GreenariA
Go Green, Learn Green
An Agricultural Monthly e-Magazine
Volume 04, Issue 05, 2026
ISSN: 2584-153X
Article ID: G-26-0513

SPEED BREEDING: TURNING YEARS INTO MONTHS

Ch. Divya Rani* and Y. Meghana

M.Sc. Genetics and Plant Breeding, College of Agriculture, Rajendranagar, PJTAU

**Corresponding Author Mail ID: divyasampath1513@gmail.com*

Abstract

Genetic gain in crop improvement depends on the length of the breeding interval. However, practicing traditional breeding approaches limit plant breeding progress by the long generation time, which limit the number of generations that can be advanced each year. Therefore, there is a need for strategies to reduce generation time, enhance breeding efficiency, and accelerate varietal development. One such strategy is speed breeding. This approach manipulates environmental factors, particularly light periods and temperature regimes, to induce early flowering and rapid seed set, allowing for an increased number of generations within a single year. By enabling multiple breeding cycles annually, speed breeding enhances selection intensity, accelerates allele fixation, and shortens the overall breeding timeline. As a result, speed breeding improves the capacity of crop improvement programs to respond more swiftly to the growing demands of agriculture.

Key words: Speed Breeding, Generation advancement, Breeding cycle, Growth chambers.

Introduction

The global population has risen rapidly and currently it is at about 8 billion, and is forecasted to grow to 9 billion by 2038. This growth, combined with climate change and challenges such as rising temperatures, irregular rainfall, floods, droughts, and emerging pests and diseases, places significant pressure on agriculture.

These factors demand rapid development of high-yielding, resilient, and climate-adaptable crop varieties through faster, more efficient plant breeding.

Conventional breeding, which involves crossing, selection, and multilocation testing, typically takes 10 - 20 years to release a new variety.

To reduce this time, breeders began manipulating plant life cycles as early as the 1940s, using methods such as single-seed descent and shuttle breeding to advance generations more quickly.

Based on these early works, modern speed breeding techniques, including accelerated single seed descent method, rapid generation cycling and rapid generation turnover - enable multiple generations per year in controlled environments, supported by molecular tools and early seed harvest. Since the 21st century, these methods have been widely applied to crops such as cereals, legumes and oilseeds, achieving faster generation turnover up to 3 times than conventional systems. Today, speed breeding plays a vital role in accelerating genetic gain and strengthening global food security.

Unlike methods such as shuttle breeding, MAS, biotron use, RGA, DH, SSD, and in vitro nursery, speed breeding can:

- Accelerate generation advancement under controlled environmental conditions
- Can be integrated with modern breeding tools
- Reduce breeding cycle duration without altering the genetic process
- Enable year-round breeding independent of season and location
- Increase rapid genetic gain
- Allow faster phenotyping

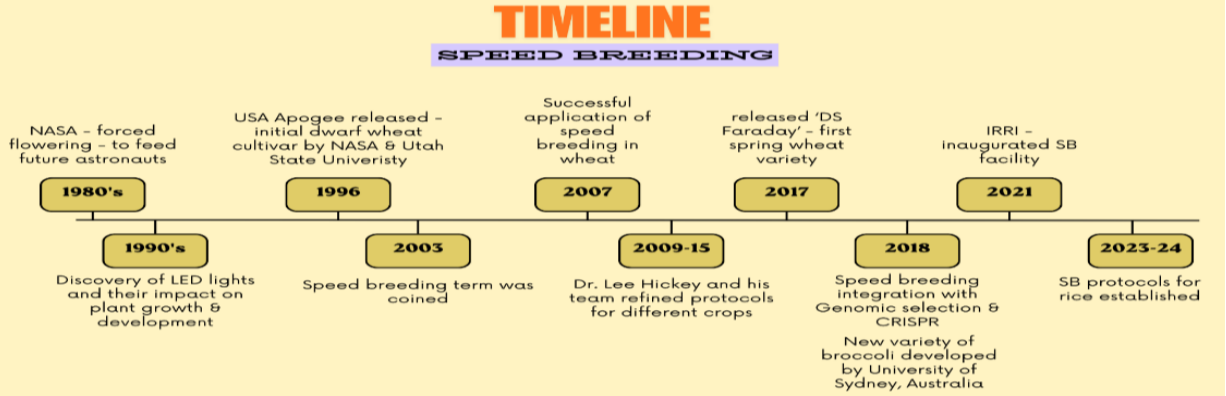

Fig: Evolution of Speed Breeding

Table: Comparison between Traditional breeding and speed breeding

Aspect	Traditional Breeding	Speed Breeding
Time taken	Many years (8-12 years)	Much faster (3-5 years or less)
No. of generation per year	1-2 generations	4-6 generations (sometimes more)
Growing conditions	Natural field conditions	Controlled environment (growth chamber/green house with extended light)
Light duration	Normal sunlight (10-12 hrs)	Extended light (20-22hrs)
Season dependency	Dependent	Not dependent on season
Cost	Lower initial cost	Higher setup costs
Screening efficiency	Limited population	Large population
Genetic gain	Gradual accumulation	Faster (by reducing generation time)
Application	Broadly applicable to various crops	Applicable after protocol optimization

