakthroughs in yield potential have also been achieved by crossing introduced germplasm with locally adapted germplasm. Introduced Mexican semi-dwarf wheat varieties crossed with local germplasm resulted in development of landmark varieties including WL 711. Thereafter, wheat introductions carrying 1B/1R translocation (from rye) possessing higher grain yield and resistance to biotic and abiotic stresses were used extensively. In Indian mustard, two varieties (JM 1 and JM 2) were derived by utilizing white rust resistant accessions L 4 and L 6 from Canada.

Nutritional Security

Tremendous progress in productivity in certain crops led to their predominance over vast area. Though, this progress ensured food security to increasing human population but caused nutritional insecurity (hidden hunger) owing to overdependence on few crops for human diet and other changes in food consumption behaviour (processed, junk food). To achieve nutritional security and address human health concerns, research on identification of novel genes in diverse PGR and their mobilization to develop biofortified varieties has been greatly strengthened in recent years. Some nutritionally superior crop varieties released in India are, high protein rice CR Dhan 310; high Zn rice DDR Dhan 49; high Zn wheat PBW 1 Zinc, WB 2; high protein wheat HD 3226, PBW 752; high lysine and tryptophan Maize Vivek QPM 9; high provitamin A maize Pusa Vivek QPM 9 improved, Pusa HQPM 7 Improved; high iron Pearl millet RHB 234, HHB 311; high iron lentil Pusa Ageti Masoor; Kunitz Trypsin inhibitor free Soybean NRC-127; lipoxygenase-2 free soybean NRC 132; high oleic acid Soybean NRC 147; high oleic acid peanut Girnar 4 and Girnar 5; high linolenic acid linseed TL99; high provitamin A Cauliflower Pusa Beta Kesari 1; high anthocyanin potato Kufri Manik; high provitamin A Sweet potato Bhu Sona; high Fe, Zn, Vitamin C Pomegranate Solapur Lal. Hybridization between Australian genotypes led to development of canola quality Gobhi sarson variety GSC 7 that also became popular variety in North-west India. Low erucic acid varieties of Indian mustard (Pusa Karishma, LET 17, LET 18, LES 1-27) were derived from ZEM 1 and ZEM 2 from Australia.

Use of Wild Relatives

Sometimes genetic variability is not available in adapted germplasm and necessitates the use of unadapted germplasm or related species or even wild weedy relatives. In such cases, prebreeding is needed to develop usable PGR which used to be a long-term and tedious project. However, the biotechnological tools now available, are being applied to hasten it. High grain weight and grain number per spike has been transferred from diploid progenitor species (*Ae. tauschii, T. monococcum*, *T. boeoticum, T. dicoccoides*) to bread wheat. Rust resistance genes *viz. Lr 57/Yr40 (Ae. geniculata), Lr 58 (Ae. triuncialis), Lr76/Yr70 (Ae. umbellulata)* have been characterized and mobilized from wild species to elite wheat background leading to development of varieties Unnat PBW 343, PBW 803, etc. High grain protein gene

Maize germplasm having plant type required for the development of cultivars suited for cultivation under high plant density

Gpc B1 (originally from *T. dicoccoides*) and high grain Fe and Zn QTL's (from *T. monococcum, T. boeoticum*) have been transferred to durum and bread wheats. In rice, ***O.** nivara, a*cc. 101508, the only known source of resistance to grassy stunt virus is being widely used as donor. Many genes imparting resistance to brown plant hopper and bacterial blight of rice have been introgressed from related wild species. These include widely used *Xa* 21 gene from O. *longistaminata* identified at IRRI and *Xa* 38 gene from ***O.** nivara* at PAU. Resistance to aphid and Sclerotinia stem rot in *B. juncea* has been achieved through introgression from *B. fruticulosa* and *Erucastrum cardaminoides.* In pigeonpea*, C. scarabaeoides* was used as a source of genes for tolerance to *Maruca vitrata* and *Phytopathora* stem blight besides higher productivity. In chickpea, resistance to Botrytis grey mould and Ascochyta blight has been introgressed from *C. pinnatifidum* and *C. reticulatum*.

Nobilization of sugarcane is a classic example of use of wild relatives. It was initiated by CA Barber and Venkataraman in 1912 at Sugarcane Breeding Institute, Coimbatore. Local strains of *Saccharum barberi*, (unproductive species that grows wild in North India) was crossed with tropical noble cane *S. officinarum* (thick soft stem, high sucrose content but unsuited to North India). The resultant hybrid was crossed with wild cane *S. spontaneum*, and tri-hybrid canes with high sucrose content suitable for North India were developed.

Future Perspectives and Action Points

- PGRs are the backbone of plant breeding programmes and are vital for food and nutritional security of human being. However, after the establishment of WTO, germplasm exchange and use of PGR obtained from other sources is becoming increasingly difficult and complex. The 'International Treaty on Plant Genetic Resources for Food and Agriculture' needs to be implemented in letter and spirit and be accompanied by the efforts to facilitate acquisition of germplasm.
- The IPRs on PGR needs to be balanced with 'benefit sharing' and 'farmers rights'.
- The database on linking acquisition, characterization and conservation needs to be strengthened and regularly updated to facilitate PGR use.
- The transformation of multi-institutional CG system to 'One CG' should not adversely affect the germplasm exchange between CG and national agricultural research systems.
- National Genetic Stock Nurseries needs to be strengthened.
- Dedicated prebreeding programmes need to be strengthened as an integral part of crop breeding programmes at least at a few centres to promote the utilization of genes of interest from wild relatives.
- Deposition of precious breeding lines developed under multi-institutional collaborative ad hoc research projects with NBPGR and their sharing should be made mandatory.