

Role of Pre-breeding in Crop Improvement

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Abstract: -

Pre-breeding plays a pivotal role in crop improvement by bridging genetic resources and modern breeding strategies. It involves identifying and transferring valuable traits—such as yield enhancement, pest and disease resistance, and tolerance to abiotic stresses—from exotic or unadapted germplasm into elite breeding materials. By broadening the genetic base, pre-breeding reduces vulnerability caused by genetic uniformity and supports the development of resilient cultivars. It also facilitates hybrid programs, strengthens biodiversity, and addresses challenges posed by climate change and emerging pests. Ultimately, pre-breeding enriches germplasm diversity, ensuring sustainable crop improvement and the creation of superior varieties for farmers.

Keywords: *Pre-breeding, traits, genetic resources, yield and genetic base etc.*

Introduction:

Pre-breeding refers to the set of activities aimed at capturing useful traits and genes from unadapted or exotic sources that cannot be directly used in breeding programs, and transferring them into intermediate materials that breeders can later utilize to develop new crop varieties (Mohan et al., 2021). This process, often called “genetic enhancement,” represents the initial stage of

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sustainable plant breeding and follows the same basic principles as conventional breeding. Its main objective is to broaden genetic diversity within germplasm, making the improved material suitable for cultivar development. By drawing from a wider genetic pool, pre-breeding creates new base populations for breeding programs (Hausmann et al., 2004).

Genes from wild or exotic species have

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successfully been introduced into adapted crops such as rice, tomato, soybean, cotton, maize, wheat, barley, groundnut, chickpea, pigeon pea, sorghum, and pearl millet, leading to improvements in both qualitative and quantitative traits (Sebolt et al., 2000). The Global Crop Diversity Trust describes pre-breeding as “the art of identifying desired traits and incorporating these into modern breeding materials.” The products of pre-breeding are designed to integrate seamlessly into standard breeding pipelines.

Ultimately, pre-breeding seeks to enhance yield, resistance to pests and diseases, and other valuable traits without compromising genetic uniformity. It achieves this through base broadening or genetic enhancement, either by pinpointing genes linked to desired characteristics or by transferring them from unadapted to adapted backgrounds. In doing so, pre-breeding strengthens germplasm performance and resilience against biotic, physiological, and agronomic stresses (Mohan et al., 2021).

Role of Pre-Breeding in Crop Improvement

Pre-breeding serves as the most effective bridge between genetic resources and breeding strategies (Fig 1). It involves identifying valuable traits and genes from unadapted sources - such as exotic, semi-exotic, or even adapted materials that have undergone selection for improvement. These

approaches help create new base populations for breeding programs and aid in recognizing heterotic patterns in hybrid development.

One of the main challenges in utilizing landraces and exotic germplasm collections is the lack of structured pre-breeding programs. By introducing genetic enhancement, pre-breeding adds value to diverse genotypes, improving their resilience against both biotic and abiotic stresses. In turn, the use of germplasm broadens the genetic base of crops, thereby enriching their overall diversity and strengthening future breeding efforts.

Purpose of pre breeding

The widening disconnect between the management of plant genetic resource collections and modern breeding practices poses a serious challenge to the development of new cereal varieties needed to meet emerging agronomic and environmental demands. The success of any crop improvement program depends on access to sufficient genetic diversity, but this diversity must be in a form usable within conventional agriculture. When variation is limited, breeding progress slows. The replacement of diverse local cultivars and landraces with genetically uniform modern varieties has also increased vulnerability to pests and diseases (Jain & Omprakash, 2019).

Pre-breeding addresses this issue by tapping into a broader genetic pool to enhance

yield, pest and disease resistance, and other quality traits, thereby reducing genetic uniformity in crops (Shimelis & Laing, 2012). It is designed to efficiently transfer desirable traits into cultivars for farmers while serving as a source of valuable genes. The need for pre-breeding arises from the restricted genetic base, the decline in biodiversity caused by dominance of uniform modern varieties, the heightened susceptibility to pests and diseases, as well as the pressures of climate change and the emergence of new pests.

