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Marker Assisted Selection Approach for Improvement of Quality Traits in Tomato

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ARTICLE ID: 28

Introduction

Vegetable crops are rich in dietary micronutrients, antioxidants and functional photochemical. Among vegetables solanaceous vegetables are the good source of health-protective dietary elements such as vitamins, minerals and antioxidant in the human diet. These solanaceous family includes Tomato, Brinjal, Chilli and Potato (Kumari *et al*., 2017). The attempts through conventional breeding methods have been slow and inadequate. By use of conventional breeding method to get the product will take more number of years and labours, so if we start by new technologies such as DNA markers are serve as a new tool to detect the presence of allelic variation in the genes underlying the economic traits. DNA markers have enormous potential to improve the efficiency and precision of conventional plant breeding *via* marker-assisted selection (MAS) by reducing the reliance on laborious and fallible screening procedures. Molecular markers, have great promise in reducing the time and cost involved in quality breeding. The present review summarizes attempts and potential of improving the quality traits by marker assisted selection in tomato.

Classification of Quality traits

Any degree of excellence is called quality. There are mainly 5 categories-

1. Morphological traits- Related to product appearance which includes fruit size, shape, color and thickness
2. Orgenoleptic traits- Concerned with palatability of the produce, examples are taste, *etc*.,
3. Nutritional traits (Neutraceuticals)- These are determine value of the product such as Beta carotene, ascorbic acid, TSS, Protein , vitamins, minerals

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4. Undesirable traits- Includes Solanine content in brinjal and browning in potato
5. Other traits- Includes keeping quality, cooking quality

Quality traits of Tomato

Tomato is the second highest produced and consumed vegetable in the world today. Tomato fruits are an important source of nourishment for the whole world's population. And it is botanically called *Solanum lycopersicum* L. having its chromosome number is 24 (Kumari *et al*., 2017).

Specific Breeding objectives for quality traits are-

- ✓ For fresh market-quality purpose- Breeding Objectives includes size, shape, Appearance, color and smoothness
- ✓ If we want to breed for processing quality traits some of important breeding objectives such as high Tss (5.5 Brix), Low pH (< 4.5) and low acidity.
- ✓ And also to develop variety rich in lycopene, vitamin C and Tomatine content.

Marker Assisted Selection

Molecular markers and marker-assisted selection (MAS) technology can potentially overcome at least some of the limitations associated with Plant Selection, major advantage of DNA markers is that they are 'neutral 'in phenotypic reactions, that is, they do not have any pleiotropic effect on the phenotype, nor are they influenced in their segregation and inheritance by the growing conditions of the plant. Currently, most of the markers used for tomato genetic mapping and breeding purposes are PCR-based, including randomly amplified polymorphic DNA (RAPD), simple sequence repeat (SSR; microsatellite), amplified fragment length polymorphism(AFLP), sequence characterized amplified region (SCAR),cleaved amplified polymorphic sequence (CAPS), single nucleotide polymorphism (SNP) and insertion-deletion (InDel) markers. For genetic markers to be useful for breeding purposes, several requirements must be met. MAS refer to the indirect selection for a desired plant phenotype based on the banding pattern of linked molecular markers (Singh *et al*., 2021).

Table 1. Molecular breeding for quality traits

Marker	Trait	Crop	Reference
SCAR	High-lycopene	Tomato	Lixia *et al.*, 2011
CAPS	High Pungency in *C. Chinense*	Chilli	Tanaka *et al.*, 2016

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SSR	Cold induced sweetness	Potato	Fischer *et al.*, 2013
SNP	High Beta carotene and Chlorophyll	Tomato	Manoharan *et al.*, 2017
SNP	Increased shelf life	Tomato	Maxwell *et al.*, 2022

Steps in Marker Assisted Selection

1. **Selection of Parents:** The parents selected for the mapping population will differ for one or more traits of interest. It means parents should be distantly related so that it provides adequate polymorphism.
2. **Development of mapping populations:** The mapping population should be larger in size. Several different populations may be utilized for mapping: 1. F2 populations 2. Backcross (BC) populations, 3. Recombinant inbred (RI) lines, 4. Doubled haploid (DH) populations.
3. **Identification of Polymorphism**
4. **The construction of Linkage Map with Polymorphic Markers:** Linkage map will be constructed by using the computer software's.
5. **Identification of Molecular Markers linked to the Trait of interest:** Based on the Linkage maps constructed, the tightly linked markers to the gene of interest are selected.
6. **Marker Validation:** Markers should also be validated by testing for the presence of the marker on a range of cultivars and other important genotype.

