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SPEED BREEDING A RAY OF HOPE FOR THE FUTURE GENERATION IN TERMS OF FOOD SECURITY : A REVIEW

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ABSTRACT

Speed breeding has revolutionized the whole of the world in today's era. The first-ever speed breeding procedure was developed through an inspiration from NASA which was adopted by the University of Queensland scientists. Speed breeding is a protocol which enables plant breeders to enhance the crop production changing the temperature and light duration and intensity to enhance the growth of the plant. It is using an artificial source of light that too continuously which triggers the photosynthesis process results in the growth and the process of a reproduction comes very early as compared to normal timing. The researches show that by Speed breeding techniques we can grow approximately 6 generations of wheat, chickpea & barley and around 4 generations of canola plants in a single year. This will help us to meet the demands of the growing population of the future. This can be accomplished through various technologies such as genotyping, MAS, high-throughput phenotyping; gene editing, genomic selection, re-domestication which can be integrated with speed breeding to enable plant breeders to keep up with an evolving climate and ever-increasing human population. The purpose of this review paper is to define the research gap regarding the speed breeding as this is the new and effective procedure by which we will be able to come over the problems related to the scarcity of the food in future.

Keywords: Speed breeding, life cycle, crop improvement

Introduction

The world population is growing over the last several years and is projected to increase by at least 25% in geometrical way but the food resources are still limited (Ray *et al*., 2012; Ray *et al*., 2013). The traditional or the conventional method of breeding will not be sufficient to meet the demands of future generations so the breeders and the cultivators are in constant pressure to improve the crop production and develop new variety of crop which is of higher quality and gives higher yield which should be of superior quality in every respect i.e. in terms of nutritional values, disease resistance and climatic changes etc. Unlike the older times the plant breeders are today having the innovative technologies which can help to overcome these crises in future and improve the crop line. Some of the ways which are used these days are the development of automated high-throughput phenotyping technology systems which helps to increase the selection strength and improves selection precision (Araus *et al*., 2018). Another approach is to use the 2nd& 3rd generation sequencing platforms which mean that breeders can use DNA markers which are affordable for them. It assists in facilitating gene discovery and analytical breeding technology which tread to increase the production quantity and quality (Bassi *et al*., 2016). Although all these technologies help to give the best results but one of the limitation in these are that it only produces one or two generation per year so the problem for the crop production in terms of quantity is still questionable but this limitation has been Lightened by 'Speed Breeding' protocol that uses the light and temperature control systems and are capable of producing at least six generation of crops per year Speed breeding is a potential tool to improve our crop varieties in less time period. It is an artificial environment with enhance duration of light to create longer day light which helps to manipulate the life cycle of photo- insensitive crops. Generally, a new variety development through conventional method it required 8- 10 years but through speed breeding we shorten generation cycle (2-3× times). According to recent available research data related to speed breeding it's evident that we can take six generation of wheat, barley, pea and chickpea, and four generations for canola (Wolter *et al*., 2019).

Speed breeding came into existence by the concept which was used around 150 year ago where botanist first showed that under artificial light the plants can grow. Later the effect of light was analysed on the different species of the plants. In mid 1980 NASA collaborated with 'Utah State University' to explore the rapid growing cycle of plants under the constant light on space station on wheat and this results in the development in 'USU-Apogee' meanwhile Space mirrors were proposed by Russian scientists. Inspired by the work of NASA, Queensland University coined the term Speed Breeding in 2003 to convert night into day (Bugbee & Koerner, 1997; Pfeiffer, 1926).

Speed breeding protocols are available for different variety of plant crop which works on the chromosomes and are provided with optimal light quality, light intensity, proper temperature which enhances the process of photosynthesis and which increase the growth and breeding. This process

results in the production of at least six generation of specific species. Speed breeding doesn't require any specialized labs; it can be done in normal setups (Shivakumar *et al*., 2018).

Speed breeding apart from enhancing the growth also has several advantages over other technologies; it can accelerate the back crossing, pyramiding traits, transgenic pipelines etc. The first variety of spring wheat crop by speed breeding was produced in 2017 in Australia and it was named as 'DS Faraday'. Speed breeding can be done in smaller areas also the researchers who don't have access for the larger areas can have smaller set ups of speed breeding units (Svitashev *et al*., 2016).

Speed breeding use has increased now-a-days as it can be combined with several different technologies to accelerate the growth of crop with controlled temperature and light settings even the disease resistant type crop can be released by this type of method. As the speed breeding is new protocol so there is still limitation in the available research evidences but according to the available research data some of the important combination techniques has been discussed:

Integrated Phenotyping with speed breeding as a tool for improving yield: Phenotyping is defined as the evaluation of complex plant traits which are related to growth, development, and related to all the characteristics which form the basis for complex trait evaluation. As the temperature is having various fluctuations throughout the year in every part of the world so it affects the crop production and this results in the suffering among the people due to lack of food resources. Jack Christophera *et al.*, 2015 carried out an experimental research on the Australian environment as there was evidences in continuous increase in the temperature and drop in the rainfall in that region so an experimental research was conducted to analyse the effectiveness of combining the pheno-typing and speed breeding to improve root adaptation in changing environment and water-limitation. A multi-purpose approach was used to improve the yield by integrating phenotyping and SB. The study result determined that overpopulation development of more than 1000 recombinant inbred lines of wheat was advanced to the generation within 18 months. So this research offers a solid history that integrating will accelerate genetic advancement towards improved adaptation to water-limited environments(Christopher *et al*., 2015; Watson *et al*., 2017; Zsögön *et al*., 2017).

