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Speed Breeding: An Innovative Method for Crop Improvement

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The growing human population and a changing environment have raised significant concern for global food security, with the current improvement rate of several important crops inadequate to meet future demand. This slow improvement rate is attributed partly to the long generation times of crop plants. Here, we present a method called 'speed breeding', which greatly shortens generation time and accelerates breeding and research programmes. 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. We demonstrate that speed breeding in fully enclosed, controlled-environment growth chambers can accelerate plant development for research purposes, including phenotyping of adult plant traits, mutant studies and transformation. The use of supplemental lighting in a glasshouse environment allows rapid generation cycling through single seed descent (SSD) and potential for adaptation to larger-scale crop improvement programs. Cost saving through light-emitting diode (LED) supplemental lighting is also outlined. We envisage great potential for integrating speed breeding with other modern crop breeding technologies, including high-throughput genotyping, genome editing and genomic selection, accelerating the rate of crop improvement (Watson *et al*, 2018)

The main 'recipe' for setting up speed breeding conditions includes:

1. Light: the preferable light for use in speed breeding is one covering the Photosynthetic ally Active Radiation (PAR) i.e. 400–700 nm with focus on red, far-red and blue range. This spectrum can be achieved by using Light Emitting Diodes (LEDs), or a combination of LEDs and halogen lamps. Photosynthetic Photon Flux Density (PPFD) of ~450–500 $\mu mol/m^2/s$ at plant canopy height is also recommended which can be adjusted at slightly lower or higher levels according to need of crop.

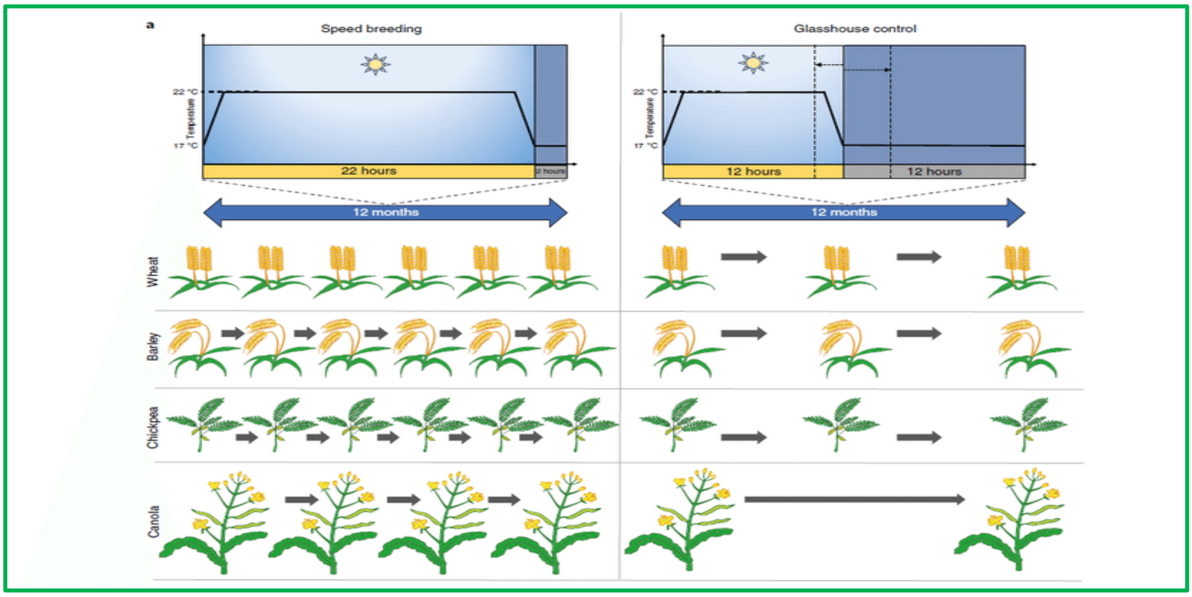
2. Photoperiodic regime: A photoperiod of 22 hour light and 2 hour darkness in diurnal cycle of 24 hours is ideal photoperiodic regime for speed breeding. Another alternative is continuous light but slight period of darkness is known to improve the health of plant.

