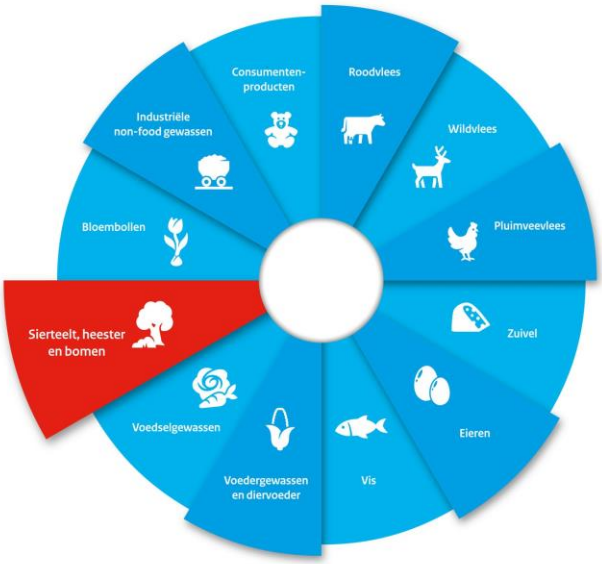
Advisory Report on the Risks of the Ornamental Horticulture Production Chain

Annexes
7 December 2020
TRCVWA/2020/6437



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1.1 Aim

The aim of the risk assessment for the ornamental horticulture production chain is to identify the hazards and risks for plant health, nature and the environment, public health and animal health that could arise in the various phases of the ornamental horticulture production chain and to recommend measures to reduce these risks.

1.2 Definition, focus and scope

Ornamental horticulture includes all plants that are grown for their ornamental value. Floricultural products include breeding and propagating material for ornamental plants, ornamental plants and parts of ornamental plants (cut flowers, cut branches, ornamental fruit, etc.) that are traded.

The ornamental horticulture sector is very diverse. Accordingly, for the purpose of assessing risks to plant health, we have divided ornamental horticulture into:
- cultivation in heated greenhouses;
- cultivation outdoors, in unheated greenhouses and in plastic tunnels; and
- marsh and aquatic plants.

Because a separate production chain assessment has been performed for flower bulb cultivation, this cultivation type falls outside the scope of the risk assessment for the ornamental horticulture production chain[1].

The ornamental horticulture production chain can be divided into several links. The supply chain starts with breeding and runs through propagation and production (pretreatment, cultivation and post-harvest treatment) to trading of the end product. Floricultural products may be imported at any phase of the supply chain. The risks from imported products are included in the supply chain assessment. Consumer behaviour falls outside the scope of this assessment, with the exception of the eating of plants and parts of plants grown for their ornamental value.

Hazards were identified and risks assessed for plant health, nature and the environment, public health and animal health in the Netherlands.

1.2.1 Plant health

For plant health, we assessed the risks from:
- harmful organisms for ornamental horticulture and for plants in nature[2] and tropical greenhouses (in zoos, arboretums, etc.). In doing so, we primarily looked at organisms with quarantine status and those that are or could be eligible for that status.

Harmful organisms are organisms (viroids, viruses, bacteria, fungi, pseudofungi, insects, mites, nematodes, gastropods and plants) that can infect or infest plants. This can lead to a reduction in the quantity and/or quality of plants or harvested products. In the risk assessment, we primarily looked at risks from organisms that have quarantine status in the European Union (Union quarantine pests or EU Q-pests) or that might be eligible for that status (new harmful organisms

[1] BuRO advisory report on risks from the flower bulb supply chain, see https://www.nvwa.nl/documenten/plant/plantziekte-en-plaag/plantziekte-en-plaag-overig/risicobeoordelingen/advies-van-buro-over-de-risico%E2%80%99s-van-de-bloembollenketen

[2] For the purposes of this report, 'nature' (also called 'green spaces') have been broadly defined as all open areas of land with plants and/or water, whether public or private, where no commercial cultivation is taking place. This means 'nature' include public and private gardens, parks, open water and forests. However, for the assessment of the risk from invasive exotic plants, plantings in parks and public and private gardens are excluded from the concept of 'nature'.

and potential EU Q-pests) under Regulation (EU) 2016/2031 (the Plant Health Regulation)[3] (Table 1). An EU Q-pest is defined in the Plant Health Regulation as an organism with a clear identity that is not present in the EU or, if present, is not widely distributed, which could establish itself in the EU and would have unacceptable consequences after introduction, against which feasible and effective measures are available and which is listed in Annex II of Commission Implementing Regulation (EU) 2019/2072 (Article 4 of the Plant Health Regulation). There is a zero-tolerance policy for EU Q-pests. Priority EU Q-pests form a special group within the wider category of EU Q-pests and are subject to additional requirements. In this risk assessment, in addition to the organisms listed in Annex II of the implementing regulation referred to above, organisms for which measures apply via an implementing act (Article 30 of the Plant Health Regulation) are also treated as EU Q-pests, since these organisms are also subject to a European control obligation.

In this report, a 'new harmful organism' is defined as an organism that is not present in the EU, or, if present, is not widely distributed, and does not have quarantine status. If the organism is already present in the EU (in a limited area), it is usually an organism that did not originate in the EU and has thus been introduced from outside the EU. A potential EU Q-pest is a 'new harmful organism' that meets all of the criteria for an EU Q-pest. Potential EU Q-pests are therefore harmful organisms that could possibly be given European quarantine status in the future. The Plant Health Regulation also states that, if a Member State finds an organism that, based on a preliminary risk assessment, meets the criteria for an EU Q-pest, the Member State must take measures to eradicate the organism (Article 29). In the Netherlands, these organisms are referred to as 'NL-provisional Q-pests'. Organisms can also be given the NL-provisional Q-pest status in the Netherlands following a request from a company or institution to be allowed to import the organism for research purposes. In the rest of this report, EU Q-pests will simply be called Q-pests.

The following categories of organisms fall outside the scope of this risk assessment (see also Table 1):

- protected zone quarantine pests – pests that are only regulated in certain areas of the EU. The Netherlands has no PZ Q-pests, so this category will not be discussed further;
- EU regulated non-quarantine pests (RNQP);
- organisms with quarantine status in a third country, but not in the EU ('third-country quarantine pests');
- all other organisms.

The presence of harmful organisms in a plant supply chain may lead to reductions in yield, higher plant protection costs and the limitation of sales opportunities. These aspects are included in the assessment of risks from known and potential Q-pests. No estimate has been made of the effects on trade and export from any tightening of the EU phytosanitary laws and regulations. The economic risk from the rejection of an import consignment due to the presence of a known or potential Q-pest also falls outside the scope of this assessment. The risks from known and potential Q-pests have been assessed on the basis of the current laws and regulations and their implementation. Accordingly, the current import flows through which harmful organisms could enter the Netherlands, including import flows from other EU Member States, have been considered. Risks can change when regulations change and/or when import flows, including import flows from other EU Member States, change. The finding of a Q-pest or a potential Q-pest can have a significant impact for a company, landowner and/or other stakeholders, due to the cost of the measures that have to be taken to contain or eradicate the organism. No estimate has been made of the scale of these costs. However, the report does identify the Q-pests for which the likelihood of an infestation at a growing site or in natural space has been assessed as relatively high.