Marker-Assisted Backcrossing (MABC)

- Marker assisted selection refers to indirect selection for a phenotype based on banding pattern of linked molecular markers. Molecular breeding is effective in introgression of desirable genes from wild into cultivated genotypes (Singh *et al.*, 2021).There are mainly two stages in Marker assisted backcrossing those are-

Foreground Selection- Is used to identify our target locus with help of linked marker

Background Selection- Is used to test recovery of recurrent parent

Advantages of MABC over conventional method of breeding-are

1. Effective selection of target loci- In Conventional breeding selection is based on phenotypic, that's why there was no effective selection in case of backcross breeding

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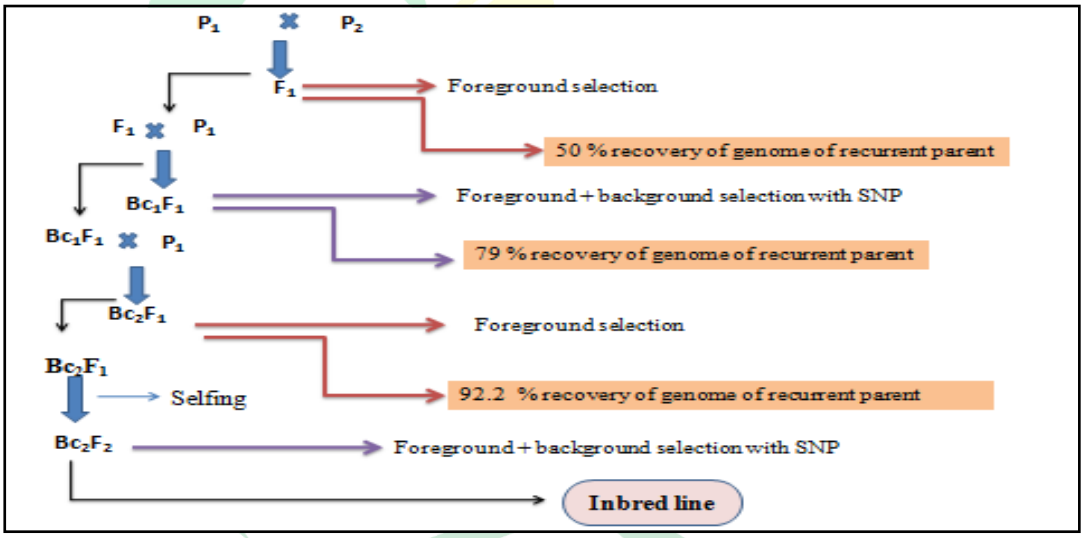
here with help of marker we can select our target loci means gene of interest which gene we want to transfer from donor to recurrent parent.

2. Minimize linkage drag- Actually back crossing we are using two parents (one is recurrent parent and another one is donor parent) donor parent is any wild variety have poor economic importance so that's why along with gene of interest some undesirable genes are transferred these is called linkage drag, so with help of MABC we can minimize linkage drag.
3. Accelerated recovery of recurrent parent- In Conventional breeding method we need more number of back cross population to get recovery of recurrent parent but in marker assisted selection we using marker than we need only two back cross population for complete recovery of genome up to 99.99 per cent.



Figue. 1. Schematic representation of marker-assisted back cross breeding in tomato by transferring *alcobaca* gene

Population development between recurrent and Donor parent

Here recurrent parent will be used as female and donor parent as male. Each recurrent parents are crossed with donor parent which is carrying gene of interest that is *alc* to generate F_1 seeds. (Fig.1). Next as we can see F_1 plants will be subjected to true hybridity gene test by using foreground selection. By this will get to know about F_1 plants which are in heterozygous nature. After the conformation of target gene present in F_1 plants they will used these F_1 for backcross with RP to generate BC_1F_1 seeds. In each generation they will go for foreground and background selection. In BC_1F_1 generation they got 79 per cent of recovery

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of RP. The selected BC_1F_1 plants again backcross with RP to generate BC_2F_1 seeds. Here they got 92.2 per cent recovery of genome of RP. And after these BC_2F_1 plants carrying gene of interest so they will go for continue selfing for two generation to produce BC_2F_2 and BC_2F_3 population. The final BC_2F_3 family called inbred line or near isogenic lines these will be evaluated for agronomic performance (Maxwell *et al*., 2022).

Conclusion

Nutritional qualities and associated health benefits of vegetable crops is becoming important criteria for their increase in consumer preference. Molecular markers associated with genes or QTLs have been reported for numerous economically-important traits in tomato. Theoretically, such marker information should be useful for improving qualitative traits in tomato *via* marker assisted breeding. Utilization of conventional breeding techniques along with powerful tools like Molecular markers, have great promise in reducing time and cost involved in breeding for improvement of quality traits in solanaceous vegetables.

References

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