National Institute for Public Health
and the Environment
Ministry of Health, Welfare and Sport

Inventory on the potential import of non-authorized genetically modified ornamentals in the Netherlands

RIVM Letter Report 300003004/2014
J.W.A. Scheepmaker

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Colophon

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This investigation has been performed by order and for the account of ILT, within the framework of M/300003/01/RA, Ketens and analyse

Rapport in het kort

Inventarisatie van mogelijke import niet-toegelaten genetisch gemodificeerde sierplanten in Nederland

Internationaal zijn veel ontwikkelingen gaande om sierplanten genetisch te modificeren. Op die manier is het bijvoorbeeld mogelijk om bloemen een kleur te geven die van nature niet voorkomt (zoals een blauwe roos), of zijn ze beter bestand tegen droogte, ziekten of het gebruik van gewasbeschermingsmiddelen. Voordat genetisch gemodificeerde planten op de markt mogen worden toegelaten, moet eerst worden beoordeeld of ze een risico vormen voor mens of milieu. Uit verkennend onderzoek van het RIVM blijkt dat er in Nederland waarschijnlijk geen genetisch gemodificeerde siergewassen verkrijgbaar zijn die niet officieel zijn toegelaten. Het onderzoek is een opdracht van de Inspectie Leefomgeving en Transport (ILT). De ILT is verantwoordelijk voor het toezicht op en de handhaving van de regelgeving voor genetisch gemodificeerde organismen (GMO-regelgeving), inclusief de monitoring van niet-toegelaten genetisch gemodificeerde (GM) siergewassen.

Het onderzoek geeft een overzicht van siergewassen waarvoor wereldwijd succesvolle genetische modificaties in het laboratorium zijn uitgevoerd. Vervolgens is weergegeven welke experimenten sinds 2000 binnen en buiten de EU zijn uitgevoerd om te testen of de nieuwe eigenschappen ook in de kas of het veld zichtbaar zijn. Daarna is beschreven welke GM-siergewassen binnen en buiten de EU zijn toegelaten, zoals in Australië, Nieuw Zeeland, USA, Canada, Japan. Hieruit zijn GM-sierplanten geselecteerd die mogelijk geïmporteerd kunnen worden in Nederland, nu of in de nabije toekomst. Voor deze ‘kandidaten’ (anjers, rozen, *Petunia*, het graszaad *Agrostis stolonifera* (creeping bentgrass), en *Pelargonium* (in de volksmond geranium)) zijn vier factoren gewogen, op basis waarvan de ILT kan aangeven welke GM sierplanten ze voorrang willen geven bij toezicht en handhaving. De belangrijkste factor is het (eventuele) risico voor mens en milieu, en dat bleek in de meeste gevallen laag. Alleen het GM-gras *A. stolonifera*, dat resistent is tegen het onkruidbestrijdingsmiddel glyfosaat, kan een potentieel risico vormen voor het milieu. Bij toepassing van glyfosaat heeft dit gras namelijk een reproductief voordeel en kan gaan woekeren. Het is echter nog niet als commercieel product op de markt gebracht.

Abstract

Inventory of presence of unauthorized genetically modified ornamentals on the Dutch market

Genetic modification of ornamentals is on the rise worldwide. Using this technique it is, for instance, possible to modify the colour of cut flowers (e.g. a blue rose) and to make ornamentals more resistant against drought, diseases or the use of herbicides. Before their admittance to the market, genetically modified plants have to be assessed for potential risks to human health and the environment. An inventory performed by the Dutch National Institute for Public Health and the Environment (RIVM) shows that genetically modified ornamentals without an official permit do not seem to be present on the Dutch market. The inventory was commissioned by the Netherlands Human Environment and Transport Inspectorate (ILT), which is responsible for supervising and enforcing government regulations on Genetically Modified Organisms (GMO), including the monitoring of unauthorized genetically modified ornamentals.

The inventory provides a list of ornamentals for which genetic modifications have been achieved successfully in the laboratory. The report also lists experiments which have been performed since 2000, both within and outside the EU, to test whether new traits are visible in greenhouses or in the field. In addition, the report includes a list of genetically modified ornamentals which are currently authorized in the EU and outside the EU, including in Australia, New Zealand, the United States, Canada and Japan. From these lists, genetically modified ornamentals were selected that could be imported into the Netherlands, either now or in the near future. These ‘candidates’ are carnations, roses, *Petunia*, the grass seed *Agrostis stolonifera* (creeping bentgrass) and *Pelargonium* (popularly known as geranium). Four factors were assessed to enable ILT to prioritize genetically modified ornamentals for monitoring purposes and enforcement of regulations. The most important factor was the potential risk for human health and the environment. This risk turned out to be low. Only the GM grass *A. stolonifera* that is resistant against the weedkiller glyphosate may present a risk to the environment as it may become invasive following application of glyphosate. However, glyphosate-resistant *A. stolonifera* has not yet been commercialized.

Inhoud

1 Introduction

Worldwide, a steady increase of genetically modified products is observed, both in numbers and in diversity. Products in the agro sector are most prominent. Ornamentals such as cut flowers and annuals are ideal candidates for genetic modification as there is a large consumer demand for new products. There has been extensive research on the genetic modification of different flowering plant species, and many ornamental species have now been successfully modified, including those which are most important commercially. Deroles (2002) listed more than 30 ornamental species that have been transformed, including *Anthurium*, begonia, carnation, C*hrysanthemum*, *Cyclamen*, *Datura*, daylily, gentian, gerbera, gladiolus, hyacinth, iris, lily, lisianthus, orchid, *Pelargonium*, *Petunia*, poinsettia, rose, snapdragon and *Torenia*.

The Human Environment and Transports Inspectorate (ILT) of the Netherlands is responsible for supervising and enforcing GMO regulations, including the monitoring of unapproved GMOs. However, it is unknown to what extent unapproved GM ornamentals are being imported into the Netherlands. Upon request of the ILT, the RIVM has investigated the possible import of unapproved genetically modified ornamentals.

Two inventories preceding this work have been published in 2009 en 2012, also upon request of the ILT. In 2009, a report on the potential introduction of unapproved GM crops in the Netherlands was generated, comprising a shortlist of species that (may) require specific attention with regard to (potential) environmental dispersal. Taking into account actual trade and import data, the shortlist was subsequently translated into a priority list for monitoring of unapproved GMOs (Prins et al., 2009). In 2012 RIVM has published a report on the potential introduction of unapproved GM animals and GM products in the Netherlands, now or in the near future (Van den Akker and Wassenaar, 2012). In this report bacteria (for use in pesticides), viruses, insects, fish, domestic animals, cattle, veterinary vaccines and gene therapies/vaccines for human use were included. Ornamentals were not part of these two above mentioned reports. This current report can therefore be considered as a follow-up to these two reports.

This report aims to identify whether there are any unapproved GM ornamentals on the Dutch market or if any unapproved introductions with these GM ornamentals may occur in the Netherlands in the near future.

1.1 Objectives and demarcation

This inventory is aimed at including the following information concerning the most relevant GM ornamentals:

1. An exact description of GM ornamentals on or about to come onto the market, including name and nature of the product, the genetic modification and the technique applied for modification. Also ornamentals that are suspected of being GMOs, but not regarded as such under European legislation will be described.
2. The extent of the import and potential import of GM ornamentals and of the availability of these products for the Dutch consumer market.
3. From which countries, by whom and by which routes introduction could take place.

4. An indication of the potential hazards/risks associated with the GM ornamental; inclusion of an existing environmental risk assessment (if available).
5. Exploration of possibilities for the detection and control of these products.

In first instance, a limited search was performed of the open literature for studies performed with varieties of GM ornamentals. This initial search gave an impression of the range of possible modifications and the type of ornamentals modified. To generate the main part of the inventory, information on relevant GM ornamentals was gathered from the internet, especially focusing on databases and sources that supply information on the marketing status or licensing of GM ornamentals.

Searches were made to find:

1. Studies on successful modifications of ornamentals (limited search),
2. Approved field experiments with ornamentals in the EU, Australia, New Zealand, USA and Canada,
3. GM ornamentals with approvals in the EU,
4. GM ornamentals with approvals outside the EU,
5. GM ornamentals with approvals pending in and outside the EU,
6. GM ornamentals not regulated or de-regulated in the USA,
7. Listed patents of GM modifications in ornamentals.

1.2 GMO regulations

1.2.1 Regulatory framework and competent authorities within the European Union

In the European Union, the deliberate release of genetically modified organisms into the environment is regulated by the EU Directive 2001/18/EC. Directive 2001/18/EC is applicable for import or cultivation of GM ornamentals. This Directive concerns both the placing on the market of GMOs and deliberate release of GMOs into the environment for non-commercial purposes (e.g. field trials) (Directive-2001/18/EC). The Directive obliges member states to ensure that all appropriate measures are taken to avoid adverse effects on human health and the environment which might arise from the deliberate release or the placing on the market of GMOs.
Annex II of the Directive 2001/18/EC describes in general terms the objectives to be achieved, the elements to be considered, and the general principles and methodology to be followed to perform an environmental risk assessment involving the deliberate release of GMOs. Only products that have been risk assessed and granted a marketing authorization by the Community and the Member State involved, can be placed on the market.

1.2.2 Regulations outside the EU

In most countries outside the EU, GM regulations are in place. This means that like in the EU, plants obtained by means of genetic modification techniques are generally considered to be a GM product. The exceptions are the USA and Canada, where the regulation of a GM product is not based on the technique that has been used, but on the new characteristics of the product (product-based regulation). This means that there may be some products on the USA and Canadian market that would be considered a GMO in the EU, but are not considered as such in the USA and Canada.

1.3 Definition of a GMO and ornamentals for this report

The definition of a Genetically Modified Organism (GMO) as used in this report is the definition as is laid down in the EU Directive 2001/18/EC on the deliberate release into the environment of genetically modified organisms. A GMO is defined as organism, with the exception of human beings, in which the genetic material has been altered in a way that does not occur naturally by mating and/or natural recombination (Directive-2001/18/EC).

This report will focus on GM ornamentals. Ornamental plants can be divided into eight major categories (Dobres, 2008). These are the annuals, perennials, potted flowering, potted foliage, trees and shrubs, cut flowers and vines, ornamental grasses and palms.

In the report of Prins et al. (2009) grasses were already included in the priority list for the Netherlands as they have a high likelihood of dispersal. As the actual GM varieties were not listed in the report, ornamental grasses were also included in this report.

2 Material and Methods

To generate the inventory, information on relevant GM ornamentals was mainly gathered from the internet, especially focusing on databases and sources that supply information on the marketing status or licensing of GM ornamentals. The open literature was also searched for studies performed with varieties of GM ornamentals. If these ornamentals were successfully modified, this was considered to give an indication of their marketing potential.

2.1 General information sources on the status of GM ornamentals in the EU

GMO compass (GMO-Compass)
This service provides a GMO database on all GM crops that are registered in the EU.

Joint Research Centre (JRC), Deliberate Release and Placing on the EU markt of GMOs – GMO register)
The purpose of this web site, managed by the Joint Research Centre of the European Commission on behalf of the Directorate General for Health and Consumers is to publish information and to receive comments from the public regarding notifications on GMO's about deliberate field trials and placing on the market of genetically modified organisms, as defined in Directive 2001/18/EC.

2.2 General information sources on the status of GM ornamentals worldwide

The Biosafety Clearing-House (BCH)
BCH is a site set up by the Cartagena Protocol on Biosafety to facilitate the exchange of information on Living Modified Organisms (LMOs) and assist the Parties to better comply with their obligations under the Protocol. Global access to a variety of scientific, technical, environmental, legal and capacity building information is provided in the six official languages of the UN.

Canadian Food Inspection Agency (CFIA)
The Canadian Food Inspection Agency and Health Canada work together to assess the safety of plants with novel traits, some of which are also known as genetically modified plants.

CERA's GM Crop Database (CERA)
This database is hosted by the Center for Environmental Risk Assessment. CERA's database of safety information (formerly hosted by AGBIOS) includes not only plants produced using recombinant DNA technologies (e.g., genetically engineered or transgenic plants), but also plants with novel traits that may have been produced using more traditional methods, such as accelerated mutagenesis or plant breeding. In this database only information on carnation is available, not on other ornamentals. Not all countries are included in this database, for instance New Zealand is not included.

Environmental protection Authority (EPA)
The EPA of New Zealand provides a list of Approvals of field tests of ornamental plants since 1988.

The International service for the acquisition of agri-biotech applications (ISAAA)
This service provides a database with registered GM crop events in all countries of the world.

Information systems for biotechnology, A National Resource in Agbiotech Information (ISB)
ISB provides information resources to support the environmentally responsible use of agricultural biotechnology products. Here documents can be found and searchable databases pertaining to the development, testing and regulatory review of genetically engineered (GE) plants, animals and microorganisms within the United States and Hawaii.

