The Use Of Genetic Engineering Methods In Breeding Ornamental Plants

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From the mid 1980s the use of recombinant DNA technology for plant improvement began to be developed commercially. Now, genetic modification methods can access genes for disease and insect resistance, modification of biochemical pathways and herbicide resistance from a much wider range of sources than previously available. Plant varieties can be modified with no loss of the original parental phenotype, saving many generations in back crossing. Genetic engineering programs in the ornamental area are focused on improving agronomic quality (e.g. disease resistance, keeping quality, pest resistance) and creating novelty (e.g. form, colour) in the important cutflower and pot plants crops. Progress in these areas will be reviewed. From the context of commercialisation, the areas of intellectual property, patent ownership (as opposed to plant breeder rights), government regulation of genetic engineering, and public perception of genetic engineering are central and will be briefly reviewed.

INTRODUCTION

The purpose of this article is to summarise the commercial aspects associated with marketing new ornamental crops developed using genetic engineering. The science behind the technology has been covered elsewhere in this symposium. The review has in mind the main foliage and flowering pot plants and the world's major cut flowers, despite potential applications of genetic engineering to ornamental forestry, turf management, orchards, and the hundreds of other foliage and flower crops. Genetic engineering methods can only economically be applied to major crops.

For further information interested readers are recommended to read recent articles by Boulter (1995), Goy and Duesing (1995), Hammerschlag (1995), and Owens (1995).

POTENTIAL OF GENETIC ENGINEERING FOR ORNAMENTAL PLANT IMPROVEMENT

Most work on plant genetic engineering has targeted major food crops, e.g. soybean, wheat, maize, potato, tomato, oilseed rape, and sugar beet (Goy and Duesing, 1995). In these crops the first commercial products, now available overseas, include varieties in which genes:

- Confer insect resistance by expression of insect toxin genes from the bacterium *Bacillus thuringiensis* (the Bt genes).
- Confer resistance to the herbicides bromoxynil, glyphosate, sulphonylureas, or Basta by insertion of "resistant protein" genes and detoxification genes. In this case, genes are from bacteria or plants.

- Improve postharvest quality of tomato by inhibiting expression of genes involved in the degradative process, i.e. ethylene biosynthesis or carbohydrate degradation.
- Modify fatty acid composition of oilseed rape (canola).
- Induce virus resistance in squash.

Ornamental plants have seen less development using genetic engineering. However, the technology is equally applicable (Hammerschlag, 1995). Owens (1995) lists in detail the type of genes which might be put to good use by breeders of ornamental plants.

Disease Resistance. Major pathogens such as *Botrytis*, *Fusarium,* and *Pythium* cost the ornamental industry a huge amount of money, in control and losses. By insertion of anti-pathogen genes such as chitinases, glucanases, and proteinase inhibitors, the plant will hopefully have an in-built defence against pathogen attack. This could be beneficial during both vegetative growth and post harvest, and projects are underway by government institutes in both the Netherlands and Israel.

Insect Resistance. In the cutflower industry particularly, any variety which could be resistant, or even immune to attack by insects (particularly thrips, aphids, and mites) would be very valuable. A survey of Dutch flower growers indicated insect resistance, after fungal resistance, would be the most useful application of the technology from their perspective.

Flower Colour. Flower colour is a primary selection trait for breeders of cut and pot flower crops. Novel colours attract attention in the market, and may also capture higher prices. The ability to produce colour ranges in very good varieties, or to create colour groups novel to particular crops is therefore one current use of the technology. Florigene has isolated the blue gene from petunia—a gene essential for biosynthesis of the blue delphindin pigments. By inserting this into the major cut flower crops novel blue, mauve, violet, and lavender flowers will be produced. It is also possible to produce white and pink colours from red and purple varieties.

Growth Form. The amount of flowering and the habit (e.g. branching, stature) of a plant can be controlled by application of growth regulators such as cytokinins and auxins. Insertion of genes for the biosynthesis of these compounds has been shown to affect growth habit of the pot-grown rose and ornamental tobacco by French workers.

