Advancements in Genetic Engineering
ISSN: 2169-0111
Sharma, et al., Adv Genet Eng 2016, 5:3
DOI: 10.4172/2169-0111.1000155
Short Communication

Transgenic Research in Fruit Crops: Current Status

Nimisha Sharma[1*], Sanjay Kumar Singh[1] and Lal S[2]

[1]*ICAR- Indian Agricultural Research Institute, New Delhi, India*

[2]*Central Institute of Temperate Horticulture, Srinagar, Jammu & Kashmir, India*

***Corresponding author:** Nimisha Sharma, 1ICAR- Indian Agricultural Research Institute, New Delhi, India, 110012, Tel: +91-1125843214, Fax No: +91-11-25843214, E-mail: nimishasharma@iari.res.in, nims17sharma@gmail.com

Received date: April 16, 2016; **Accepted date:** May 30, 2016; **Published date:** June 1, 2016

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 a 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 tilling, 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 *M. domestica*	• Reduced polyphenol oxidase • PQ-Polyphenol Oxidase Levels Reduced • Ethylene suppression • Altered sorbitol levels • Juvenile stage reduced • Resistance to fire blight • Scab resistance	• *PPO* suppression transgene, • *nptII PPO suppression transgenes (AP14, APO5, PGAS, PGAS2), nptII* • ACC oxidase, ACC synthase *S6PDH* sorbitol 6 • phosphate dehydrogenase, *GUS, nptII* • *BpMADS4, NPTII attE, nptII, gusA* • *ech42, nag70, npt* • *II*	Gebbers Farms, Cornell University, University of California/Davis, USDA ARS; [1-3]
Banana *Musa* spp.	• Bunchy top resistance • Resistant to *Xanthomonas* wilt • Tolerance to *Sigatoka* • leaf spot • Resistance to virus • Resistance to *Fusarium* wilt	• Replicase associated protein, replicase inverted repeat, *nptII* • *Hrap* and *Pflp* • *pYC39* • *pAB6, pAHC17, pH1* • *pflp, nptII*	University of Hawaii; [4-7]
Papaya	• Female to male or hermaphrodite • PRSV resistant	• *EST116, EST5, FSH11, FSH19, Gene11Y, Gene5, GM183, nptII* • Coat Protein gene	Hawaii Agriculture Research Center, Cornell U. and U. Florida; [8-15]
Grapevine *V. vinifera*	• *Xylella fastidiosa* resistance • Powdery mildew resistance • Increased anthocyanin • Increased seedlessness • Resistance to viruses, • crown gall, fungal pathogen	• Endogenous grapevine *antifungal gene, Albgene, defensin gene, EGFP/NPTII, Lima-A, Lima-B, PR1 gene, Snakin gene, SuSy* antisense,*VvMybA1, VVTL-1*, rice *chitinase gene, hgt* • Mutant *virE2,nptII* • *GLRaV-3cp; chitinase, rip, nptII*	University of Florida; [16-19]
Grape Rootstock	• Grapevine fanleaf *nepovirus* resistance • Grapevine leafroll-associated *ampelovirus* • resistance • Grapevine leafroll-associated *closterovirus* • resistance	• Coat protein gene, heat shock 90 homologous • *nptII gene*	Cornell University
Grapefruit *Citrus* *paradisi*	• Aphid resistance • *Citrus tristeza* virus resistance	• agglutinin, coat protein, *GUS, nptII*	Texas Agri Life Research (Texas A&M), [20]
Plum	• Non-browning; resistance to Plum pox virus (PPV)	• PPV coat protein -	Okanagan Specialty Fruits, [21-23]
Guava	• *Endochitinase* gene against guava wilt • *nptII and GUS* • genetic transfor-mation of guava with cold hardiness genes *(CBF1, CBF2 and CBF3)*	• 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 *pIIHR-JBMch* with *endochitinase* and *nptII* genes	[24-26]
Cranberry *Vaccinim* *macrocarpon*	Herbicide resistance	*bar, aphII*	[27]
Orange,	Resistance to fungi;	*nptII, PR-5*	[28]

C. sinensis			
C. aurantifolia	Resistance to virus	*nptII, sgfp, p23*	[29]
Poncirus trifoliate	Enhanced salt tolerance	*nptII, AhBADH*	[30]
Kiwifruit *A. deliciosa*	Improved rooting	*nptII, rol* A,B,C	[31]
Source: Information Systems for Biotechnology, Virginia Tech			

Table 1: Details of transgenic research in fruit crops for different traits.

