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Major Era of Plant Breeding

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Plant breeding is a technique for altering and improving plant species in order to meet human needs and desires. It's a field important to our existence and the long-term sustainability of our agricultural landscapes. Breeding is required to create resistance to biotic stress, as well as drought and temperature extremes, and to increase quality attributes that can help people all over the world. Plant breeders are really an important link between farmers and consumers, contributing in the development of features that make farming easier and more efficient, as well as enhancing consumer satisfaction with the end product. Plant breeding is a centuries-old method of crossing, selecting, and modifying crops for human qualities. Many of the basic elements that have been used since history, as well as novel techniques found in the twentieth century, such as DNA-based selection strategies and advanced statistical models, are used in modern plant breeding. Several disciplines of plant breeding that help us in understanding the fundamentals of crop plant genetic behaviour as well as utilization of germplasm.

Keywords
Plant Breeding, Pre Breeding, Reverse Breeding, Speed Breeding, Shuttle Breeding, Analytic Breeding, Participatory Breeding, Introgression Breeding, Heterosis Breeding, Polyploidy Breeding, Mutation Breeding, Transgressive Breeding and Molecular Breeding.

Pre Breeding
"Pre breeding" refers to all actions including the identification of favorable genes in wild and weedy ancestors, as well as other un-adapted materials, and the transfer of these qualities to an intermediate group of materials that breeders can exploit to create new varieties for farmers. Rick created the term "pre-breeding" in 1984. It's a different phrase for "genetic enhancement," and it's become an important, deliberate feature of all plant breeding activities in recent years. Through the utilization of a larger pool of genetic material, pre-breeding aims to generate a new base population for the breeding programme (Haussmann *et al.*, 2004).

Reverse Breeding
Reverse breeding is a unique plant breeding strategy that aims to establish direct parental lines from any heterozygous plant, which is one of the most desired goals in plant breeding. The phrase "reverse breeding" was first used to describe by Dirks *et al*. (2009). Reverse breeding assures the transmission of non-recombinant chromosomes to haploid gametes by suppressing meiotic crossovers in a hybrid. Three genes (DMC1 gene: Disrupted Meiotic cDNA, SPO1 gene: Sporulation Specific gene, and RecA gene: Recombinase A gene) encode meiotic recombination in hybrids of Arabidopsis thaliana, which can be silenced by RNA

interference (Wijnker *et al*. 2012). Chemical substances like MIRIN, an inhibitor of the Mre11-Rad50-Nbs1 complex, can also prevent meiotic recombination. It suppresses phosphorylation of ATM (Ataxia Telangiectasia Mutated serine/threonine protein kinase) and so pauses the G_2 stage (Dupree *et al*., 2008). This method is only applicable to crops with a n=12 or lower and when haploid production by anther culture is possible.

Speed Breeding

Speed breeding is a technology or technique for quick generation advancement that considerably decreases crop harvest time in order to accelerate agricultural research and boost food production to meet the expanding population's need. (Sankar *et al.*,2020). NASA is the motivating force behind this concept, which aims to grow food crops and wheat in space. Dr. Lee Hickey, together with several coworkers at the University of Queensland, the John Innes Centre, and the University of Sydney in Australia, started working on wheat and peanut crops. As a result, speed breeding allows for the rapid production of homozygous and stable genotypes, as well as the rapid progress of generations, resulting in the development and release of novel cultivars (Watson *et al.*, 2018). In today's world, three important ways of speed breeding are used, according to Watson *et al*. 2018, (1) controlled environment conditions in the chamber (John Innes Centre, UK) (2) glasshouse conditions (Hickey Lab, Univ. of Queensland, Australia) (3) low cost homemade growth room design (Hickey Lab, Queensland, Australia).

Participatory Breeding

Farmers are consistently involved in a plant breeding programme with opportunity to make decisions throughout the process, which is known as participatory plant breeding. Farmers can participate in participatory plant breeding in a number of different ways, including defining breeding goals and priorities and hosting trials on their land. Participatory plant breeding must invest time and intellectual capital, as well as usually typical production inputs like land, labour, and capital. The amount of money farmers must invest rises in direct proportion to their level of involvement. This could be a particular issue for poor farmers, who have minimal resources to give by definition. As a result, poor farmers may be uncomfortable or unable to join in PPB schemes due to the higher costs of participation (Joshi *et al.*, 2001).

