Transgenic Research in Fruit Crops: Current Status

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Abstract

Gene mining for various biotic and abiotic stresses could be utilized only when we can transfer them to our important crops so that a large number of the population can be benefitted by this. In this light gene transfer through various methods can be done and it will be more useful where traditional breeding approach is not feasible. However, transgenic research in fruit crops is very low so that present information will be utilized by fruit breeders to design future program for developing transgenic that ultimately open the way for those crops where gene transfer is difficult through conventional breeding.

Keywords: Transgenic; Gene transfer; Genetically modified foods; Fruit crops

Short Communication

A transgenic crop plant contains a gene which has been artificially inserted instead of the plant, acquiring them through fertilization or pollination. The inserted gene sequence (known as the transgene) may come from another unrelated plant. Breeder always tries to incorporate beneficial genes in a crop which will be more useful and productive. Through conventional breeding approaches genes can be incorporated from related species, but most of the times it does not possible due to several reasons, so in that case transgene pave the wonderful way, where gene can be taken from unrelated species. This technology provides the means for identifying and isolating genes controlling specific characteristics in one kind of organism, and for moving copies of those genes into another quite different organism, which will then also have those characteristics. This technology enables plant breeders to do what they have always done generate more useful and productive crop varieties containing new combinations of genes, but it expands the possibilities beyond the limitations imposed by traditional cross-pollination and selection techniques. The most important transgenic crop in terms of acreage planted is soybean, followed by corn, cotton, and canola. However, transgenic research in fruit crops is very low due to difficulty in regeneration and transformation procedure being perennial and woody in nature. Details of transgenic research in fruit crops are presented in Table 1. Success of this technology is of great concern due to associated possible risks. For that proper Biosafety guidelines must be followed.

Advantages of Genetically Modified Fruit Crops

The world population is predicted to double in the next 50 years. Ensuring an adequate food supply is going to be a major challenge, therefore, genetically modified fruit crops may pave a way to meet these challenges in a number of possible paths:

Insect-pests and disease resistance

Crop losses from insect-pests and diseases are of big concern due to devastating financial loss for farmers and starvation in developing countries. Applications of chemical pesticides are increasing annually. This is a serious cause for potential health hazards, and even run-off of agricultural wastes from excessive use of pesticides and fertilizers can poison the water supply and cause harm to the environment. Fruits usually we consume in raw form so it is more harmful if we eat them as such. Therefore, growing insect-pest and disease resistance GM fruits such as papaya, grapes, and apple etc. not only reduces the economic losses but also ensure to provide chemical free fruits (Table 1) [1-31].

Herbicide resistance

For some fruit crops, it is not cost-effective to remove weeds by physical means such as tillng, so farmers will often spray large quantities of different herbicides to destroy weeds, a time-consuming and expensive process that requires care so that the herbicide doesn’t harm the crop plant or the environment. Crop plants genetically-engineered to be resistant to one very powerful herbicide could help prevent environmental damage by reducing the amount of herbicides needed. For example, cranberry is genetically modified using bar, aphII gene possess herbicide tolerance properties (Table 1) [1-31].

Cold tolerance

The unexpected frost can destroy sensitive seedlings in many fruit crops. Genetic transformation of guava with cold hardiness genes (CBF1, CBF2 and CBF3) make these plants able to tolerate cold temperatures that normally would kill unmodified seedlings (Table 1) [24-26].

Drought/salinity tolerance

The tailoring plants that can withstand long periods of drought or high salt content in soil and groundwater will help farmers to grow crops in formerly inhospitable places. For example Poncirus trifoliate showed enhanced salt tolerance after transformed with nptII, AhBADH gene [30].
Pharmaceuticals medicines and vaccines

These are costly to produce and sometimes require special storage conditions. With the help of genetic engineering, reaching that goal is becoming more realistic. In recent years, researchers have developed "edible vaccines," foods that contain the power to protect against disease and must only be eaten to be effective. These vaccines will be much easier to ship, store and administer than traditional injectable vaccines. These edible vaccines would certainly provide a more practical method of disease control than traditional immunizations and could come at much less cost and inconvenience for the consumer. Tests are already underway to determine the effectiveness of edible vaccines against the Hepatitis B virus and for the bacterial disease cholera.

