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Genetically Modified Horticultural Crops

Motapalukula Jyothi[1] and Sabavat Raju Naik[2]
[1]Ph.D. Scholar, Department of Horticulture, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, (M.S.)
[2]Ph.D. Scholar, Department of Agricultural Botany, Vasantrao Naik Marathwada Krishi Vidyapeeth, Parbhani, (M.S.)

SUMMARY

Genetically modified (GM) crops are products of the introduction of one or more characterized genes in a crop plant using recombinant DNA technology. The inserted gene is known as a transgene and the plants containing transgenes are often called as transgenic crops. Herbicide tolerance and insect resistance are the main traits that are currently under commercial cultivation. Research on GM carrot, potato, eggplant, cucumber, and other vegetables in many countries which is directed at resistance and/or tolerance to insects, bacteria, fungi, viruses, herbicides and abiotic stress to improvement of economic properties, prolongation of consumption time, improvement of nutrition values and seedlessness of fruits.

INTRODUCTION

Ttransgenic crops are also referred as genetically modified crops having a part of alien gene or genes for elite traits have been inserted artificially into the genome. In the World, a total of 28 countries majorly United States, Brazil, Argentina, India, Canada, China, Paraguay, Pakistan, South Africa, Uruguay, Bolivia, Philippines, Australia, Burkina Faso, Myanmar, Mexico, Spain, Colombia, and Sudan were involved in commercial cultivation of GM crops. The commercial cultivation was started in 1990. More number of genetically modified crops were developed for commercial production due to the reduced use of chemicals, labours, costs and improved economic gain.

Insect Resistance

Transgenic eggplant, tomato, potato, cabbage, cauliflower, garlic, broccoli and chinese cabbage were developed with the use of various cry genes [cry1A, cry1Ab, cry1Ac, cry1A(b), cry1Ab3, cry1Ba1, cry1C, cry1Ba1, cry1Ia3, and cry9Aa] from Bt for resistance against numerous insects such as *Leptinotarsa decemlineata, Helicoverpa armigera, Macrosiphum euphorbiae, Bemisia tabaci, Colorado potato beetle, Plutella xylostella* etc. (Shelton *et al.*, 2002). Bangladesh was the first country approved and commercialized Bt brinjal in 2014. Transgenic plantain (Musa sp.) Cv. "Gonja manjaya" plants expressing a maize cystatin gene that inhibits the digestive cysteine proteinases and a synthetic peptide that disrupts nematode chemoreception (Roderick *et al.*, 2012).

Disease Resistance

For imparting bacterial and fungal resistance, various genes such as chitinase, glucanase, attacin, osmotin, cercopin, defensing, etc. are being transferred into various horticultural crops globally. Biotech grapevine resistant to viral, bacterial, and fungal diseases with abiotic stress tolerance and health benefits was developed in South Africa. Potato was made resistant to late blight by adding resistant genes blb1 and blb2 that originate from the Mexican wild potato (*Solanum bulbocastanum*). The transgenic plants of tomato with an AC4 gene - RNAi construct and the transgenic plants were found to show the suppression of tomato leaf curl virus activity (Praveen *et al.*, 2010). Girhepuje and Shinde (2011) developed transgenic tomato plants expressing a wheat endochitinase gene and during disease screening the transgenic plants exhibited enhanced resistance to *Fusarium oxysporum*.

Transgenic tomato plants expressing hairpin RNA (hpRNA) constructs against Agrobacterium iaaM and ipt oncogenes were found to be resistant to crown gall disease (Escobar *et al.*, 2001). The HcrVf2 gene from a wild apple conferred scab resistance to a transgenic cultivated variety of apple (Belfanti, 2004). Faize *et al.*, (2004) developed transgenic apple plants with a wheat puroindoline-b (pin B) gene under a CaMV35S promoter and observed that the expression of pin-b gene reduced scab susceptibility in transgenic apple plants. The commercial watermelon cultivars transformed with an untranslatable chimeric construct containing truncated zucchini yellow mosaic virus CP and PRSV WCP genes (Yu *et al.*, 2010). "Sun Up" is a transgenic red-fleshed Sunset papaya cultivar and "Rainbow" is a yellow-fleshed F1 hybrid papaya resistant to papaya mosaic virus is grown in the United States and China (James, 2011). Honeysweet plum is highly resistant to PPV, the most devastating disease of plums and other stone fruits.