OECD BioTrack Product Database (OECD)
Database provided by the OECD. The objective of this database is to allow regulatory officials in the OECD member countries to easily share basic information on products derived from the use of modern biotechnology, as well as some products with novel traits (GM or not) acquired by the use of conventional breeding or mutagenesis, that have been approved for commercial application in terms of food, feed or environmental safety.

Office of the Gene Technology Regulator (OGTR)
The OGTR provides a list of applications and licenses for Dealings involving Intentional Release of GMOs into the environment in Australia. The OGTR has been established within the Australian Government Department of Health and Ageing to provide administrative support to the Gene Technology Regulator in the performance of his functions under the *Gene Technology Act 2000*. This office provides GMO records on all approved GMOs and GM products in Australia.

United Stated Department of Agriculture, Animal and Plant Health Inspection Service (USDA-APHIS)
APHIS' Biotechnology Regulatory Services regulates the introduction (importation, interstate movement, and release into the environment) of genetically engineered organisms. APHIS provides a database to check the status of a permit, notification or petition.

2.3 Other searched databases/sites

International Trade Centre, Market Analysis and Research (ITC)
Trade Map provides - in the form of tables, graphs and maps - indicators on export performance, international demand, alternative markets and competitive markets, as well as a directory of importing and exporting companies. Trade Map covers 220 countries and territories and 5,300 products.

Patent Lens (Patent-Lens)
A free public resource for patent system navigation worldwide. No information in addition to other databases was gained from this resource and results are not further mentioned in this report.

www.alibaba.com
This internet site offers the opportunity of trading all sorts of commodities, including fresh cut flowers.

2.4 Statistical data on import into the Netherlands

The import into the Netherlands was analysed using Trade Map supplied by the International Trade Centre (ITC), EuroStat (EuroStat, 2008) and the Dutch Central Bureau of Statistics (CBS StatLine, 2008).

3 Results

3.1 Published articles on GM ornamentals

Many successful modifications have been accomplished at laboratory scale. Shibata (Shibata, 2008) listed forty eight ornamental plants (Table 1). More references can be found in Teixeira da Silva (2006) and Chandler and Sanchez (Chandler and Sanchez, 2012). They also give broad overviews on aspects of genetic engineering in ornamental plants.

Table 1. List of ornamental species for which transgenic plants have been generated (after Shibata (2008)).

Species	Species
Agapanthus sp.	*Gladiolus grandiflorus*
Alstroemeria spp.	*Hemerocallis* sp.
Antirrhinum majus	*Ipomea nil*
Anthurium andraeanum	*Iris germanica*
Begonia spp.	*Kalanchoe* spp.
Calanthe sp.	*Lavatera* sp.
Campanula spp.	*Lentopodium alpinum*
Cattleya spp.	*Linum* spp.
Chrysanthemum morifolium	*Lilium* spp.
Cyclamen persicum	*Lobelia erinus*
Cymbidium spp.	*Nierembergia scoparia*
Datura spp.	*Ornithogalum* spp.
Delphinium spp.	*Osteospermum* spp.
Dendrobium spp.	*Pelargonium* spp.
Dianthus caryophyllus	*Petunia hybrida*
Doritaenopsis hybrids	*Phalaenopsis* spp.
Eschscholzia californica	*Rhododendron* spp.
Euphorbia pulcherrima	*Rosa* spp.
Eustoma grandiflorum	*Rudbeckia hirta*
Forsythia×intermedia	*Saintpaulia ionantha*
Gentiana spp.	*Torenia fournieri*
Geranium spp.	*Verbena hybrida*
Gerbera hybrida	*Verticordia grandis*

Within the scope of this report, in depth investigations to generate an exhaustive overview of GM modifications performed at laboratory scale is not feasible. Instead, Table 2 lists the most important modifications with a few relevant and recent references.

Table 2. Some recent reports on successful transformations.

Species	New characteristic	Company / Research institute	Source
Colour modification			
Torenia	A diversity of flower colors, including white, yellow, pink and red instead of the original violet or blue	Tokyo University of Science	(Nagira et al., 2006) (Nishihara et al., 2013)
Chrysanthemum	Bluer-coloured chrysanthemums	National Agriculture and Food Research Organization (NARO), Japan	(Naonobu et al., 2013)
Gerbera, *Rose,* *Carnation,* *Eustoma grandiflorum* (Lisianthus), *Blue gentia,* *Cyclamen,* *Impatiens,* *Viola tricolour,* *Forsythia x intermedia,*			(Dobres, 2008) (Teixeira da Silva, 2006) (Deroles et al., 2002) (Rosati et al., 2003)
Petunia	From purple to white or red From red to orange	Institute for Advanced Research, Suntory, Kobe University, Florigene Ltd., Suntory flowers Ltd.,	(Tsuda et al.)
	Blue	Vrije Universiteit Amsterdam	(Tornielli et al., 2009)
Increased disease resistance			
Anthurium	Resistance against *Anthurium* blight	University of Hawaii	(Kuehnle et al., 2004)
Petunia	Tolerance to *Botrytis cinerea*	Nanjing Agricultural University, China	(Wang, 2013)
Torenia	Resistance against *Botrtyis cinerea*	Florigene/Suntory	(Muroi et al., 2012)
Agrostis stolonifera (Bentgrass) and *Zoysia japonica* (Zoysiagrass)[1]	Fungal resistance	Japan Turfgrass	(Yalcin-Mendi et al., 2006)
Petunia and *Chrysanthemum*	Virus and viroid resistance	Suntory Ltd and Kirin of Japan	(Yalcin-Mendi et al., 2006)
Modified appaerance			
Kalanchoe	Growth retardation	Plant and Soil Sciences Laboratory, Copenhagen, Denmark Institute for Ornamental and Woody Plant Science, Hannover, Germany, and two other institutes	(Lütken et al., 2010)

Species	New characteristic	Company/Research institute	Source
Impatiens, *Viola tricolour* (Pansies)	Reduced leaf and flower size, petal form and number		(Dobres, 2008)
Garden roses, *Hydrangea*, *Rhodondendron*, *Azalea*	Flower and foliage colour, petal number, habit		(Dobres, 2008) (GMO-Compass)
Pelargonium zonale	Highly branched stems, compact habit	Instituto de Biología Molecular y Celular de Plantas (CSIC-UPV	(García-Sogo et al., 2012)
Increased stress tolerance			
Petunia	Drought tolerance	Ornamental Bioscience GmbH, Germany	(Boehm, 2009)[1] (Green-biotech.eu)
Euphorbia pulcherrima (Poinsettia)	Drought and frost tolerance	Ornamental Bioscience GmbH, Germany	(Bio-Pro)
Tolerance to herbicides			
Zoysia japonica (Zoysia grass)	Glufosinate resistant	Faculty of Biotechnology, Cheju National University, Jeju, Korea	(Bae et al., 2008)
Poa pratensis (Kentucky blue grass)	Chlorsulfuron resistant	Scotts Company, USA	(Zhang et al., 2010)
Agrostis spp.	Glufosinate resistant	University of Rhode Island, Kingston, USA	(Wang et al., 2003)
Increase of phytoremediation capacity			
Torenia, *Petunia*, *Verbena*	hyperaccumulation of inorganic phosphate	Suntory Flowers Ltd.	(Matsui et al., 2013)
Prolonged shelf-life			
Campanula persicifolio (Canterbury bluebells) *Kalanchoe* (Flaming Katies)		University of Hannover, Germany	(GMO-Compass)
Modification of floral scent			
Pelargonium	Expression of a scent biosynthetic gene	Lucknow University, India	(Saxena et al., 2007)
Rosa hybrida	Production of anthocyanin pigment[1] transcription factor	University of Florida; Institute of Plant Sciences and Genetics in Agriculture, Israel	(GMO-Compass) (Zvi et al., 2012)
Male sterility			
Cyclamen persicum	Suppression of floral-organ identity genes	National Institute of Floricultural Science (NIFS), National Agriculture and Food Research Organization (NARO)	(Ohtsubo, 2011) (Tanaka et al., 2013)
Pelargonium zonale	male sterile PsEND1::barnase transgenic plants	Instituto de Biología Molecular y Celular de Plantas (CSIC-UPV	(García-Sogo et al., 2012)

Species	New characteristic	Company/Research institute	Source
Petunia	Genetic information is inserted in the plastids and is not transferred by pollen	University of Rostock	(Science-live, 2010)

1: This project will probably be ceased by the company Ornamental Biosciences in Stuttgart as the introduced genetic material did not perform well. The cultivars produced sofar were not worth marketing (personal communication R. Boehm). The company has the intention to transfer the same protocol to impatiens, geraniums and poinsettias (Potera, 2007).

3.2 Field trials with genetically modified ornamental plants/cut flowers

Field trials are a necessary next step following the research on the GM ornamental in the greenhouse. The new GM ornamental needs to be tested on several characteristics, among others the stability of the new trait, agronomic and product quality before it can be commercialized. The estimated time for a product to come to the market from modification is 8 to 12 years (Arundel and Sawaya, 2009). According to Chandler and Sanchez this period is 3-5 years (Chandler and Sanchez, 2012).
Table 3 shows field trials performed inside the EU and Table 4 shows field trials performed outside the EU from 2000 to 2013. This period has been chosen taking into consideration the longest period of 12 years for a product to come onto the market (see above). It can be assumed that field trials before 2000 resulted in a selection of GM ornamentals with marketing potential. Any successful GM ornamentals that were tested in a field trial before 2000 are expected to be present in databases of the JRC, OGTR, EPA and ISB in 2013, by the time this report was written. It should be stressed that not all species listed may make their way to the market, but at least the list gives an indication of future marketing possibilities of the listed species.
For many species, a long list of permits was available within the observed period. In the USA, for instance, Dobres (2011) counted more than 91 movement permits and 73 field trials have been issued for more than 10 genera of bedding plants, foliage plants and shrubs. In Tables 3 and 4 permits of field tests were limited to the latest permit of each variety. In case of field tests with two different modifications in the same variety, both permits were listed.

Table 3. List of field trials since 2000 with GM ornamentals in the EU.

Species	New characteristic	Company/Research institute	Notification number	site
Dimorphotheca hybrids (Cape marigold, African daisy, Star-of-the-veldt)	virus resistance (potato leaf roll virus)	Instituto Sperimentale per la Floricoltura	B/IT/00/05	(JRC)
Dimorphotheca hybrids (Cape marigold, African daisy, Star-of-the-veldt	virus resistance (tomato spotted wilt virus)	Instituto Sperimentale per la Floricoltura	B/IT/00/06	(JRC)
Lilium longiflorum (lily)	virus resistance (lily symptomless virus)	Applied Plant Research Section Flower bulbs	B/BE/01/V1	(JRC)
*Limonium otolepsis (*limonium)	synthesis of rol gene product(s)	Istituto Sperimentale per la Floricoltura	B/IT/00/02 B/IT/00/03 B/IT/00/04	(JRC)
Petunia x hybrida	gene transfer of plastid DNA via pollen, male sterility, resistance towards streptomycine and spectinomycine	University of Rostock	B/DE/08/203	(JRC) (EPA) (Science-live, 2010)
Strawberry (adj. *ananassa*)	induction of parthenocarpic fruit	Universita' Ancona - Facoltà di agraria - Dipartimento di biotecnologie agrarie e ambientali	B/IT/02/11	(JRC)

The table below presents the field trials that were performed outside the EU since 2000. Databases mentioned in chapter 2 revealed field experiments that were performed in the USA, Japan, Australia en New Zealand. No field experiments were found in the database of Canada. Field experiments from other countries such as China, Korea, all countries in Africa, were not mentioned in the databases. This does not necessarily mean that field experiments were never performed. The explanation might well be that not all countries deliver this information for inclusion in the databases.

Table 4. List of field trials with GM ornamentals outside the EU.