3. Temperature: Ideal temperature for each crop should be applied. During photoperiod higher temperature should be maintained, while during dark period fall in temperature can help with stress recovery. Temperature has a major impact on the rate of plant development; therefore generation time can be accelerated by elevating temperature. However in some cases higher temperature may induce stress like conditions and affect performance of plant.

4. Humidity: Control over humidity even in controlled environment chambers is limited, but 60–70% RH is ideal for crop growth, this level can be modified according to type of crop. For crops more adapted to arid conditions, lower humidity level is recommended.
Procedure of Speed Breeding

Procedure of Speed Breeding

A general procedure for low cost speed breeding in a homemade growth room design is as follows:
1. As an alternative to normally used Conviron BDW chamber, a room having insulated sandwich panelling fitted with seven LED light boxes (one light box per 0.65 m^2) and a 1.5 horsepower inverter split system domestic air conditioner can be used.
2. The light quantity of PAR at bench height should range from210–260 μmol/ m^2s^1& at 50 cm above the pot from 340–590 μmol/ m^2s^1.The lights should be situated at a height of 140 cm above the bench. The room should be able to accommodate 90 pots of 20.3 cm.
3. Automatic watering can be achieved by using Irrigation Controller, having one solenoidper room and one spike dripper per 20.3 cm pot.
4. The humidity conditions should be ambient.
5. The lighting should be enriched in the blue, red and far-red part of the spectrum. It should be set to 12 hour photoperiod and 12 hour darkness for 4 weeks and then slowly be increased to 18 hour photoperiod and 6 hour darkness.
6. An air-conditioner can be used for regulation of temperature and set at 21°C during the photoperiod and 8°C in darkness. Speed breeding approach is ideally realized using Single Seed Descent method, particularly for cereal crops. By increasing the sowing density in speed breeding, we can achive rapid cycling of many lines having healthy plants and viable seed.
The plants grown under speed breeding reached anthesis in approximately half time as compared to those grown in same conditions under glasshouse conditions. The above described procedure has been used for speed breeding of wheat, barley, oat and triticale (Wanga *et al*, 2021).



Applications of speed breeding are as follows

1. Accelerating the crop improvement programmes by achieving upto 6 generations per year in photo insensitive crops and 2-3 generations in case of photo sensitive crops.
2. Speeding up the process of genomic selection.
3. An ideal method for generating large breeding populations.

4. For boosting transgenic and CRISPR pipelines.
5. It can be extended to study physiological traits of importance in crop plants.

Limitations of Speed Breeding

Some major limitations of speed breeding are:
1. The early harvest of immature seeds before completing normal ripening process interferes with the phenotyping of some seed traits.
2. There is no universal protocol of speed breeding because of diverse response of plant species to photoperiodic conditions.
3. Differential responses of various plant species when exposed to extended photoperiodic conditions.
4. Initial investment of setup is high.

Conclusion

With the ever increasing population, by 2050 farmers will have to increase food production by 60-80% to feed the potential 9 billion people. Another main issue which arises is that breeding programmes should be in tandem with the changing climatic conditions and to achieve rapid results in both these respects, speed breeding is the way to go. Speed breeding in combination with modern crop breeding technologies, including genome editing, genomic selection and high throughput genotyping, can be a great asset in accelerating the rate of crop development. Speed breeding can serve to enhance the plant growth by accelerating research program in terms of reducing the breeding cycle of plant. In India, particular success has been seen in case of wheat in speed breeding which can be extended to other crop varieties, and similar facilities can be set up for the faster development.

References

1. Watson, A., Ghosh, S., Williams, M. J., Cuddy, W. S., Simmonds, J., Rey, M. D., ... & Hickey, L. T. (2018). Speed breeding is a powerful tool to accelerate crop research and breeding. *Nature plants*, *4*(1), 23-29.
2. Wanga, M. A., Shimelis, H., Mashilo, J., & Laing, M. D. (2021). Opportunities and challenges of speed breeding: A review. *Plant Breeding*, *140*(2), 185-194.