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Speed Breeding: Opportunities and Challenges

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Breeding a new and high performing crop cultivars *via* traditional approach requires selection of complementary parental genotypes with desired traits, followed by various crosses and a series of selection and progression of superior progenies to release candidate cultivars that meet market-preferred demands. In any crop breeding programme, the following procedure is used: (i) selection of desirable parents; (ii) crossing of the selected parents; (iii) selection and genetic advancement of the best progenies; (iv) selection of the best progenies for screening; and (v) cultivar registration and seed multiplication and distribution to growers. Though, traditional breeding procedures can take more than 10 years to develop and release an improved cultivar in the absence of any integrated pre-breeding programme. So, we can use modern techniques like double haploid and speed breeding programmes to shorten the length of each breeding cycle.

Speed Breeding: Speed breeding is a group of practices that involves changing the environmental conditions in which crop genotypes are produced with the goal of accelerating flowering and seed development and moving as rapidly as possible to the next breeding generation. Rapid generation development in the method reduces breeding time and costs. Various selection techniques like single seed descent (SSD), single pod descent (SPD), single plant selection (SPS), clonal selection and marker-assisted selection (MAS) can be incorporated into speed breeding to shorten the breeding cycle. Speed breeding results in ~3 to 9 generations per year as compared to 1 to 2 generations per year as achieved with traditional selection approaches.

Opportunities of speed breeding

1) **Rapid development of homozygous lines:** Speed breeding techniques have been used on a variety of crops to quickly develop homozygous lines. The method relies on adjusting photoperiod, light intensity, temperature, soil moisture, soil nutrition and high-planting density. These techniques have been used to accelerate seed germination, early flowering, shortening the time needed to produce each breeding generation.

Speed breeding depends on the purposeful manipulation of several growing conditions, which are discussed below.

- Changing the photoperiod regime
- Regulating the temperature regime
- Management of soil moisture
- Plant population density
- Modifying carbon dioxide levels
- Use of plant nutrition, hormones and organ tissue culture

2) **Amenability with selection methods:** Speed breeding is frequently used for generation advancement without the phenotypic selection. However, it is possible to successfully incorporate advanced technologies (such as high-throughput genotyping approaches, marker-assisted selection, etc.) for the selection of target traits. The maintenance of a sound breeding population and genetic variability in environments that limit plant growth, as well as the generation of the highest yields, should be possible with the help of speed breeding and efficient selection techniques. For the selection of genotypes with the highest yields, conventional selection techniques including bulk, mass, recurrent, pedigree, and pure line selection require a genetically stable plant population. Therefore, these methods are not ideal for speed breeding due to the long inbreeding and selection cycles that they require. Single seed descent (SSD), single pod descent (SPD), and single plant selection (SPS) are the selection techniques that are most suitable for fast breeding.

Challenges of speed breeding

Speed breeding is an useful strategy for accelerating traditional breeding programmes. However, in order to use the technology effectively it requires expertise, effective and complementary plant phenomics facilities, appropriate infrastructure and continuous financial support for research and development. However, the most common challenges hampering the use of speed breeding include:

- a lack of knowledgeable plant breeders and breeding specialists
- Inadequate infrastructure
- Inability to rely on water and electricity for sustainable operations
- access to suitable facilities
- lack of trained staff in the protocol
- the need for long-term funding

Conclusion

The use of speed breeding can accelerate the development of high performing cultivars by reducing the amount of time, space and resources invested in the selection and genetic advancement of superior crop varieties. Plant breeders can more quickly deliver improved crop cultivars due to this technology. The effective selection of elite genotypes and lines with innovative features, such as increased yield and superior nutritive value, along with biotic and abiotic stress tolerance, can be enhanced by integrating speed breeding with conventional, MAS, and GE breeding techniques. Currently, there is also lack of financial and policy support from the government to start and maintain speed breeding in public plant breeding programmes.

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