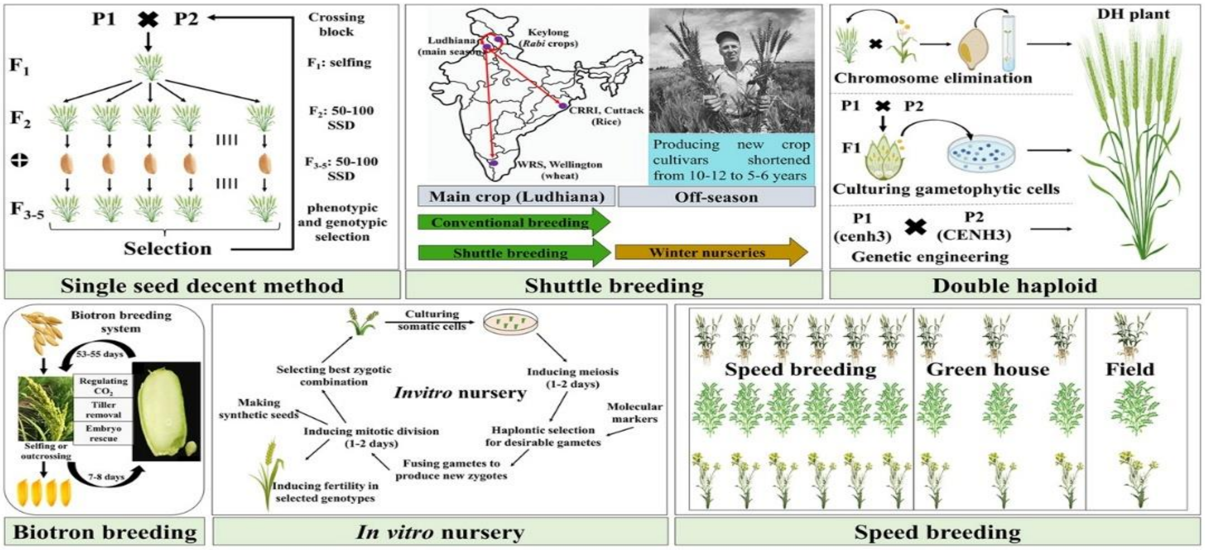

Fig: Various approaches to accelerate breeding process (Gudi et al., 2022)

Core manipulations in speed breeding:

1.Photoperiod

Photoperiod is duration of light and dark exposure, and these prolonged light periods can speed up plant development, flowering, and seed set thus fastening the transition from vegetative to reproductive stage. Long day and day neutral crops shown best results under 22 hours of light and 2 hours of darkness, whereas short day crops, such as pigeon pea, prefer short duration. Although plant species exhibit varying light intensity requirements, light intensity of 450-500 $\mu mol\ m^{-2}\ s^{-1}$ at canopy height, is most applicable. (Blinkov et al., 2025)

2.Temperature

Maintaining optimal temperatures helps synchronise germination, flowering, and seed set across different crops. Controlled systems such as solar or battery-powered air conditioning can be used in growth chambers to regulate conditions precisely. For instance, germination of direct seeded immature seed in chickpeas, under temperatures of 25 ± 1 °C, 12/12 hr light/dark cycle gave satisfactory results. (Shreya et al., 2022)

3.Soil moisture

Manipulation of soil moisture can be used to accelerate crop maturity. Both drought and flooding stress are known to trigger earlier flowering and faster life cycle completion in several crops. In cowpea, drought stress caused flowering to occur 12 days earlier compared to irrigated conditions. Similarly, in wheat, barley, and chickpea, reducing irrigation after flowering promoted earlier seed maturity. Therefore, controlled water stress is often employed in speed breeding as a strategy to shorten crop duration.

4.Elevated CO2

Increasing atmospheric CO_2 enhances photosynthesis and can accelerate flowering. In controlled chambers, CO_2 levels are maintained between 400-700 ppm. Studies have shown reduced flowering time in crops such as soybean (by 2 days), rice (by 7 days), and cowpea (by 12 days).