"Anti-senescence" Genes. The production of, or exposure to , ethylene causes flower abscission or senescence in a number of very important cutflower and pot flower crops, e.g. carnation, begonia, lily, and rose. Technology is now available to prevent ethylene production by the plant and/or to confer plants resistant to exogenous ethylene. Florigene has genetically engineered carnation to last 2 to 3 times longer in water than the unengineered parents. Varieties containing these genes will prove beneficial at all levels in the marketing chain; grower, wholesaler, and consumer.

PROGRESS TOWARDS COMMERCIALISATION

Commercialisation of genetically engineered plants is complex, as the technology introduces the need to deal with commercial avenues not necessary for conventionally bred ornamentals. These are:

Intellectual Property. The technology used in genetic engineering is protected by broad patent protection. The promoters, genes, tissue culture techniques, and even the final trait, may be the subject of specific patents, usually owned by different companies. Commercialisation will therefore require the negotiation of licences, licence fees, and royalty payments to the owners of the technology. As the final product contains patented technology it is afforded the protection of patent law. This raises the question of whether it is useful to go to the additional expense of registration of a variety under plant breeder rights legislation.

Regulatory Approval for Release. All governments either legislate or enact guidelines to monitor and control the marketing of genetically engineered organisms, including ornamentals. In Australia, the Genetic Manipulation Advisory Committee (GMAC) does this work. Following a public enquiry in 1992 the intention is to legislate to control releases. The purpose of regulation is to assess whether the modification will have any undesired environmental or health effects.

For example:

- Could the inserted gene escape to weed populations and increase the noxiousness of these weeds?
- If the target crop is a food could there be any toxin production?
- For ornamentals, which are generally not consumed and are intensively cultivated, genetic modifications carried out to date do not pose any significant risk to the environment.

Of course, such assessments have to be made on a crop-by-crop, gene-by-gene, case-by-case basis prior to any commercial release. The only genetically engineered ornamental to be approved for market release anywhere in the world so far are Florigene's carnation flowers, which can be sold in Australia.

Public Perception. The public are aware of "genetic engineering" and are concerned that the technology be used carefully (Kahler, 1995). This has engendered debate on issues ranging from gene therapy, manipulation of germ lines, use of plants and animals as chemical "factories", or modification of food with DNA from divergent sources, including humans. The development of genetically engineered ornamentals is caught up in this debate. Commercially, this raises the question of whether products should be labeled as genetically engineered, and if so, what information should be, or can usefully be, conveyed on the label.

DISCUSSION

Because of the commercial factors listed above, and the cost of the research, genetic engineering is very, very expensive. Primary to any commercial project is therefore a consideration of the value of the crop, the likely benefit of the modification and the potential long-term income to the developer of the new variety. Effectively, this limits work to the most important cut-flowers (rose, lily, gerbera, carnation, chrysanthemum, tulip) and perhaps a few pot plants (*Ficus*, *Begonia*, *Dracaena*). Florigene has established a strong intellectual property position in colour modification, and post-harvest manipulation applicable to the major cut-flower crops. In the next few years we hope to commercialise the products of this research, in both Australian and overseas markets (Anon, 1994), beginning with carnation in Australia, Japan, Europe, and Israel.

Florigene's competitors in the world also have research on the genetic engineering of ornamentals. They include Kirin, the Japanese brewer, who are interested in blue roses and blue chrysanthemum and Moet - Hennessey of France, also chasing the blue rose. Several cut flower breeders are now acquiring in-house gene transfer technology. In the Netherlands, Israel, Spain, Italy, Japan, United Kingdom, and the United States of America there are also numerous company- and government-based researchers working on smaller genetic engineering based ornamental projects. Whatever the outcome of the race to commercialise the technology, the industry will be the winner, thanks to the introduction of new varieties.

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