Species	New characteristic[1]	Company/ Research Inst.	Notification number	Expiry date
Australia (OGTR)				
Festuca arundinacea (Tall fescue)	Improved forage quality	Victorian Department of Primary Industries (DPI Victoria)	DIR 082/20072	licence for Dealings involving Intentional Release (DIR) into the environment
Lolium perenne (Perennial ryegrass)	Improved forage quality	Victorian Department of Primary Industries (DPI Victoria)	DIR 082/20072	licence for Dealings involving Intentional Release (DIR) into the environment
Torenia cv. "Summerwave®" (*Torenia X hybrida*)	Modified flower colour	Florigene/Suntory	DIR 068/2006	licence for Dealings involving Intentional Release (DIR) into the environment
Torenia (*Torenia x hybrida*)	Enhanced phosphate uptake	Florigene/Suntory	DIR 084/2008	licence for Dealings involving Intentional Release (DIR) into the environment
New Zealand				
Eustoma grandiflorum (Lisanthus)	Modified colour	Not clear (Christley and Woodfield, 2001)		Not listed by CERA
Petunia	Modified colour, dwarf stature	Crop & Food Research (Christley and Woodfield, 2001)		Not listed by CERA
USA (ISB)				
Potted plants, foliage				
Anthurium andreanum	*Xanthomonas campestris* resistant	University of Hawaii	05-339-02n	12/01/2006
Anthurium	*Xanthomonas Campestris Diffenbachiae* resistant, selectable	United States Department of Agriculture/ Agricultural	13-085109r	05/14/2016

Species	New characteristic[1]	Company/ Research Inst.	Notification number	Expiry date
	marker, nematode resistant	Research Service		
Dendrobium	*Cymbidium* mosaic virus resistant	University of Hawaii	06-279-106n	12/01/2007
Dendrobium	Bacterial resistant, fungal resistance	University of Hawaii	06-030-09n	12/01/2006
Dendrobium	Cymv resistant	University of Hawaii/Manoa	06-030-09n	11/01/2005
Dendrobium	*Calonectria* resistant, *Erwinia* resistant, *Phytophthora* resistant, *Botrytis* resistant	University of Hawaii/Manoa	99-302-16n	11/01/2000
Dendrobium	Flower colour altered	University of Hawaii/Manoa	99-302-17n	11/01/2005
Easter Lily	Phosphinothricin tolerant, reporter gene	United States Department of Agriculture/ Agricultural Research Service	11-038-108n	04/15/2012
Iris	Carotenoid levels increased	Oregon State University	10-204-101n	10/01/2011
Bedding plants				
Begonia semperflorens	Glyphosate tolerant	Scotts	03-052-71n	03/15/2004
Begonia semperflorens	Flower colour altered	Scotts	04-106-04n	04/30/2005
Crambe cordifolia[3]	Altered fatty acid profile	MacIntosh & Associates Inc	10-355-104rm	06/10/2012
Gladiolus	Bymv resistant, phosphinothricin tolerant	United States Department of Agriculture/ Agricultural Research Service	05-122-06n	11/30/2005
Marigold	Production of Astaxanthin in flower petals	BASF Plant Science L.L.C.	07-068-101n	05/03/2008
Marigold	carotenoid content altered	BASF	06-045-03n	04/01/2007
Marigold	Glyphosate tolerant	Scotts	03-052-03n	03/15/2004
Pelargonium	Colour altered	Scotts	05-123-01n	05/15/2006
Pelargonium	Glyphosate tolerant	Scotts	02-115-02n	05/31/2003
Petunia x hybrida	Modified scent	Max Planck Institute for Chemical Ecology	09-323-101r	03/01/2013
Shrubs				
Rhododendron	*Phytophthora* resistant	University of Connecticut	04-156-05n	06/01/2005

Species	New characteristic[1]	Company/ Research Inst.	Notification number	Expiry date
Rhododendron	Visual marker	University of Connecticut	04-156-04n	?
Rosa hybrida	Flower colour altered	Jackson & Perkins	05-318-07n	11/10/2006
Rosa hybrida	*Diplocarpon rosae* resistant	Scotts	04-133-04n	06/08/2005
Rosa	Modified flower colour	Jackson & Perkins	07-184-101n	12/13/2008
Grasses				
Miscanthus[4]	Nitrogen utilization efficiency increase	Ceres Inc.	11-031-110rm	07/01/2014
Cynodon spp. Bermudagrass	Phosphinothrin tolerant	University of Georgia	07-204-101r	09/10/2010
Agrostis stolonifera[5] (creeping Bentgrass)	Drought tolerance increased, enhanced phosphate uptake, salt tolerance increased, phosphinothricin tolerant	Clemson University	12-080-101r	03/20/2012
Paspalum notatum (Dwarf Bahiagrass)	Dwarfism, drought tolerance, salt and cold tolerance	University of Florida	06-219-01r	01/27/2008
Festuca arundinacea (Tall fescue)[6]	Gray leaf spot resistant, Rhizoctonia solani resistant	North Carolina State University	11-276-101r	10/14/2011
Festuca arundinacea (Tall Fescue Endophyte)	Mycotoxin deficient	University of Kentucky	13-242-102r	08/30/2013
Lolium multiflorum (Italian Ryegrass)	Visual marker, pollen allergen reduced	Noble Foundation	05-278-02r	04/05/2007
Poa pratensis (Kentucky bluegrass)	Altered morphology, glyphosate tolerant	Scotts	05-112-01r	12/02/2006
Poa pratensis (Kentucky bluegrass)	Drought tolerance increased	Rutgers University	01-353-04n	01/17/2002
Lolium perenne (Perennial ryegrass)	Drought tolerance increased	University of Florida	10-243-109n	10/01/2010
Japan (BCH)				
Agrostis stolonifera (creeping bentgrass)	Tolerant to glyphosate	Monsanto Japan Limited	ASR368; OECD UI:SMG-36800-2	2004
Florigene®Moonique™	Modified flower colour & tolerance to ALS inhibiting herbicides chlorsulfuron and sulfonylurea	Florigene/ Suntory	19907; IFD-19907-9	2009
Florigene®Moonvelvet™	Modified flower colour & tolerance to ALS inhibiting	Florigene/ Suntory	26407; IFD-26407-2	2011

Species	New characteristic[1]	Company/ Research Inst.	Notification number	Expiry date
	herbicides chlorsulfuron and sulfonylurea			
Florigene®Moonberry™	Modified flower colour & tolerance to ALS inhibiting herbicides chlorsulfuron and sulfonylurea	Florigene/ Suntory	25958, IFD-25958-3	2011
Eucalyptus[7]	Cold tolerance	University of Tsukuba		2013
Cyclamen persicum[1]	Multi-petal cyclamens with complete sterility		n.d.	n.d.

1: According to Ohtsubo (Ohtsubo, 2011) this cyclamen will be released in the near future as the third GM commodity following Suntory's blue carnations and rose. No records have been found on the Japanese BCH site, and the author did not respond to questions on its current status. It is not clear whether field experiments have been performed already.
2: Licence is for both perennial ryegrass and tall fescue
3: *Crambe cordifolia* can be used as an ornamental in the garden. An altered fatty acid profile is however not a trait that is advantageous for gardeners.
4: *Miscanthus* is a long grass that could be used as an ornamental grass in gardens.
5: Many other field trials were performed before 2000 by different companies and universities, among others Scotts with a HT-Glyphosate tolerant variety. This grass is particularly used on golf courses but can also be used in gardens.
6: Many other field trials were performed before 2000 by different companies and universities, among others Noble Foundation with a PQ-hygromycid tolerant variety and Purdue University with a HT-Phosphinothricin tolerant variety
7: *Eucalyptus* trees are used as ornamentals in the Netherlands

3.3 Approvals in EU

Ornamentals that are approved in the EU are limited to carnations of the company Florigene/Suntory (Table 5).

Table 5. Cut flowers with approvals in EU[1].

Trade name and ID-number	Notification number	Species	New characteristic	marketing conditions	site
Florigene®Moonaqua™ FLO-40689-6	C/NL/06/01	*Dianthus caryophyllus*	Modified flower colour	Import and marketing	(JRC)
Florigene®Moonlite™[2] FLO-40644-4	C/NL/04/02	*Dianthus caryophyllus*	Modified flower colour	Import and marketing	(JRC)

1: Both products are developed by Florigene/Suntory. They are also registered in other countries, this is not further mentioned in this report.

2: the name “Moonlite” is given in the site op GMO compass, not in the JRC site. Confirmed by S. Chandler.

3.4 Approvals outside EU

Apart from carnations very few other ornamentals are on the market (Table 6). In Table 6 Florigene®Moonaqua™ and Florigene®Moonlite™ are not mentioned again.

Table 6. Cut flowers with approvals outside EU.

Trade name	Species	New characteristic	Company	Registration in country	site
Florigene®Moonshadow2™ (FLO-11363-1)	*Dianthus caryophyllus*	Modified flower colour & tolerance to ALS inhibiting herbicides chlorsulfuron and sulfonylurea	Florigene/ Suntory	Australia, Japan	(CERA) (OECD)
Florigene®Moonvista™ (FLO-4Ø685-1)	*Dianthus caryophyllus*	Modified flower colour & tolerance to ALS inhibiting herbicides	Florigene/ Suntory	Australia, Japan, Malaysia	(CERA)
Florigene®Moonberry™ (IFD-25958-3)	*Dianthus caryophyllus*	Modified flower colour & tolerance to ALS inhibiting herbicides chlorsulfuron and sulfonylurea	Florigene/ Suntory	Malaysia (import and use)	(CERA)
Florigene®Moonique™ (IFD-199Ø7-9)	*Dianthus caryophyllus*	Modified flower colour & tolerance to ALS inhibiting herbicides chlorsulfuron and sulfonylurea	Florigene/ Suntory	Malaysia (import and use)	(CERA)
Florigene®Moonpearl™ (IFD-25947-1)	*Dianthus caryophyllus*	Modified flower colour & tolerance to ALS inhibiting herbicides chlorsulfuron and sulfonylurea	Florigene/ Suntory	Malaysia (import and use)	(CERA)
Florigene®Moonshade™ (FLO-40619-7)	*Dianthus caryophyllus*	Modified flower colour & tolerance to ALS inhibiting herbicides	Florigene/ Suntory	Australia, Japan, Malaysia	(CERA)

Trade name	Species	New characteristic	Company	Registration in country	site
				(Import and use)	
Florigene®Moonvelvet™ (IFD-26407-2)	*Dianthus caryophyllus*	Modified flower colour & tolerance to ALS inhibiting herbicides chlorsulfuron and sulfonylurea	Florigene/ Suntory	Malaysia (import and use)	(CERA)
No commercial name Event name Petunia-CHS	*Petunia hybrida*	Unknown, probably a modification of colour	Peking University	China	(ISAAA)[1]
no commercial name IFD-52901-9	*Rosa x hybrida*	Modified colour	Florigene/ Suntory	Japan (cultivation and use) Colombia (cultivation)	(BCH)
Suntory blue rose Applause IFD-52401-4	*Rosa x hybrida*	Modified colour	Florigene/ Suntory	Japan (cultivation and use) Colombia (cultivation) Australia	(BCH) (OGTR) (OGTR, 2009)

1: This site is not very accurate and any authorizations mentioned may have been removed from the market. Authorization of this *Petunia* is mentioned in several publications, grey literature and the press (IPS-Vlaanderen, 2013). According to the BBC (2002) it concerns a colour modified *Petunia* (Figure 1).

Figure 1. Colour modified *Petunia* from China (BBC, 2002).

3.5 Notifications pending in and outside the EU

Very few notifications are pending in the EU. It only concerns three carnations (Table 7).

Table 7. Cut flowers, notifications pending in EU.

Trade name and ID-number	Notification number	Species	New characteristic	marketing conditions	site
Florigene®Moonvista™ IFD-40685-1	C/NL/13/02	*Dianthus caryophyllus*	Modified flower colour, Herbicide resistance (marker gene)	Import and marketing	(JRC)
SHD-27531-4 (no commercial name)	C/NL/13/01	*Dianthus caryophyllus*	Modified flower colour, Herbicide resistance (marker gene)	Import and marketing	(JRC)
Florigene®Moonberry™ IFD-25958-3	C/NL/09/01	*Dianthus caryophyllus*	Modified flower colour, Herbicide resistance (marker gene)	Import and marketing	(JRC)
Florigene®Moonvelvet™ IFD-26407-2	C/NL/09/02	*Dianthus caryophyllus*	Modified flower colour, Herbicide resistance (marker gene)	Import and marketing	(JRC)

The following table lists the notifications that are pending outside the EU. Databases of New Zealand, Australia, Canada and the USA were searched. Pending notifications were only found in the USDA-APHIS database.

Table 8. GM ornamentals (cut flowers and grasses), notifications pending outside the EU.

Trade name and ID-number	Notification number	Species	New characteristic	Country	marketing conditions	site
No commercial name	12-115-104n	*Petunia*	Not documented	USA	release	(USDA-APHIS, 2013)
No commercial name	10-062-106n	*Petunia*	FR-Powdery Mildew Resistant	USA	import	(USDA-APHIS, 2013)
No commercial name	13-297-103n	*Panicum virgatum* (Switch grass[1])	Modified starch content	USA	Probably release	(USDA-APHIS, 2013)
No commercial name	12-158-101n	*Zoysia japonica* (Zoysia grass[2])		USA	Probably release	(USDA-APHIS, 2013)

1: Switch grass (in Dutch “vingergras”) is used as a crop for bio fuel, but can also be used as an ornamental grass in gardens. It can be combined with other grasses and perennials.

2: Zoysia grass is a warm-season turfgrass that spreads by rhizomes and stolons to produce a very dense, wear-resistant turf which makes them better adapted to a broader range of environmental conditions. It has good tolerance to cold, shade, salt and traffic, but its slow growth makes them difficult to establish.

