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Speed Breeding: An Advance Approach

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Introduction

The globalization replaces the agriculture land areas with the maximum industrial plant, which is causing climate change along with varied abiotic and biotic stresses. The increasing stresses demanding for prompt release of new resistant varieties. The breeding methods of both self and cross-pollinated crops gave insight towards how to develop specific varieties but the evolution through these methods has a very low pace. The contemporary world has increases the gear with more work in the least time from a quick solution to quick communication; everything is increasing its rate. This depicted that in future fastness is another name modernization and advances. The era where everything reaches into the next generation by increasing its rate then why not Plants? The question initiate from here lead to a discovery of the eminent method of breeding, which is Speed Breeding. The drought, flood and global losses due to weed, insect and pest ask for immediate resistant varieties and through convention breeding the release took approx 14 years for the new variety to come in the market for sale. This is the major cons from which breeders are suffering, although the molecular breeding supplemented the conventional one, but it can't be taken as the sole method of application. Thus, considering all this a new method developed with accelerated growth and reduced breeding cycle called Speed Breeding. It is known as accelerated breeding. The higher selection intensity and rate of generation turnover under Speed Breeding may enable a greater rate of genetic gain than direct field phenotyping (Watson and Lee et al, 2019). The working was initiated by Dr. Lee along with Amy Watson and Shreya gosh on wheat crop and got a successful result with six generations per year.

How Speed Breeding Is Better Than Other Accelerated Breeding?

When the question arises of reducing the breeding cycles many methods come into consideration and few such methods amongst them are discussed here with their major

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drawback. The acceleration of breeding is done through both molecular and non-molecular breeding methods.

A. Non-molecular breeding methods

1. Rapid generation advancement shortens the development of variety by two years through the manipulation of growing conditions like good seed set in less time.
2. In shuttle breeding, one can take breeding in offseason also by growing it in different suitable locations. Therefore two generations per year can be taken which reduces the time of the cycle to just half.
3. The double haploid production through bulbosum technique, anther or ovary culture or chromosome elimination techniques. It reduces the time of cycle from seven-year to just two years but it also reduces the genetic gain as the variability is lost due to homozygosity.

B. Molecular breeding methods

1. Marker-assisted selection gave authentification of the selected variety through phenotyping along with genotyping, which increases accuracy, cost and reduces time by a few years.
2. Genome selection focuses on a large amount of DNA, not just one or two genes as done in MAS. This made the accurate selection to increase genetic gain.

Now the speeding breeding is better than all because it reduces the time of crossing and breeding from 3-7 to 1-2 years with the potential to double the rate of genetic gain. The speeding up of the method without loss of potential gain makes it the popular and advance future method.

How Speed Breeding Is Done?

To know the exact working, fist we have started with its principle of working. The speed breeding is the combination of principles of above acceleration breeding aspects. The breeding is done under the controlled artificial environment with artificial conditions like rapid generation advanced and it can also be grown in offseason as we do in the shuttle breeding method. The main idea of such innovation comes from NASA which has the aim to grow food crops and wheat in space. Then further Dr. Lee Hickey initiated his work in this

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along with some co-workers at the University of Queensland, John Innes Centre and the University of Sydney in Australia in wheat and peanut crop.