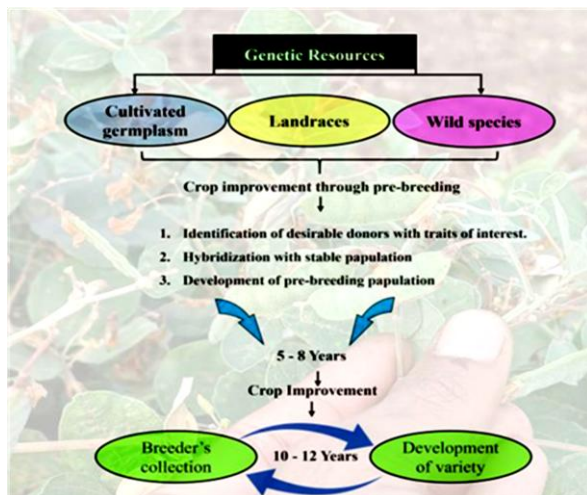


Fig. 1: Pre-breeding as a bridge between genetic resources and crop improvement

Identification of New Resistances

The initial step in pre-breeding involves locating sources of resistance within existing germplasm and from global collections. To confirm broad and durable resistance, materials are tested across multiple years, environments, and growth stages. Once resistant donors are identified, they can be directly incorporated into breeding programs

or used for population development, genetic marker discovery, and mapping of new resistance genes (Mohan et al., 2009).

Major Applications of Pre-breeding in Crop Improvement

Pre-breeding plays four key roles in crop improvement:

1. Expanding the genetic base to reduce crop vulnerability.
2. Detecting valuable traits in exotic germplasm and transferring those genes into breeder-friendly materials.
3. Introducing genes from wild species into breeding populations when this approach is most effective.
4. Using genetic transformation techniques to identify and transfer novel genes from unrelated species.

Introgression

Introgression refers to the transfer of one or more genes from wild, exotic, or unadapted germplasm into adapted breeding populations. This is achieved through crosses between the donor and recurrent parent. The concept of introgression via backcrossing was introduced by Dr. Edgar Anderson and first demonstrated in cotton by Knight (1945). The central aim of pre-breeding through introgression is to incorporate traits that enhance yield, protect against stresses, or improve nutritional and quality characteristics into elite backgrounds, while validating their

usefulness through trials in target environments.

Incorporation

Incorporation involves using foreign or unadapted germplasm in large-scale programs to develop populations that gradually become adapted to their environments.

Methods of Using Plant Genetic Resources

Three conventional approaches for crop improvement using genetic resources:

1. Introgression – transferring genes from unadapted germplasm into elite material.
2. Incorporation – broadening the genetic base by adapting exotic material.
3. Wide crosses – synthesizing new base populations.

Modern genomic tools further enhance these methods by unlocking the genetic potential of wild and domesticated germplasm (Tanksley & McCouch, 1997). Techniques such as diversity evaluation, somatic hybridization, anther culture, embryo rescue, marker-assisted breeding, QTL mapping, association studies, introgression libraries, and genetic transformation are key tools for exploiting plant genetic resources.

Methods of Pre-breeding

Introgression and incorporation are two major strategies in pre-breeding. Introgression specifically involves transferring genes from donor germplasm into elite recurrent parents

through backcrossing. Dr. Anderson's backcross concept has been refined into three approaches:

- Repeated Backcross: Six or more cycles of backcrossing, with or without selection.
- Inbred Backcross: Proposed by Wehrhahn and Allard (1965), involving three backcrosses followed by several generations of selfing.
- Congruity Backcross: Alternating backcrosses using both donor and recurrent parents across generations.

Limitations of Pre-breeding

Pre-breeding faces several challenges: it requires long timelines (often 5–10 years), germplasm exchange is restricted by intellectual property rights, hybridization can cause cross incompatibility and linkage drag, recombination levels may be low, and new pests, diseases, and climate change pressures complicate breeding efforts.

Conclusion

Pre-breeding encompasses all activities aimed at isolating desirable traits or genes from unadapted germplasm and transferring them into intermediate materials suitable for breeding programs. It focuses on separating useful traits (e.g., disease resistance) from undesirable wild characteristics and incorporating them into elite lines that can be crossed with modern cultivars. By

reintroducing lost genetic variation, pre-breeding strengthens diversity in elite gene pools and supports the development of resilient, high-performing crop varieties for farmers.

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