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Genetic Enhancement for Effective Use of Plant Genetic Resources in Plant Breeding

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The term "enhancement" was first used by Jones (1983) which according to him can be defined as transferring useful genes from exotic or wild types into agronomically acceptable background. Rick (1984) used the term pre-breeding or developmental breeding to describe the same activity. Plant breeding is an art, science and technology of improving genetic make up plants for the benefit of human kind. It is practiced worldwide by profession al plant breeders and farmers with a proven track record over the centuries. The genetic diversity of crop plants is the foundation for the sustainable development of new varieties for present and future challenges which arises due to the various biotic and abiotic stresses. Genetic diversity provides an option to farmers and plant breeders to develop new and more productive crops / varieties through selection, hybridization and breeding, that are resistant to virulent pests and diseases and adapted to changing environmental conditions. Genetic enhancement or Pre-breeding or crop wild relatives (CWR) are necessary for making the germplasm usable in traditional breeding. Maxted *et al.* (2006) defined a CWR as a wild plant taxon that has an indirect use derived from its close genetic relationship to a crop. It is useful in creating vast genetic diversity, broadening genetic base of the population, improving adaptation, value addition by transferring useful alleles from un-adapted sources to adapted cultivars etc. However, use of genes from wild species poses several problems such as cross incompatibility, hybrid inviability, hybrid sterility and linkage between desirable and undesirable alleles. Pre-breeding work has yielded significant results in many field crops such as maize, sorghum, barley, rice, potato, cotton, oilseeds, pulses etc. The aim should not only be to exploit intraspecific variation within a crop but also to increase interspecific diversity in agriculture through genetic improvement and promotion of less popular, neglected or underutilized crop species (e.g. Padulosi *et al.*, 2002). Arora and Nayar (1984) reported the occurrence of over 320 wild relatives of crops (51 cereals and millets; 31 grain legumes; 12 oilseeds; 24 fibre plants; 27 spices and condiments; 109 of fruits, 54 of vegetables and 27 of others) in India.

What is Genetic Enhancement?

Genetic enhancement also called Pre-breeding or development breeding or crop wild relatives refers to all activities designed to identify desirable characteristics and/or genes from unadapted materials that cannot be used directly in breeding populations programme, and to transfer these traits to an intermediate set of materials that breeders can use further in developing new varieties for farmers. It is a necessary first step in the "linking genetic variability to utilization" use of diversity arising from wild relatives and other unimproved materials in genestock. These activities are a collaboration between the germplasm curator and the plant breeder who need to work together to understand the scope and value of germplasm collections and how novel traits from these collections can be bred into new varieties. It refers to transfer of useful genes from exotic or wild types into agronomically acceptable background. In 1984, Rick used the term pre-breeding to describe the same activity. Now terms genetic enhancement and pre-breeding are used as synonyms and interchangeable. However, the term genetic enhance is in more usage.

Objectives of Genetic Enhancement

1. Improved germplasm and associated genetic knowledge that enhance resistance expression and diversity in variety.
2. Improved parental stocks which can be readily utilized within breeding programs and Improved selection methodologies (Shankar, *et al* 2012).
3. Identify potentially useful genes in a well-organized and documented gene bank.
4. Design strategies that lead to development of an improved germplasm that are ready to use in varietal programme.
5. Development Pre-breeding is a collaborative endeavor that is buttressed by communication, between gene bank curators and breeders.

Gene Pool Concept

Gene pool: "All the genes and their alleles present in the individuals, which hybridize or can hybridize with each other**".** The gene pool is classified into four groups by (Haussmann *et al*., 2004).

1. Primary Gene Pool (GP$_1$): It includes all such strains and species, which hybridize readily with each other and give rise to fertile hybrids. It consists of all the different strains or varieties of a crop species and some related species. The members of primary gene pool are the most commonly used in breeding programmes.

2. Secondary Gene Pool (GP$_2$): Members of secondary gene pool are all those species that hybridize with the members of primary gene pool with some to considerable difficulty and the hybrids are partially fertile. These species are difficult to hybridize with those of GP1 due to ploidy differences, chromosome alterations or genetic bariers.