3.6 GM ornamentals de-regulated or non-regulated in the USA

Several GM modified ornamentals have been exempted from regulation in the USA as they are, by the nature of their modification or their weed potential, not subject to regulation by either APHIS or the USDA. Some of these ornamentals could not be found in the databases of APHIS or USDA, but are mentioned in the grey literature.

3.6.1 De-regulated GM ornamentals

1. Carnation in general (modified for colour and improved vase life)

2. Applause rose (IFD-52401-4)
   This blue hybrid tea rose (Figure 2) is de-regulated in the USA (BCH), (USDA-APHIS, 2011a). According to the news release of Suntory (Suntory) Applause is on the market in the USA since November 2011. However, no retail information was found on the internet. According to S. Chandler (personal communication) Applause rose was unsuccessful in the USA market and imports have ceased.

Figure 2. Applause rose.

3. *Rosa hybrida* (IFD-52901-9)
   The colour of this rose is similar to that of Applause rose (personal communication S. Chandler). IFD-52901-9 has not been grown commercially, even in Japan. It was grown for a short time in Colombia on a trial basis, but it was deemed IFD-52901-4 had more commercial potential (personal communication S. Chandler).

3.6.2 Non-regulated GM ornamentals

1. *Poa pratensis (Kentucky bluegrass)*
   Scotts Miracle-Gro used a biolistic method, also known as a gene gun, rather than the bacterium *Agrobacterium tumefaciens*, a plant pathogen, as a vehicle for introducing the glyphosate tolerance gene. This means that the DNA transfer does not involve *Agrobacterium* or any other plant pest regulated under the Plant Protection Act (Cummins, 2011). The genetically 'enhanced' bluegrass expresses a more glyphosate tolerant form of 5-enolpyruvylshikimate-3-phosphate synthase from *Arabidopsis thaliana*. Other donor genetic elements include: ubiquitin promoter from *Oryza sativa* - actin intron from *Oryza sativa* - alcohol dehydrogenase 3' UTR from *Zea mays*. Kentucky bluegrass is not a federal noxious weed. It is therefore not

evaluated by the USDA (Federal-Register, 2011). It is listed as an agricultural seed, and is commonly grown on both home and government lawns, golf course greens. Kentucky bluegrass is not yet on the market but still in the early stages of research and development.

2. *Agrostis stolonifera* (creeping bentgrass), APHIS number 03-104-01p. a genetically engineered plant (Event ASR368) from the turf cultivar 'Backspin'. A petition for a non-regulated status suggests that *A. stolonifera* (ASR368) currently has a regulated status. This is not the case. This event was not present in the database of the BCH database (BCH). The creeping bentgrass line ASR368 was produced by means of microprojectile bombardment of plant cells from the conventional variety B99061R. The inserted gene is EPSPS, rendering a HT-Glyphosate tolerant phenotype. A petition for the non-regulated status of creeping bentgrass was submitted by Monsanto Company and the Scotts Company (see petition for the non-regulated status (Nelson, 2003)) but is still pending (USDA-APHIS, 2005). This grass is particularly used on golf courses but can also be used in private lawns. The use of herbicides reduces the maintenance of private lawns and is therefore interesting to the public.

3. *Petunia*
   According to Voosen (2011) APHIS decided that modified *Petunia*s did not fall under its jurisdiction. The types of possible modifications are unknown.

4. *Pelargonium*
   According to Voosen (2011) APHIS decided that modified geranium did not fall under its jurisdiction. The modifications of actually marketed *Pelargonium* are unknown. Field experiments performed by Scotts company in the USA (Table 4) concerned colour altered and glyphosate tolerant *Pelargonium.*

3.7 Import into the Netherlands

The databases of CBS and Eurostat were consulted on statistics of imported volume. The CBS did not provide import data on ornamentals. Eurostat has not defined a category of cut flowers or ornamentals for agribulk.

An earlier version of Eurostat however provided an overview of countries supplying ornamentals to the Netherlands (Table 9). This table shows the main exporting countries for several cut flowers. Countries appear to have growers that are specialized in the culture of certain cut flowers. It should be realized that these data are probably all based on legal imports (GM ornamentals included).

Table 9. The leading suppliers of cut flowers and foliage to the Netherlands, 2004 (Fliess et al., 2006).

Flower species	Share of suppliers (%)	Share of developing country suppliers (%)
Rosa	Kenya (54), Ecuador (10), Zimbabwe (10)	94
Dianthus	Colombia (46), Spain (22), Portugal (8)	63
Orchids	Thailand (57), Germany (14), South Africa (12)	72
Gladiolus	Spain (46), Germany (37), Israel (10)	3
Dendranthema	Germany (49), Poland (10), Denmark (7)	11
Other cut flowers	Israel (34), Kenya (16), Ecuador (12)	45
Prepared cut flowers	Israel (25), Spain (19), Italy (12)	23
Foliage	Turkey (20), China (19), India (14)	68
All cut flowers & foliage	**Kenya (34), Israel (15) Ecuador (10)**	**72**

Source: Eurostat, 2005, cited in CBI (2005), *Cut flowers and foliage, EU Market Survey 2005*, Table 5.5. on page 48.

The International Trade Center (ITC) provided accumulated information on the import of cut flowers and flower buds for bouquets. For rose, carnation, and several grasses detailed information can be generated in maps (Figures 4 to 8). These maps show the actual import of ornamentals, GM ornamentals included. Therefore, these data may only indirectly provide information on possible trading routes of GM ornamentals. The top 10 exporting countries to the Netherlands are Kenya, Ecuador, Belgium, Ethiopia, Uganda, Colombia, Germany, Italy, Spain and Zambia. For full details, see Appendix 1.

The site www.alibaba.com was searched using the strings “Blue” and “rose” or “genetically modified”. No results were obtained other than dyed roses.

4 Discussion

GM ornamentals that are currently allowed on the market in either the EU or outside the EU all have a colour modification as a result of the genetic modification. Apart from colour modifications, there is considerable interest in the introduction of agronomically useful traits into ornamentals, such as herbicide resistance, pathogen resistance, modified appearance, drought and stress resistance. The tables with GM ornamentals (Table 1 and 2) that were developed on laboratory scale, show that there is indeed a great potential for modifications both in terms of the number of varieties/species as well as in the number of possible genes to be introduced. In the open literature, many other studies with ornamentals are available. This supply of new GM ornamentals can potentially lead to a number of GM ornamentals on the market. The field experiments in Tables 3 and 4 show that GM ornamentals with other new characteristics may be close to introduction into the market.
Despite the many field studies that have been performed only a few GM ornamentals are currently commercialised. Assumedly many GM ornamentals tested in the field do not meet the required quality standards. In addition, several other barriers to the successful marketing of GM ornamentals were identified by Chandler and Sanchez (2012), Dobres (2008, 2011) and Ohtsubo (2001). Difficulties in obtaining regulatory approvals, a small niche of GM ornamentals in the market and a short commercial life were the main obstacles mentioned in these reviews.

4.1 Candidates for illegal import into the Netherlands

The list of GM ornamentals that are candidates for illegal import into the Netherlands in the near future is short (see Table 10) and is based three lists:

- cut flowers with approvals outside the EU (Table 7),
- GM ornamentals that are pending outside the EU (Table 8) or
- GM ornamentals that are de-regulated in the USA or non-regulated in the USA (Chapter 3.6).

Table 10. Candidates for illegal import into the Netherlands.

Species	**Country of approval/de- or non-regulated in USA**	**remarks**
Carnations other than those allowed in the EU	Australia, Japan, Malaysia, Colombia, Canada, Japan, USA Ecuador (production)	Modified colour and a marker gene with resistance to herbicides
Rosa x hybrida IFD-52901-9	Japan, Colombia	Modified aesthetic quality
Rosa x hybrida Suntory blue rose Applause IFD-52401-4	Japan, Colombia, Australia, USA	Modified aesthetic quality
Petunia	China	Modification unclear, possibly colour modification
Petunia	USA	Modification unclear, possibly several modifications, modified colour, drought resistance, disease resistance
Agrostis stolonifera (creeping bentgrass)	USA	Petition for de-regulation is pending since 2003
Pelargonium	USA	Modification unclear

The commercialisation of GM roses was not successful and came to a halt (personal communication S. Chandler). Import of GM roses from any of the countries which have registrations (Japan, Colombia, Australia, USA) is therefore considered to be absent or at least minimal.
Two other GM ornamentals, *Petunia* and *Pelargonium* are non-regulated in the USA. Sales of GM *Petunia* and GM *Pelargonium* in the USA therefore seem very likely. Field experiments with glyphosate tolerant and colour altered *Pelargonium* have already been performed in 2003 and 2006, respectively, by Scotts company. In 2002, Scotts increased its investment in GM technology, by signing a research and commercialization agreement with New Zealand's Crop & Food Research that could lay the groundwork for the production of genetically modified flowering ornamental plants (Crocodyl, 2009). It was announced that the research would initially focus on *Pelargonium.* A search on the internet did not reveal any signs of marketing of Scotts *Pelargonium* in Europe. Scotts company has several subsidiary locations in Europe, including one in the Netherlands, but their products are focussed at lawn care, plant food, disease and insect control and weed killers. Bedding and pot plants are not part of the assortment. A problem that arises with non-regulated GM ornamentals such as *Pelargonium* and *Petunia*, is that information on GM modifications may not be specifically mentioned on the labels that are attached to the plants. Appendix 2, Figure 6 shows that the import of cut flowers from the USA is minimal (0-2.600 US$ (*1000)). Therefore, import of bedding and potted plants is expected to be minimal as well. Import of GM *Petunia* and GM *Pelargonium* from the USA into the Netherlands is therefore considered to be unlikely.

4.2 Prioritising the candidates for potential introduction

For each of the candidates mentioned in Table 10, several aspects are being considered in order to make a priority list. The four aspects below are in order of the sequence in transport in time.

1. *Approvals of the GM ornamental in the exporting country*
   The likelihood of illegal imports depends on the existence of a GMO regulation in the exporting country. When no GMO regulation is available, the exporting company may not have included information on genetic modifications on the label of the ornamental.

2. *Potential import into the Netherlands*
   The Netherlands is well known for its lively trade in ornamentals. For 2012, table 10 shows an import value of 735.438.000 dollars for cut flowers and for flower buds for bouquets. The top 10 EU countries exporting to the Netherlands are Kenya, Ecuador, Ethiopia, Uganda, Colombia, Zambia, Israel, Zimbabwe and United Republic of Tanzania. Import into the EU is legislated under 2001/18/EC, therefore companies need commercial approval for their products under this Directive if they want to import GM ornamentals in the Netherlands.

3. *Possibilities for detection*
   New characteristics, such as small flowers of the annual *Torenia* can be attained by either genetic modification as well as by traditional breeding. Therefore, a first relatively simple visual screening of the appearance of the ornamental can never be decisive and can only be used for screening ornamentals for genetic modifications. Visual screening should be followed by a molecular detection method. The development of a molecular technique requires the availability of the exact sequence of the modified gene. This information should available with the company that is trading the GM

ornamental. New traits such as herbicide resistance can be proven with relatively simple germination tests.

4. *Potential environmental and human health risks*
For the environmental risk assessment, the following topics will be taken into consideration:

1. Scope of the risk assessment (depends on type of product)
2. Characteristics of the GM ornamental pertinent to the risk assessment
    a. Ecology of the GM ornamental
    b. Mode of reproduction
    c. Survival and dormancy
    d. Dissemination
3. Specific areas of risk
    a. Persistence and invasiveness including plant-to-plant gene flow
    b. Interactions between the GM ornamental and target and non-target organisms
    c. Effects on human health
    d. Effect on the soil ecosystem

4.2.1 Carnation

The blue colour of the GM carnation is achieved by insertion of the *dfr* and *F3'5'H* gene originating from *Petunia* X *hybrida* and *Viola* sp. respectively, in the genome of carnation varieties with white flowers. These genes produce enzymes which convert certain flavonoids into delphinidin. Accumulation of delphinidin in petals results in different shades of violet of the flowers depending on the level of accumulation (Florigene) (Uchida et al., 2006). This type of modification is similar for all Florigene carnations.

The four aspects to prioritise GM carnation for its potential introduction are dealt with below:

1 *Approvals of the GM ornamental in the exporting country.*
Imports to the Netherlands come from Colombia and Ecuador. The database of the BCH gives approval for cultivation of carnation in Colombia. According to Vega (2013) Ecuador has no regulation for the approval of GM traits.

2 *Potential import into the Netherlands*
Florigene/Suntory produces carnations in Colombia and Ecuador under contract conditions and they buy all the products. Thus carnations are not marketed by any other company besides Florigene/Suntory. As Florigene/Suntory hugely invested in obtaining approvals for their assortment of carnations it is not expected that this company would take any risks by undertaking illegal transports (personal communication S. Chandler).

