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Speed breeding and doubled haploid technology for accelerated crop improvement

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Intricacies of the subject

Developing a new crop variety through conventional breeding takes time. Breeders often need four to six generations of self-pollination to obtain genetically stable, highly homozygous lines, with each generation potentially requiring a full growing season. When multi-location testing is added, the journey from an initial cross to a farmer-ready variety can extend to a decade or more. With climate change bringing new pest pressures, heat stress and unpredictable rainfall, such long timelines are increasingly difficult to justify. Speed breeding (SB) and doubled haploid (DH) technology offer two complementary ways to shorten this journey and are changing the pace at which new crop varieties can be developed.

Manipulating light and time

Speed breeding is better understood as a group of controlled-environment approaches that shorten the interval between generations by creating conditions that encourage earlier flowering. By extending the daily photoperiod, often to 20–22 hours of light per day, and carefully managing temperature, humidity and light intensity, breeders can encourage long-day crops such as wheat, barley, oat and canola to flower and set seed much earlier than under natural field conditions. Early seed harvesting, before full physiological maturity, followed by rapid germination of the harvested seed, can then allow several generations to be completed in the time normally required for one. A 2025 review in Frontiers in Plant Science highlights precise temperature control as an important requirement for speed breeding. Large temperature fluctuations can induce plant stress and slow vegetative growth, although crops such as wheat

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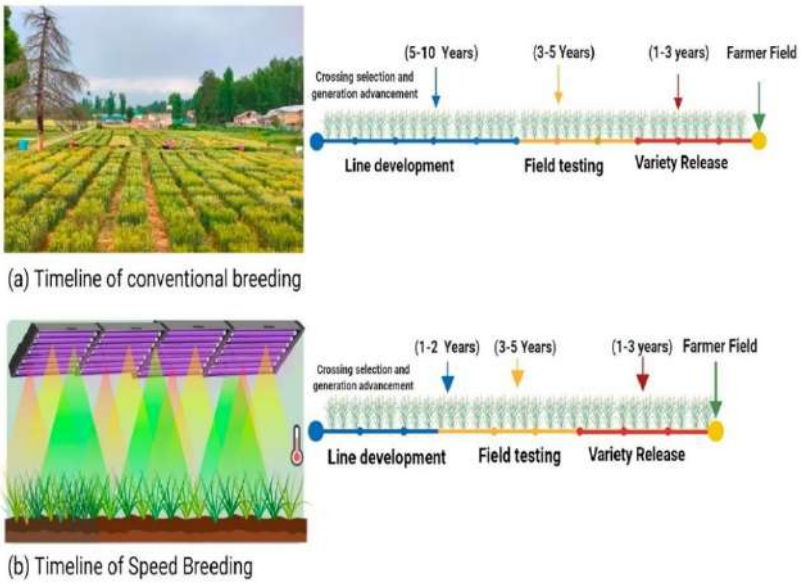
may tolerate some greenhouse variation when other speed-breeding conditions are well optimized. Speed breeding has also been used to develop wheat lines with improved baking quality and altered grain starch properties, showing that faster generation turnover does not necessarily compromise important end-use traits.

Fig: How speed breeding works in closed chambers facility

How much time does it save?

Under optimized conditions, speed breeding can produce as many as four to six generations of some crops per year, compared with one or two generations under normal field conditions. When combined with single-seed descent, in which one seed per plant is used to advance a generation, speed breeding has been reported to increase generational turnover roughly threefold compared with older approaches such as shuttle breeding between geographically distinct growing seasons.

Fig: Comparison and timeline required for speed breeding



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Doubled haploid technology: instant homozygosity

Speed breeding reduces the time needed to complete each generation, whereas doubled haploid technology tackles another major bottleneck: the number of generations required to obtain a genetically pure, homozygous line. Conventional breeding normally requires repeated self-pollination to approach complete homozygosity. DH technology bypasses much of this process by first producing haploid plants with a single chromosome set and then doubling the chromosome number, chemically or naturally, to obtain a fully homozygous, fertile diploid plant.

How haploids are induced

Haploids can be produced through several biological routes. One important approach is in vivo induction using specialized haploid-inducer genotypes. When these are crossed with a target plant, the inducer chromosomes can be eliminated during early embryo development, leaving the maternal chromosome set. A 2025 review in Plant Biotechnology Journal describes five possible mechanistic routes for haploid induction associated with double fertilization in flowering plants and identifies sperm DNA fragmentation and ectopic activation of embryogenesis genes as promising areas for discovering additional haploid-induction genes. In wheat, researchers have combined haploid-induction genes with visual marker systems and dominant male-sterility genes to develop high-throughput in vivo DH pipelines, helping address the lower efficiency that historically made wheat more challenging than maize. Once haploid plants are obtained, their chromosome number generally has to be doubled to restore fertility and produce a doubled haploid line. Chemical agents such as colchicine have traditionally been used for this purpose. Depending on the crop and method, the process from haploid induction to a stable, seed-producing DH line can take roughly one to one-and-a-half years, replacing several generations of self-pollination with a much shorter pipeline.