[3] Regulation (EU) 2016/2031 of the European Parliament and of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) No 228/2013, (EU) No 652/2014 and (EU) No 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC. OJ L 317 23.11.2016, p. 4–104

Table 1.1. Categories of harmful organisms that do/do not fall within the scope of this assessment (see the text and Annex 3 for complete definitions).

Category	Abbreviation	Brief definition	In scope
EU quarantine pest	EU Q	Organism in Annex II of Implementing Regulation (EU) 2019/2072	Yes
Priority pest	Priority EU Q	EU Q-pest with additional requirements under Article 6 of Regulation (EU) 2016/2031	Yes
Provisional EU quarantine pest	EU Q[1]	Organism for which temporary EU measures apply via an implementing act	Yes
Protected zone quarantine pest	PZ Q	Organism with quarantine status for specific areas within the EU	No
EU-regulated non-quarantine pest	RNQP	Organism that is only regulated for certain plant material	No
New harmful organism	-	Harmful organism that is not present in the EU or, if present, is not widely distributed (one of the criteria for an EU Q-pest)	Yes[2]
Potential EU quarantine pest	Potential EU Q	New harmful organism that meets all of the criteria for an EU Q	Yes
NL-provisional Q-pest	NL-provisional Q	Potential EU Q-pest for which official measures apply in the Netherlands	Yes
Third-country quarantine pest	Third-country Q	Organism that has quarantine status in a third country	No
Other organisms	-	Organisms that do not fall under any of the above definitions	No

[1] Please note that, according to Regulation 2016/2031, only the organisms listed in Annex II of Implementing Regulation 2019/2072 are EU quarantine pests.
[2] An assessment is required of whether the organism meets all of the criteria for an EU Q-pest.

1.2.2 Nature and the environment

For nature, in addition to the risks posed by known and potential quarantine pests, we also assessed the risks from:

- the introduction of other invasive exotic species through the ornamental horticulture production chain; and
- the use of organisms for biological pest control in ornamental horticulture.

Invasive exotic species are non-native organisms that have entered or could enter the Netherlands through the actions of human beings and after introduction constitute a threat to flora and fauna in the Netherlands. This term can refer both to plants and to other organisms. Biological control agents include insects, mites and nematodes used to control pests and diseases; the use of exotic organisms for this purpose can pose a risk to native flora and fauna.

In relation to the environment, we identified the risks for surface water and groundwater that may arise from the use of plant protection products and biocides; our examination was limited to the risks from the active substances in plant protection products and biocides (to the extent this information was available) and did not look at any risks from adjuvants[4] or basic substances[5]. Although the NVWA itself does not take measurements of surface water or groundwater, it does monitor correct agricultural use of plant protection products. Incorrect use can lead to standards being exceeded. These environmental risks are identified in the risk assessment but not addressed in detail, since this policy area is the responsibility of the Ministry of Infrastructure and Water Management. Potential risks for animal health are also not included in this risk assessment, such as those relating to farm animals in pastures next to fields that have been sprayed, ditch water that may be drunk by farm animals after spraying or pets that enter a barn or shed after treatment. The risks for nature and the environment resulting from the application of fertiliser to ornamental plants also fall outside the scope of this risk assessment, as does the use of plant protection products by private individuals in ornamental gardens, on pot plants, etc. However, the risks to bees from plant protection products are discussed briefly.

1.2.3 Public health

For public health, we assessed the risks from:

- the use of plant protection products and biocides in ornamental horticulture, for consumers and local residents. The risks for workers and processors are also discussed briefly. As with the risks for nature and the environment, we only looked at the risks from active substances and did not examine any risks from adjuvants or basic substances;
- residues from plant protection products on floricultural products (including imported products);
- the dyeing and preserving of floricultural products (post-harvest treatment);
- the accidental consumption of ornamental plants;
- plant allergens; and
- the introduction of organisms that are harmful to humans through the importing of floricultural products.

Risks for growers and workers in the ornamental horticulture production chain (work-related risks) are identified but not discussed in detail, since monitoring of such risks falls under the purview of the Social Affairs and Employment Inspectorate rather than that of the NVWA.

1.2.4 Animal health

For animal health, we assessed the risks from:

- the introduction of organisms that are harmful to animals through the importing of floricultural products.

The risks from ingestion of floricultural products by pets and farm animals are identified but not discussed in detail. The risks for farm animals from plants of all kinds are discussed in the BuRO's 'animal feed supply chain risk assessment'.

1.3 Assessment framework

The Office for Risk Assessment & Research (BuRO) performed the risk assessment for the ornamental horticulture production chain in accordance with the Food and Consumer Product Safety Authority Independent Risk Assessment Act (WOR). Two criteria played a role:

- scientific substantiation; and
- independence.

BuRO designed and performed the risk assessment independently. No other departments of the NVWA were permitted to be involved, except at the initiative of BuRO to obtain additional information or for fact checking. The policy directorates of the Ministry of Agriculture, Nature and

[4] An adjuvant may be added to a plant protection product to improve its effectiveness. Adjuvants require administrative registration; the legislation for the assessment of these substances needs to be more detailed.
[5] A basic substance is one that is already on the market for use for another purpose (for example, in cosmetics or food). Any risks have therefore already been identified. Basic substances may be used for plant protection, but they cannot be sold as plant protection products. There is a list of 'permitted basic substances'.

Food Quality and the Board for the Authorisation of Plant Protection Products and Biocides (Ctgb) were also asked to provide factual information. The recommendations resulting from the risk assessment are designed to assist the risk management activities performed by the NVWA directorates and the Ministries of Agriculture, Nature and Food Quality and Health, Welfare and Sport.

BuRO has applied the definition of 'risk' as formulated by Rosa (1998).

"(A risk is:)
A situation or event in which something of human value (including humans themselves) has been put at stake and where the outcome is uncertain."

Under the concept of risk, BuRO therefore distinguishes between the *likelihood* of something of human value being threatened and the *effect* of the threat.

A 'hazard' is defined as a biological, chemical or physical agent with potential adverse effects for something of human value[6]. In the ornamental horticulture production chain, these are mainly the values of plant health, nature and the environment, public health and animal health.

Other social values are also important in any supply chain, such as honesty and trust. These values are linked to fair trade, product integrity and fraud. Although Rosa's definition allows these values to be analysed, the BuRO analysis was limited in this risk assessment to the first values listed, namely plant health, nature and the environment, public health and animal health. As a side note, the public value of plant health in practice coincides to a significant extent with economic values such as trading positions and product quality. After all, as well as having consequences for the health of the ornamental plants in question, the presence of pests and diseases in ornamental horticulture also has economic consequences: consignments are worth less and may even be unsaleable, and the export position of the Netherlands may be compromised. Partly due to the interconnectedness of the values of plant health, export and export position, the export aspect was included in the risk assessment. The same applies to imports, primarily because the importing of floricultural products creates a risk for plant health and the natural environment. The economic consequences of the rejection of import consignments due to the presence of a harmful organism were not considered in the risk assessment.

[6] Based on the definition in the General Food Law Regulation (Regulation (EC) No 178/2002 of the European Parliament and of the Council of 28 January 2002 laying down the general principles and requirements of food law, establishing the European Food Safety Authority and laying down procedures in matters of food safety).