Most carnations that arrive at airports in the Netherlands or in the port of Rotterdam, are not intended for the Dutch market, but are directly transferred to other countries (in particular Russia).

3 *Possibilities for detection*
Florigene carnations have a modified colour and can be simply visually recognized as such by inspectors. However, visual detection should be followed by genetic detection methods (e.g. PCR on the inserted transgene) to confirm the genetic modification. Images of carnations are given in the figure below.

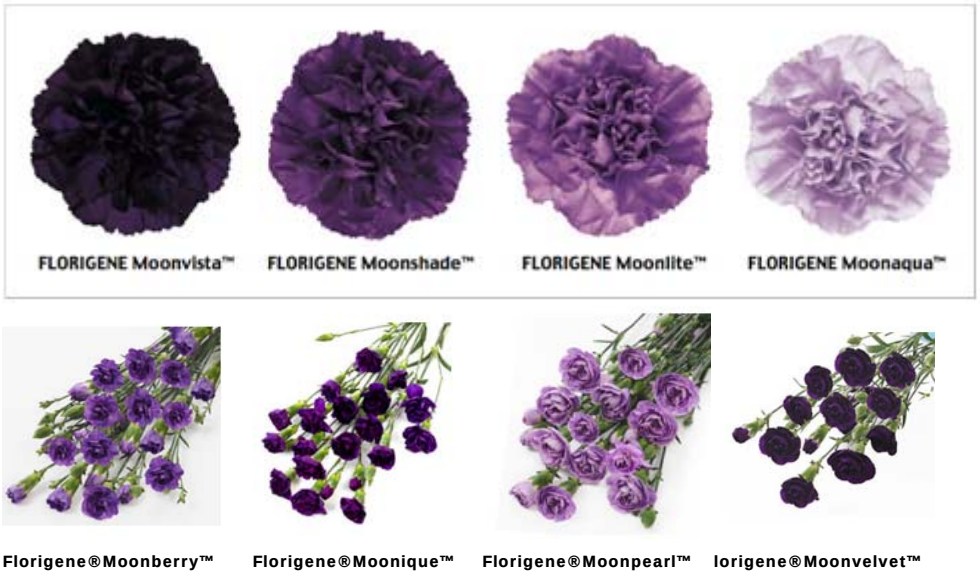

Figure 3. Four carnations of Florigene (photos from Florigene from site (Florigene). A picture of Florigene®Moonshadow™ was not available at this site.
Florigene®Moonaqua™ and Florigene®Moonlite™ have approvals in the EU.
Notifications of Florigene®Moonvista™, Florigene®Moonberry™ and Florigene®Moonvelvet™ are pending in the EU.
Florigene®Moonshade™, Florigene®Moonique™ and Florigene®Moonpearl™ do not have approvals in the EU.

4 Potential environmental and human health risks

Scope of the risk assessment
GM Carnations are only sold as cut flowers and are not intended to be cultured in the Netherlands as the approvals do not include cultivation.

Characteristics
Dianthus is a genus of about 300 species of flowering plants in the family Caryophyllaceae. Carnations (*D. caryophyllus*), have been extensively bred and hybridised to produce many thousands of cultivars for garden use and floristry. In the Netherlands, some rare *Dianthus* species occur: *D. deltoides* (steenanjer; Maiden pink), *D. armeria* (ruige anjer; Deptford pink), *D. superbus*, (pracht anjer; Large pink) and *D. carthusonarium* (Kartuizer anjer; Charterhouse pink). The species *D. barbatus* (duizendschoon; Sweet William) is commonly grown as a garden plant and has established itself in the wild. Cross-hybridisation with any of these wild *Dianthus* species would be possible in theory. However, spontaneous hybridisation between cultivated carnation and wild *Dianthus* species has never been reported, despite decades of cultivation in gardens.

Persistence and invasiveness including plant-to-plant gene flow
Carnation is not able to spread vegetatively, neither does it produce vegetative organs like bulbs, stolons or rhizomes (COGEM, 2006). As these carnations are cut flowers, potential flowers cannot form seeds. Thus, survival and weediness do not need to be considered.

Interactions between the GM plant and target and non-target organisms

No target or non-target effects are likely to arise from a different colour.

Effects on soil

Exposure of soil microorganisms to GM carnations introduced in the environment is limited to composting of the withered material. The inserted genes responsible for the modified colour are not known to be antimicrobial, and are not expected to persist in soil. Thus, potential adverse effects on the soil ecosystem because of composting are not expected.

Effects on human health

Consumption of leaves or flowers of carnation might occur incidentally although they are not intended to be used as food. The petals, however, might be used as garnishing of salads and desserts. Negative effects of transgenic proteins on human and animal health are not expected as these proteins do not share homologies wit known toxins or allergens (COGEM, 2006).

Conclusion

It can be concluded that an illegal import of carnations does not pose a significant risk to human health or the environment. As the new traits of the different carnation varieties are similar the EFSA scientific opinion on Moonaqua can be referred to (EFSA, 2008). The chances of illegal import of carnations are considered to be minimal.

4.2.2 Rosa x hybrida

GM rose is a possible candidate for illegal environmental introductions in Europe. In Japan, two GM rose varieties have been approved (IFD-52901-9 and IFD-52401-4) with modified flavonoid biosynthesis pathway (Table 8). The roses contain introduced *f3'5'h* and *5at* genes from Florigene plasmid pSPB130 (IFD 2010). Production of these roses takes place in Japan and Colombia. Applause rose (IFD-52401-4) is produced at a small scale in Japan.

The four aspects to prioritise GM rose for its potential introduction are dealt with below:

1 *Approvals of the GM ornamental in the exporting country.*
Approvals for cultivation of the two GM roses are present in both Japan and Colombia. Japan also has approved the marketing of the GM roses.

2 *Potential import into the Netherlands*
IFD-52401-has not been grown commercially. It was grown for a short period in Colombia on a trial basis, but Applause rose IFD-52401-4 had more commercial potential (personal communication S. Chandler). Import of IFD-52401-9 is therefore nonexistent. Therefore, the only candidate for potential import is Applause. Marketing of Applause rose IFD-52401-4 in the USA (exported from Japan/Colombia) was not successful (personal communication S. Chandler).
Florigene/Suntory produce these flowers under contract conditions and buy all the product, so there is no possibility of entry of illegal events from the grower (personal communication S. Chandler). As Florigene/Suntory hugely invested in obtaining approvals for these two GM roses, it is not expected that this company would take any risks by undertaking illegal transports. The EU distributor of these carnations has not heard of any illegal imports by other customers of Florigene/Suntory into the EU (personal communication E. Groot, Florigene Flowers Rijnsburg).

3 Possibilities for detection

Florigene roses have a modified colour and can be recognized as such by inspectors. Visual detection should be followed by genetic detection methods (e.g. PCR on the inserted transgene) to confirm the genetic modification.

4 Potential environmental and human health risks

Risk assessments for these roses are available from Australia (OGTR, 2009) and the USA (USDA-APHIS, 2011b). The risk assessments cover both culture of the roses and potential risks related to the cut flowers.

Scope of the risk assessment

GM rosesare only sold as cut flowers and are not intended to be cultured in the Netherlands as Florigene/Suntory does not have approvals for cultivation in the Netherlands

Characteristics

Florigene's roses are modern rose cultivars that have low pollen viability. This poor viability leads to poor seed set and will produce, even under optimal conditions of artificial crosses, only 5-15 seeds (OGTR, 2009). Flower stems for sale are harvested before the buds have opened. Stems are kept in storage prior to sale.

Florigene's IFD-524Ø1-4 and IFD-529Ø1-9 roses (*Rosa* x *hybrida*) were produced using disarmed *Agrobacterium tumefaciens* (IFD 2010) and contain 3 transgene fragments (IFD 2010) from plasmid pSPB130 (IFD 2010): a neomycin phosphotransferase gene, a flavonoid 3', 5'- hydroxylase gene and ananthocyanin 5-acyltransferase gene.

Persistence and invasiveness including plant-to-plant gene flow

According to the risk assessment of USDA-APHIS (2011b) IFD-52901-9 roses (IFD-52901-4 roses as well) are L1 periclinal chimeras. The introduced *f3'5'h* and *5at* genes are only found and expressed in the epidermal tissues and cannot be passed on to progeny through cross pollination (i.e., outcrossing). This was demonstrated in field experiments. Moreover, it is unlikely that pollination occurs after sale because of the limited vase life of the flowers. Thus, reproduction, survival and dissemination do not need to be considered.
Roses are not listed as a weed in several major weed references. There is no increased weediness potential due to the inserted DNA as compared with their non-modified comparators. It can be concluded that IFD-52401-4 and IFD-52901-9 roses do not have an increased risk of becoming persistent and invasive compared to conventional hybrid tea roses.

Interactions between the GM plant and target and non-target organisms

No target or non-target effects are likely to arise from a different colour.

Effects on soil

The exposure of soil microorganisms to GM roses introduced in the environment is limited to composting of the withered material. The genes expressing the modified colour are not known to be antimicrobial, and are not expected to persist in soil. Thus, potential adverse effects on the soil ecosystem as a consequence of composting are not expected

Effects on human health

Consumption of leaves or flowers of roses might occur incidentally although they are not intended to be used as food. The petals, however, might be used as garnishing of salads and desserts. Negative effects of transgenic proteins on human and animal health are not expected as these proteins do not share homologies with known toxins or antigens.

None of the foods or ornamental plants that contain delphinidin are known to pose unique environmental risks because of the presence of delphinidin, its precursor biochemicals or catalytic enzymes (i.e., F3'5'H or 5AT) in the anthocyanin pathways.

Conclusion
It can be concluded that an illegal import of these GM roses (both the rose and the cut flower) in the Netherlandswould not pose a significant risk to human health or the environment. Moreover, the chances of illegal import into the Netherlands are considered to be minimal.

4.2.3 Creeping bentgrass

Although creeping bentgrassgrass will be primarily used as feed, it can also be used in private lawns or in gardens as an ornamental. Creeping bentgrass is native to Western Europe including the Netherlands. Particularly for this reason the potential risks of GM creeping bentgrass needs to be assessed.

The four aspects to prioritise GM creeping bentgrass for its potential introduction are dealt with below:

1. *Approvals of the GM ornamental in the exporting country.*
   GM ornamentals are regulated in the USA. For creeping bentgrass a petition for de-regulation is ongoing. An approval for creeping bentgrass was not found in the BCH database. It seems that a petition of de-regulation can be made directly, without a preceding approval. GM creeping bentgrass is not available on the market yet.

2. *Potential import into the Netherlands*
   Figures 7 to 9 show that the USA is exporting several grasses to the Netherlands. The trade value is 1.400-5600 US$ (*1000) for Kentucky blue grass (*Poa pratensis*), 3.000-5200 US$ (*1000) for fescue and 2.100-8.400 US$ (*1000) for rye grass (*Lolium perenne*). This shows that the trade of grass seeds is well embedded in current import routes. For creeping bentgrass trade values are not available. Since a petition for the non-regulated status of a specific GM creeping bentgrass strain *A. stolonifera* (event ASR368 from the turf cultivar 'Backspin') is still pending since 2003, import of this grass is therefore considered to be unlikely.

3. *Possibilities for detection*
   As only the seeds will be imported, inspectors will not have possibilities for visual detection, apart from the product name on the label. A first easy way of detection is a germination test. An application with glyphosate at the recommended concentration will give a strong indication that the seeds are genetically modified when the seedlings will survive the glyphosate application. According to Table 13 in the Appendix 3, the germination time of bentgrass is 10-14 days. Depending on the age of the seedlings at testing, the time needed to accomplish this test would be at least three weeks. In a next step molecular techniques such as polymerase chain reaction (PCR) assay and Southern blot analysis could confirm that the plants are indeed transgenic and fall under GMO regulation.

4. *Potential environmental and human health risks*
   Scope of the risk assessment
   Prins et al. (2009) included grasses in their proposed priority list as they have a likelihood of dispersal. Species that were considered were creeping bentgrass (*Agrostis stolonifera*), meadow fescue (*Festuca pratensis*), tall fescue (*F. arundinacea*) perennial ryegrass (*Lolium perenne*), Italian

ryegrass (*L. multiflorum*), Kentucky bluegrass (*Poa pratensis*) and westerwolds ryegrass (*L. multiflorum* var. *westerwoldicum*).
According to these authors, GM creeping bentgrass (*A. stolonifera)* is not allowed for cultivation anymore in any part of the world and import into the EU is therefore less likely. However, in the USA a petition for de-regulation GM glyphosate resistant creeping bentgrass is now pending (USDA-APHIS, 2005). If the petition will be accepted, GM creeping bentgrass could be available on the market soon and could therefore be illegally imported in the Netherlands.
A preliminary risk assessment was prepared by USDA-APHIS (2003) for *A. stolonifera.* In addition potential risks of GM *A. stolonifera* were described in a case study (Bauer-Panskus et al., 2013). In case of a possible illegal introduction into the Netherlands (or Europe) only the introduction of seeds is considered relevant for the risk assessment.

