International Marketing of Genetically Modified Carnations

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Abstract

Florigene has developed genetically engineered varieties of carnation which have an improved vase life. The regulatory process to allow release of these new varieties has been completed or in progress in Australia, Europe, USA, Japan and Israel. It has been necessary to draw a distinction between whether plants are gown in, or imported into, a specific country. In either case the biology of the cultivated carnation is such that there is very little risk of gene dispersal in any part of the world. This is because seed set can not occur in a harvested crop, many varieties are sterile, it is vegetatively propagated crop and pollination is prevented by the double form of the flower.

Carnation is an internationally traded commodity, and one of the world's top three cut flowers. The major markets are Europe (which receives imports from Africa, Colombia and Israel), the USA (which receives most carnation from Colombia) and Japan. The wholesale and retail trading avenues are different in each of these markets and will be described. The marketing strategy for a genetically engineered carnation variety is much the same as that for a conventionally bred one, and largely dictated by the character of the specific market. The question of whether to label the flowers from the new varieties in some way, to indicate that they are genetically engineered, is the only marketing issue.

Introduction

Carnation is one of the world's top three cut flowers, the other two being rose and chrysanthemum. It is grown in all parts of the world, but as Table 1 below shows, the largest acreages are in southern Europe, South America and Japan.

On a consumption basis, the largest markets in the world are Spain and Italy. These two countries, along with the USA, each consume over one billion stems per annum. Other large markets are Japan (600-700 million stems per annum), Germany (ca. 900 mill.), France (ca. 900 mill.) and the UK (ca.650 mill.). The carnation is a valuable flower. The value of the crop at wholesale is estimated to be over 2 billion U.S. dollars annually, and twice this at retail. Carnation is traded internationally and this has an important bearing on the regulatory process.

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Table 1. Carnation acreage in countries with the largest area of carnation under cultivation.

COUNTRY	APPROXIMATE ACREAGE (ha)
Spain	2,200
Colombia	2,000
Italy	1,450
Japan	600
Kenya	280
Netherlands	200
Israel	190

Genetically modified carnation

The carnation flower begins to deteriorate and senesce as soon as it is removed from the plant. Though it will look fresh in water for some time, after 6-10 days the flower inrolls and very quickly thereafter becomes brown and dries up. This "inrolling" process, as it is called, characterized by curling inwards of the outer petals (known as sleepiness in the flower trade) is triggered by the growth regulator ethylene (Reid and Wu, 1992). Almost all the carnation varieties produce large amounts of ethylene at the time of inrolling and can be induced to senesce early by exposure to exogenous ethylene.

The effect of ethylene can be inhibited by treatment of the flowers with chemicals which either block ethylene biosynthesis or ethylene from binding to the receptors (perception). The most widely used of these chemicals is silver which blocks ethylene perception. Properly treated flowers will last up to 2 or 3 times longer than untreated ones but the use of silver is not without problems. Firstly, it is a cost to the grower. Secondly, not all growers use it and not all growers use it properly. This means there is no guarantee to retailers of correct treatment unless quality is monitored by wholesalers. Thirdly, silver is a polluting chemical which must be disposed of correctly. Because of environmental concerns some countries are restricting the use of silver in the flower industry.

Genetic engineering offers another means to guarantee vase life, by inhibiting the biosynthesis of ethylene. Using genetically engineered varieties the grower reduces costs, the consumer has a better product and there is no environmental pollution with silver. Ethylene is synthesized from S-adenosyl methionine (SAM) through 1-aminocyclopropan-1-carboxylic acid (ACC). Florigene has modified carnations using cosuppression, inserting a sense cDNA for the enzyme ACC synthase responsible for ethylene biosynthesis. ACC synthase is a multigene family in carnation, and the cDNA was isolated from carnation petal ACC synthase.

The pathway for ethylene biosynthesis is shown below

ACC oxidase ACC synthase
SAM---------->ACC---------->ETHYLENE

In addition to the cDNA for ACC synthase there is also a herbicide resistance gene contained in the T-DNA of the binary vector used for transformation. The transgenic plants were produced by cocultivation with disarmed *Agrobacterium* (Lu *et. al.*,1991).

