Volume 2, Issue 6
June I 2024

Agri Roots
e- Magazine

www.agrirootsmagazine.in

ISSN: 2583-9071

Genetic Engineering of Horticultural Crops Contributes to The Improvement of Crop Nutritional Quality and Shelf Life

ARTICLE ID: 0108

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Biotechnology is considered one of the keys means to the country to achieve the goals of development strategies. Nowadays, there are several research groups spread all over the country, and dedicated to projects in horticultural biotechnology, quite strategic in the short- and long-term runs, as follows: development of insect or disease resistant crops and tolerant to abiotic stresses; improvement of nutritional composition of edible crops; manipulation of secondary metabolite routes in plants; reduction of post-harvest storing losses, shorting juvenile cycles for rapid improvement of native and exotic forest and fruit trees, and enhancing the nutritional quality of fruit crops.

Genetic engineering consists of isolation of a gene of interest, ligating that gene with a desirable vector to form the recombinant-DNA molecule and then transferring that gene into the plant genome to create a new function. In contrast to conventional breeding, which involves the random mixing of tens of thousands of genes present in both the resistant and susceptible plants, recombinant DNA technology allows the transfer of only the desirable genes to the susceptible plants and the preservation of valuable economic traits. Moreover, the genetic sources for resistance are not limited to closely related plant species (Lurquin, 2002). In contrast to the increasing global adoption of biotech field crops, biotechnology has had limited commercial success to date in horticultural crops, including fruits, vegetables, flowers and landscape plants. Horticultural biotechnology has been a leading example in the

following mentioned areas for more than two decades, right from the commercialization of the first ever transgenic crop in the form of Flavr-Savr transgenic tomato with enhanced shelf life trait. Amongst various genetically modified horticultural crops, GM papaya showing resistance to Papaya ring spot virus contributes to approx. 53% of the total share of GM horticultural crops cultivated globally. Herbicide tolerance trait is dominating the GM horticultural crop acreage followed by insect resistance and virus resistance traits.

Conventional Strategies to Prolong the Shelf Life

Commercially increased shelf life is accomplished by different strategies such as early harvest, control of storage atmosphere, and selection of late ripening genotypes. These methods are, however, not invariably applicable to all and results are sometimes unsatisfactory Ethylene is the determining agent to make climacteric fruits palatable albeit it also encourages senescence. Control of the internal ethylene induction contributes to the improvement of fruit quality. Modification and control of the atmosphere surrounding crops effectively reduce the product loss. Composition of gasses such as carbon dioxide, oxygen, and nitrogen affects the overall quality of the crop during the postharvest period. Manipulation of these gasses

reduces the ethylene rate and subsequently delays senescence (Beckles, 2012).

The Metabolic Basis Underlying Fruit Ripening and Shelf Life

Although ripening is considered as a destructive stage of development in fruits, the process is a precisely orchestrated act of development in plants (Klee and Giovannoni, 2011). Softening of fruit tissue ensures the dispersal of seeds inside and causes a successful spread of genetic alleles

in nature. Model plants have been a proper platform to study the plant metabolisms during different developmental stages.Fruit development and ripening are regulated by the interaction of different hormones and metabolites. Changes in the levels of hormones such as ethylene, abscisic acid (ABA), auxin, jasmonic acid (A), and methyl jasmonate (MeJA) affect the fruit ripening by altering the metabolites composition of cell.

Metabolic Alterations Incorporating the Increased Shelf Life

An enormous amount of fruit loss occurs during the postharvest period. To cope with the postharvest losses, conventional methods, such as harvesting the fruits while green and firm, have been applied widely. This, however, negatively affects the aroma, flavour, and tissue of the fruit . Investigations for efficient approaches to overcome Extension of postharvest storage period has been extensively investigated . Based on investigations, NOR gene regulates the majority of the genes associated with ripening process.

Resistance to Abiotic Stress Factors

Exposure of crops to abiotic factors in the field reduces the plant growth and productivity. Factors such as salinity, drought, high temperatures, freezing, metal toxicity, and nutrient deficiencies have been integrated to agriculture and crop production. Transformation of horticultural crops with genes involved in signalling and regulatory pathways as well as Osmo protective features have successfully improved the tolerance against abiotic stresses.

Resistance to Biotic Stress Factors

Insects and pathogens like viruses and fungi are the most devastating biotic factors forcing the farmers to spend millions of dollars to protect their produce each year. Besides the imposed costs and being unfriendly to the environment, application of chemicals like insecticides threatens the farmer and consumer's health (Curry, 2002), particularly for fruits and vegetables

Biofortification Of Fruits and Vegetables

Bio-fortification is a promising approach to sustainably deliver sufficient nutrients to the populations suffering from limited food resources (Saltzman et al., 2014). Crops such as apple, banana, tomato, cassava, potato, sweet potato, cauliflower, lettuce, and carrot have been successfully biofortified for vitamins, minerals, secondary metabolites, antioxidants, etc., through transgenic approaches (Garg et al., 2018)

Genome Editing as An Efficient Approach to Develop Crops with Better Nutritional Qualities

The employment of sequence-specific nucleases (SSNs) such as ZNFs, TALENs, and recently CRISPR)/Cas9 system has provided a promising horizon to reverse genetics to improve the quality and yield of crops and confer disease resistance (Klumper et al., 2014). Recently, CRISPR/Cas9 genome editing tool has been successful in genetic engineering of vegetables and fruits. The effectiveness of the CRISPR/Cas9-based genome editing in plants was first demonstrated in the model plants, Arabidopsis and Nicotiana benthamiana (Li et al., 2013;
Nekrasov et al., 2013).

Conclusion

It is challenging to control polygenic features, such as fruit flavour and nutritional quality, in hybrids using traditional breeding techniques. The drawbacks of traditional techniques have been effectively addressed by transgenic technologies. The public's approval is the main obstacle to the development of genetically engineered crops, though. Various regulatory procedures continue to limit the commercialization of genetically modified crops, despite a great deal of research being done to allay public fears. Numerous positive studies have attested to the significance of the plant genetic engineering method in terms of crop enhancements. It may be possible to accurately induce mutagenesis in the plant genome, especially with the development of new genetic editing techniques. The CRISPR/Cas9 system, the newest genome editing technology, has been effectively applied to a number of field crops.

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