AgriCos e-Newsletter
ISSN: 2582-7049
AgriCos e-Newsletter
Open Access Multidisciplinary Monthly Online Magazine
Volume: 03 Issue: 09 September 2022 Article No: 22

FasTrack Breeding –A Speciality Crop Breeding in Perennial Fruits

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SUMMARY

A typical super market reveals a stunning diversity interms of shapes, size and colour of myriad fruits. Almost all today's commercial produce reflects the result of continuous breeding programme, most focused on longstanding goals such as palatable quality, storage potential, yield, colour and size. However, efforts have been successful in generating commercial cultivars that bear high quality produce under the best current production regimes. Breeders generally lack the capacity to generate new cultivars quickly in response to evolving consumer preferences and crisis situations, since fruit crops exhibit high juvenile period. To quicken the breeding programme in perennial fruit crops attempts has been made and developed the new approach called 'FasTrack breeding'.

INTRODUCTION

A breeding system that uses a genetically engineered (GE) tree flowering gene that produces generation cycles of one year or less. It is also known as high-speed breeding technology/ rapid cycle breeding/ fast breeding. It is a remarkable tool for quickly adapting crops to climate change and increasing challenges of drought, flooding, emerging diseases and shifting agricultural zones. It may also be used as ornamental plant that continually flowers and fruits in home garden. FasTrack that can speed germplasm improvement by rapid incorporation of trait(s) of interest using the ECF (Early and Continual Flowering, ECF) genetic construct to reduce the time between flowering and fruiting. The ECF gene construct would then be selected against in segregating seedlings and the resulting non-genetically engineered germplasm would be utilized directly by the breeders.

History

In 2010, FasTrack breeding technique was discovered, which promotes early flowering and fruiting, and enables cycles of tree breeding to be accomplished faster than conventional breeding. The team focused on improving the breeding system for plum, a fruit scientist have spent many years working on it. With FasTrack breeding, they have found a way to lessen the time it takes to create new improved plum. Instead of taking 15-20 years to breed tree with combination of desired trait such as disease resistance and high quality, the scientist can now develop a variety within 3-5 years. Unlike conventional breeding, FasTrack breeding uses purelines that have transformed with special gene called "PtFT1" that induces early flowering. The scientist discovered this gene earlier from California poplar into plum cultivar bluebryd to induce early flowering (www.nature.com/hortres).

Limitations of Conventional breeding

1.Large crown architecture

Perennial fruit trees has large crown architecture as it has long juvenile phase, vegetative growth will be more and hence canopy will be denser. So this poses a problem for a breeder to undertake the activity of crop improvement in perennial fruit crops.

2.Prolonged juvenile phase

Woody perennial plants, including trees that produce fruits and nuts of horticultural value, typically have longer breeding cycles. Hence, development and introduction of improved cultivars by plant breeders may require many breeding cycles and dozens of years.

3. Seasonal dormancy

Almost all temperate fruit crops undergoes seasonal dormancy to escape from frost injury. This is a phase where a crop doesn't flowers or bear fruits. So, in this condition a breeder cannot undertake any activity and therefore breeding cycle will be extended.

4.Environmental barriers

Due to global warming there is drastic changes in climatic conditions. Variation in temperature, Relative humidity, rainfall and soil moisture *etc*. directly or indirectly affect the breeding programme.

5.Genetical barriers

Many of the temperate fruit crops are self-incompatible and sterile in nature. *e.g.* Apple, Almond, cherry.

Other barriers

- Complex Reproductive biology
- High level of heterozygosity
- Linkage drag of undesirable traits from wild relatives
- Very less information available on inheritance pattern and genomics.

Methods to manipulate Fruit juvenile phase

- Manipulation of photoperiod and temperature.
- Application of hormones or growth retardants i.e., daminozide and paclobutrazol.
- Trunk ringing, bark scoring, root pruning, defoliation and horizontal positioning.
- Grafting on dwarf rootstocks.
- Embryo rescue and seed chemical treatment.
- Microbudding.
- Early flowering mutants.