Environmental impact of genetically engineered carnation

In the course of seeking regulatory approvals we have reviewed the botanical and ecological literature reviews for all markets, sought the opinion of carnation breeders throughout the world and undertaken field trials in Australia, Japan, Israel and Holland. From this work Florigene has concluded that transgenic carnation poses no greater environmental risk than unengineereed carnation.

1. Botany of the cultivated carnation

The cultivated carnation comprises cultivars of a wild *Dianthus* species, *Dianthus caryophyllus.* This species is very rare in the wild and confined to very few sites on the Mediterranean coast of France, Italy, Corsica and Sardinia (Tutin and Walters, 1993). Within the genus there are 300 species, naturally distributed from Alaska to all of western Europe and the western part of Russia. The center of species diversity is the Balkan region encompassing Serbia, Croatia, Albania, Bosnia, Romania, Greece and Bulgaria (Tutin and Walters, 1993). The *Dianthus* flower has five petals and is about 2 cm in diameter. Some species have commercial value and are grown for bedding plants and small cut flowers. These are often called "pinks" and include species such as *D.chinensis* and *D.barbatus.* The cultivated carnation no longer bears any resemblance with the wild species and this plays a role in the assessment of environmental risk. In the course of breeding over the last 200 years the flower has become doubled and consequently the number of petals ranges from 50 to over 100 in each flower. In the course of breeding many varieties, particularly the large standard types, have become sterile, producing no or very little pollen (Kho and Baer, 1973).

2. Weediness of the cultivated carnation

The cultivated carnation has no weedy attributes and has never been reported to have escaped cultivation, anywhere, despite the fact that at any one time there are probably over one billion carnation plants around the world and this situation has been observed for the last 40 years. Carnation is vegetatively propagated, from cuttings produced by specialist propagators. Whilst cuttings can be readily struck under controlled conditions, with rooting hormones, carnation does not have any natural propensity for adventitious rooting, from discarded leaves for example.

A carnation crop under cultivation could never disperse by seed production as all

the flowers are removed during collection. In any event, a harvested flower would be discarded long before seed set could possibly occur, as seed formation takes 4-6 weeks in carnation(Sparnaaij and Beeger, 1973). The probability of a neglected crop going to seed is also extremely remote;

a) Many varieties do not produce pollen. Other varieties are self-incompatible.
b) The wild species can only be pollinated by insects with a very long proboscis, such as hawkmoths and butterflies (Knuth, 1908). The large number of petals in commercial varieties does not allow these insects access to the pollen (if produced) at the base of the flower.
c) Even under the most favorable conditions carnation will not survive for more than 3-4 years.

3. Related weed species

Despite the lack of pollen production in carnation and the inaccesibility of flowers to potential insect pollinators, the possiblity of gene dispersal to related species must be considered, because several *Dianthus* species have escaped from cultivation and become established as wild populations. A few of these, *D. armeria* and *D.barbatus* can now be found all over the world. As a result, these species are defined as weeds, though they have no serious economic impact. Because of the low pollen production, the need for specific insect vectors to transfer pollen, the fact that flowers are removed and because carnation is cultivated in enclosed structures (glasshouses in northern Europe and Japan) the possibility for pollen to be transfered from a cultivated carnation to a wild *Dianthus* species is very unlikely.

4. Field trials

In the course of screening primary transgenic plants, and during the trials, we selected transgenic lines which are as far as possible, agronomically identical with the original parental variety. This is essential to the marketing of new varieties and has involved measuring flower size, petal number, stem height , yield and quality grades. As a result, transgenic lines exhibiting any significant change are discarded. For the selected lines we have also measured the size of reproductive structures, counted pollen grains present and assessed pollen viability. No changes have been detected. Molecular analysis has been carried out, and in Japan possible toxin production has been assessed using methods recommended by the regulatory agency in that country.