2 Description of the ornamental horticulture production chain

2.1 Introduction

2.1.1 Plant groups within the ornamental horticulture production chain

Ornamental horticulture includes all plants that are grown for their ornamental value and are thus not intended for human or animal consumption or for industrial purposes. Ornamental horticulture is part of the horticultural industry and covers a wide variety of plants, which can be divided into a number of different categories and subcategories. For example, in its statistics on the agriculture and horticulture industries, Statistics Netherlands (CBS) divides horticulture into three main categories: 'greenhouse horticulture', 'open-field horticulture' and 'other horticulture'. Within these main categories, the CBS recognises several different plant groups (CBS, 2018):

- greenhouse horticulture (including plants grown under plastic);
    - floristry plants;
        - amaryllis bulbs;
        - flower seeds;
        - bedding plants;
        - pot plants;
        - cut flowers;
        - other floristry plants;
        - growing-on of floristry plants;
    - tree nursery plants and perennials;
        - propagation and/or attraction;
        - full greenhouse cultivation;
- open-field horticulture;
    - flower bulbs and tubers;
    - floristry plants;
        - flower seeds;
        - other floristry plants;
    - tree nursery plants and perennials;
        - forest trees and hedging plants;
        - *Buxus;*
        - avenue and park trees;
        - rose bushes;
        - ornamental conifers;
        - ornamental shrubs and climbing plants;
        - forced and berry-bearing shrubs;
        - fruit trees;
        - perennials;
- other horticulture;
    - forced bulbs;
        - forced hyacinths;
        - forced narcissuses;
        - forced tulips;
        - other forced bulbs.

The Ctgb (Board for the Authorisation of Plant Protection Products and Biocides) uses the following classification/application areas for the authorisation of plant protection products for use on ornamental plants (Ctgb, 2019a):

- flower bulb and flower tuber crops;
    - flower bulbs and flower tubers;
    - bulb flowers and tuber flowers: flower cultivation and pot plant cultivation of flower bulbs and flower tubers;
- floristry plants;
    - pot plants, including annual bedding plants, bulb flowers and tuber flowers;
    - cut flowers, incl. summer flowers, dried flowers, bulb flowers and tuber flowers;

    - forced shrubs;
    - cut foliage;
- tree nursery plants;
    - avenue trees;
    - climbing plants;
    - ornamental shrubs (including roses);
    - conifers (including Christmas trees);
    - heather species;
    - forest trees and hedging plants;
    - fruit trees and shrubs;
- perennial cultivation;
- flower seed cultivation;
- marsh and aquatic plants;
- breeding and seed cultivation.

In this classification system, bulb flowers and tuber flowers fall into two categories: flower bulb and flower tuber crops and floristry plants.

2.1.2 Classification used in this study

In this document, for the assessment of the risks for plant health (Chapter 5: Risks from known and potential quarantine pests), ornamental horticulture is divided into three categories:

- cultivation in heated greenhouses;
- cultivation outdoors, in unheated greenhouses or in plastic tunnels; and
- marsh and aquatic plants.

This method of classification, which incorporates elements from the CBS and Ctgb classification systems described above, was chosen because the climate conditions (heated greenhouse versus cultivation outdoors, in an unheated greenhouse or in a plastic tunnel) have a significant effect on the risks from known and potential quarantine pests. For example, several quarantine pests can only become established in the Netherlands in heated greenhouses. There are also known and potential quarantine pests that are specifically adapted to aquatic environments. Marsh and aquatic plants are therefore discussed as a separate group. The categories were not further divided into subcategories, because many quarantine pests can affect plant species from different cultivation categories (such as cut flowers and pot plants). The cultivation of flower bulbs and flower tubers falls outside the scope because BuRO has already conducted a risk assessment for this category (see 1.2 'Definition, focus and scope').

When assessing the risks from plant protection products and biocides for humans, the environment and nature (Chapter 8: Risks from plant protection products and biocides), we applied both the CBS classification, to analyse the use of plant protection products, and the Ctgb classification, to analyse the authorisations for plant protection products and biocides. The CBS records the use of plant protection products through a survey, using its classification system. When authorisations are granted for plant protection products, the Ctgb classification system applies.

The classification has little relevance when assessing the risks for biodiversity (Chapter 6) or for public and animal health (Chapters 7 and 9).

A general description of the ornamental horticulture production chain is given in Chapter 2.2, while Chapters 2.3 and 2.4 provide a brief description of economically important crops grown in heated greenhouses and outdoors (including in unheated greenhouses and plastic tunnels) respectively.

2.2 The ornamental horticulture sector in general

The ornamental horticulture production chain starts with breeding or the search for suitable genotypes, followed by propagation and production, and ends with trade and sale to end users/consumers (Figure 2.1). One or more steps in the breeding, propagation/production of propagating material or production stages may take place outside of the Netherlands.

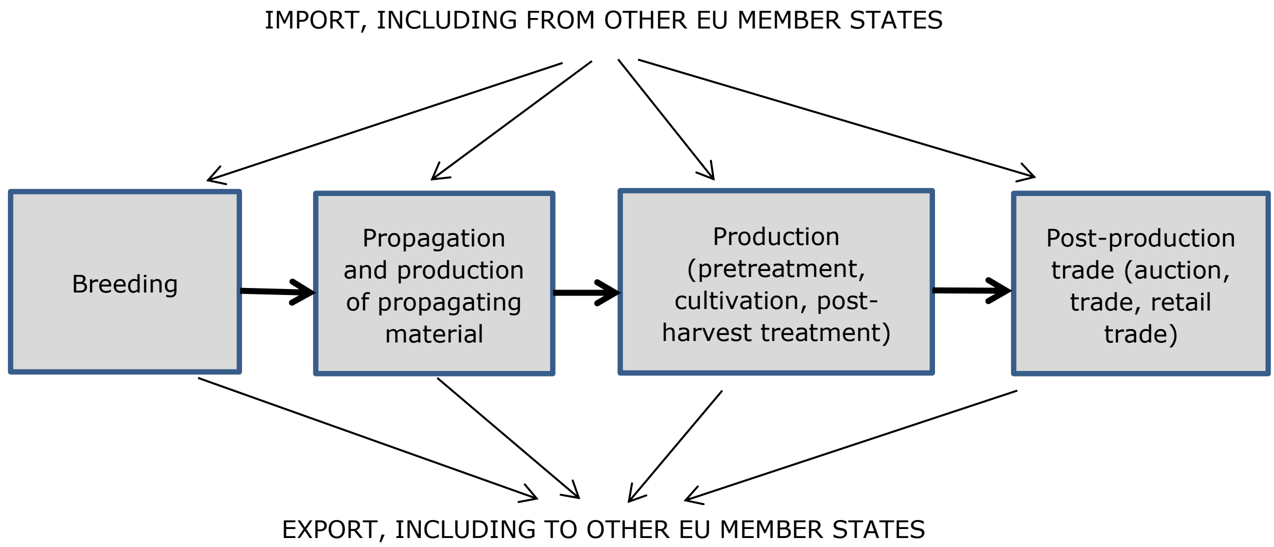

Figure 2.1 Schematic overview of the ornamental horticulture production chain.

Plant breeding is concerned with the development of new cultivars that satisfy users' needs as fully as possible, such as cultivars with new flower colours, cultivars that are resistant to pests and diseases or cultivars that grow more quickly or more slowly. Cross-breeding is used to create huge numbers of new genotypes, and a limited number of new cultivars emerge through selection (conventional breeding). New genotypes can also be created using modern techniques, with which more targeted new characteristics (genes) can be introduced. The Netherlands is a major global player in the field of breeding ornamental plants (as well as other plants). Major companies as well as many small companies are involved in plant breeding (EVO, 2009; Kal, 2012). Companies have locations on a range of continents, allowing them to test new cultivars, but the majority of the most knowledge-intensive work is done in the Netherlands (Kal, 2012).