Prerequisite for FasTrack Breeding

1.Early flowering transgenic protocol.
2.Knowledge of integration site and copy no. in the early flowering transgenic line.
3.Knowledge about position of transgene and trait of interest on the chromosome.
4.Tightly linked reliable marker for trait of interest.
5.Ensuring pollen availability and pollen vitality.
6.Assessment of morphological performance of transgenic line, F1 and back crossed progenies.
7.Greenhouse (Biosafety level-II).

Genetically Engineered PPV Resistance in Plum

In 1992, the PPV coat protein (CP) gene was isolated and sequenced. In collaboration with Ravelonandro, Dennis Gonsalves, and members of Gonsalves research group, the PPV-CP gene was engineered into the plasmid pGA482GG. *Agrobacterium*-mediated transformation of plum was based on the procedure developed by Mante *et al.* (1991) utilizing hypocotyl slices from seed derived from open pollination. During the period of greenhouse-based inoculation and testing studies, the transgenic plum line C5 appeared to be highly resistant to PPV. The reduction or elimination of the non-reproductive juvenile stage of plum trees would provide the necessary break through to speed the breeding of plum cultivars with resistance to PPV or with any other improved trait(s). The extreme reduction of juvenility has been achieved through the manipulation of genes involved in flowering, primarily transcription factors (Flachowsky *et al*., 2011). The development of early flowering transgenic trees has been reported in several other tree species including citrus (Pena *et al*., 2001), apple (Flachowsky *et al*., 2011) and pear (Matsuda and Narumi, 2009).

'HoneySweet' originated as a seedling from the open pollination of 'Bluebyrd' plum (Scorza and Fogle, 1999). The pollen parent of 'HoneySweet' is unknown. 'HoneySweet' was originally selected in vitro as a regenerated shoot from a hypocotyl slice that had been transfected with *Agrobacterium tumefaciens* EHA 101 carrying the plasmid pGA482GG/PPV-CP-33 (Scorza *et al*., 1994) through FasTrack Breeding.

Benefits of the FasTrack Breeding System

1.Greater speed of variety development

As FasTrack breeding system reduces juvenility period 3-4 folds, crop improvement could be done faster as breeder doesn't want to wait for 10-15 years to check whether his/her work is successful or not. As juvenility phase is reduced varietal development will be faster.

2.Less costly method

In case of perennial fruit crops, there is a need of training and pruning to maintain canopy, this may add additional cost for a breeder. FasTrack bred plant will be shruby in nature and there is no need of canopy management, also

can be grown in green house *i.e.,* in insect proof net where incidence of pest and disease is less thus cost to be incurred on pesticide can be reduced.

3.Non transgenic plants

As there will be human aversion over transgenic plants they will not be readily accepted. Hence the work was done in such a way that, ultimately product selected at the end will be similar to that of conventionally bred plant.

Limitations in FasTrack breeding

- In most woody fruit species, transformation and regeneration protocol is not available.
- Over expressing or silencing of early flowering genes in plants may lead to undesirable phenotypic effects: plants constitutively overexpressing BpMADS4 is often malformed also fruit yield and seed set is very low.
- In India current regulations does not permit the FasTrack breeding
- FasTrack bred plants cannot be directly used as variety for commercial purpose but can only be used as parental line in breeding.

CONCLUSION

As many breeding approaches are practised from past several years not even single approach has reduced the generation cycle of crop which is major hinderence in early varietal development of fruit crops. One of the biotechnological approach that is FasTrack breeding has reduced generation cycle 3-4 folds in case of temperate fruit crops which enabled scientist to undertake quick process of varietal development. It utilizes genetic engineering strategies, but the product released for commercial use is not a genetically modified plant. Also has the potential to revive and expand tree breeding in general.

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