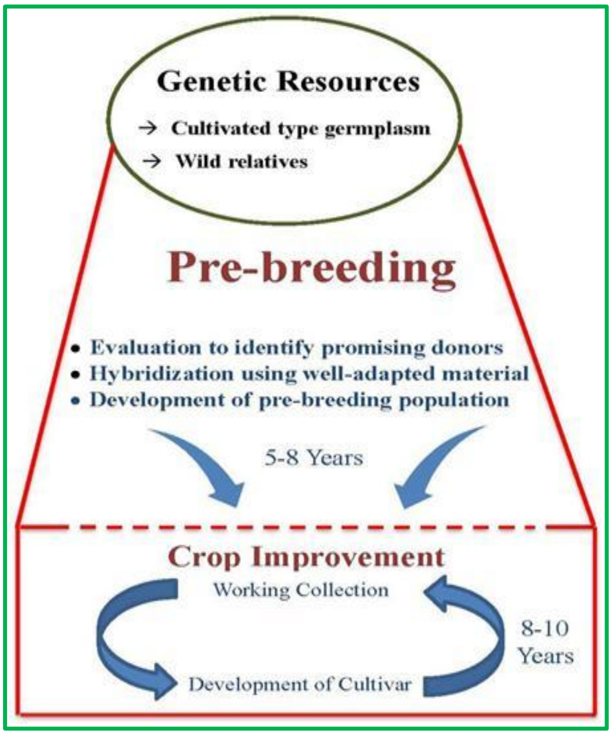
Gene transfers from GP$_2$ to GP$_1$ are possible but usually difficult. Members of this group are often used in breeding programmes.

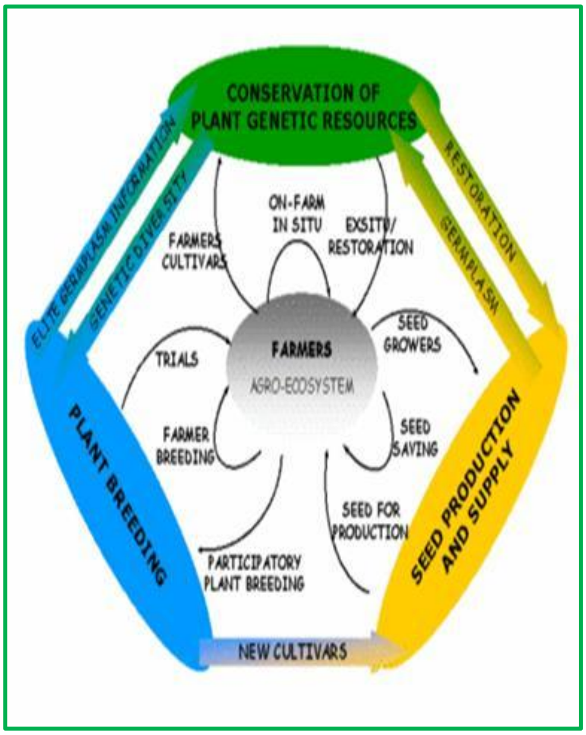
3. Tertiary Gene Pool (GP$_3$): The species belonging to this group cross with the members of primary gene pool with considerable to great difficulty, and hybrids, if produced, are anomalous, lethal or completely sterile. Gene transfers from this group to the primary gene pool are very difficult and require special techniques. Hybrids are invariably sterile. Gene transfers from GP3 to GP2 are relatively easier. GP3 is used only occasionally in breeding programmes.

4. Quaternary Gene Pool (GP$_4$): It refers to crop cultivars that have been developed through biotechnological approaches. It have trasgeneic varieties and other value added strain.

Use of Exotic Germplasm

Exotic germplasm has to undergo "conversion or genetic enhancement" to find its best use in crop improvement. Having said that best endeavor it is realized that for most of the crops the genetic gap between elite adapted gene pools and exotic pools is growing larger with each breeding cycle. Better knowledge of underlying genetic differences between adapted and exotic germplasm might help to overcome such obstacle to gene flow. Studies on cotton have indicated ample scope for genetic enhancement. In some crops like wheat the number of exotic land races introgressed in to elite germplasm is increasing overtime.