Characteristics
Creeping bentgrass is native to Eurasia and North Africa (US-Forest-Service). In the flora of the Netherlands (Van Oostrum, 1977) *A. stolonifera* is described as a native species. Next of kin are *A. canina*, *A, tenuis* and *A. gigantea*. It was probably introduced to North America prior to 1750, and has become naturalized throughout the southern Canadian provinces and most of the United States. Bentgrass reproduces by seed and stolons. It is sexually compatible with many other related species of *Agrostis* (bentgrass) and *Polypogon* (rabbit's-foot grass) (USDA-APHIS, 2003). In the USA, creeping bentgrass can form hybrids with at least 13 naturalized or native species. In pastures and meadows of Europe, creeping bentgrass seeds can survive in the soil for at least 1 year. Others (Bauer-Panskus et al., 2013) mention a period of four years. Bentgrass is wind-pollinated and produces large amounts of pollen. Up to 100.000 pollen per square meter were detected at a 2-3 kilometer distance from a bentgrass field (Bauer-Panskus et al., 2013).

A genetically modified creeping bentgrass has been developed that is tolerant to herbicides containing glyphosate as the active ingredient (Watrud et al., 2004). It contains a single insert of the *EPSP* gene. The CP4-EPSPS protein is an enzyme, 5-enolpyruvyl-shikimate-3-phosphate synthase, derived from *Agrobacterium* sp. strain CP4, that unlike most native plant and microbial EPSPS enzymes, is naturally tolerant to the glyphosate herbicide (USDA-APHIS, 2005).

Persistence and invasiveness including plant-to-plant gene flow
Field trials were performed in central Oregon (USA) in 2004 with the above described GM creeping bentgrass. The field trial covered an area of 160 ha. The bentgrass was glyphosate treated. It was found that pollen from transgenic bentgrass had introgressed into wild growing bentgrass populations. Outcrossing into wild bentgrass populations and the sexually compatible species *Agrostis gigantea* took place at distances of up to 14 kilometers; cross-pollination by using trap plants was even found at a distance of 21 kilometers.
Application of glyphosate confers an advantage to GM bentgrass compared with non-modified bentgrass. The preliminary conclusion of USDA-APHIS (2003) was that there is the possibility that glyphosate-tolerant creeping bentgrass and/or glyphosate tolerant relatives (hybrids) would establish in various urbanized, rural and natural areas.

Interactions between the GM plant and target and non-target organisms
For all other aspects GM bentgrass probably does not differ from its natural counterpart as the inserted gene conferring tolerance to glyphosate is not likely to give any advantage in these aspects.

Effects on soil
Similar as written above.

Effects on human health
Grasses are not suitable for human consumption. Accidental consumption is not expected either. Therefore, negative effects of transgenic proteins on human health are not expected. Effects on animal health are not expected as the new trait is based on herbicide-tolerance and the CP4 EPSPS protein is not considered a toxicant or allergen (OECD, 1999).

Conclusion
It can be concluded that there is a high risk of outbreeding of creeping bentgrass in case glyphosate is applied. This species is native in the Netherlands and outcrossing can occur with other native species. This is a serious concern as these species are strongly outbreeding.
The chances of illegal import into the Netherlands are considered to be minimal as this GM grass is not yet available on the market.

4.2.4 Petunia

Known as garden petunias, this genus has a long history (since the 19th century) of artificial crossings, and the hybrids between *Petunia axillaris* (Lam.) and *Petunia integrifolia* (Hook.) are disseminated worldwide as ornamental plants (*Petunia hybrida*) (Lorenz-Lemke et al., 2006). The genetics of the flower colour has been reviewed by Tornielli et al. (2009) while the background of other modifications has been described in a book of Gerats and Strommer (2009). Tables 2, 3 and 4 shows that modifications for many different characteristics such as drought resistance, modified colour, disease resistance, modified habit, male sterility and modified scent have been successful.

1. *Approvals of the GM ornamental in the exporting country*
   In China at least one GM *Petunia* variety appears to be on the market. In China GM organisms need to be registrated. The Biosafety Clearing House of China (BCH_CHINA) however does not provide information on petunias. One *Petunia* is approved for cultivation in 1998 although an official document is not available according to ISAAA (ISAAA), (Gale et al., 2001). Details on its modification are not available but there is indirect evidence that it concerns a reddish colour modification (Figure 1).
   In the USA *Petunia* is non-regulated. It is unclear whether GM *Petunia* is currently available on the USA market and what the new traits would be.

2. *Potential import into the Netherlands*
   In the Netherlands, many different *Petunia* varieties are on the market. Introduction of a new variety only stands out against all others when it is different from colour or a new trait such a drought or cold resistance. Import from China of all cut flowers is quite low with 115.000 US$ (*1000) (ITC). Thus, the import of bedding plants might even be lower. Exact data are, however, not available. Import of seed packages of red Shock Wave™ *Petunia* from the USA, on the other hand, is relatively easy. It is however not known if red Shock Wave™ *Petunia* is genetically modified. In principle, some new characteristics can be achieved through genetic modification as well as through conventional breeding. The red Shock Wave™ petunias sold by Park Seed is a good example as the colour red does not occur naturally in petunias except in *Petunia exserta* (Griesbach et al., 1999). This species is very rare and only occurs in the Serra do Sudeste region in the extreme south of Brazil and is not brought into cultivation. Apart from being red, this red Shock Wave™ *Petunia* is claimed to be disease resistant, heat tolerant and pest resistant. The question arises how these new traits have been

achieved. Seeds are sold on the internet by Park Seed in the USA in packages of 10 seeds for $4.50. It is not possible through this desk research to establish whether these petunias are genetically modified or obtained through conventional breeding.

3. *Possibilities for detection*
The exact modifications of the USA GM petunias are unknown. For these petunias detection methods are therefore not available. Allegedly, the Chinese GM *Petunia* can be recognized by its red colour. As a red colour can also be achieved through traditional breeding techniques, it is difficult to visually recognize a GM *Petunia* by its colour.

4. *Potential environmental and human health risks*

Scope of the risk assessment
Petunias are marketed as bedding and pot plants as well as seeds. As the inserted gene is unknown, the following environmental risk assessment could not be based on existing risk assessments and will be incomplete.

Characteristics
The genus *Petunia* consists of 14 currently recognized species native to temperate and subtropical South America (Stehman et al., 2009). An historical overview on *Petunia* research is given by Gerats and Strommer (2009). Petunia has been an ideal model system for several reasons. It has an easy and fast growth cycle, donates prolific material, and it is easy to transform. Many forward and reverse genetic strategies have been worked out thanks to its transposable element system.

Persistence and invasiveness including plant-to-plant gene flow
Petunia is not indigenous in the Netherlands and its seed is not expected to survive the cold winters as *Petunia* is native to temperate and subtropical South America. The risk of invasiveness is considered to be minimal as *Petunia* has no potential for weediness.

Interactions between the GM plant and target and non-target organisms
As the exact modifications of the possibly GM *Petunia* from the USA and the Chinese GM *Petunia* are unknown, this part of the risk assessment cannot be performed. Concerning the assumed red colour of the Chinese GM *Petunia*, no target or non-target effects are likely to arise from a different colour. There are no effects on pollinating insects either as insects are able to see the colour red. Other risks depend on other introduced traits.
Effects on soil
No effects of a modified colour on soil organisms are known to occur.

Effects on human health
If GM *Petunia* had indeed only a modified colour negative effects of transgenic proteins on human and animal health are not expected as these proteins probably do not share homologies with known toxins or allergens.

Conclusion
The exact modification of the above described petunias is unknown. In case of a modification of the colour it can be concluded from a preliminary risk assessment that an illegal import of these GM *Petunia* in the Netherlands does not pose a significant risk to human health or the environment. Illegal imports into the Netherlands of seed packages are considered to be likely.

4.2.5 Pelargonium

Several successful transformations are listed in Table 2. New characteristics include a modified appearance and a modification of the floral scent. Field experiments have been performed in the USA with glyphosate-resistant and colour modified *Pelargonium* (Scotts company).

1. Approvals of the GM ornamental in the exporting country
   GM *Pelargonium* is not regulated in the USA.

2. *Potential import into the Netherlands*
   Field experiments performed by Scotts company in the USA (Table 4) concerned glyphosate tolerant *Pelargonium* and *Pelargonium* with a modified colour. It is unknown whether GM *Pelargonium* is actually on the market in the USA. *Pelargonium* can be easily bought on the internet as seed packages.

3. *Possibilities for detection*
   As the modification of GM *Pelargonium* from the USA is unknown there are no possibilities for its detection.

4. *Potential environmental and human health risks*

   Scope of the risk assessment
   As the inserted gene is unknown, the following environmental risk assessment will be incomplete. In general, *Pelargonium* is sold as a potting or bedding plant. Seeds of *Pelargonium* can also be purchased.

   Characteristics
   Pelargonium is a genus of flowering plants which includes about 200 species of perennials, succulents, and shrubs, commonly known as geraniums. Confusingly, Geranium is the correct botanical name of a separate genus of related plants often called cranesbills or hardy geraniums. Both genera belong to the family Geraniaceae. *Pelargonium* species are evergreen perennials indigenous to Southern Africa, and are drought and heat tolerant, but can tolerate only minor frosts. They are extremely popular garden plants, grown as bedding plants in temperate regions (Wikipedia).

   Persistence and invasiveness including plant-to-plant gene flow
   Pelargonium is not indigenous in the Netherlands and is not able to hibernate in the garden. The risk of invasiveness is considered to be minimal as *Pelargonium* has no potential for weediness.

   Interactions between the GM plant and target and non-target organisms
   As the exact modification is unknown, this part of the risk assessment cannot be performed.
   Effects on soil
   As the exact modification is unknown, this part of the risk assessment cannot be performed.

   Effects on human health
   As the exact modification of *Pelargonium* is unknown it is not possible to assess whether an illegal import of GM *Pelargonium* in the Netherlands poses a significant risk to human health or the environment.

   Conclusion
   The exact modification of GM *Pelargonium* is unknown. In case of a modification of the colour it can be concluded from a preliminary risk

assessment that an illegal import of these GM pelargoniums in the Netherlands does not pose a significant risk to human health or the environment. Illegal imports into the Netherlands of seed packages are considered to be likely.

4.3 Prioritisation

In the table below the evaluated aspects are summarized. The priority for ILT to survey the specific GM ornamental depends on the availability on the foreign market, the possibility of import, the detection methods and the potential environmental and human health risks. In case either the import or the potential risks are considered to be low, the resulting priority is low.

Table 11. Summary of evaluated aspects.

Species	**Priority**	**Exporting country; Company**	**Import**	**Detection method**	**Potential environmental and human health risks**
Carnations other than those allowed in the EU	Low	Colombia, Ecuador; Florigene/ Suntory	Only transit shipments	Visual, followed by molecular techniques[4]	Low
Rosa x hybrida	Low	Japan, Colombia; Florigene/ Suntory	Not likely[1]	Visual, followed by molecular techniques[4]	Low
Rose Applause	Low	Japan; Florigene/ Suntory	Not likely[1]	Visual, followed by molecular techniques[4]	Low
Petunia	Low	China	Unknown but not likely[1]	Visual, followed by molecular techniques[5]	Low, in case of colour modification
Agrostis stolonifera (creeping bentgrass)	Low, but changes to high when commer-cialized	USA; Scotts Company	No, not commer-cialized yet	Seedling test, followed by molecular techniques[6]	Environmental risks potentially high
Petunia	Medium	USA	Unknown[2, 3]	Unknown, discrimination between GM and traditional breeding techniques is unclear	Low, in case of colour modification
Pelargonium	Medium	USA	Unknown[2, 3]	No, modification unknown[5]	Unknown

1. Import is unlikely as Florigene/Suntory is well in control of the trade
2. Import of annuals unlikely as total value of import from this country is very low (Appendix 2, Figure 6)
3. Import of seed packages through the post is considered to be a possible route
4. Detection method for the insert is present in the dossier
5. Detection method should be accessible with the exporting company
6. Detection method is known to Scotts Company

Table 11 shows that only a few candidates of illegal import into the Netherlands were identified.
Carnations, other than those that have approvals in the EU may pass the Netherlands through transits.