Propagation is basically about creating more plants, for example through the production of seeds or cuttings. Through the production of propagating material such as a seed or cutting, a young plant can be grown that is then used to produce a plant or product intended for end users. The production phase may consist of one or more pretreatments, such as treatment of propagating material with plant protection products, the growing phase and one or more post-treatments, such as post-harvest preserving and dyeing of cut flowers. A brief description of the post-breeding phases for the economically most important ornamental plants (excluding the cultivation of flower bulbs) is set out below, divided into cultivation in heated greenhouses and cultivation outdoors, in unheated greenhouses and in tunnels.

2.3 Ornamental plants grown in heated greenhouses

2.3.1 Pot and bedding plants

Propagation and propagating material

A large percentage of the propagation of pot and bedding plants takes place in countries in Africa, Central America and southern and eastern Asia, due to the more favourable climate conditions and lower labour costs (EVO, 2009; Harkema & Westra, 2012). There are, however, exceptions, such as the production of petunia cuttings. These are primarily produced in Israel and southern Europe. Petunias belong to the nightshade family (Solanaceae), and the import of plants from this family from third countries is prohibited, with the exception of European countries/parts of countries and countries bordering the Mediterranean, due to the risk of introduction of new plant viruses (Implementing Regulation 2019/2072, Annex VI, Point 18). After import, unrooted cuttings are generally rooted by specialist companies (EVO, 2009). However, growers can import unrooted cuttings themselves and combine the propagation and cultivation phases. For certain plants and certain growers, propagation still takes place entirely in the Netherlands. The list of the top 10 most-sold pot plants in 2015 (Table 2.1) includes two species largely imported as half-grown plants (*Dracaena* and *Ficus*), mainly from Central America and China (Table 2.2). *Dracaena* can also be imported as a piece of stem without leaves. Other examples of pot plants that are predominantly imported as half-grown plants include bonsai, mainly from China, Japan and South Korea, and palm trees, primarily from Asia and Central America. Plants are sometimes sold more or less immediately after being imported – in other words, without having a growing phase in the Netherlands. Table 2.2 shows the import volumes for a number of pot plants that are primarily imported 'half grown'. Some of these imports may be intended for transit to other EU Member States.

Table 2.1 Auction turnover (in millions of euros and plants) for the top 10 most-sold pot plants in 2019 (source: Royal FloraHolland).

Name[1]	2019 auction turnover	
	Euros	**Plants**
Phalaenopsis	400	117
Arrangements	73	20
Kalanchoe	63	89
Rosa (rose)	62	49
Anthurium	56	18
Hydrangea	53	17
Chrysanthemum	36	44
Ficus	35	9
Dracaena	30	14
Hyacinthus (hyacinth)	24	36

[1] The common name is given in brackets, where it is different from the scientific name.

Table 2.2 Import volumes (in millions of plants) and main countries of origin for a number of pot plants that are partly or entirely imported as 'half-grown plants' from non-European countries (NVWA Import Database).

Name[1]	**Year**			**Main countries of origin (collectively >90% of imports)**
	2017	**2018**	**2019**	
Dracaena	40.4	38.3	38.9	China, Costa Rica
Ficus	4.9	4.3	4.2	China, Costa Rica, Guatemala, Sri Lanka
Sansevieria	9.5	12.8	15.3	China, Costa Rica, The Philippines, Guatemala, Thailand
Pachira	3.6	3.4	3.3	China, Taiwan
Chrysalidocarpus/Areca/Dypsis	1.8	3.1	2.3	Costa Rica, El Salvador, Honduras, Tanzania
Beaucarnea (ponytail palm)	1.3	1.3	1.0	China, Guatemala, Thailand
Livistona	1.2	1.3	1.0	Sri Lanka
Cycas (sago palm)	0.7	0.6	0.7	Costa Rica, Guatemala, Honduras

[1] The common name is given in brackets, where it is different from the scientific name.

Production

Growers import a lot of propagating material and half-grown plants from third countries (see the 'Propagation/propagating material' section), which, after a short growing period in the Netherlands, are suitable for sale to end users. Plants are sometimes sold more or less immediately after being imported (see also the 'Trade' section below).

Pot and bedding plants are grown in a substrate (potting mix). The main component in most potting mixes is peat, which is primarily imported from the Baltic states (white peat) and Germany (black peat) (VPN, 2018). Orchids (e.g. *Phaleanopsis*) are usually grown on pine tree bark, which is mainly imported from Portugal (Van der Gaag et al., 2013).

The length of the growing period for pot and bedding plants varies from a few weeks to several months, depending on the species and the pot size. Some plants are only grown in certain seasons (e.g. bedding plants, poinsettia, cyclamen), while others are grown nearly all year round (many foliage plants such as *Ficus* and *Dracaena*).

The acreage used to grow pot plants increased over the period 2000–2019, but the number of growers shrank significantly (Table 2.3). Statistics Netherlands (CBS) distinguishes between flowering pot plants and foliage plants, but does not keep acreage or turnover figures for the different pot plant species. However, auction figures (Table 2.1) can be used as an indication of the scale of cultivation of a number of species, since, unlike with cut flowers, the majority of the pot plant supply comes from Dutch growers. Due to the higher transport costs, pot plants tend to be transported over shorter distances (Kal, 2012). Based on the 2015 auction figures, *Phalaenopsis* is by far the most significant pot plant.

The acreage used to grow bedding plants in greenhouses has decreased in recent years. The same applies to the number of growers of bedding plants, so that, on balance, the average acreage per grower has increased (Table 2.3). In 2014, the most-sold bedding plants at flower auctions were pansies, geraniums, *Osteospermum* and petunias (FloraHolland, 2014).

Most greenhouse horticulture growers, including pot and bedding plant growers, are located in areas of high greenhouse horticulture concentration, such as Westland-Oostland, Aalsmeer, North Limburg, West Brabant and Zeeuws-Vlaanderen (AgriHolland, 2018).

Table 2.3 Pot and bedding plants: total acreage and number of growers (CBS, 2018;2020)

	Bedding plants		**Pot plants**	
Year	**Acreage (ha)**	**Number of growers**	**Acreage**	**Number of growers**
2000	497	959	1,261	1,492
2005	550	785	1,377	1,212
2010	430	461	1,383	824
2014	406	351	1,292	637
2015	369	290	1,334	613
2016	332	266	1,327	580
2017	312	225	1,317	550
2018	312	208	1,329	529
2019*	333	216	1,438	581

* Provisional figures

Trade

Pot and bedding plants are primarily sold within Europe. Due to the high transport costs, there are few sales outside Europe (Kal, 2012). Products are sold at auction or outside of the auction process (EVO, 2009). Growers can also deliver directly to retailers without going through an auction or trader. Consumers primarily buy pot plants in garden centres, followed by florists and supermarkets. A small percentage of plants are sold by growers directly to consumers (Kal, 2012). Plants may also be sold immediately after being imported, which means they do not have a growing phase in the Netherlands, only a trading phase (import and sale).

