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Space Inspired Breeding: A New Paradigm

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An innovation for rapid crop growth and production developed by Australian scientists at the John Innes Centre, University of Queensland and University of Sydeny that got inspired by NASA's experiments to cultivate wheat in space by exploiting uninterrupted light that reduced the length of breeding cycles and stimulated early reproduction. under controlled temperature and extended photoperiod just after eight weeks the production of wheat boosted upto three times by six generation of crops produced per year as compared to regular breeding techniques.

This technique has proven worthy for various range of crops like wheat, chickpea barley and canola for promoting rapid increase in production by using enclosed standard glasshouses fitted with LED lights to grow plants under controlled environmental conditions and extended photoperiod .It accelerate crop research by reducing breeding cycle and enables breeder to develop more robust plant varieties which are more adaptive in biotic and abiotic stresses through rapid cross breeding and generation advancement. It shortens the traditional breeding pipeline and speeds up genetic gain by diminishing generation time and accelerating plant growth, flowering and seed maturation.

Major application of speed breeding includes rapid development of homozygous and stable genotypes, mutation studies, disease resistance, phenotyping of adult plant traits, cytogenetic studies, discovery of novel traits and transformation experiments. Integration of speed breeding with conventional methods and non conventional methods provides great potential to accelerate the process of selection of desirable genotypes and rate of crop improvement.

Need

To meet the future demands of global food security for growing human population and development of climate resilient crops is need of hour for changing environmental conditions due to global warning. It will act as effective tool to achieve target regarding 2050 genetic gain for four F's that is food, feed, fiber and fuel. It provides great opportunity for production of non-genetically modified crops due to ethical issues and hazardous effects on human health. Currently we are in the phase of slow crop improvement rate due to long generation time in crops attained through convectional breeding methods so we need to supplement conventional breeding methods with speed breeding to produce multiple generation in a year as they provide better means for crop improvement but not enough for accelerating the rate of crop improvement and the future research programmes in crops .In addition to that it allows researchers to mobilize genetic variation from wild to elite varieties

Methods

Under artificial growth environment in standard green house with controlled temperature, extended photoperiod and light (22 hours of light / 2 hours dark) from normal light-emitting diodes (LED) used for the process of photosynthesis. The speed breeding can be practiced mainly under three methods as per Watson *et al.*, (2018).

Speed Breeding I - Controlled Environment Chambers Speed Breeding Condition

In controlled environmental condition BDW chamber lighting system should cover photo synthetically active radiation (400-700) specific focus on blue, red and far-red regions of light spectrum under 70% humidity with intensity of (360- 380) µmol m^{-2} s^{-1} at bench height and (490- 500) m^{-2} s^{-1} at adult plat height, temperature cycling regime of 22 °C for light period and 17 °C for dark period , photoperiod of 22-hours for light and 2 hour for dark period is ideal. Mainly LED and ceramic halogen lights used but in long term LEDs are more efficient and cost effective.

Speed Breeding II - Glasshouse Speed Breeding Condition

Under controlled temperature condition a standard Glasshouse is setup with high pressure sodium vapour lamps which runs under 70 % humidity with light intensity of (440-650) µmol m^{-2} s^{-1} at adult plant height and above bench height approximately 45cm, temperature regime of 22 °C for light period and 17°C for dark period followed by a photoperiod of (20-22) hour for light and 2 hour for dark period regarded as ideal for its proper functioning.

Speed Breeding III - Homemade Growth Room Design for Low Cost Speed Breeding

Homemade growth room design is an inexpensive alternative to the conviron BDW has insulated sandwich paneling with dimension of 3 m x 3 m x 3 m fixed with 7-8 LED light boxes from grow candy as 1 light box is required for per 0.65 m^2 connected with inverter split system domestic air conditioner of 1.5 hp .The lighting system is regulate to run a 12 hour with photoperiod 12 hour for light period and 12 hours for dark period for 4 weeks and then increased to photoperiod 18hour for light and 6 hours for darkness, temperature 21°C for light period and 18°C for dark period, intensity (210-260) m^{-2} s^{-1} at bench height and (340-590) m^{-2} s^{-1} at adult plant height.

Conclusion

Speed breeding is able to provide potential advantages for accelerating the development and successful release of market-oriented, climate resilient and non genetically modified crops in short time as compared to regular breeding by shorten the breeding cycle, alleviating the proportion of time, labour, space and resources spent in the selection process. Integration of speed breeding with traditional breeding can assist rapid genetic gain and enhance effective choice of elite genotypes with novel traits related to higher productivity, less anti nutritional factors, better nutritional qualities, activating defense mechanism towards biotic as well as abiotic stress. Moreover for hastening the rate of crop enhancement we are able to integrate speed breeding with other non conventional high-throughput technologies. Due to elevated startup expenses in architecture for supporting a sustainable working, insufficiency of skillful plant breeders and breeding technicians, erratic electricity and water deliverance for sustainable working, the process of implementation of speed breeding techniques in many developing countries are lagging behind but will be the viable option to speed up the research programme.