Pros of Genetic Enhancement

1. It assists in broadening the genetic base of the population which is essential for achieving stability in yield over multilocational.
2. The genetic diversity has depleted in the improved variety which invites danger of uniformity. Genetic enhancement is benefit in restoring genetic diversity in such cultivars.
3. It helps in combining useful genes or gene combination from landraces, perennials and wild species into the cultivated or well adapted genotypes. Such traits include resistance to biotic and abiotic stresses, earliness and improvement in quality parameters.
4. It assists in developing plant types which are suitable for machine harvesting.
5. It also leads to creation of new genetic variability in various economic traits, Thus it leads to value addition in the germplasm.
6. The germplasm lines developed through genetic enhancement become usable in traditional breeding programmes for development of productive cultivars/hybrids.

Cons of Genetic Enhancement

1. In the Introgressive hybridization using wild species, there are problems of cross incompatibility, hybrid in-viability and hybrid sterility.
2. Linkage between desirable and undesirable alleles poses problems in utilization of desirable alleles.
3. Generally, the genetic re-combinations are restricted in introgressive breeding.
4. Small populations are available due to poor seed setting in interspecific crosses.

Achievements of Genetic Enhancement

i. Maize: In maize new inbred lines have been developed through pre- breeding which are used as parents for development of productive single cross hybrids. These single cross hybrids are superior to double cross hybrids. The heterotic pool has been developed by Nass and Paterniani (2000).

ii. Sorghum: In sorghum, desirable traits have been introgressed from Ethiopian and Sudanense land races into adapted Indian cultivars at ICRISAT(2004)

iii. Sugarcane: In sugarcane, pre-breeding has resulted in development of interspecific genetic stocks of *S. spontaneum*, *S. sinense* and *S. offcinarum* by Seetharam (2007).
iv. Barley: In barley, pre-breeding has resulted in creating vast genetic diversity and broadening the genetic base of breeding populations.
v. Potato: In potato, day long tretraploid populations have been developed through introgressive hybridization. The new germplasm is being used widely in potato Improvement. In potato, genetic enhancement has been achieved mainly through polyploidy breeding.
The genetic enhancement has also been achieved in other crops such as oil seeds, lentil, tomato, chick pea, ground nut, cassava etc. This work is in progress at various International and National Crop breeding centres. Various plant characters such as yield, quality parameters, resistance to biotic and abiotic, stresses, adaptation, genetic base, crop maturity, plant type, photo and thermo insensitivity, etc. are kept in mind during pre-breeding programmes.
v. Cotton: In cotton, fibre quality parameters and resistance to biotic and abiotic stresses have been introgressed from wild species by Lokanathan *et al*., (2003).

Applications of Genetic Enhancement in Crop Improvement

1. Narrow genetic base or adaptation results into the crop prone to different biotic and abiotic stress. Genetic enhancement is adopted for broadening the genetic base, to reduce vulnerability.
2. Identifying desirable traits in exotic materials and moving those genes into material more readily accessed by breeders.
3. Wild species and crop wild relatives are the harbor of the gene for cope with the changing climate, identification of this important gene and moving them from wild species into breeding populations when this appears to be the most effective strategy.
4. Identification of novel genes in the unrelated species and transfer them using genetic transformation techniques.

Conclusion

For field crops improvement, enough genetic diversity exists in the form of landraces and wild relatives, which carry several useful genes for cultivar improvement. Nonwithstanding, utilization of these resources in breeding programs is time-consuming and resource demanding. To overcome this, genetic enhancement activities should be initiated to generate new genetic variability using promising landraces and wild relatives or wild source for use by the breeders in crop improvement programs. Genetic enhancement should focus on the continuous supply of useful variability into the breeding pipeline to develop new high-yielding cultivars with a broad genetic base, crop wild relatives should not focus on increasing yield. Though genetic enhancement is useful to enrich the primary gene pool for cultivar improvement, it is a time-consuming and difficult affair as well.

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