Figure: First Genetically Engineered Plum Pox Virus- Resistant Plum

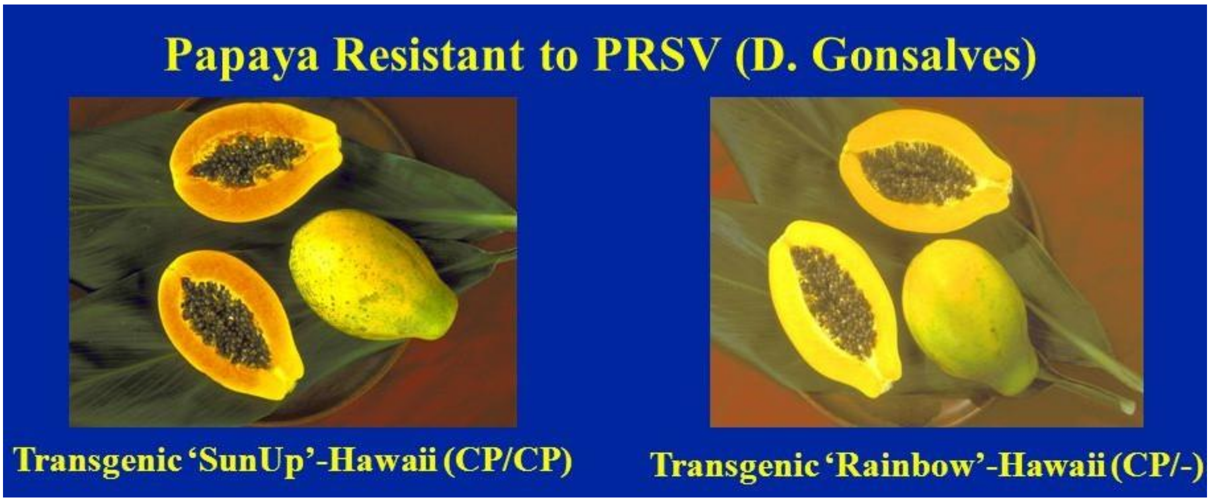

Figure: Genetically Modified Papaya Varieties

Herbicide Resistance

The herbicide glyphosate is a potent inhibitor of the enzyme 5-enolpyruvylshikimate-3-phosphate synthase (EPSP) in higher plants. Transgenic pineapple plants transformed with the bar gene for bialaphos resistance were developed by Sripaoraya *et al.*, (2006). Transgenic plants tolerant to glufosinate ammonium should facilitate more effective weed control in pineapple plantations without damage to the crop.

Nutritional Improvement

Calgene Inc., USA (1994), developed the first commercialized transgenic plant, a long shelf-life tomato (Flavr Savr) by the suppression of the polygalacturonase (PG) gene by antisense strategy. The Flavr Savr tomatoes have improved flavor and total soluble solids, in addition to enhanced shelf-life. Nambeesan *et al.*, (2010) expressed a yeast spermidine synthase (ySpdSyn) gene under constitutive (CaMV35S) and fruit-ripening-specific (E8) promoters in Tomato. The ySpdSyn transgenic fruits had a longer shelf-life, reduced shriveling, and delayed decay symptom development in comparison with the wild-type fruits. Zhang *et al.*, (2011) developed transgenic tomato plants by silencing the expression of the mitochondrial APX gene by an RNAi mechanism and observed increased vitamin C content in the transgenic tomato fruits. In 2014, the USDA approved a GM potato developed by J.R. Simplot Company that contained 10 genetic modifications that prevented bruising and produced less acrylamide when fried.

Researchers at Horticultural Research International, UK, have identified the genes that control the taste, smell, and color of strawberries. GM pineapple that is pink in color and that "overexpresses" a gene derived from tangerines and suppresses other genes, increasing production of lycopene. In 2015, Arctic Apples were approved by the USDA, becoming the first GM apple approved for sale in the United States.

