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Speed breeding methods for soybean improvement: recent advances

Abstract

Food security is one of the key issues with the increase of world population. Continuous food production is important to enhance yield with increase of world population and food demand. Slow Soybean generation times is one of the key problems for its improvement and yield production. Speed breeding is one of the novel methods to increase the number of generations thereby decrease generation time. Many researchers have developed novel speed breeding protocols to produce early days to flower initiation, early maturity and overall growth and development of soybean genotypes, thus decreasing the generation times. Here we highlighted some of the efficient speed breeding protocols, developed by different researcher's for important oilseeds crop soybean. This review will help researchers to use these systems for other important crop species improvement. However further work is needed to bring novelty in existing systems or to develop new speed breeding systems for enhancing yield related traits thus allowing soybean to grow at least 5 generations/year.

Keywords: generations/year, food security, speed breeding, soybean, yield improvement

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Introduction

The cross-breeding method is time consuming and requires a minimum of eight generations for proper characterization and evaluation. So, it seriously retards its yield, quality, and resistance to biotic stresses.[1–3] Speed breeding is a new method for developing new long day plant cultivars in a short time by reducing the generation time.[4] Plants are used as a major source of medicine, food, and feed.[5–8] Among these plants, Soybean is an annual oilseed crop belonging to family *Leguminosae* and mainly grown as edible seeds. It is one of the key cash crops for poultry and food industries.[9,10] Therefore, development of new high yielding soybean cultivars is needed to solve food security issues by using novel strategies such as speed breeding. Speed breeding has potential to enhance accumulation of carbon and seed production in soybean if it is used efficiently so that flowering initiation is not compromised as well.[11]

Many researchers developed efficient speed breeding techniques that help to grow soybean at least 4-5 generation per year as compared to the 1-2 generations per year. Here we discussed some of the novel soybean speed breeding protocols developed by different researchers to grow soybean for many generations (Table 1). For examples, Jahne et al.[11] established a new method to increase the number of soybean generations up to four/year. They developed a new efficient speed breeding system based on combining off-site nursery, fresh-seeding method, and marker-assisted selection. The developed system reduced the generation cycles at natural environmental conditions. Fang et al.[12] developed a speed breeding system by using light-emitting diodes (LEDs) for three important crop species i.e. soybean, rice and amaranth. They noted that optimizing photoperiod to 10 h and using a blue-light enriched, far-red-deprived light spectrum promoted soybean growth and development, early flowering (23 days to flowering after sowing), and maturity (77 days), hence allowing to grow soybean in 5 generations/year. Harrison et al.[13] developed a new speed breeding system for US soybean genotypes improvement. They used red and blue (RB) light, coupled with photothermal conditions to grow the plants for five generations at controlled conditions. They noted that RB treatment decreases interval planting to physiological maturity as well as they observed a significant decrease in days period between planting and harvesting of mid- and late-maturity soybean from approximately 120 days in field conditions to 63-81 days under controlled conditions.

Table 1 List of efficient Soybean speed breeding protocols developed

Sr. No.	Technique/protocol used	No. of Generation/ year	Reference
1	Off-site nursery, fresh-seeding method, and marker-assisted selection	Least 4 or more	Fang et al.[12]
2	Use of red and blue (RB) light, coupled with photothermal conditions	5	Harrison et al.[13]
3	CO_2 supplementation (>400 p.p.m) and fluorescent lamps (220 mmol m–2 s–1 at the canopy level)	5	Nagatoshi and Fujita. [20]
4	Light-emitting diodes (LEDs) system, temperature and immature seed germination	5	Jahne et al.[11]

The increase in the number of generations per year is key for soybean breeding improvement. The greenhouse methodology via adjusting optimum temperature, CO_2 level and other climate factors improve its development and reduce generation time.[1,4,14–19] Nagatoshi and Fujita[20] established an efficient CO_2 supplemented compact growth chamber to increase soybean growing up to 5 generations/ year. They used fluorescent lamps (220 mmol m–2 s–1 at the canopy level), a 14 h light (30°C)/10 h dark (25°C) cycle and carbon dioxide (CO_2) supplementation at >400 p.p.m and as a results life cycle was reduced to 70 days as compared to 132 days at natural condition. They

noted that CO_2 supplementation increases plant growth and yield. In addition, the optimum light and temperature promote early flowering, decrease harvesting time and also lower reproductive periods. This model system helps to grow soybean at 5 generations instead of 1-2 generations using conventional breeding methods. They suggested this novel system for the improvement of other important crop species.

Conclusion

Speed breeding is a novel, advanced method that helps to grow plants in multiple generations per year. There is a need to increase generation times per year to solve food security issues. Speed breeding protocols for soybean crops have been developed by different researchers that help to grow plants up to five generations per year that definitely will increase its annual production many times. So, it is the responsibility of breeders to develop some new efficient speed breeding protocols for the improvement of this important crop species. This will help the agricultural industry to produce a maximum soybean yield in a short time. It is highly recommended that the developed optimized protocols should be used for other important crop species to increase their annual yield.

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Conflicts of interest

The author states there are no conflicts of interest.

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