5. Effect of inserted genes

We would not have expected the inserted genes to have had any effect on the fecundity or vigor of the transgenic carnations. After all, the effect of the inserted gene for long life is the same on phenotype as a postharvest chemical treatment. Whilst the selectable marker is a herbicide resistance gene, the specific herbicides in question are not used in the carnation industry because their spectrum is too narrow. For the rea-

sons detailed above, there is no possibility that carnation could escape, establishing a herbicide-resistant population.

The international carnation market

Table 2 Summary of recorded carnation export movements through Europe,1994

Million stems per annum*

EXPORTED FROM	EXPORTED TO Germany	Benelux	France	Holland	UK	REST of EU
Holland	318.0	17.0	60.4	n.a	165.2	18.3
Spain	6.7	3.5	5.5	237.5	60.3	6.9
Italy	27.3	0	3.2	1.8	22.6	0.2
Colombia	94.2	0	21.0	76.0	363.1	67.1
Kenya	129.1	1.1	0.1	176.9	47.8	0
Israel	33.7	1.1	1.5	121.6	9.2	0.2
Turkey	4.7	1.4	0.4	6.6	105.8	0.3

* From Yearbook of the International Horticultural Statistics 1995, AIPH, UNION FLEURS, Den Haag

The extent to which local production is used to supply domestic markets depends on the country in question. Flowers produced in Japan are all used locally. In contrast, production in Kenya, Israel and Colombia is virtually all for export whilst Italian and Spanish producers serve both a domestic market and export to other European countries. The Netherlands is a unique case since whilst the growers in that country supply the local market, the auction system there acts as a large distribution center. Both locally produced and imported carnations move from the Netherlands to other European countries, as indicated in Table 2 above.

As table 2 also shows, there is considerable direct import into Germany and the United Kingdom from Colombia, Turkey, Israel and Kenya. However, most of the carnations produced in Colombia are exported to the USA. The strength of this export trade is such that 85-90% of the one billion carnations consumed in the USA come from Colombia.

The three main markets for carnation (Europe, USA and Japan) are very different.

USA. Carnations grown in Colombia are imported to the USA through wholesalers based in several major capital cities. Miami is the most important entry point. The wholesaler may also own the growing operation in Colombia. From these points of entry, flowers are shipped to secondary wholesalers from where they go to the florists. Apart from the local market in California, where there a still are few growers, the link between the florist and grower is therefore quite distant.

Japan. The auction system is the basis of the distribution of carnation in Japan. There is virtually no trade from grower to florist. In Japan there are approximately 500 auctions, of varying sizes. The two largest are in Tokyo and Osaka. Be-

cause there are so many auctions most carnations are produced and sold locally, and growers are able to establish a reputation. The need to maintain this reputation, and to supply top quality at all times is one of the reasons why imports do not constitute a large share of the Japanese market.

Europe. Of course, Europe consists of many different markets. There are also many distribution avenues for carnation and the route the flowers take will depend on whether they are imported or not. In this short review it is impossible even to summarize details of the trade in Europe. However there are a few avenues that are very significant;

1. The role of the Dutch auctions is critical. The three most important auctions at Aalsmeer, Rijnsburg and Westlands serve as a point for delivery of imports. At each of the auctions some of the wholesalers are experts in transportation. They serve the whole of northern Europe.
2. In Italy and Spain, since the industry is dominated by local growers and wholesalers and retail markets it is highly fragmented.
3. The supermarket chains, in Germany and the UK particularly, are major retailers, directly importing large amounts of flowers from Africa, Turkey and Colombia. They are also using buyers and wholesalers at the auctions.

Carnation trade and genetically engineered varieties

The brief description above of the trade in carnation raises two issues for the potential commercialization of genetically engineered varieties.

Tables 1 and 2 show that in order to market the cut flowers in any particular country it may not be sufficient to obtain regulatory clearance in just that market, as the flowers may well be produced elsewhere. As a result, marketing approval will be required in Colombia, Israel, USA, Japan and Europe if the genetically engineered varieties are to be successfully marketed.

In Europe,the flowers are very likely to be grown in one country, auctioned or sold at wholesale in a second, and retailed in a third. Obtaining marketing approval in the EC possible, but any commercial or legislative decisions on labelling must take this inter country trade into account.

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