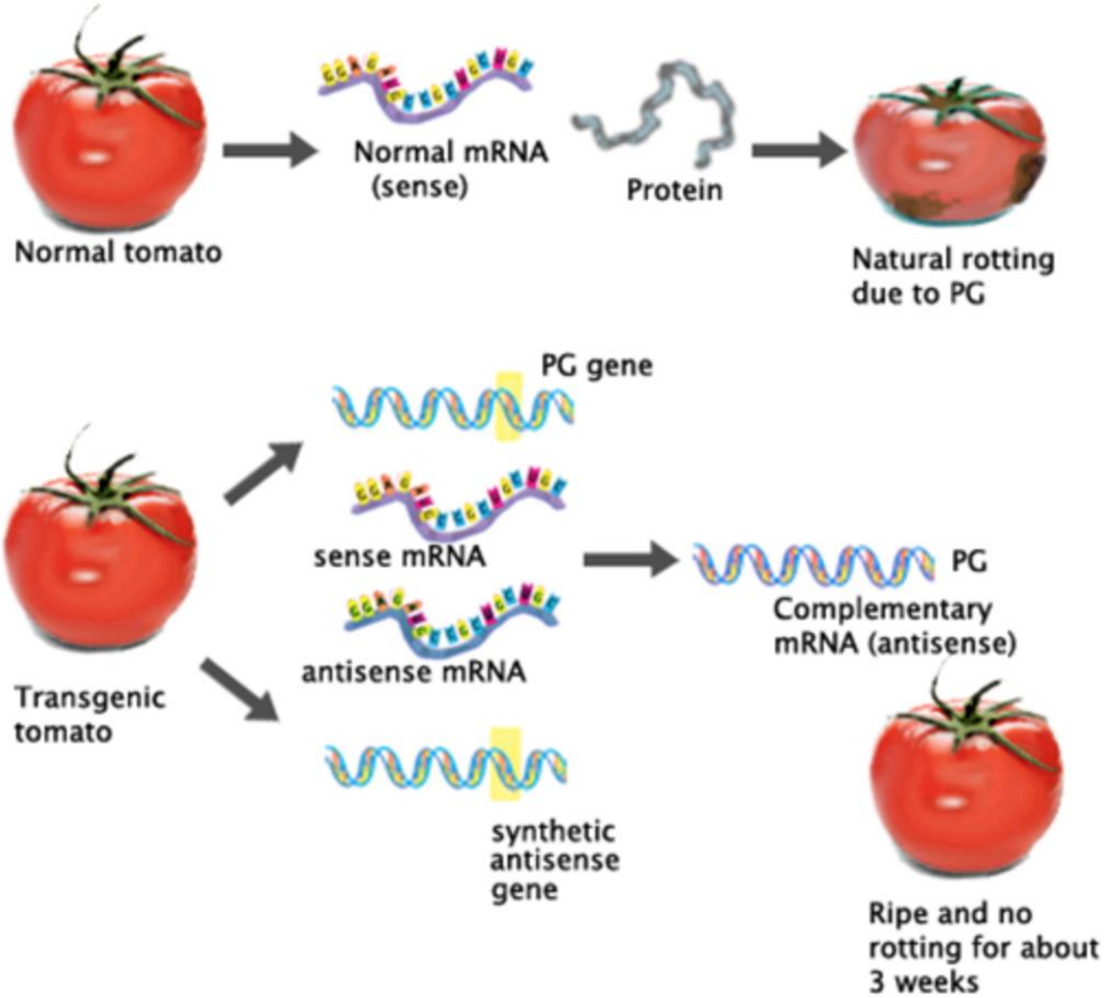

Figure: Long shelf-life tomato (Flavr Savr) which remains fresh for a longer period than normal tomato variety

Abiotic Stress Resistance

Research on genetic modification of various horticultural crops for improved abiotic stress tolerance has been explored with transformed tomato plants with a DNA cassette containing an Arabidopsis C repeat/dehydration-responsive element binding factor 1 (CBF1) complementary DNA (cDNA) and a nos terminator, driven by a cauliflower mosaic virus 35S promoter. These transgenic tomato plants were more resistant to deficit water stress than the wild-type plants (Tsai-Hung *et al.*, 2002). The transformation of the bacterial mannitol-1-phosphodehydrogenase (mtlD) gene, which is involved in mannitol synthesis, in eggplants expressed stress against drought, salinity, and cold (Prabhavathi *et al.*, 2002). The induced salt tolerance in cabbage through the introduction of the bacterial glycine betaine biosynthesis (BetA) gene, which is involved in biosynthesis of glycine betaine (Bhattacharya *et al.*, 2004). The expression of the tobacco osmotin gene in *Capsicum annuum* and the transgenic chilli plants exhibited improved salt tolerance. Cheng *et al.* (2009) developed transgenic tomato plants expressing the yeast SAMDC gene, which improved the efficiency of CO_2 assimilation and protected the plants from high-temperature stress (38°C) as compared to the wild-type plants. A bacterial mannitol-1-phosphate dehydrogenase (mtlD) gene driven by the constitutive cauliflower mosaic virus (CaMV) 35S promoter was transferred into tomato plants in an attempt to improve abiotic stress tolerance (Khare *et al.*, 2010).

Over-expression of the MusaWRKY71 gene from Musa spp. Cv. Karibale Monthan (ABB group), encoding a WRKY transcription factor protein, provides multiple abiotic stress tolerance in banana. An improved tolerance to cold and drought stress in transgenic apple through overexpression of the cold-inducible Osmyb4 gene from rice, encoding a transcription factor belonging to the Myb family (Pasquali *et al.*, 2008). Osmotin is one of the important pathogenesis-related proteins released during abiotic stress conditions. Subramanyam *et al.*, (2011) reported the overexpressed tobacco osmotin gene in transgenic strawberry *(Fragaria* x *ananassa* Duch.) plants exhibited tolerance to salt stress.

CONCLUSION

The cultivation and commercial production of GM crops are capital intensive because of the high costs of seed and technology. Nevertheless, their cultivation has increased, mainly because of the benefits accrued from lower labor and production costs, reduction in the use of chemical inputs, and improved economic gain. GM crops are a possible solution for the widely discussed current problems of food and nutritional security. GM foods have the potential to solve many of the world's hunger and malnutrition problems and to help protect and preserve the environment by increasing yield and reducing reliance upon chemical pesticides and herbicides.

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