GM roses are produced at a small scale in Colombia and Japan but illegal imports into the Netherlands are considered to be absent. Its new characteristic is probably a red colour but this could not be confirmed in the official databases. *Petunia* is non-regulated in the USA. Therefore it is unclear whether GM modified *Petunia* is available on the USA market. A problem in the identification of possibly GM petunias is that many characteristics could also be achieved with traditional breeding techniques. Medium priority was given to GM *Petunia* from the USA as the seeds can be easily ordered by internet. Low priority was given to GM *Petunia* from China as the risks of a modification of the colour are considered to be low.
The potential environmental risks of the grass *Agrostis stolonifera* (creeping bentgrass) are considered to be high if grown in combination with glyphosate. But, since this grass is no yet commercialized, ILT inspection is not needed yet. At last, the presence of GM *Pelargonium* in the USA is unknown. A medium priority was given to GM *Pelargonium* from the USA as the seeds can be easily ordered by internet.

Perspectives in ornamental breeding

Databank of constructs
The CRES-T system (Chimeric REpressor gene-Silencing Technology) is a novel gene silencing technology for genes encoding transcription factors. In the resulting transgenic plants, certain genes will be suppressed even in presence of redundant transcription factors. A database was designed to provide phenotypic information of various plants which were modified with this CRES-T technology (CRES-T). This database shows all possible constructs that are available for carnation, *Rosa, Torenia fournieri, Gentiana, Pharbitis, Chrysanthemum, Eustoma* and *Cyclamen*. This CREST-T system may shorten and accelerate the development of a marketable GM ornamental as the initial laboratory work has already been accomplished.

Reverse genetics
Reverse genetics seeks to find what phenotypes arise as a result of particular genetic sequences. Using various techniques, a gene's function is altered and the effect on the development of the plant is analyzed. The techniques include either classical non-transgenic mutagenesis methods or transgenic methods such as transposon insertion mutagenesis. Thus, reverse genetics is potentially accelerating the breeding of new varieties using either non-transgenic or transgenic techniques. As the regulatory system in Canada and the USA is different from the EU, several products of reverse genetics using transgenic mutagenesis methods may already be on the market. This could however, not be confirmed during this inventory.

Recommendations
This desk research did not reveal evidence of illegal imports of GM ornamentals into the Netherlands. This was confirmed by recent reviews on this topic. This report however shows that many GM ornamentals could potentially be introduced on the market. As some GM ornamentals in the USA and Canada are non-regulated, ILT inspections should remain alert, in particularly of introductions of grass seed of *Agrostis stolonifera.* The main problem that will be encountered is that the exact modifications of non-regulated GM ornamentals, such as *Petunia* and *Pelargonium* from the USA, are unknown and detection methods are therefore absent. In case of suspicious introductions, further

inquiries can be made with the exporting company in order to establish whether the suspicious introductions are genetically modified or not.

Acknowledgements
The realization of this report was accompanied by my colleagues Boet Glandorf and Eric van den Akker. I thank them for giving me very useful suggestions on how to organize this desk research and for their efforts to scrutinize the interim reports. I also highly appreciated the input of Steve Chandler on the regulatory status of all GM carnations and his willingness to answer many questions.

Appendix 1, Countries exporting to the Netherlands

Table 12 lists the exporting countries for all cut flowers and flower buds for bouquets.

Table 12. List of supplying markets for cut flowers and flower buds for bouquets, fresh or dried. Imports values per year (unit: US dollar thousand) (prepared from (ITC).

Exporters	2008	2009	2010	2011	2012
World	821100	711073	634123	750498	735438
Kenya	337324	300933	295811	329893	321908
Ecuador	93680	78789	72907	79533	81969
Belgium	18581	48850	54086	84216	64524
Ethiopia	92665	89840	35725	39869	43731
Uganda	35931	34299	27398	30394	30982
Colombia	27293	25526	27211	26479	30745
Germany	15595	12462	11358	27164	29999
Italy	20446	15288	16090	24926	25147
Spain	13770	8475	8991	18899	17687
Zambia	17754	12693	10923	11337	14635
Israel	46419	8620	8907	10990	11865
Zimbabwe	23745	18121	18260	13300	10345
United Kingdom	11219	7094	4191	7357	8855
United Republic of Tanzania	15021	13257	9795	9747	7114
South Africa	6684	5414	6374	6032	5780
France	8089	5461	4588	5523	4453
Portugal	7571	5257	3631	4172	4373
Thailand	4166	2592	2389	2956	3311
Turkey	865	951	549	248	3274
Peru	2926	2734	2420	3174	2632
Europe Othr. Nes	343	310	526	2314	2380
Costa Rica	750	600	502	623	1851
Ghana	134	939	1062	1277	1424
Egypt	2097	1237	818	1027	989
Australia	1491	1190	947	817	633
Chile	2350	1410	1092	948	612
India	3934	2811	1302	800	596
Poland	586	439	404	368	519
Ireland	220	202	162	321	462
Guatemala	411	411	448	414	302
Malaysia	180	96	84	222	293
Serbia	78	96	235	181	267
Mexico	1018	573	81	84	252
Denmark	221	123	867	1850	233
Norway	0	0	0	0	203
Côte d'Ivoire	342	114	17	73	159
United States of America	220	120	160	72	134

China	246	515	632	40	115
Suriname	113	121	138	133	109
New Zealand	1239	494	402	441	101
Malawi	317	25	101	53	100
Japan	258	293	211	121	95
Morocco	382	198	16	19	76
Philippines	177	96	52	65	58
Palestine, State of	551	6	395	220	42
Brazil	1306	854	422	229	20
Romania	0	0	0	0	16
Bulgaria	0	0	0	0	10
Hungary	84	40	30	22	8
Argentina	75	236	85	13	6
Sri Lanka	22	25	0	21	6
Lithuania	87	0	12	13	6
Croatia	0	0	11	5	5
Tunisia	6	43	310	160	5
Luxembourg	0	0	1	0	4
Chinese Taipei	611	74	73	53	4
Saudi Arabia	0	0	0	0	4
Viet Nam	1	156	86	1	3
Burundi	280	27	0	0	2
Sweden	0	0	0	0	2
Czech Republic	0	0	0	1	1
Korea, Republic of	0	0	0	3	1
Slovakia	10	0	0	0	1
Slovenia	0	0	0	0	1
Nauru	0	0	3	0	0
Albania	55	3	0	0	0
Austria	850	459	744	1112	0
Armenia	0	0	0	0	0
Bolivia	4	0	15	0	0
Canada	0	29	0	0	0
Dominican Republic	35	3	0	27	0
Eritrea	0	0	0	2	0
Estonia	0	0	3	3	0
Gambia	1	0	0	0	0
Honduras	0	0	0	96	0
Indonesia	1	0	0	0	0
Iran (Islamic Republic of)	10	1	11	5	0
Jordan	0	0	0	7	0
Mauritius	0	1	0	0	0
Mozambique	118	39	12	0	0
Nepal	1	0	0	0	0
Nicaragua	3	0	0	0	0
Rwanda	91	0	0	0	0
Sao Tome and Principe	4	0	0	0	0

Singapore	0	7	0	0	0
Switzerland	0	0	0	0	0
Syrian Arab Republic	0	0	49	0	0
Uruguay	40	0	0	33	0

Appendix 2, Trade of ornamentals

In Figures 4 and 5 the trade of roses and carnations expressed in US$ (*1000). Figure 6 expresses the trade of all cut flowers (excl. roses, carnations, orchids, chrysanthemums and gladioli).
Figures 7 to 9 show the trade of three grass species. The different colours in the map correspond with the tariffs applied by Netherlands to all exporting countries. For this report, only the extent of the trade is of interest, which is presented by the pink circles in each map.

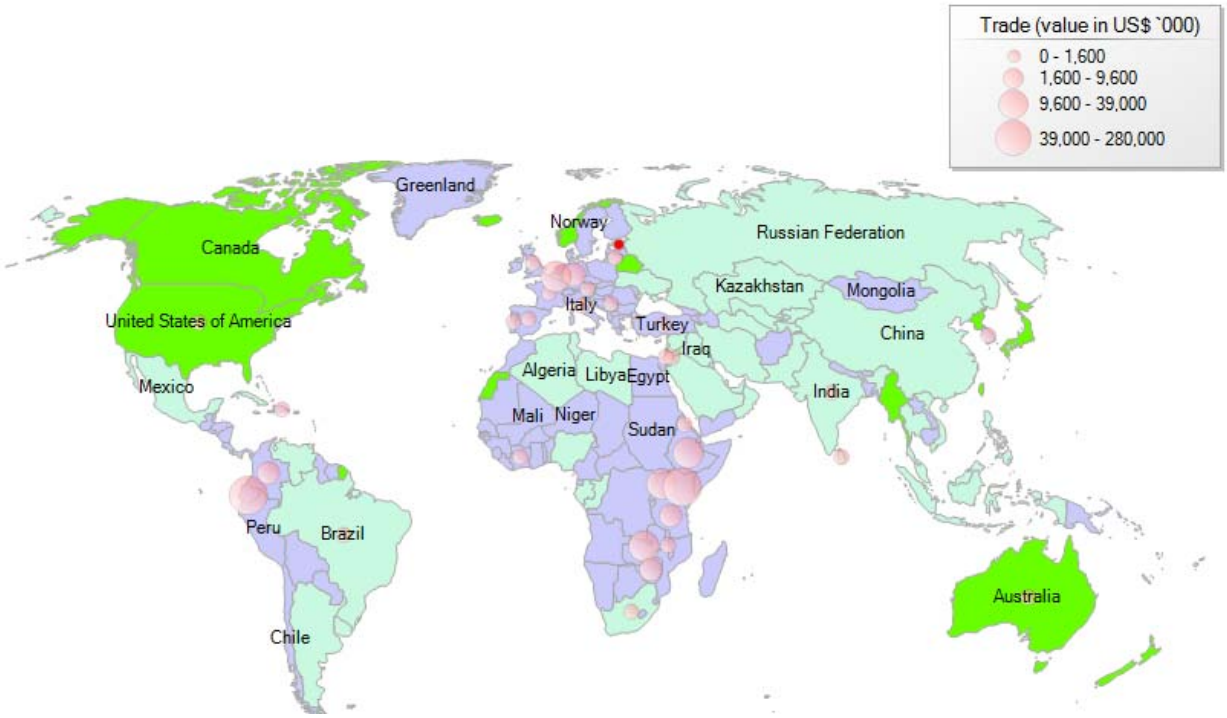

Figure 4. Import of into the Netherland of fresh cut roses and buds.

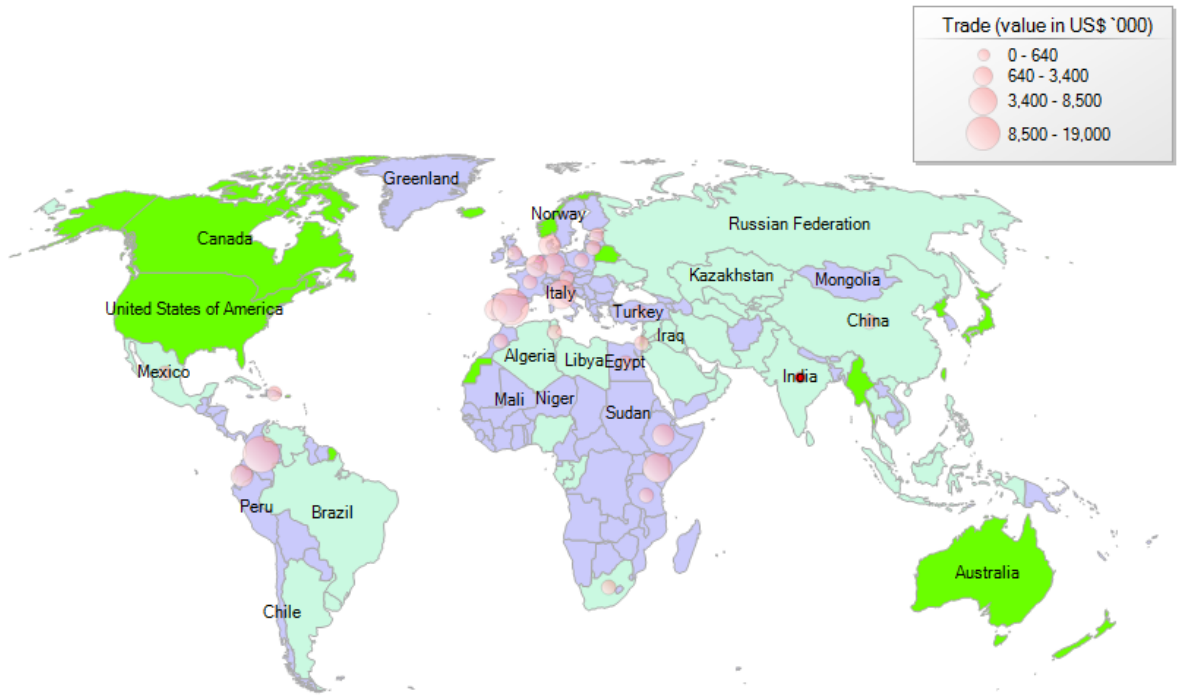

Figure 5. Import of into the Netherland of fresh carnations and buds (Source: Trade Map supplied by the International Trade Centre (ITC)).

