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Pre-Breeding for Genetic Enhancement of Pulses

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Introduction

Given that genetic variety is a key component of agricultural enhancement programmes, the small genetic base of crops today is concerning. In self-pollinated grain legumes such as chickpea, mungbean, urdbean, clusterbean, cowpea, rajmash, fieldpea, and mothbean, the use of uniform high yielding few varieties poses a serious threat to our rich biodiversity because the highly diverse local cultivars and landraces have been replaced by genetically uniform modern varieties in traditional agro-ecosystems, making the cultivars more susceptible to pests and diseases. Additionally, cultivators need to widen the flexibility of their varieties and boost production stability in order to assist minimise risks generated by climate change and foster resilience. Varieties are produced to benefit farmers in specific target regions, but growing climate unpredictability has made this necessary. Grain legumes are cultivated mostly in marginal lands under rainfed conditions and their yield is inconsistent and low. Numerous biotic and abiotic stressors negatively impact their production. Due to low genetic variation in the cultivated gene pool and low productivity from biotic and abiotic stressors, it is necessary to identify and use a variety of germplasm sources to create new, high-yielding cultivars with a wide genetic foundation. Important sources of genetic variety for crop improvement come from wild relatives who have higher tolerance or resistance to various stresses, such as heat, drought, pests, and diseases. Because they are at the extreme end of the gene pool, hybridization is difficult for them, and even when it is possible, linkage drag makes it impossible to employ them for cultivar development.

Pre-Breeding

All activities aimed at identifying desirable traits and genes from unadapted materials that cannot be used directly in breeding populations and transferring these traits to a set of intermediate materials that breeders can use to further produce new varieties for farmers are referred to as pre-breeding. Any pre-breeding program's success mostly hinges on finding a promising donor who possesses the trait with good expression, selecting the right type of germplasm to utilise as the donor, and ensuring the donors are cross-compatible.

Activities in Pre-Breeding

Characterization of germplasm: Different types of germplasm exist, such as landraces, wild relatives, wild forms, advanced breeding lines, and well-known varieties [1]. These distinct genotypic lines need to have helpful genes for desirable qualities including pest and disease resistance, local adaptability, earlyness, and others. Additionally, they can be employed to create or characterise a novel feature absent from domesticated germplasm.

Introgression or incorporation of new traits from germplasms: When one or more alleles from exotic genotypes are transferred to adapted breeding populations devoid of the alleles governing a particular trait, this process is known as introgression. Making crosses and backcrosses between the parent of the recipient and the donor accomplishes this [2]. In contrast, incorporation refers to the large-scale use of alien germplasm to create locally adapted populations (genotypes), hence expanding the genetic foundation of newly developed breeding materials. Potential parents are developed as a result, and these can be utilised in future breeding programmes.

Challenges to Adopt Pre-Breeding in Pulses

- The inability to characterise, assess, and record the genetic diversity in grain legumes makes it more difficult to employ accessible accessions in the pre-breeding programme.
- Wide hybridization is difficult, and interspecies cross incompatibility is a major barrier that restricts the utilisation of diverse species, particularly in the transfer of important genes across species in pigeonpea and chickpea.
- Plant breeders do not have easy access to facilities and techniques for embryo rescue.
- In a typical system, it takes several generations of back-crossing to break linkage drag, which separates good genes from undesirable ones. However, molecular markers can help break this linkage drag quickly.

Prospects for the Future and Conclusion

Pre-breeding plays a bigger part in the breeding pipeline's ongoing supply of valuable variety from prospective landraces and wild relatives. There is enough genetic diversity in the form of landraces and wild relatives for grain and legume improvement, and these populations carry several important genes for cultivar improvement. Nevertheless, it takes time and resources to use these resources in breeding programmes. Pre-breeding efforts should be started in order to overcome this, employing potential landraces and untamed relatives to create new genetic variability that breeders can exploit in crop improvement initiatives. Plant biotechnology has made recent strides that allow us to monitor the introduction of new alleles into breeding stocks and expand the genetic base of crops. Using molecular markers can be done in a number of ways, such as choosing parents who exhibit desirable traits or testing offspring for donor trait introgression [3,4]. Pre-breeding with genomic assistance will aid in overcoming linkage drag and enable targeted gene/segment transfer from wild relatives for grain legume genetic advancement.

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