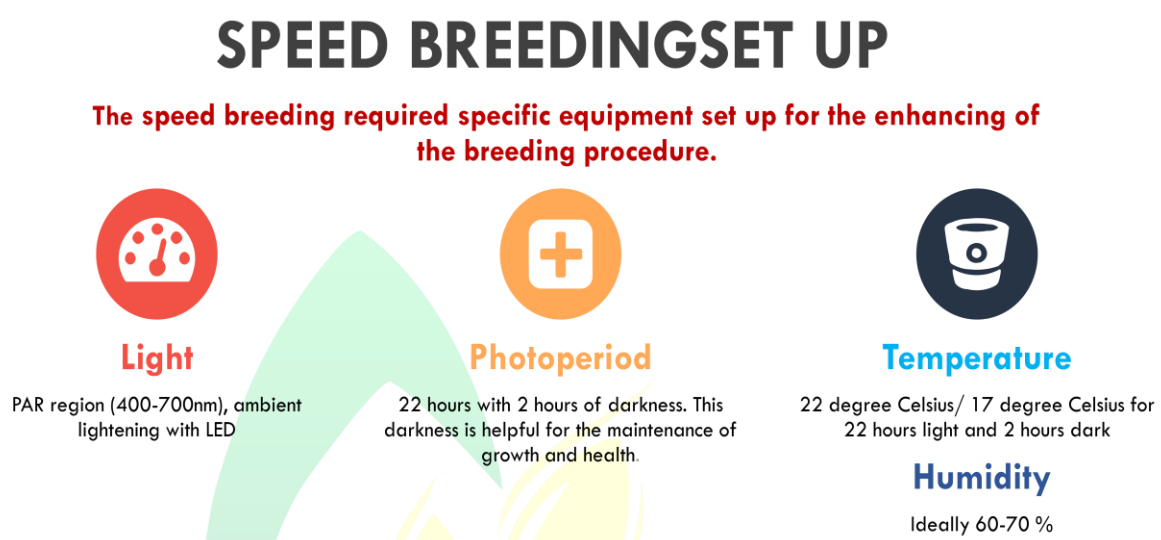

Fig 02:- A Set-Up for Speed Breeding

The artificial environment created in a glasshouse is different from sped breeding as in the former one alternative 12 hours light and darkness is given but in speed breeding, the plants are exposed to continuous light for 22 hours. This prolonged light hour increases the photoperiodic hours which help in accelerating the developmental rate of plants. The speed breeding chamber has temperature controlled fitted with light with some LEDs of low-cost growth room. The speed breeding set up is shown in fig -02. The speed breeding fulfils the breeder's equation with six generations per year.

Procedure Of Speed Breeding

1. Initially, the seeds are prepared for sowing by providing the proper treatment and environmental conditions.
2. The significant growing stages are taken into consideration and specific emphasis is given to phenotyping of only those stages. Like the time of anthesis or flowering is observed and their associated parameters are observed.
3. Majorly seed is harvested at an immature stage and then given specific cold treatment for maturation. Although the seed produces this process somewhat shriveled on hydration they regain their shape and vigour and germinated. But this process reduces the time from 15 days to 3 days.

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4. The energy monitoring helps us to be specific while providing light, temperature and other biological setups.

Application

1. Useful in developing multiple disease resistance crops
2. Can collaborate with new technology like CRISPER CAS9 and give result in a shorter period.
3. Spring wheat, durum wheat, barley and *Brachypodium distachyon* has given amazing result by decreasing the time of progression to anthesis to just half.
4. According to some protocols, even 8-9 generations of barley were found.
5. There are many opportunities to combine it with transgenic and genomic selections to get good results.
6. The first varieties originated through speed breeding are “DS Faraday” using speed breeding with high protein, milling and tolerant to post-harvest sprouting.
7. The disentangling of photoperiod revealed that vernalization and dormancy, two plant traits previously considered necessary to the proliferation of *Humulus lupulus L.* (hop flowers), do not influence hop flower yield and quality, this finding paves the way for speed breeding and controlled-environment production to achieve 4 hops generation cycles per year, as opposed to 1 under field-grown conditions. (Bauerle et al, 2019).
8. In Peanut: - Speed breeding was successful in reducing generation time of full-season maturity cultivars from 145 to 89 days. Speed breeding can rapidly progress the inbreeding of F2, F3 and F4 generations in less than 12 months, and potentially accelerate the development of the first cross to commercial release in around six to seven years. (O’Connora et al, 2013)
9. Application of a high-speed breeding programme for disease resistance in apple. (Flachowsky et al, 2011)
10. Multiple quantities traits in durum wheat.
11. Mutant transformation for waxy traits in barley.

Future Challenges

1. There is a very high initial investment.

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2. As there is great diversity on this earth therefore the protocols are different for different crops. The response towards photoperiod is different for the different crops therefore the protocols of glasshouse differ among them.
3. There is an early harvest of immature spikes which interferes with the phenotyping of seed parameters.

Conclusion

The science in agriculture has explored every corner of research and plants are fully exploited for improvement of the trait. The recent technology inspired by NASA and elaborated by Dr. Lee, Amy Watson and Shreya Gosh that combines the advantages of all the methods and put them in a single canvas termed as Speed Breeding. The procedure utilizes the currently available information of plant biology and its ecology to form a crop-specific protocol, manipulate the photoperiod to shorten their life cycle, boost the growth through controlled environment condition such as temperature, humidity, light, etc and stage peculiar assessment to ultimately gain more than five-generation per year without reduction of yield is speed breeding. The scenario is not only focused on glasshouse control measures but also taken plant requirements as the priority for setting up the protocols. The article discusses the key aspects with major cynosure on wheat crops. The limitations which the method involves are high initial cost and the protocols differ in concern with crops.

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