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, more 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.

Acknowledgement

We thank Director IARI, New Delhi for facilitating the research work.

References

1. Ko K, Norelli JL, Reynoird JP, Boresjza-Wysocka E, Brown SK, et al. (2000) Effect of untranslated leader sequence of AMV RNA 4 and signal peptide of pathogenesis-related protein 1b on attacin gene expression, and resistance to fire blight in transgenic apple. Biotechnology Letters 22: 373-381.
2. Bolar JP, Norelli JL, Wong KW, Hayes CK, Harman GE, et al. (2000) Expression of endochitinase from Trichoderma harzianum in transgenic apple increases resistance to apple scab and reduces vigor. Phytopathology 90: 72-77.
3. Faize M, Malnoy M, Dupuis F, Chevalier M, Parisi L, et al. (2003) Chitinases of Trichoderma atroviride induce scab resistance and some metabolic changes in two cultivars of apple. Phytopathology 93: 1496-1504.
4. Tripathi L (2012) Transgenics in crop improvement research at IITA. IITA Research for Development (R4D) Review 8: 58-60.
5. Vishnevetsky J, White Jr. TL, Palmateer AJ, Flaishman M, Cohen Y, et al. (2011) Improved tolerance toward fungal diseases in transgenic Cavendish banana (Musa spp. AAA group) cv. Grand Nain. Transgenic Research 20: 61-72.
6. Ismail RM, El-Domyati FM, Wagih EE, Sadik AS, Abdelsalam AZE (2011) Construction of banana bunchy top nanovirus-DNA-3 encoding the coat protein gene and its introducing into banana plants cv. Williams. Journal of Genetic Engineering and Biotechnology 9: 35-41.
7. Yip MK, Lee SW, Su KC, Lin YH, Chen TY, et al. (2011) An easy and efficient protocol in the production of pflp transgenic banana against Fusarium wilt. Plant Biotechnology Reports 5: 245-254.
8. Cai WQ, Gonsalves C, Tennant P, Fermin G, Souza M, et al. (1999) A protocol for efficient transformation and regeneration of Carica papaya L- In Vitro Cellular and Developmental Biology. Plant 35: 61-69.
9. Fitch MM, Manshardt RM, Gonsalves D, Slightom JL, Sanford JC (1992) Virus resistant papaya derived from tissues bombarded with the coat protein gene of papaya ringspot virus. Bio-Technology 10:1466-1472.
10. Chen G, Ye CM, Huang JC, Yu M, Li BJ (2001) Cloning of the papaya ringspot virus (PRSV) replicase gene and generation of PRSV-resistant papayas through the introduction of the PRSV replicase gene. Plant Cell Reports 20: 272-277.
11. Lines RE, Persley D, Dale JL, Drew R, Bateson MF (2002) Genetically engineered immunity to papaya ringspot virus in Australian papaya cultivars. Molecular Breeding 10:119-129.
12. Tennant PF, Gonsalves C, Ling KS, Fitch MM, Manshardt R, et al. (1994) Differential protection against papaya ring spot virus isolates in coat protein gene transgenic papaya and classically cross-protected papaya. Phytopathology 84:1359-1366.
13. Fermin G, Inglessis V, Garboza C, Rangel S, Dagert M, et al. (2004) Engineered resistance against PRSV in Venezuelan transgenic papayas. Plant Disease 88 (5):516-522.

