SUMMARY ARTICLE
WWW.BIOINGENE.COM/PSJ

Bioingene PSJ

ISSUE NO. 1 VOLUME NO. 1

SPEED BREEDING: A POWERFUL TOOL FOR ACCELERATING CROP RESEARCH AND BREEDING

Note: This is a summary article on the following original article

Watson, A., Ghosh, S., Williams, M.J. et al. (2018) Speed breeding is a powerful tool to accelerate crop research and breeding. Nature Plants 4, 23–29. https://doi.org/10.1038/s41477-017-0083-8

BIOINGENE.COM/PSJ

Article No. : D20MLY20R11
Article type: Summary
Accepted: Feb. 2021
Online: March 2021

Summarized by:
Meghana, D. P.,
Punjab Agricultural University, Punjab, India.
meghanadp.0598@gmail.com

INTRODUCTION

The growing human population and the changing environment have become leading challenges for global food security. It is predicted that by 2050 the global population will reach 10 billion, requiring 60% to 80% more food. Developing high-yielding cultivars in a short duration of time and rapidly increasing productivity is the need of the era. For this, the speed breeding technique throws the limelight in this direction.

Speed breeding is a powerful technique to shorten the breeding cycle by accelerating the plant growth, flowering, and seed maturation time by controlling all environmental conditions (including photoperiod, temperature, and light intensity) from seedling to maturity. In 2003, researchers of Queensland coined the term "Speed Breeding". It reduces the generation time by five times compared to field conditions and 2.5 times compared to normal greenhouse conditions.

In the 1980s, this idea was developed by NASA to grow crops in space. Later, many plant scientists became interested in comprehending more in this and now it is successful in Wheat, Barley, and Chickpea to achieve six generations per year and four generations per year in Canola instead of 2-3 generations per year under normal conditions.

Speed breeding is otherwise called the 22h approach as 22 hours light and 2-hours dark condition is maintained in the greenhouse. The effect of the light spectrum is crucial in accelerating plant growth such as purple and recolor show a positive impact. Maintaining a higher temperature is recommended during the photoperiod and less temperature during the dark period to cope up with the stress.

Time duration can be reduced at many stages of the lifecycle- from breaking the dormancy of seed to maturity. Imposing physiological stress in terms of water, nutrients, and plant density hastens to flower. Immature seeds are harvested and later dried under a humidifier. Chemicals such as GA3 are usually used to germinate immature seeds. Hence, it is a time-saving tool.

The main idea of this approach is to increase the rate of photosynthesis thereby early flowering, early maturity, and seed harvesting are achieved.

METHODOLOGY OF SPEED BREEDING

Controlled environmental conditions of 22h light and 2h dark, 22°C day/17°C night, humidity of 70%, and 360-380μmol/m2s light intensity were maintained. In the glasshouse, Sodium vapor lamps with 17h at 22°C and 2h darkness were maintained. The light intensity was 440-650μmol/m2s. For a homemade growth room, designed for low-cost speed breeding, a room of 3×3×3m was made to accommodate 90 pots of 8 inch diameter with 5L volume. A photoperiod of 12h light and 12h darkness was maintained for the first four weeks; later the photoperiod was increased to 18h light and 6-hour dark period. Wheat, barley, and oats were grown in this method.

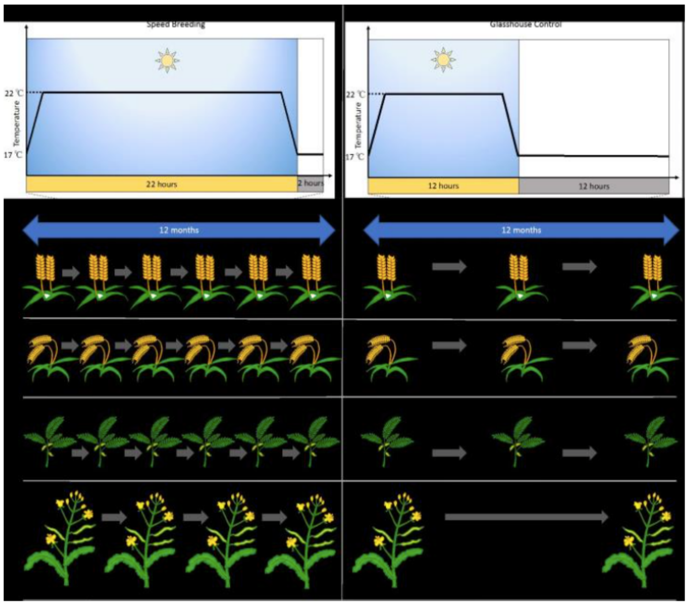

Figure 1: Speed breeding accelerates generation time of some major crop plants for research and breeding, (Source: Nature Plants, https://doi.org/10.1038/s41477-017-0083-8)

SPEED BREEDING IN SHORT DURATION CROPS

Speed breeding is limited in photosensitive short-duration crops as prolonged photoperiod (>12h) hampers flowering induction. However, carbon accumulation increased to hasten seed production. Research has been conducted in sorghum, millets, pigeon pea, soybean, rice, and amaranthus in ICRISAT as a part of a project funded by Bill and Melinda Gates Foundation. ICRISAT in collaboration with the University of Queensland standardized this speed breeding protocol.

Now, soybeans can be grown under speed breeding to get 5 generations/year compared to one generation/year in the fields and 2-3 generations in winter nursery by maintaining the carbon-di-oxide level, 10h photoperiod, and other factors for enhanced photosynthesis at night.

BENEFITS

Speed breeding is advantageous for long-duration crops as it overcomes the limitation of seasons, enabling rapid generation cycling. It fetches only light-emitting diode (LED) and other regulators which saves labor, cost, and time for researchers. It promises to be an efficient technique for new variety release when coupled with modern techniques like CRISPR, high throughput phenotyping, genome editing, and genomic selection. It is highly cost-effective than single seed descent (SSD) and double haploids (DHs). It is efficient for gene insertion of distinct phenotypes followed by marker-assisted selection (MAS). It employs breeders to expedite genetic improvements such as yield gain, disease resistance, and climate resilience in certain crops. The 'RapidGen' technology at ICRISAT reduced the breeding cycle by 40%.

LIMITATIONS

The protocol needs to be customized according to the crop, the species, temperature, and lighting conditions since the photoperiod is independent of the crops and their agro-climatic conditions. It affects quality, quantity, and phenotype such as loss of awn suppressor, dwarf genes, etc.

CONCLUSION

Speed breeding approach can double the annual genetic gains as compared to the winter nurseries. It is highly convenient for crossing studies, gene transformation, plant phenotyping, and mutation studies when combined with speed breeding.