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Pre-breeding: its applications in crop improvement

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Introduction

Plant breeding is an art and science of genetically improving plants for the benefit of humankind. It is practiced worldwide by professional 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. Plant genetic resources for food and agriculture (PGRFA) are the biological cornerstone of global food security. They comprise diversity of genetic material contained in traditional varieties, modern cultivars, crop wild relatives and other wild species. The agricultural diversity and genetic resources that support food crops need to be used efficiently both to maintain current levels of food production and to confront future challenges (FAO, 2007).

What is Pre breeding?

Pre-breeding refers to all activities designed to identify desirable characteristics and/or genes from unadapted materials that cannot be used directly in breeding populations, and to transfer these traits to an intermediate set of materials that breeders can use further in producing 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. 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 new traits from these collections can be bred into new varieties.

Why Pre-breeding is required?

Progress in breeding is limited from perceived lack of diversity:

- ✓ Current limited genetic base of agriculture today is apparent a threat to food security.
- ✓ Reduction of Biodiversity: genetically uniform modern varieties are replacing the highly diverse local cultivars and landraces in traditional agro-ecosystems.
- ✓ Genetic uniformity: Increases genetic vulnerability for pests and diseases.
- ✓ The effects of climate change: search for new genes/traits for better adaptation.
- ✓ Evolving pest and pathogen populations: motivating plant breeders to look for new sources of resistance in genebanks.

The decision to do pre-breeding is based on the expected efficiency and efficacy of ultimately moving the target traits into cultivars for farmers and source of desired gene(s). Pre-breeding is necessary, if desired genes are available only in one of the following:

(1) Genebank accessions those are not well-adapted to the target environment; (2) Closely related wild species that are easily crossed with the crop species and; (3) More distant wild species which are more difficult to cross.

Pre-breeding strategies:

Plant genetic resources can be defined as all materials that are available for improvement of a cultivated plant species. Genebanks are repositories of genetic diversity of cultivated as well as their wild relatives and other wild species. The ultimate role of genebanks is to ensure the long term availability of crop germplasm to sustain agricultural production, by providing pre-breeder and breeder with new genetic diversity that adds value to the future varieties. Pre-breeding helps in building a bridge that brings together the people who understand the scope of germplasm collections (genebank managers) with those who introduce new traits into their varieties (plant breeders). Pre-breeding acts as a link between plant genetic resources PGR (gene bank managers) and breeding (plant breeders). Plant breeders and genebank managers must find ways to make it easier to effectively use germplasm from genebanks to produce new varieties with the traits the world needs.

The Gene Pool Concept:

“The gene pool is the total genetic variation in the breeding population of a species and closely related species capable of crossing with it’. The gene pool of a crop is made up of botanical varieties, landraces, inbred lines, ancient landraces, obsolete and modern cultivars, related wild species, subspecies, and weedy companion species (Haussmann *et al.,* 2004).

- **Primary gene pool:** same species cultivated and wild
- **Secondary gene pool** : different species than the cultivated
- **Tertiary gene pool**: more distantly related
- **Quaternary gene pool**: unrelated plant species and/or other organism

Methods of using Plant genetic resources (PGR) in crop improvement:

Classical approaches of using plant genetic resources in crop improvements (Cooper *et al.,* 2001) are: (1) Introgression (2) Incorporation or broadening of genetic base and (3) Wide crosses: synthesis of new base populations.

The tools of genome research may finally unleash the genetic potential of our wild and cultivated germplasm resources for the benefit of the society (Tanksley and McCouch, 1997). The utility of molecular markers and genomic tools/techniques in the context of using PGR for crop improvement includes: (1)Diversity assessment (2) Somatic Hybridization (3) Anther culture (4) Embryo rescue (5) Marker assisted breeding (6) Mapping of quantitative trait loci (QTL) (7) Introgression libraries, association studies and (8) Genetic transformation.

Major applications of pre-breeding in crop improvement:

There are major four applications of pre-breeding:

(1) Broadening the genetic base, to reduce vulnerability (2) Identifying traits in exotic materials and moving those genes into material more readily accessed by breeders (3) Moving genes from wild species into breeding populations when this appears to be the most effective strategy and (4) Identification and transfer of novel genes from unrelated species using genetic transformation techniques. The adoption of pre-breeding facilitates the efficiency and effectiveness of crop improvement programmes by enabling increased access to, and use of, genetic variations conserved in genebanks

Challenges:

(i)Lack of characterization and evaluation data; (ii) Knowledge of the genetic diversity; (iii) Inter species relationship and; (iv) Strong breeding program and funding sources. The use of genebank accessions in breeding programmes is limited by the high degree of difficulty and length of time often associated with separating the desirable genes from the undesirable ones.

Conclusion:

The process of pre-breeding identifies a useful character in unadapted materials, ‘captures’ it’s genetic diversity, and incorporates those genes into a *usable* form employing different techniques:

Future Prospects:

- Urgent need for collection, characterization and documentation of wild species, including crop wild relatives, due to increased likelihood of extinction for narrowly adapted and endemic species. There is an increased demand for novel genes in germplasm/ genebanks collections for adapting agriculture to biotic and abiotic stresses, including the need of effective screening of germplasm for different characters like, quality traits and biofortification.
- Genome mapping and synteny of the genes sequenced from wheat and barley could be assigned to encoding abiotic stress tolerance and can be utilized for crop improvement.
- The potential of genetic transformation technique could be exploited to transfer the desired gene(s) form the tertiary gene pool and/or beyond.
- New breeding strategies and bioinformatics tools are required to use the information gathered from genetic and genome analysis programs for dealing with complex traits more effectively.

References:

1. Cooper, H.D., Spillane, C. and Hodgkin, T. (2001). Broadening the genetic base of crops: an overview. In: Cooper HD, Spillane C and Hodgkin T (eds.) Broadening the Genetic Base of Crop Production. Wallingford: CABI Publishing in cooperation with FAO and IPGRI, CAB International, pp.1–23.
2. FAO. (2007). Adaptation to Climate Change in Agriculture, Forestry and Fisheries: Perspective, framework and priorities. Rome, Italy, Interdepartmental Working Group on Climate Change, FAO. pp.32.
3. Haussmann, B.I.G., Parzies, H.K., Prester, T., Susic, Z. and Miedaner, T. (2004). Plant genetic resources in crop improvement. *Plant Genetic Resources;* 2(1): 3-21.
4. Tanksley, S.D. and McCouch, S. (1997) Seed banks and molecular maps: unlocking genetic potential from the wild. *Science* 277: 1063–1066