2.3.2 Cut flowers

Propagation and propagating material

The majority of propagation takes place abroad, with the exception of bulb flowers. In Africa and Central America in particular, unrooted cuttings are produced that are then grown into rooted plants in the Netherlands (EVO, 2009). In terms of acreage, chrysanthemums, roses and gerberas are the most significant cut flowers grown in greenhouses (Table 2.4). For chrysanthemums, nearly all cuttings are produced outside Europe (in 2019, around 1.5 billion cuttings were imported; this could include cuttings for pot plant cultivation). For roses, mainly Dutch material is used. Gerberas are mainly propagated through tissue culture. Flower bulbs are the propagating material for the cultivation of bulb flowers. These are primarily grown in the Netherlands. The cultivation of flower bulbs has already been described in the risk assessment for the flower bulb supply chain.

Production

The acreage used to grow cut flowers in greenhouses decreased significantly in the period 2000–2019 (Table 2.4). Over that period, part of the production was shifted to countries outside Europe, particularly African countries, due to the lower production costs (Kal, 2012; CBS, 2015). The cultivation methods for the three biggest cut flower crops differ significantly. Chrysanthemums are grown in the ground and produce several crops per year (around five). Roses and gerberas are grown in a substrate (e.g. stone wool) and have a cultivation period of several years (usually three years for gerberas and four to eight years for roses).

Table 2.4 Acreage and number of growers for cut flowers in greenhouses: total and per species for chrysanthemums, roses and gerberas (CBS, 2017;2018;2020).

	Total		**Chrysanthemums**		**Roses**		**Gerberas**	
Year	**Acreage (ha)**	**Number of growers**	**Acreage (ha)**	**Number of growers**	**Acreage (ha)**	**Number of growers**	**Acreage (ha)**	**Number of growers**
2000	3,727	4,112	774	597	932	765	253	170
2005	3,250	3,026	598	357	780	470	212	117
2010	2,442	1,674	504	209	499	232	181	79
2014	2,042	1,217	475	152	311	241	176	60
2015	1,877	1,132	391	125	283	120	161	49
2016	1,850	1,028	383	113	257	113	188	56
2017	1,859	933	334	98	228	85	167	51
2018	1,639	834	369	97	225	76	156	45
2019*	1,821	966	440	113	204	62	163	46

* Provisional figures

Trade

As with pot plants, there are a range of possible trading methods, although cut flowers are sold beyond national borders to a more significant degree and can also be transported over greater distances due to the lower transport costs (Kal, 2012). There is also a large supply of cut flowers produced outside of Europe. In 2016, Dutch businesses imported and exported 917 million and 3,757 million euros worth of cut flowers respectively (Benninga & Jukema, 2017). Nearly two-thirds (66%) of the imports (in euros) originated from countries outside the EU. In particular, many cut roses were imported from African countries – 2.8 billion pieces in 2013 (CBS, 2015). Bulb flowers are primarily sold within Europe (Hartkamp & Oei, 2009).

Consumers mainly buy cut flowers from florists, followed by supermarkets and market and street traders. In 2012, around two percent of flowers were sold by growers directly to consumers (Kal, 2012). Wherever possible, the transport and storage of cut flowers is chilled, due to the short shelf life of the product.

2.3.3 Bulb flowers

Propagation and propagating material

Production of flower bulbs mainly takes place in the Netherlands. A description of the production of flower bulbs can be found in the risk assessment for the flower bulb supply chain by the Office for Risk Assessment & Research[7].

Production

The four main crops in the bulb flower industry are tulips, daffodils, hyacinths and lilies, and the cultivation of these four is briefly discussed below.

Tulips, daffodils and hyacinths

Tulips, daffodils and hyacinths are mainly grown in a substrate (boxes or pots) or in water. A specific cold treatment is applied to the bulbs, after which early flowering is forced by supplying heat. Tulips are far and away the biggest forced bulb crop (Van Everdingen, 2015; Table 2.5).

[7] BuRO advisory report on risks from the flower bulb supply chain, see https://www.nvwa.nl/documenten/plant/plantziekte-en-plaag/plantziekte-en-plaag-overig/risicobeoordelingen/advies-van-buro-over-de-risico%E2%80%99s-van-de-bloembollenketen

Lilies

Barendse (2015) provides a description of the lily production chain. Lilies (as cut flowers) are grown both outdoors and in greenhouses (they are grown year round, with assimilation lighting and heating). Both the cultivated acreage and the number of lily growers have declined since 2000 (Table 2.6).

Table 2.5 Forced bulbs: scale and number of growers in the period 2000–2019 (CBS, 2018;2020).

	Tulips		Daffodils		Hyacinths	
Year	**1000 pieces**	**Number of growers**	**1000 kg**	**Number of growers**	**1000 pieces**	**Number of growers**
2000	1,021,031	970	3,421	254	-	-
2005	1,529,786	823	3,223	211	97,981	119
2010	1,386,297	538	3,067	140	88,436	92
2014	1,686,837	403	2,742	98	86,722	73
2015	1,816,688	394	3,324	87	97,207	69
2016	2,059,178	361	3,307	81	99,577	63
2017	2,214,061	354	3,252	69	93,848	54
2018	2,278,930	316	2,979	59	90,293	48
2019*	2,407,967	304	2,593	59	88,703	50

* Provisional figures

Table 2.6 Cultivation of lilies as cut flowers in greenhouses and outdoors (CBS, 2018;2020)

	Greenhouses		Outdoors	
Year	**ha**	**Number of growers**	**ha**	**Number of growers**
2000	276	397	-[1]	-
2005	255	308	-	-
2010	195	163	-	-
2014	171	102	-	-
2015	167	103	-	-
2016	138	86	-	-
2017	136	72	125	31
2018	114	59	90	20
2019*	157	68	107	22

[1] No figures available

* Provisional figures

Trade

See the 'Trade' section under 'Cut flowers'.

2.4 Cultivation outdoors, in unheated greenhouses and in plastic tunnels

2.4.1 Tree nursery plants and perennials;

Propagation and propagating material
In the cultivation of trees, shrubs and perennials, plants are often propagated at the same nursery where they will be grown into an end product (Bremmer et al., 2012). The importing of propagating material is therefore much less common than for the cultivation of cut flowers, pot plants and bedding plants. With a few exceptions, no official statistics are known for individual tree nursery plants and perennials. In 2017, the import values for nursery products were 6 and 200 million euros respectively for imports from third countries and imports from other EU Member States (WUR, 2018a). Within the EU, the most significant countries of origin were Germany, Belgium and Italy (in that order) (WUR, 2018a). The NVWA records all imports of plants intended for planting from third countries, but the database does not indicate the sector/production chain for which the material is intended, nor exactly what kind of material is being imported. Imports can involve a diverse range of materials: *in vitro* plants, unrooted cuttings, rooted cuttings, half-grown plants, bonsai (which, in this study, fall into the pot and bedding plant subchain) and plants sold directly to the consumer market.

Production
Production mainly takes place in cultivation centres. The largest cultivation centres are Boskoop, Opheusden, western North Brabant including Zundert and eastern North Brabant/North Limburg. Bremmer et al. (2012) provide a brief description of each cultivation centre:

- Boskoop: wide variety of species, more labour-intensive species, many growers who do their own propagation;
- Opheusden: avenue and park trees, propagating material produced by specialist growers;
- Western North Brabant: multiple smaller centres, traditionally focusing on the cultivation of forest trees and hedging plants, now tending more towards cultivation of ornamental shrubs and container plants;
- Eastern North Brabant/North Limburg: concentration of cultivation of rose bushes and fruit trees (the cultivation of fruit trees falls outside the scope of this assessment; this type of cultivation comes under the food crop supply chain).