Analytic Breeding

In general, breeding polyploid crops is more difficult than breeding diploid crops due to autopolyploids have polysomic inheritance, which means character segregation is often not apparent, making the process of selecting for favourable combinations of traits more complex. Due to these challenges, different breeding procedures are required. Chase (1963) offered a revolutionary approach for autopolyploids, known as "analytic breeding," which was used in the case of the cultivated potato, *Solanum tuberosum* L. This procedure includes reducing tetraploids to diploids, then selecting superior genotypes through breeding at this level, and then producing tetraploid cultivars (through sexual polyploidization) from the selected diploid parents in the Wnal step (Jacobsen *et al*. 1991).

Introgression Breeding

Introgression is a basic term in plant evolutionary biology. It refers to the transfer of genetic material across species after hybridization and backcrossing to the original species. Anderson and Hubricht (1938) were the first to define introgression or "introgressive hybridization." Introgression is a phrase used to describe how alleles at one location interogress with alleles

at other loci. That is, for the above definition to apply, some percentage of each of the hybridising taxa's gene pool must remain stable and uncontaminated, allowing us to detect two different gene pools.

Shuttle Breeding

Shuttle breeding, created by Norman Borlaug in the 1950s at the International Centre for Maize and Wheat Improvement (CIMMYT), enabled growing two or more generations per year by sowing wheat populations at field locations in Mexico that differed in altitude, latitude, and environment. Shuttle breeding makes use of a variety of ecological conditions to create more adaptable types. Early breeding materials are cultivated in distinct conditions in alternate generations. Cooperation between nations and institutions is the foundation of shuttle breeding. Increased breeding efficiency is a benefit.

Transgressive Breeding

Transgressive breeding refers to the use of transgressive segregation to improve yield or contributing attributes. Individuals in the F_2 or following generation who are superior to both parents are referred to as transgressive segregation. The accumulation of favourable genes from both parents as a result of recombination is the cause of transgressive segregation (Rieseberg *et al*. 1999). For assessing transgressive segregation within a population, Dunnett's test and quantitative trait loci (QTL) studies are often utilised. Dunnett's test can be used to determine whether hybrid species performed better than the control group (parent species) by determining whether the control group's mean differs considerably from the mean of the other groups. If there is a discrepancy, it indicates that transgressive segregation is taking place.

Mutation Breeding

Mutation breeding is a method of breeding that uses mutagens to create new genetic forms to useful agricultural species. L. J. Stadler's experiment in the 1920s, in which he utilised radiation to cause genetic alterations in plants, was the beginning of "mutation breeding". Mutagenesis is the process by which chemical, physical, or biological factors generate rapid heritable changes in an organism's genetic information that are not caused through genetic segregation or genetic recombination. The method of identifying individuals having a target mutation, which involves two primary steps: mutant screening and mutant confirmation, is crucial in mutation breeding. When compared to the parent, mutant screening is a method that involves selecting individuals from a large mutated population who meet specified selection criteria, such as early flowering and disease resistance.

Polyploidy Breeding

Polyploidy is defined as the existence of more than two complete sets of chromosomes per cell nucleus, and it has been thought to be a common occurrence in plant evolution and diversification. The enlargement of plant organs ("gigas" effect), buffering of harmful mutations, enhanced heterozygosity, and heterosis are some of the most important implications of polyploidy for plant breeding (hybrid vigor). In terms of tools, cultivars with greater yield levels have been developed, enhancing product quality and boosting resistance to both biotic and abiotic stressors. Furthermore, polyploidy causes lower fertility due to meiotic mistakes, allowing seedless varieties to be produced. A newly produced sterile hybrid, on the other hand, can have its fertility restored by doubling its Genetic material.

