THE SCIENCE WORLD
A Monthly e Magazine
ISSN:2583-2212
April, 2023; 3(04), 589-592

Popular Article

Techniques for rapid generation advancement in crops

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https://doi.org/10.5281/zenodo.7881294

Abstract

Crop improvement refers to the genetic alteration of plants. With the increase in global population and the changing environment at an alarming rate, there is an urgent need to increase food production at the same rate or even faster to fulfil the food and nutritional. requirements. Improvement of cultivated plants depends on introducing natural variability through traditional and biotechnological breeding techniques. These technologies empower breeders to keep the pace with increasing food demand by developing more productive and robust varieties sooner.

Key words: Speed breeding, Embryo rescue, Double haploid breeding, Shuttle breeding

Introduction

Plant breeders need to focus on development of new varieties with increased productivity as well as ability to tolerate various biotic and abiotic stresses. Besides, recent climate change and global warming demand climate-smart agriculture with new crop varieties that can minimize crop loss due to adverse conditions and emergence of new pests and diseases. Sustainable food production will remain a preeminent challenge in the decades to come. Breeding techniques enables researchers to grow up to 4–6 generations per year instead of 1–3 generations in the field or under regular glasshouse conditions.

In this article, strategies for rapid generation of crops are discussed, along with the opportunity to integrate technologies to further accelerate the rate of genetic gain in crops.

Techniques for rapid generation in crops:

- Speed breeding
- Embryo rescue
- Double haploid breeding
- Shuttle breeding

Speed breeding

Traditional or conventional breeding methods will not be sufficient to meet the demands of future generations, so breeders and cultivators are constantly under pressure to improve crop production and develop new varieties of crops that are of higher quality. However, a process known as 'speed breeding' for rapid generation advancement has been successfully implemented in agricultural plants to achieve rapid rates of crop improvement. Speed breeding has the ability to develop crop varieties in a smaller duration of time. This technique involves extending photoperiod and controlled conditions such as temperature, soil media and appropriate spacing in glasshouses to shorten breeding cycle. With speed breeding, almost three to nine generations can be grown in a year, as compared to one to two generations per year in case of conventional method. Speed breeding techniques have been well-established in many plant species, including long-day plants, day-neutral plants, and a limited number of short-day plants. Speed breeding can be used to achieve up to 6 generations per year for spring wheat (*Triticum aestivum*), durum wheat (*T. durum*), barley (*Hordeum vulgare*), chickpea (*Cicer arietinum*) and pea (*Pisum sativum*), and 4 generations for canola (*Brassica napus*), instead of 2–3 under normal glasshouse conditions. Growing crops in a speed breeding-specific growth chamber speeds up research on adult plant phenotyping, crossing, mutants, and transformation.

Embryo rescue

Embryo rescue is an *in vitro* culture technique used to assist in the development of an immature or weak embryo into a viable plant. The embryo rescue technique plays an important role in modern plant breeding. The culture of immature embryos is used to rescue those embryos that would normally abort or that would not undergo the progressive sequence of ontogeny. Embryo rescue technique has been successfully applied in grapes, mango, papaya, olive, tomato, capsicum,

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Published 29.04.2023

chillies, okra and radish. The production of soybean seeds for breeding purposes is usually constrained by a long reproductive phase. One possible way to shorten soybean reproduction cycle is through immature embryo culture. This technique has also proved to be valuable tools for maize improvement, since they allow reducing the duration of the generation cycles for speed breeding. The technology has been used in about 100 different species from both temperate and tropical climates, comprising crops, fruit, and forest trees as well as wild species.

Doubled haploid breeding

Doubled haploids are haploids that are produced after chromosome duplication. DHs shorten the time required to produce homozygous plants in comparison with the conventional breeding which requires several generations of selfing. Double haploid is a rapid method of producing pure lines. DHs have several advantages, such as shortening the breeding cycle by immediate fixation of homozygosity, offering high-selection efficiency. The doubled-haploid (DH) breeding technique is now widely used in Maize, Brassica, *B. napus* and *B. juncea* breeding programs.

Shuttle breeding

It is an off-season field-testing technique whereby genetic material is grown in contrasting environments to turn over two plant generations per year. The strategy was first developed by Norman Borlaug at the International Maize and Wheat Improvement Centre (CIMMYT) Mexico in 1946. Currently the shuttle breeding approach is being used to develop improved varieties of wheat-maize, and rice. By implementing this effective technique, breeders have successfully reduced the time required to complete a breeding cycle by 50%.

Conclusion

Crop production must increase by 50% by 2050 to meet the future demand for food. To feed the world's ever-growing population, food security in a changing environment is a serious concern. The rapid development of better plant varieties is one strategy to alleviate food scarcity issues and increase food security. Speed breeding provides various advantages over conventional approaches, including the ability to accelerate backcrossing, pyramiding characteristics, and transgenic pipelines. Embryo rescue technique is particularly interesting in the development of genetically modified plants, considering the need to stabilize transgenes to achieve homozygous lines before phenotypic evaluation. These breeding techniques are a form of protocol that can be used to increase agricultural yield by reduce plant production times, altering the light duration, intensity, and

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Published 29.04.2023

temperature-controlled zone and help research to meet rising demand.

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