Gene editing in combination with Speed breeding for crop improvement: As the traditional way of plant breeding has already proven to be successful in generating the great crop varieties but in the modern era there is degradation of genetic quality because of continuous selection and long-time domestication of the crops so this is one of the limiting factor for the improvement in crop quality. Genome editing technology has proven to be of advantage in this era. Gene editing is a technology in which there is editing in the genes of that particular crop species in order to enhance its production. In their study, Felix Wolter *et al.* (2019) examined the power of CRISPR / Cas to generate guided genetic diversity at several sites The CRISPR / Cas method provides for new ways for genetic diversity. It has the ability to multiplex, and the number of targets can be effectively altered simultaneously. It targets the actual problem and a high yielding variety can be generated but this process takes longer duration of time and requires large amount of effort so integrating genome editing and speed breeding has power to overcome this crises and number of generations can be produced in single year(Doudna & Charpentier, 2014; Jighly *et al*., 2019; Liang *et al*., 2017; Richardson *et al*., 2014; Wang *et al*., 2019; Ziliani *et al*., 2018).

Boosting Genetic Gain by speed breeding and Genomic selection:

For improving the genetic benefit, speed breeding along with genomic selection is used. There are researchers who have provided evidence that speed breeding and genomic selection is capable of increasing the genetic benefit in various crops. GS was first suggested by Meuwissen *et al.*,2001. The main property of applying GS is that it reduces the length of breeding cycle and produces the superior quality of plant variety at very short time duration which improves the genetic gain. Researchers have proved that the Integration of GS with other modern breeding strategies may further enhance its efficiency on improving the quality of crops. The recent development of 'speed breeding' protocols has the potential to accelerate breeding programs significantly for different crops by increasing the generation in the shorter duration of time(L. T. Hickey *et al*., 2019; Liang *et al*., 2017; Zsögön *et al*., 2017).

Speed breeding to accelerate domestication:

Plant Domestication is the process where wild variety of the plants has been evolved into crop plant through artificial methods. In this process early hybridization is followed by selective breeding technique. PB is particularly linked with polyploidy crop. It is a lengthy process and it takes large amount of time so to overcome this problem it has been combined with the speed breeding which reduces the time duration and number of generation of that crop has been released. The evidences regarding the plant domestication in combination with speed breeding has to be found in polyploidy plants such as peanuts and banana. D.J. O'Connora *et al.* conducted an experiment regarding the assessment of potential use of speed breeding method in peanut breeding. This study results in the reducing the time in producing the several generations in shorter duration of the time as compared with the normal breeding phase (Hayes & Goddard, 2001; O'Connor *et al*., 2013).

Multiple disease resistance by Speed Breeding: To respond in a faster way to the changing climate, evolving pathogens, the plant breeders are exploring different ways to enhance the quality of crop production. Lee T. Hickey *et al.* 2017 performed a research in which they applied the two-rowed barley cultivar Scarlett with novel methods for rapid trait introgression. They used 4 donor lines incorporating multiple disease resistance in a revamped backcross strategy that integrated phenotypic multi-trait screens as well as rapid generation advance technology 'speed breeding', to develop 87 BC1F3:4 Scarlett introgression lines (ILs) within two years(L. Hickey *et al*., 2017; Rana *et al*., 2019).

Speed-Breeding with SNP Marker-Assisted reducing salt tolerance: Climate change would intensify a number of plant abiotic stresses including salinity, heat, drought, etc thus reducing growth. Rice is considered to be one of the crops which are salt sensitive. Salinity is having severe effect on the metabolism, growth and productivity worldwide. Md Masud Rana *et al.* a study was conducted to improve the salt resistance of locally yielding crop, Rice. It is slow process and it takes time. Here, in this experiment precisely

introgressed the hst1 gene, transferring salinity tolerance from "Kaijin" into high-yielding "Yukinko-mai" (WT) rice through single nucleotide polymorphism (SNP) marker-assisted selection. It uses a biotron speed-breeding technique (Alahmad *et al*., 2018).

Conclusion

In agriculture sector the conventional method of breeding takes longer duration of time although the crop is of high yielding variety. The breeding cycle is approximately for about 8-10 years. As the population of the world is growing continuously so it will be difficult to overcome food scarcity in the future generation. In context of the breeding rapid generation production will be able to facilitate the genetic gain. Speed breeding is type of the protocol which can be used to improve the crop productivity by creating an alteration in the light duration, intensity and temperature controlled zone, disease resistant variety production, decrease the salt sensitive in some crops particularly Rice. Speed breeding enhances the photosynthesis process which results in the rapid growth of the crop. This process results in the release of many generation of the same crop in shorter duration of time as compared to traditional way of breeding. Literature review this protocol is not so much sufficient to lighten up the various sectors which is still unexplored. There are various possibilities in case of speed breeding but as this is new sector of today's world which needs proper exploration. The research gap needs to be filled. It can create wonders for our future generation and they will not have suffered from the hunger as well malnutrition. So we can justify our title of the study that speed breeding is a ray of hope for our future generation in terms food security which is the main concern for everyone around the world.

Conflicts of Interest/ Competing Interest

- The authors have no relevant financial or non-financial interests to disclose.
- The authors have no conflicts of interest to declare that are relevant to the content of this article.
- All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or non-financial interest in the subject matter or materials discussed in this manuscript.
- The authors have no financial or proprietary interests in any material discussed in this article.

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