Trade
The plants are sold through a number of channels (auction, wholesale, directly to consumers, exporters; many growers also export their plants themselves). Avenue trees are primarily planted in public green spaces, and ornamental shrubs and perennials are primarily purchased by consumers (Hartkamp & Oei, 2009). Consumers buy most of their plants from garden centres (Feenstra, 2013). A lot of material is exported. In 2017, the export of nursery products was worth around 1.5 billion euros; this equates to nearly 97% of the material produced in the Netherlands (WUR, 2018a).

2.4.2 Cut flowers and cut foliage grown outdoors, in unheated greenhouses and in plastic tunnels

A wide variety of cut flowers are grown outdoors, including a range of flower bulb species (see above). Among the outdoor flowers, peonies occupied the largest acreage in 2017 (580 ha). The total acreage dedicated to outdoor flowers (including bulb flowers) was 2,465 ha in 2017. The ‘outdoor flowers’ category also includes a range of summer flowers, including *Aconitum, Astrantia, Delphinium, Helianthus, Monarda* and *Phlox* (Meuleman et al., 2009; Slootweg & Dijksma, 2014).

3 Risk assessment of organisms harmful to plants: legislation, scope and methodology

3.1 Introduction

A large number of organisms (viroids, viruses, bacteria, fungi, pseudofungi, insects, mites, nematodes, gastropods and plants) can infest or infect plants and thereby harm plants. They are referred to in this report as 'harmful organisms'. Based on phytosanitary legislation, harmful organisms can be divided into non-regulated organisms, regulated organisms and organisms with the potential to be regulated. Regulated organisms are those listed by name in EU legislation. Organisms with the potential to be regulated are those that are not yet listed in EU legislation but do meet the criteria for regulation. The paragraphs below discuss (i) the EU legislation and the various categories of regulated organisms, (ii) national cultivation regulations relating to harmful organisms and (iii) the approach adopted for the risk assessment of harmful organisms.

3.2 EU legislation

Phytosanitary legislation is harmonised within the EU. The basis of the European phytosanitary legislation are Regulation (EU) 2016/2031 (Plant Health Regulation)[8] and Regulation (EU) 2017/625 (Control Regulation)[9].

The Control Regulation ((EU) 2017/625) applies not only to plant health, but also to other fields within the NVWA. With regard to plant health, the Control Regulation lays down rules for official inspections of imports of plants, plant products and other objects[10] on which harmful organisms could be accidentally imported. The regulation also provides for the designation of reference laboratories that are permitted to perform diagnoses on samples collected as part of official controls. For example, the NVWA's National Phytosanitary Reference Centre has been designated as a European Reference Laboratory (EURL) for bacteria and viruses.

The Plant Health Regulation ((EU) 2016/2031) only applies to plant health. The Plant Health Regulation focuses on organisms, which means that the majority of plants and plant products may be imported without a prior risk assessment. Following identification of a harmful organism new to the EU that meets all of the criteria of an EU quarantine pest, the organism is placed on the list of

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[8] Regulation (EU) 2016/2031 of the European Parliament and of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) No 228/2013, (EU) No 652/2014 and (EU) No 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC. OJ L 317 23.11.2016, p. 4–104.

[9] Regulation (EU) 2017/625 of the European Parliament and of the Council of 15 March 2017 on official controls and other official activities performed to ensure the application of food and feed law, rules on animal health and welfare, plant health and plant protection products, amending Regulations (EC) No 999/2001, (EC) No 396/2005, (EC) No 1069/2009, (EC) No 1107/2009, (EU) No 1151/2012, (EU) No 652/2014, (EU) 2016/429 and (EU) 2016/2031 of the European Parliament and of the Council, Council Regulations (EC) No 1/2005 and (EC) No 1099/2009 and Council Directives 98/58/EC, 1999/74/EC, 2007/43/EC, 2008/119/EC and 2008/120/EC, and repealing Regulations (EC) No 854/2004 and (EC) No 882/2004 of the European Parliament and of the Council, Council Directives 89/608/EEC, 89/662/EEC, 90/425/EEC, 91/496/EEC, 96/23/EC, 96/93/EC and 97/78/EC and Council Decision 92/438/EEC (Official Controls Regulation). OJ L 95 7.4.2017, p. 1–142.

[10] In this report, 'plants and seeds' means 'plants for planting', defined in Regulation 2016/2031 as "plants intended to remain planted, to be planted or to be replanted". This includes all reproductive material such as seeds, tissue culture plants, cuttings and young plants, as well as complete plants with a root ball or in a pot. For the purposes of this risk assessment, 'plant products' means products of plant origin in an unprocessed state, as well as processed products that, by their nature or that of their processing, may create a risk of spread of quarantine pests. This includes cut flowers, cut branches, fruit and vegetables. Note that, in Regulation 2016/2031, cut flowers, cut branches, fruit and vegetables come under the term 'plants', and 'plant products' are defined as "unmanufactured material of plant origin and those manufactured products that, by their nature or that of their processing, may create a risk of the spread of quarantine pests". In this supply chain assessment, the term 'plants' is used exclusively to mean 'plants intended for planting', other than seeds.

EU quarantine pests (EU Q-pests), and special requirements are often imposed on plants and products on which the organism may be found. A number of plants and products are subject to general import requirements (without reference to specific organisms) or import bans to reduce the likelihood of the introduction of harmful organisms (Implementing Regulation (EU) 2019/2072)[11]. There is also an article in the Plant Health Regulation on the basis of which a temporary import ban can be imposed for "*plants, plant products and other objects*" of which the import is considered to pose a high and unacceptable risk of introduction of harmful organisms new to the EU ('high-risk plants'). Based on this article, an import ban is currently in place for 35 genera and species of plants intended for planting (with the exception of seeds, *in vitro* material and bonsais); there is also a ban on imports of a number of other products (from specific countries) (Implementing Regulation (EU) 2018/2019)[12]. A phytosanitary certificate (PC) is required for import shipments of plants, seeds and almost all plant products. The phytosanitary certificate indicates that the shipment has been inspected and complies with the requirements laid down by the EU (shipments from Switzerland are exempt from the PC requirement). Annex XI of Implementing Regulation (EU) 2019/2072 lists the plants, seeds, plant products and other objects for which a certificate is required as well as those that are exempted. All shipments of plants, seeds, plant products and other objects (with specific origins) listed in Part A of this annex must be inspected upon import for the presence of known or potential EU Q-pests. For some products and materials (with specific origins), 'reduced frequency checks' apply (Regulation (EC) 1756/2004)[13]. These reduced frequency checks are regularly applied on the basis of a number of criteria (such as the number of shipments and interceptions of EU Q-pests). For other seeds and plant products for which a phytosanitary certificate is required, at least 1% of the shipments must be inspected (Commission Implementing Regulation (EU) 2019/66, Article 5). For internal EU trade, a certificate (known as a 'plant passport') is required for all plants and for certain seeds, products and materials.