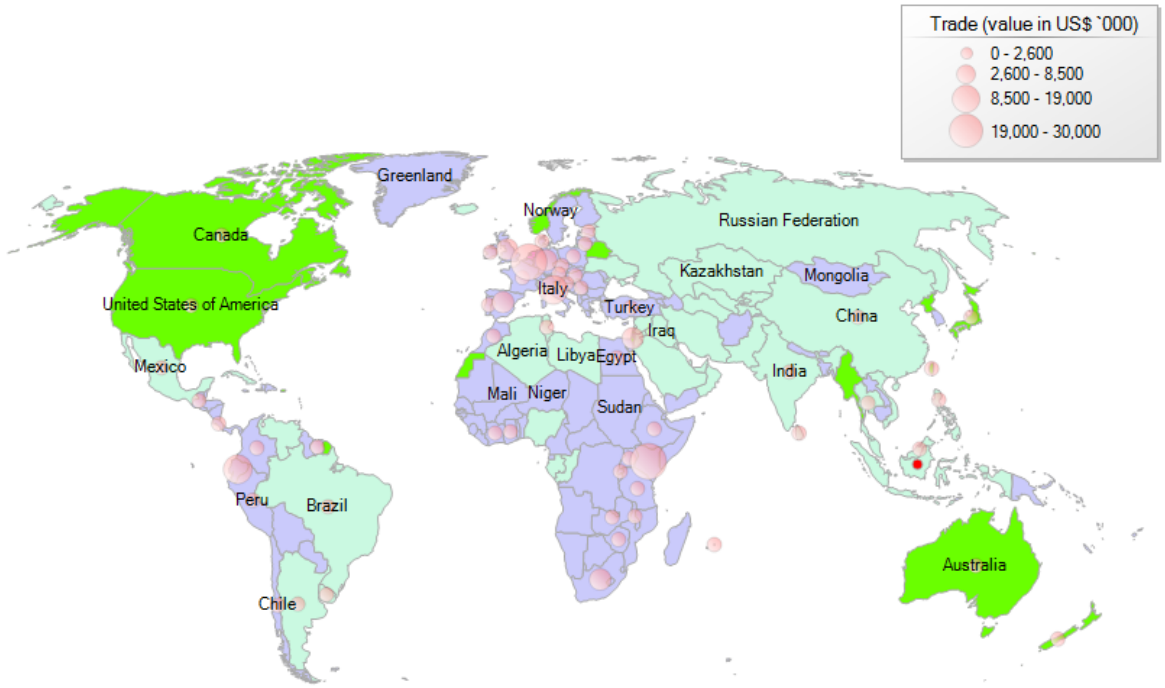

Figure 6. Import of into the Netherland of fresh cut flowers and buds (excl. roses, carnations, orchids, chrysanthemums and gladioli). (Source: Trade Map supplied by the International Trade Centre (ITC)).

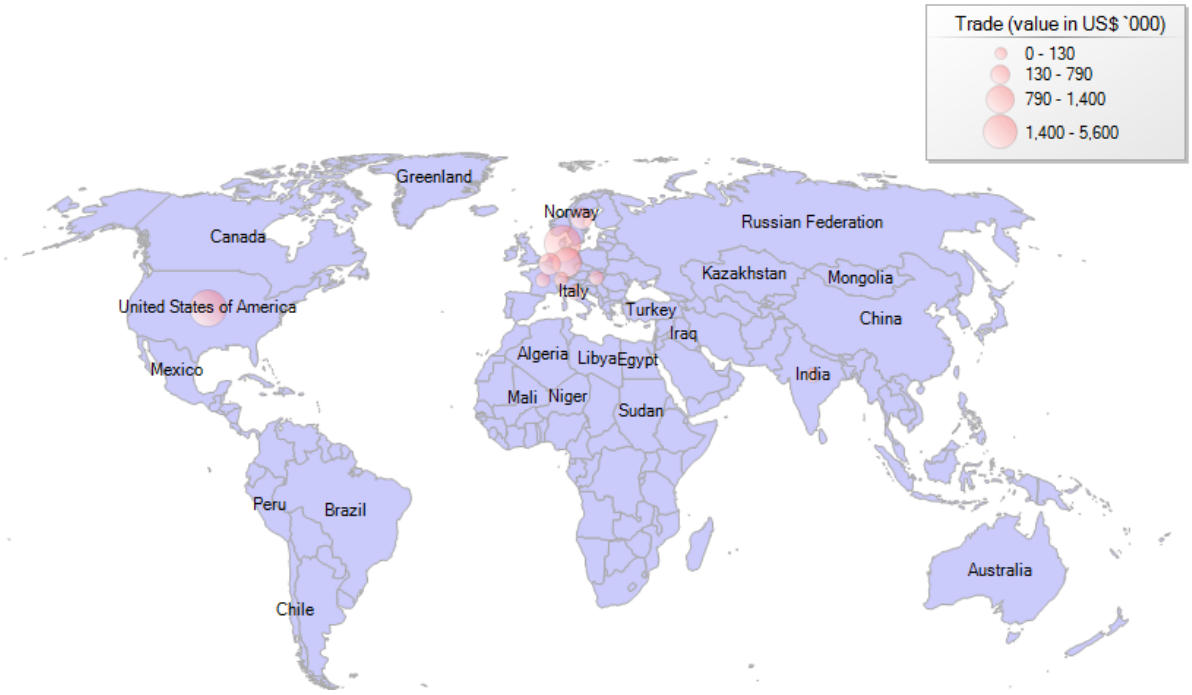

Figure 7. Import of into the Netherland of seeds of Kentucky blue grass (*Poa pratensis*) for sowing. (Source: Trade Map supplied by the International Trade Centre (ITC)).

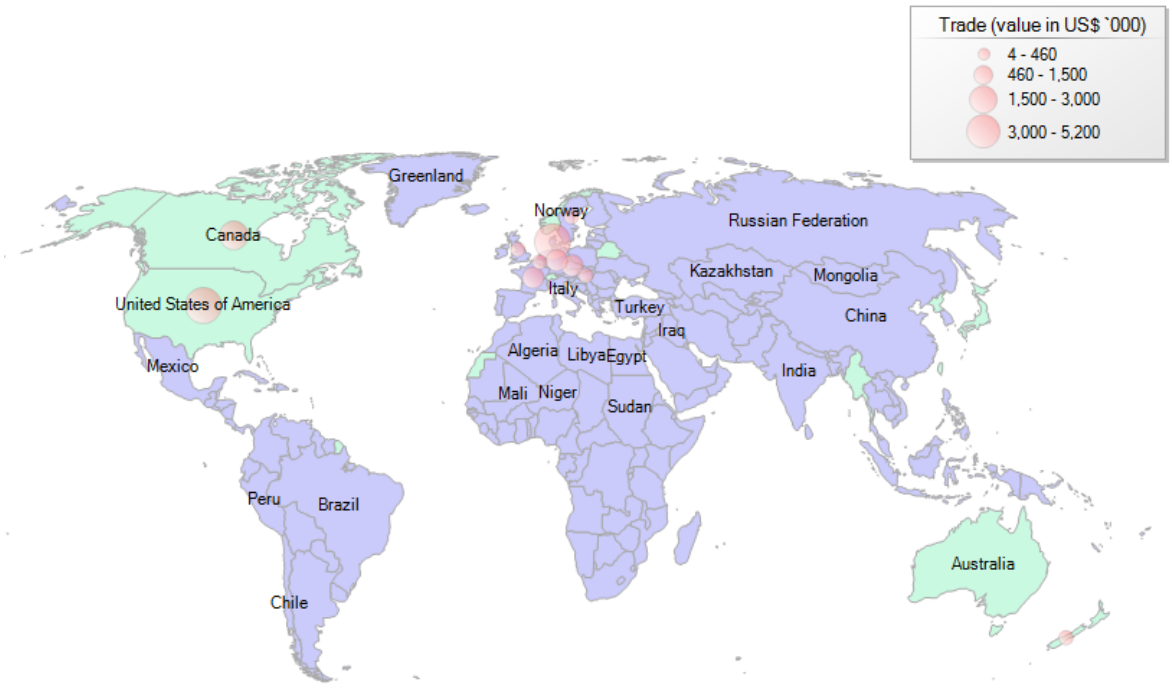

Figure 8. Import of into the Netherland of seeds of fescue (*Festuca arundinacea*) for sowing. (Source: Trade Map supplied by the International Trade Centre (ITC)).

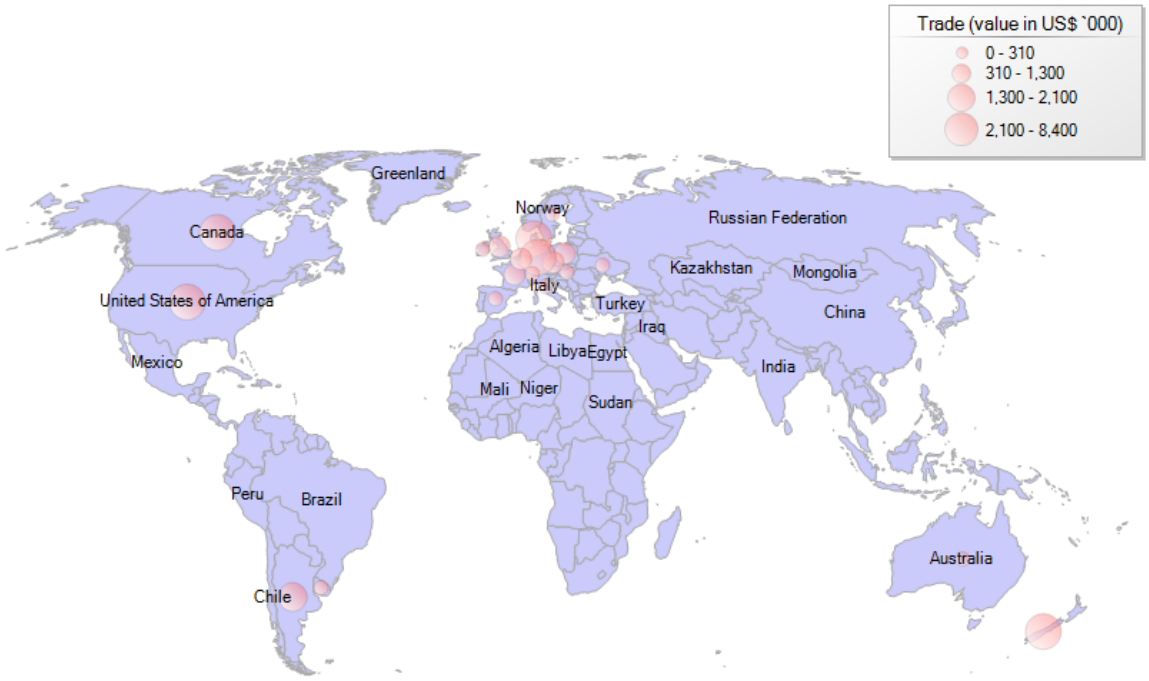

Figure 9. Import of into the Netherland of seeds of rye grass (*Lolium perenne*) for sowing. (Source: Trade Map supplied by the International Trade Centre (ITC)).

Appendix 3, Grass seed germination rates

Table 13. Germination rates of grass seed (UC-IPM-Online).

Germination rates of grass seed	
Turf species	**Expected germination time (days)**
Annual ryegrass	5 - 10
Bermudagrass (Seeded)	10 - 30
Buffalograss	14 - 30
Colonial bentgrass	10 - 14
Creeping bentgrass	10 - 14
Hard fescue	7 - 14
Kentucky bluegrass	14 - 30
Perennial ryegrass	5 - 10
Red fescue	7 - 14
Rough bluegrass	7 - 10
Tall fescue	7 - 12

Appendix 4, Blue roses obtained through traditional breeding

Applause is a GM rose which has a mauve/violet colour. Traditional breeding cannot approach this colour. Nevertheless, there are roses carrying names that suggest they are blue/purple (Table 14).

Table 14. Blue roses obtained through traditional breeding.

Trade name	**Breeder**	**Country of generation**	**website**
Blue Moon			(Rozenrijk) (LaMarco)
Blue River			(Rozenrijk)
Big Purple	P. Stephens, 1986		(Rozenrijk)
Blackberry Nip			(Rozenrijk)
Lilac Miracle		NL	(Rozenrijk)
Rhapsody in Blue	Kordes	Germany	(Rozenrijk)
Liliac Miracle	Rozenrijk	NL	(Rozenrijk)
Blue Girl	Nirp		(Rozenrijk)
Blue for You (Synonyms: Pacific Dream, Ellerines, Honky Tonk Blues)			(Thousand-islands-roses)
Blue girl			(LaMarco)
Blue Nile			(LaMarco)
Shocking Blue			(LaMarco)
Blueberry Hill			(LaMarco)

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