Thus, elevated CO_2 supports faster reproductive transition in speed breeding programs. (Wanga et al., 2021)

5.High Planting density

High-density planting creates light competition among plants, which encourages them to grow taller and transition quickly from vegetative to reproductive stages. This approach has been particularly effective in rice, where planting at 400 plants per m^2 enabled up to four generations per year. By maximizing the use of space and altering plant physiology, dense planting proves to be a simple yet effective tool to accelerate breeding cycles. (Wanga et al., 2021)

6.Nutrients and Hormones

Plant growth regulators are chemical compounds used to influence specific physiological processes such as flowering, seed development, or germination. They have been successfully employed in speed breeding to induce germination of immature seeds, hasten flowering, and improve seed set. In faba bean, the application of 6-benzylaminopurine (5–10 µM BAP) four days after flowering significantly increased seedset. Such targeted hormonal manipulations complement environmental controls to further reduce generation time. (Mobini et al., 2020)

Different Equipment used in Speed Breeding

➔ Controlled-Environment Growth Chambers

➔ LED Lighting Systems

➔ Photoperiod Controllers

➔ Temperature & Humidity Regulators

➔ CO_2 Enrichment Modules

➔ Irrigation & Nutrient Delivery Systems

➔ Sensors & Automation Platforms

➔ Data Logging & Monitoring Software

Techniques of Speed Breeding: (Watson et al., 2018)

1. Speed Breeding I – Controlled Environment Chambers (John Innes Centre, UK)

This standardised protocol uses fully controlled growth chambers to control environmental parameters precisely. Plants are grown under an extended photoperiod of 22 h light/2 h dark, with temperatures maintained at 22°C (light) and 17°C (dark) and ~70% relative humidity. A broad-spectrum light source (white LEDs supplemented with far-red) provides approximately 19,000–20,500 lux, causing rapid photosynthesis and early flowering. This system enables up to 4–6 generations per year in crops such as wheat, barley, chickpea, and pea.

2. Speed Breeding II – Glasshouse System (University of Queensland, Australia)

This approach adapts the chamber-based system to glasshouses equipped with supplementary lighting. The Hickey Lab in Australia demonstrated that a temperature-controlled glasshouse fitted with high-pressure sodium vapor lamps could achieve results similar to controlled chambers. Environmental conditions are maintained at a 22 h light/2 h dark cycle, 22°C/17°C temperature regime, and ~70% humidity, with higher light intensity (24,000–35,000 lux). It supports rapid generation advancement and is suitable for large breeding populations with limited chamber space.

3. Speed Breeding III – Low-Cost Growth Room (Hickey Lab, Australia)

It is Designed for affordability. This system uses a 3 × 3 × 3 m insulated room fitted with multiple LED light boxes. The photoperiod begins at 12 h and is extended to 18 h after early growth stages. Temperature is maintained at 21°C (light) and 18°C (dark) using split air conditioning, and irrigation is automated. Despite lower infrastructure costs, this setup still enables multiple generations per year under controlled conditions.

Achievements of Speed breeding:

Crops	Varieties
Wheat	Yumai 34, Long reach lancer, Mace, Ds Faraday, Julins, Nw4568
Barley	Excalibur, Scarlet, Tallon, WI 4240
Canola	In Vigour L140P, 45H29
Maize	NAM-NU14
Pea	Nitouche, Purple podded pea

(Gautam *et al.,* 2024)

Advantages

- Rapid generation turnover – up to 4–6 generations/year depending on crop.
- Faster trait introgression and fixation in breeding lines.
- Supports integration with molecular breeding and gene editing.
- Year-round breeding independent of field seasons.
- Space-efficient in controlled environments.
- Uniform growth conditions reduce environmental variation.

Limitations

- High setup cost for growth chambers or greenhouses.
- Energy-intensive due to artificial lighting and temperature control.
- Limited scalability for large breeding populations.
- Not all crops respond equally well to photoperiod/temperature manipulation.
- Potential for altered phenotype expression compared to field-grown plants.
- Requires technical expertise for protocol optimization.

References:

1. Blinkov A.O, Kroupin P.Y, Dmitrieva A.R, Kocheshkova A.A, Karlov G.I and Divashuk M.G (2025). Speed Breeding: Protocols, application and achievements. Frontiers in Plant Science. 16: p.1680955.
2. Gautam Y, Bishnoi L, Mishra R, Bhardwaj S, Sharma A and Mohbe G (2024). Speed Breeding: A Tool for Rapid Crop Production. In Recent Advances in Plant Breeding. 1: 31-45.
3. Gudi S, Kumar P, Singh S, Tanin M.J and Sharma A (2022). Strategies for accelerating genetic gains in crop plants: special focus on speed breeding. Physiology and molecular biology of plants. 28(10): 1921-1938.
4. Mobini S, Khazaei H, Warkentin T.D and Vandenberg A (2020). Shortening the generation cycle in faba bean (Vicia faba) by application of cytokinin and cold stress to assist speed breeding. Plant Breeding. 139(6): 1181-1189.
5. Shreya, Kumar V and Arjoo (2022). Speed breeding: Accelerated plant breeding. Journal of Agricultural Research and Technology. Special Issue (1): 036–039.
6. Wanga M.A, Shimelis H, Mashilo J and Laing M.D (2021). Opportunities and challenges of speed breeding: A review. Plant Breeding. 140(2): 185-194.
7. Watson A, Ghosh S, Williams M.J, Cuddy W.S, Simmonds J, Rey M.D, Asyraf Md Hatta M, Hinchliffe A, Steed A, Reynolds D and Adamski N.M (2018). Speed breeding is a powerful tool to accelerate crop research and breeding. Nature plants. 4(1): 23-29.