The Plant Health Regulation defines various categories of regulated organisms and lays down rules to reduce the risks from these organisms. These categories include:

- EU quarantine pests (Union quarantine pests; EU Q-pests);
- provisional EU quarantine pests;
- priority pests;
- protected zone quarantine pests (PZ Q-pests);
- EU regulated non-quarantine pests (Union regulated non-quarantine pests, RNQPs).

The following additional terms are also used in this document and in the supply chain assessment:

- new harmful organisms;
- potential EU quarantine pests;
- NL-provisional Q-pests.

These terms and the various EU categories are explained below.

3.2.1 EU quarantine pests (Union quarantine pests, EU Q-pests)

EU Q-pests are organisms that are regulated throughout the EU. Legislation and measures targeting EU Q-pests are focused on preventing the introduction of these organisms or containment if they are already established in a particular area. EU Q-pests must meet the following criteria (Article 4 of Regulation 2016/2031):

a) the identity is established,

[11] Commission Implementing Regulation (EU) 2019/2072 of 28 November 2019 establishing uniform conditions for the implementation of Regulation (EU) 2016/2031 of the European Parliament and the Council, as regards protective measures against pests of plants, and repealing Commission Regulation (EC) No 690/2008 and amending Commission Implementing Regulation (EU) 2018/2019. OJ L 319, 10.12.2019, p. 1–279.

[12] Commission Implementing Regulation (EU) 2018/2019 of 18 December 2018 establishing a provisional list of high risk plants, plant products or other objects, within the meaning of Article 42 of Regulation (EU) 2016/2031 and a list of plants for which phytosanitary certificates are not required for introduction into the Union, within the meaning of Article 73 of that Regulation. OJ L 323, 19.12.2018, p. 10–15.

[13] Commission Regulation (EC) 1756/2004 of 11 October 2004 specifying the detailed conditions for the evidence required and the criteria for the type and level of the reduction of the plant health checks of certain plants, plant products or other objects listed in Part B of Annex V to Council Directive 2000/29/EC. OJ L 313, 12.10.2004, p. 6–9.

b) the organism is not present or is not widely distributed within the EU,
c) the organism is capable of entering into, becoming established in and spreading within the EU,
d) the establishment and spread of the organism would have an unacceptable economic, environmental or social impact, and
e) feasible measures are available to mitigate the risks.

The EU Q-pests are listed in Annex II of Implementing Regulation 2019/2072. To prevent the introduction and spread of certain EU Q-pests, special requirements may be applied to plants and products in or on which the organisms may be present. These requirements are described in Annexes VII and VIII of Implementing Regulation (EU) 2019/2072. Member States are required to complete surveys to determine the presence or absence of EU Q-pests. If an EU Q-pest is discovered in an area where it was not previously known to exist, eradication measures must be taken. Specific measures apply for the control of a number of EU Q-pests that are present in the EU. These measures are currently set down in EU directives (also known as the 'control directives'), which will be replaced with implementing acts. The intention is that implementing acts will be drawn up for all EU Q-pests established in the EU.

3.2.2 Provisional EU quarantine pests (temporary EU measures)

The Plant Health Regulation also lays down the measures that a Member State must take if it discovers an organism that is not yet on the list of EU Q-pests, but which meets the criteria for an EU Q-pest (Article 29). If a Member State finds a harmful organism that might meet the criteria, the Member State must conduct a preliminary risk assessment, and if the conclusion of that assessment is that the organism meets the criteria, the Member State must immediately take eradication measures or, if the organism is discovered in a shipment of plants or products, must take measures to prevent the introduction and spread of the organism. The Member State must inform the Commission and other Member States about the organism, the risk assessment and the measures taken. If the Commission also concludes that the organism qualifies for EU quarantine status, it will immediately, by means of implementing acts, adopt temporary measures in relation to the organism (Article 30). The Commission may also adopt temporary measures without notification of a new harmful organism by a Member state if it believes the organism meets the criteria for an EU Q-pest. Organisms for which temporary measures (emergency measures) apply are also referred to as EU Q-pests in this document and in the supply chain risk assessment, since these organisms are subject to a European control obligation[14].

3.2.3 Priority pests

Within the list of EU Q-pests, a number have been identified as 'priority pests'. These are EU Q-pests that, if they were to become established or spread further within the EU, would have a severe impact (Article 6, Regulation 2016/2031). Priority pests are subject to additional requirements, on top of those that apply to 'ordinary' EU Q-pests. For example, each year, a survey must be conducted into the presence or absence of these organisms, and Member States must have a contingency plan in place in case one of the organisms is found.

3.2.4 Protected zone quarantine pests (PZ Q-pests)

PZ Q-pests are organisms that are regulated in certain areas of the EU, known as 'protected zones' (Article 32, Regulation 2016/2031). The same criteria apply for PZ Q-pests as for EU Q-pests, the difference being that the organism may not be present in the 'protected zone'. The Netherlands does not currently have any 'protected zones'.

3.2.5 EU regulated non-quarantine pests (Union regulated non-quarantine pests, RNQPs)

RNQPs are organisms that are regulated on certain plants. They are regulated as such throughout the EU and must meet the following criteria (Article 36, Regulation 2016/2031):

[14] Please note that, according to Regulation 2016/2031, only the organisms listed in Annex II of Implementing Regulation 2019/2072 are EU quarantine pests.

a) the identity is established,
b) The organism is present in the EU.
c) The organism is not an EU Q-pest and is not subject to any temporary measures.
d) The organism is transmitted mainly through specific plants intended for planting.
e) The presence of the organism on those plants has an unacceptable economic impact as regards the intended use of those plants.
f) Feasible measures are available to prevent the presence of the organism on the plants concerned.

Tolerance levels apply for each organism/plant combination. The tolerance level set for a RNQP does not have to be zero; it may also be a maximum percentage of affected plants, where this is considered acceptable. For RNQPs, there is no obligation to eradicate, but consignments that are infested above a specific tolerance level may not be placed on the market.

3.2.6 New harmful organisms, potential EU Q-pests and NL-provisional Q-pests

Harmful organisms that do not have a (provisional) EU quarantine status but do meet criterion (b) for an EU Q-pest (the organism is not present or is not widely distributed within the EU) are considered for the purposes of this risk assessment to be 'new harmful organisms'. New harmful organisms that also meet the other criteria of an EU Q-pest and for which no emergency measures apply are called 'potential EU Q-pests'. A potential EU Q-pest will become a (provisional) EU Q-pest if temporary EU measures are imposed or if the organism is placed on the list in Annex II of Implementing Regulation 2019/2072. If an organism that might meet the criteria for an EU Q-pest is intercepted or discovered in the Netherlands, the NVWA will conduct a preliminary risk assessment (quick scan), on the basis of which it is decided whether or not the organism meets the criteria. If the criteria are met, the organism is given the Dutch status of 'NL-provisional Q-pest'. A quick scan is also performed if a business or institution submits an application to work with a new harmful organism. On the basis of the scan, it is then decided whether the organism should be given the NL-provisional Q-pest status and whether the business or institution may work with the organism under containment conditions. If the Commission decides to impose EU measures for a NL-provisional Q-pest, the organism will be given a (provisional) EU quarantine status (and the NL-provisional Q-pest status will automatically expire).

3.3 National cultivation regulations

National cultivation regulations apply for a limited number of harmful organisms that are present in the Netherlands, including several quarantine pests (NVWA, 2018j). The purpose of the regulations is to prevent the spread of the specific, named organisms.