| Fruit Crop   | Trait                              | Research work                                                                 | Reference                                      |
|--------------|------------------------------------|-------------------------------------------------------------------------------|------------------------------------------------|
| Apple        | Reduced polyphenol oxidase         | PPO suppression transgene, nptII, PPO suppression transgenes (AP14, APOS, PGAS, PGAS2), nptII | Gebbers Farms, Cornell University, University of California/Davis, USDA ARS; [1-3] |
|              | Reduced PQ-Polyphenol Oxidase Levels | ACC oxidase, ACC synthase S6PDH sorbitol 6, phosphate dehydrogenase, GUS, nptII |                                                 |
|              | Ethylene suppression                | BpMADS4, NPTII attE, nptII, gusA                                               |                                                 |
|              | Altered sorbitol levels            | ech42, nag70, npt II                                                          |                                                 |
|              | Juvenile stage reduced             |                                                                               |                                                 |
|              | Resistance to fire blight          |                                                                               |                                                 |
|              | Scab resistance                    |                                                                               |                                                 |
| Banana       | Bunchy top resistance              | Replicate associated protein, replicate inverted repeat, nptII                 | University of Hawaii; [4-7]                     |
|              | Resistant to Xanthomonas wilt      | Hrap and Pflp                                                                 |                                                 |
|              | Tolerance to Sigatoka              | pYG39                                                                         |                                                 |
|              | Leaf spot                         | pAB6, pAHC17, pH1                                                             |                                                 |
|              | Resistance to virus                | pflp, nptII                                                                   |                                                 |
|              | Resistance to Fusarium wilt       |                                                                               |                                                 |
| Papaya       | Female to male or hermaphrodite    | EST116, EST5, FSH11, FSH19, Gene11Y, Gene5, GM183, nptII                      | Hawaii Agriculture Research Center, Cornell U. and U. Florida; [8-15]    |
|              | PRSV resistant                     | Coat Protein gene                                                             |                                                 |
| Grapevine    | Xylella fastidiosa resistance      | Endogenous grapevine antifungal gene, Altgene, defensin gene, EGFP/NPTII, Lima-A, Lima-B, PR1 gene, Snakin gene, SuSy antisense, VvMybA1, VVTL-1, rice chitinase gene, hsp | University of Florida; [16-19]                   |
|              | Powdery mildew resistance          | Mutant virE2,nptII, GLRaV-3cp, chitinase, rip, nptII                         |                                                 |
|              | Increased anthocyanin              |                                                                               |                                                 |
|              | Increased seedlessness             |                                                                               |                                                 |
|              | Resistance to viruses, crown gall, fungal pathogens |                                                                               |                                                 |
| Grape Rootstock | Grapevine fanleaf nepovirus resistance | Coal protein gene, heat shock 90 homologous nptII gene                      | Cornell University                             |
|              | Grapevine leafroll-associated amellovirus resistance |                                                                               |                                                 |
|              | Grapevine leafroll-associated clusteroovirus resistance |                                                                               |                                                 |
| Grapefruit   | Aphid resistance                   | agglutinin, coat protein, GUS, nptII                                          | Texas Agri Life Research (Texas A&M), [20]    |
| Citrus       | Citrus tristeza virus resistance   |                                                                               |                                                 |
| paradisi     |                                    |                                                                               |                                                 |
| Plum         | Non-browning; resistance to Plum pox virus (PPV) | PPV coat protein -                                                           | Okanagan Specialty Fruits, [21-23]            |
| Guava        | Endochitinase gene against guava wilt | Genetic transformation of guava (Psidium guajava L.) was developed for the first time using in vitro grown shoot tip explant cocultivated with A. tumefaciens strain LBA4404 harbouring binary vector piliHR-JBMc with endochitinase and nptII genes | [24-26]                                        |
| Cranberry    | Herbicide resistance              | bar, aphII                                                                    | [27]                                           |
| Vaccinium    |                                    |                                                                               |                                                 |
| macrocarpon  |                                    |                                                                               |                                                 |
| Orange       | Resistance to fungi                | nptII, PR-5                                                                   | [28]                                           |
Possible Challenges and Solutions

Genetically modified fruit crops are beneficial yet there are many challenges ahead for governments, especially in the areas of safety testing, regulation, international policy and food labelling. Therefore, we must proceed with caution to avoid causing unintended harm to human health and the environment. Some of the challenges are:

1. The transfer of pollen between modified and non-modified plants could also create health and ecological problems involves. There is a growing concern that introducing foreign genes into food plants may have an unexpected and negative impact on human health on the whole, with the exception of possible allergenicity, scientists believe that GM foods do not present a risk to human health.

2. Bringing a GM food to market is a lengthy and costly process, and of course agro-biotech companies wish to ensure a profitable return on their investment. Many new plant genetic engineering technologies and GM plants have been patented, and patent infringement is a big concern of agribusiness. Patenting these new plant varieties will raise the price of seeds so high. It is hoped that in a humanitarian gesture, companies and non-profits will follow the lead of the Rockefeller Foundation and offer their products at reduced cost.

3. Patent enforcement may also be difficult. One way to combat possible patent infringement is to introduce a "suicide gene" into GM plants. These plants would be viable for only one growing season and would produce sterile seeds that do not germinate. Farmers would need to buy a fresh supply of seeds each year. However, this would be financially disastrous for farmers in third world countries who cannot afford to buy seed each year and traditionally set aside a portion of their harvest to plant in the next growing season. In an open letter to the public, Monsanto has pledged to abandon all research using this suicide gene technology [32].

Conclusion

Genetically-modified fruit crops in addition to food grain crops 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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Table 1: Details of transgenic research in fruit crops for different traits.

| Fruit Crops | Traits | Genes |
|-------------|--------|-------|
| *C. sinensis* | Resistance to virus | nptII, sgfp, p23 |
| *C. aurantifolia* | Enhanced salt tolerance | nptII, AhBADH |
| *Poncirus trifoliate* | Improved rooting | nptII, rol A,B,C |

Source: Information Systems for Biotechnology, Virginia Tech

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