Speed breeding for Indian Agriculture: a rapid method for development of new crop varieties

In agriculture, conventional breeding takes a longer time for the development of crop varieties with a minimum of 8–10 years of breeding cycles. In the context of breeding, rapid generation advancement of segregating populations towards reaching homozygosity will facilitate genetic gain for key traits and the rapid development of improved cultivars. Extra-terrestrial experiments by NASA, USA, to grow crop seeds in space inspired scientists in the University of Queensland and University of Sydney in Australia to develop a speed-breeding platform. Speed breeding uses an artificial environment with enhanced light duration to create longer daylight regimes to speed up the breeding cycles of photoinsensitive crops. The experiments on wheat research using continuous light which induces early reproduction in the plants were utilized to grow plants quickly on earth in a controlled environment, which in turn, accelerates genetic gain in the plant breeding programmes. The speed-breeding experiments in wheat revealed that the quality and yield of the plants grown under controlled climate with extended daylight were the same as those of crops grown in regular glasshouse conditions. Farmers will have to produce 60–80% more food by 2050 to feed nine billion people and speed breeding is a potential technique in this regard. The biggest challenge of breeding higher yielding and more resilient crops is the inability to complete more generations in lesser time. Speed breeding, greatly shortens generation time and accelerates breeding and research programmes. Plant–pathogen interactions, plant anatomy and flowering time can be studied in detail and repeated using the technology[1]. It uses supplemental lighting to aid photosynthesis rate in intensive regimes of up to 22 h per day in a glasshouse environment that allows rapid generation cycling through single seed descent and potential for adaptation to larger-scale crop improvement programmes[2,3]. The technique has achieved wheat generation from seed to seed in just eight weeks. It means that it is now possible to grow six generations of wheat per year, which is a threefold increase on the shuttle-breeding techniques currently being used by plant breeders. A recent report on speed breeding mentions that up to six generations per year could be achieved for bread wheat, durum wheat, barley, pea and chickpea, and four generations for canola[2]. Speed-breeding technique has been used for breeding wheat variety DS Faraday, with tolerance to pre-harvest sprouting being a major problem in Australia. This is a high-protein, milling wheat variety having tolerance to pre-harvest sprouting[1]. The speed-breeding technique has largely been used for research purposes, but is now being adopted by the industries as well. Speed breeding as a platform can be combined with several other technologies such as marker-assisted selection, genomic selection, CRISPR gene editing, etc. to get to the end result faster[4]. With the success of speed breeding particularly in wheat crop, India can also initiate such facilities for quick development of new crop varieties. Speed breeding in the case of photoinsensitive crops like wheat, barley, chickpea and pea greatly reduces the generation time and helps in achieving six generations per year[2], but for the photosensitive crops like soybean, speed breeding is not suitable to speed up the breeding cycles. The enhanced light provided in the speed-breeding facility will not allow the plants to bear flowers in case of photosensitive crops. Therefore, alternative approaches have to be followed to speed up the breeding cycles in such crops. The ICAR-Indian Institute of Soybean Research (ICAR-IISR), Indore is extensively taking up off-season (January–April) generation advancement of segregating material at the University of Agricultural Sciences, Bengaluru. This significantly helps in reducing the duration of the varietal development programme. In addition, ICAR-IISR has greenhouse and polyhouse facility, which is being used for advancement of F_1 to F_2 and important individual plant selections during off-season (November–February). The few of selected segregating material is also advanced to shorten the varietal development programme. To conclude, breeding programmes should be at par with the changing climate, and breeding for climate-resilient crops is the immediate challenge which can be accomplished through new ideas like speed breeding.

1. https://www.sciencedaily.com/releases/2018/01/180101144758.htm
2. Watson, A. *et al*., *Nature Plants*, 2018; https://doi.org/10.1038/s41477-017-0083-8
3. http://www.newsweek.com/growing-plants-speed-breeding-could-be-key-feed-worlds-exploding-population-767450
4. https://www.jic.ac.uk/news-and-events/news/2018/01/speed-breeding/

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