14. Magdalita PM, Valencia LD, Ocampo ATID, Tabay RT, Villegas VN (2004) Towards development of PRSV resistant papaya by genetic engineering. In: New Directions for a Diverse Planet, Proceedings of the 4th International Crop Science Congress, Brisbane, Australia.
15. Azad MAK, Rabbani MG (2005) Genetic transformation of Carica papaya by infecting mature zygotic embryos with Agrobacterium tumefaciens strain. LBA-4404. Biotechnology 4 (3):235-237.
16. Nirala NK, Das DK, Srivastava PS, Sopory SK, Upadhyaya KC (2010) Expression of a rice chitinase gene enhances antifungal potential in transgenic grapevine (Vitis vinifera L.). Vitis 49: 181-187.
17. Xue B, Ling KS, Reid CL, Krastanova S, Sekiya M, et al. (1999) Transformation of five grape rootstocks with plant virus genes and a virE2 gene from Agrobacterium tumefaciens. In Vitro Cellular and Developmental Biology - Plant 35: 226-231.
18. Yamamoto T, Iketani H, Ieki H, Nishizawa Y, Notsuka K, et al. (2000) Transgenic grapevine plants expressing a rice chitinase with enhanced resistance to fungal pathogens. Plant Cell Reports 19: 639-646.
19. Bornhoff BA, Harst M, Zyprian E, Töpfer R (2005) Transgenic plants of Vitis vinifera cv. Seyval blanc. Plant Cell Reports 24: 433-438.
20. Febres VJ, Lee RF, Moore GA (2008) Transgenic resistance to Citrus tristeza virus in grapefruit. Plant Cell Reports 27: 93-104.
21. Hily JM, Scorza R, Malinowski T, Zawadzka B, Ravelonandro M (2004). Stability of gene silencing-based resistance to plum pox virus in transgenic plum (Prunus domestica L.) under field conditions. Transgenic Research 13: 427-436.
22. Malinowski T, Cambra M, Capote N, Zawadzka B, Gorris MT, et al. (2006) Field trials of plum clones transformed with the Plum Pox Virus Coat Protein (PPV-CP) Gene. Plant Disease 90: 1012-1018.
23. Polak J, Pivalova J, Kundu JK, Jokes M, Scorza R, et al. (2008) Behavior of transgenic plum pox virus-resistant Prunus domestica L. clone C5 grown in the open field under a high and permanent infection pressure of the PPV-Rec strain. Journal of Plant Pathology 90: S1.33-S1.36.
24. Mishra M, Jalil SU, Sharma N, Hudedamani U (2014) An Agrobacterium mediated transformation system of guava (Psidium guajava L.) with endochitinase gene. Crop Breeding and Applied Biotechnology 14: 232-237.
25. Biswas BK, Yadav A, Joshee N, Yadav AK (2005) In vitro plant regeneration and genetic transformation to enhance cold hardiness in guava: a nutraceutical fruit. In: Proceeding of Ist International Guava Symposium, CISH, Lucknow, India, pp. 31-32.
26. Biswas BK, Joshee N, Yadav A, Yadav AK (2007) Development and applications of biotechnology in guava: a nutraceutical fruit. In: Desjardins, Y. (ed.), ActaHortic. 744: Ist International Symposium on Human Health Effects of Fruits and Vegetables. , pp. 267-276.
27. Zeldin E, Jury TP, Serres RA, McCown BH (2002) Tolerance to the herbicide glufosinate in transgenic cranberry (Vaccinium macrocarpon Ait.) and enhancement of tolerance in progeny. Journal of American Society for Horticultural Science 127: 502-507.
28. Fagoaga C, Rodrigo I, Conejero V, Hinarejos C, Tuset JJ, (2001) Increased tolerance to Phytophthora citrophthora in transgenic orange plants constitutively expressing a tomato pathogenesis related PR-5. Molecular Breeding 7: 175-185.
29. Fagoaga C, López C, Hermoso de Mendoza A, Moreno P, Navarro L, et al. (2006) Post-transcriptional gene silencing of the p23 silencing supperssor of Citrus tristeza virus confers resistance to the virus in transgenic Mexican lime. Plant Molecular Biology 60:153-165.
30. Fu X, Khan EU, Hu SS, Fan QJ, Liu JH (2011) Overexpression of the betaine aldehyde dehydrogenase gene from Atriplex hortensis enhances salt tolerance in the transgenic trifoliate orange (Poncirus trifoliate L. Raf). Environmental and Experimental Botany 74: 106-113.
31. Rugini E, Pellegrineschi A, Mecuccini M, Mariotti D (1991) Increase of rooting ability in the woody species kiwi (Actinidia deliciosa A. Chev.) by transformation with Agrobacterium rhizogenes rol genes. Plant Cell Reports 6: 291-5.
32. Robert Shapiro B (1999) Rockefeller Foundation. Monsanto announced it will not pursue technologies that render seed sterile. Monsanto. (http://www.monsanto.com/monsanto/gurt/default.html).