Heterosis Breeding

Heterosis is the phenomena in which the progeny of different kinds of a species or crosses between species have more biomass, development speed, and fertility than both parents. These hybrids generally outperform their inbred parental lines in terms of yield and disease resistance due to heterosis (hybrid vigour) in plants. To explain the genetic causes of heterosis, several traditional ideas have been presented. Many new genetics and genomics tools have been created and used to identify heterotic genes in plants in recent years.

Molecular Breeding

The use of genetic alteration at the level of DNA to improve qualities of interest in plants and animals is known as molecular breeding, and it can also involve genetic engineering or gene manipulation, molecular marker-assisted selection, and genomic selection. Molecular breeding, also known as molecular marker-assisted breeding (MAB), is the use of molecular biotechnologies, primarily molecular markers, in association with linkage maps and genomics to modify and improve plant or animal traits using genotypic assays.

References

1. Anderson, E., and Hubricht, L. (1938). The evidence for introgressive hybridization. *Am. J. Bot.* 25:396-402.
2. Chase, S.S. (1963) Androgenesis its use for transfer of maize cytoplasm. J Hered 54:152–158.
3. Dirks, R., Van Dun, K., De Snoo, C.B., Van Den Berg, M., Lelivelt, C.L. and Voermans W.(2009). Reverse breeding: a novel breeding approach based on engineered meiosis. *Plant biotechnology journal.* **7**(9):837-845.
4. Dupré, A., Boyer-Chatenet, L, Sattler, R.M., Modi, A.P., Lee, J.H., and Nicolette M.L. *et al* (2008). A forward chemical genetic screen reveals an inhibitor of the Mre11–Rad50–Nbs1 complex. *Nature chemical biology*. **4**(2):119.
5. 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.
6. Jacobsen, E., Ramanna, M.S,, Huigen, D.J. and Sawor, Z (1991) Introduction of an amylose free (*amf*) mutant into breeding of cultivated potato *Solanum tuberosum* L. *Euphytica* 53:247–253. doi:10.1007/BF00023276
7. Joshi, K.D., Sthapit B.R. and Witcombe, J.R. (2001). How narrowly adapted are the products of decentralised breeding? The spread of rice varieties from a participatory plant breeding programme in Nepal. *Euphytica* 122: 589–597.
8. Rick, C.W. (1984). Plant Germplasm Resources. *D.A. Evens, W.R. Sharp.* Pp. 9-37.
9. Rieseberg, L.H., Archer, M.A. and Wayne, R.K. (1999). Transgressive segregation, adaptation and speciation. *Heredity.* **83**(4): 363-372.
10. Sarkar, S and Aminul Islam, A.K.M. (2020). Speed Breeding: An Effective Breeding Technique for Rapid Generation Advance in Crop. *EC Agriculture*: 09-11

11. Watson, A., Ghosh, S., Williams, M. J., Cuddy, W. S., Simmonds, J., Rey, M. –D., Asyraf Md Hatta, M., Hinchliffe, Alison, Steed, Andrew, Reynolds, Daniel, Adamski, Nikolai M., Breakspear, Andy, Korolev,Andrey, Rayner, Tracey, Dixon, Laura E., Riaz, Adnan, Martin, William, Ryan, Merrill, Edwards, David, Batley, Jacqueline, Raman, Harsh, Carter, Jeremy, Rogers, Christian, Domoney, Claire, Moore, Graham,Harwood, Wendy, Nicholson, Paul, Dieters, Mark J., DeLacy, Ian H., Zhou, Ji, Uauy, Cristobal, Boden, Scott A., Park, Robert F., Wulff, Brande B. H., & Hickey, Lee T. (2018). Speed breeding is a powerful tool to accelerate crop research and breeding. *Nature Plants*, ***4***(1), 23–29. https://doi.org/10.1038/s4147 7-017- 0083-8.

12. Wijnker, E., van Dun, K. de Snoo, C.B., Lelivelt, C.L., Keurentjes, J.J., and Naharudin, N.S. *et al* (2012). Reverse breeding in *Arabidopsis thaliana* generates homozygous parental lines from a heterozygous plant. *Nature genetics.* **44**(4):467.