Where DH technology has delivered the most

Maize: DH technology using in vivo maternal haploid inducers has become a routine part of commercial hybrid maize breeding programs worldwide.
***Brassica napus* (canola/rapeseed):** Microspore (anther) culture is a preferred DH route because of its efficiency and scalability.
Wheat and barley: Newer in vivo and gene-edited haploid-inducer systems are helping close the efficiency gap that once made these crops more difficult to work with than maize.
Orphan and recalcitrant species: DH applications are expanding beyond major staple crops and are supporting breeding for climate resilience in underexploited species.

Where the two technologies meet

The greatest gains in breeding efficiency come when speed breeding and doubled haploid technology are combined with modern molecular tools rather than used independently. DH lines still have to be multiplied, phenotyped and evaluated in trials, so growing them under speed-breeding conditions can further shorten the overall path from a cross to a finished variety. Recent reviews have highlighted the potential of integrating speed breeding with genomic selection, high-throughput genotyping and genome editing to compres breeding timelines further. Doubled haploid research is also increasingly incorporating machine-learning models to predict haploid induction success, embryo viability and downstream breeding values from genomic information. At the same time, automation of embryo

rescue and chromosome doubling is helping reduce the labour that has traditionally limited DH throughput.Where the two technologies meet.The greatest gains in breeding efficiency come when speed breeding and doubled haploid technology are combined with modern molecular tools rather than used independently. DH lines still have to be multiplied, phenotyped and evaluated in trials, so growing them under speed-breeding conditions can further shorten the overall path from a cross to a finished variety. Recent reviews have highlighted the potential of integrating speed breeding with genomic selection, high-throughput genotyping and genome editing to compress breeding timelines further. Doubled haploid research is also increasingly incorporating machine-learning models to predict haploid induction success, embryo viability and downstream breeding values from genomic information. At the same time, automation of embryo rescue and chromosome doubling is helping reduce the labour that has traditionally limited DH throughput.

Challenges that remain

Neither technology is without limitations. Speed breeding requires substantial investment in controlled-environment facilities, including growth chambers or specialized glasshouses with programmable lighting, which may be difficult for smaller breeding programs to afford. Some crops, and even some genotypes within a crop, respond poorly to extended photoperiods, while overly aggressive acceleration can reduce seed set or plant vigour. DH technology is also strongly genotype-dependent. Induction efficiency can vary widely among varieties, some species still lack reliable haploid-inducer systems, and chromosome doubling and plant regeneration can be technically demanding and costly. Where transgenic haploid-inducer lines are used, biosafety and regulatory considerations must also be addressed carefully.

The path forward

Despite these challenges, the direction of the field is clear. As the molecular mechanisms underlying haploid induction become better understood, gene-editing tools such as CRISPR/Cas9 can help develop more efficient and broadly applicable haploid inducers. Automation and AI-assisted approaches may also reduce the manual effort involved in embryo rescue and screening. Together, these advances are making speed breeding and doubled haploid technology faster, more efficient and increasingly accessible. For breeders developing climate-resilient and high-yielding varieties under growing time pressure, these approaches are becoming important components of the modern breeding toolkit.

Conclusion

Speed breeding and doubled haploid technology address the long-standing challenge of generation time from two complementary directions: one shortens the duration of each generation, while the other reduces the number of generations required to achieve homozygosity. When used together with genomic selection, molecular breeding and AI-assisted tools, they can transform a breeding journey that once required a decade or more into a process completed within a much shorter timeframe. This acceleration is particularly valuable as breeders respond to climate change and the increasing need for productive, resilient crops.

References

1. Ahtisham, M. and Obaid, Z. 2025. Enhancing crop improvement with speed breeding: Applications, challenges, and future prospects. Premier J. Plant Biol., 3: 100017. doi:10.70389/PJPB.100017.
2. 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. Front. Plant Sci., 16: 1680955. doi:10.3389/fpls.2025.1680955.
3. Li, T., Wang, C., Pan, J., Zhang, Y., Tabusam, J., Li, Y., Yao, J., Chen, W., Wang, Y., Gao, W., Rong, J., Ahmad, Z., Houben, A., Zhu, S. and Jin, S. 2025. Exploring potential strategies for haploid induction based on double fertilization in plants. Plant Biotechnol. J., 23(9): 4000–4016. doi:10.1111/pbi.70197.
4. Zhang, N., Qi, X., Wu, L., Wang, Z., Ma, H., Zhu, X., Liu, J., Niu, W., Guo, S., He, Y., Jiang, P., Wang, W., Chen, S., Wang, X., Ni, Z., Liu, C. and Liu, D. 2025. Accelerating wheat breeding by haploid induction. Crop J., 13(5): 1363–1371. doi:10.1016/j.cj.2025.04.004.
5. Ye, X. and Han, F. 2024. Editorial: Applications of fast breeding technologies in crop improvement and functional genomics study. Front. Plant Sci., 15: 1460642. doi:10.3389/fpls.2024.1460642.
6. Paspureddy, S. L., Sasirekhamani, M., Sneha, P. I., Deepanshu, Sharma, A., Harshavardhan, S. S., Chandravanshi, R. and Sahu, A. 2025. Advances in haploid and doubled haploid technology for accelerating breeding cycles in crop improvement. Plant Cell Biotechnol. Mol. Biol., 26(7–8): 61–77.doi:10.56557/pcbmb/2025/v26i7-89369.