3.4 Statutory controls

The Minister of Agriculture, Nature and Food Quality is designated as the 'competent authority' for the Plant Health Regulation and the 'central authority' for the Control Regulation. The Minister has delegated her duties and powers under the Plant Health Regulation to the Netherlands Food and Consumer Product Safety Authority (NVWA). The NVWA is also designated as the National Plant Protection Organisation (NPPO) under the International Plant Protection Convention (IPPC). The Netherlands Inspection Service for Horticulture (Naktuinbouw), an independent governing body subject to private law, is designated as the competent authority in relation to horticultural crops and forest reproductive material for certain specific subsectors of the Plant Health Regulation, such as monitoring of regulated non-quarantine pests (RNQPs) and monitoring of the issuing of plant passports. Naktuinbouw and the Quality Control Bureau (KCB) are responsible for performing import inspections of ornamental plant products. As the NPPO, the NVWA oversees all activities under the Plant Health Regulation.

3.5 Measures by the sector (in cooperation with the government)

Aside from the preventative measures taken by individual companies to prevent the introduction of known or potential quarantine pests, there are also industry-wide initiatives. In 2014, the 'Declaration of intent on agreements for phytosanitary prevention' was signed by seven industry organisations and the State Secretary for Economic Affairs[15]. The aim of the declaration of intent was "to reach agreement on phytosanitary prevention measures combined with the possibility of covering certain residual phytosanitary risks". Among other things, he declaration of intent led to a report that describes measures that businesses can take to reduce risks from known and potential Q-pests (Anonymous, 2019). This report and other information relating to phytosanitary prevention can be found on the website https://fytocompass, an initiative by multiple industry organisations. At present, there is no fund or insurance that can be used to cover phytosanitary risks for the ornamental horticulture sector.

3.6 Methodology of the risk assessment

3.6.1 Scope of the risk assessment

The Netherlands grows a wide range of different plants, and each plant may be attacked by a large number of different harmful organisms. Due to the large number of harmful organisms, we decided to only assess the risk from the harmful organisms for which there is an official control obligation: EU Q-pests and organisms that are or could be eligible for EU quarantine status. EU Q-pests and NL-provisional Q-pests are listed in the NVWA's quarantine register (NVWA, 2020). With regard to the new harmful organisms that are or could be eligible for quarantine status, a brief inventory was conducted based on alert systems, databases and the knowledge of NVWA experts. We also assessed the risk from new harmful organisms in a more general sense, based on past introductions of new harmful organisms and on current laws and regulations.

3.6.2 Risk assessments for EU Q-pests and NL-provisional Q-pests

A short risk assessment was performed for each EU Q-pest and NL-provisional Q-pest, unless the organism:

- almost certainly could not survive in the Dutch climate and/or very few of its host plants are present in the Netherlands;
- has a very low likelihood of introduction because the relevant pathways are closed due to an import ban.

If organisms have EU quarantine status at the level of a genus or higher taxon, we selected the species out of that genus or higher taxon considered to be the most risky based on the knowledge of NVWA experts.

The short risk assessment include:

- the most likely pathways by which the organisms could enter the Netherlands;
- an estimate of the likelihood of introduction (entry and establishment); and
- the potential impact for cultivation, green spaces[16] and exports.

In the short risk assessment, we estimated the likelihood that the organism could enter the country with imports of plants and products (P1), the likelihood that the organism would then reach a place where it could become established (P2) and the likelihood that the organism would in fact become established (P3), on a scale from 1 to 5. We also estimated the likelihood that the organism could still be eradicated through official measures after being discovered (P4), on a scale from 1 to 4. Combinations of these scores give a score for the likelihood of an infestation in a cultivated area or green space (P1-P2), the likelihood of an outbreak (P1-P3) and the likelihood that the organism could become established in spite of official eradication measures (P1-P4). Harmful organisms are a hazard because they can result in yield loss and additional plant protection costs, but also because they can lead to barriers for the trade and export of plants and

[15] Government Gazette No. 11543, 17 April 2014

[16] Green spaces: all open spaces in the Netherlands, both public and private, in which no commercial cultivation is taking place. In the supply chain risk assessment, the terms 'green spaces' and 'natural spaces' are used as synonyms.

plant products. For each organism, we assessed the potential impact for cultivation (harm from yield loss and increased plant protection costs) and for trade and export (harm from loss of markets and/or extra costs to guarantee that the organism is not present on the plants or products sold). We also estimated the potential impact of the organism for green spaces based on the severity of the expected harm for the plant species that could be affected by the organism and the extent to which these plant species are present in green spaces. In the risk assessment, we took account of all applicable laws and regulations, including Dutch cultivation regulations. With regard to the export risk, we estimated how easy it would be to guarantee that a product is free of an organism based on the biology of the organism, without looking at current third-country requirements, export volumes or export destinations. The actual impact on exports from the establishment of an organism may therefore be significantly different from the potential impact. NVWA (2019a) contains an extensive description of the methodology.

3.6.3 Risk assessment for the ornamental horticulture production chain

EU Q-pests and NL-provisional Q-pests
The EU Q-pests and NL-provisional Q-pests that are relevant for the ornamental horticulture production chain were selected, and Annex 5 contains a brief discussion of the EU Q-pests and NL-provisional Q-pests that have a relatively high chance of a finding and/or pose a relatively high risk. More information about the individual organisms can be found in the short risk assessments mentioned earlier, which are on the NVWA website (for EU Q-pests that are not established in the Netherlands) or in Annex 4 (for established EU Q-pests).

Inventory of potential EU Q-pests (still) without a NL-provisional Q-pest status
For each supply chain, we conducted a brief inventory of new potential hazards. In doing so, as a rule, we used the existing EPPO and APHIS[17] pest systems (PestLens, 2018; EPPO, 2019c) and the knowledge of NVWA experts. In a number of cases, we searched the EPPO Global Database and the Crop Protection Compendium for all organisms listed in the database as affecting a particular plant species or genus (CABI, 2019d; EPPO, 2019b).

[17] APHIS: Animal and Plant Health Inspection Service of the United States Department of Agriculture.

4 Quarantine and NL-provisional Q-pests established in commercial horticulture in the Netherlands: EU status and a short description

In the European Union (EU), approximately 180 organisms (or groups of organisms) have the quarantine status (defined for the purpose of this report as organisms listed in Annex II of Implementing Regulation 2019/2072 and organisms regulated under emergency measures). Of these organisms, seven have the status of 'established' in the Netherlands:

- *Globodera pallida* and *G. rostochiensis;*
- *Meloidogyne chitwoodi* and *Meloidogyne fallax;*
- *Phytophthora ramorum;*
- *Ralstonia solanacearum;*
- *Synchytrium endobioticum.*

This document provides a short description of each of these organisms.

4.1 *Globodera pallida* (Stone) Behrens and *Globodera rostochiensis* (Wollenweber) Behrens

4.1.1 Short description:

The nematode species *Globodera rostochiensis* and *Globodera pallida* (the potato cyst nematode and the white potato cyst nematode respectively) cause potato cyst nematode disease. The nematodes attack the roots of the plants, and affected plants show retarded growth. In the field, nematode damage is evidenced by patches of poor growth. Both species have the potential to be very harmful. Furthermore, both species pose a threat to the trade and export of seed potatoes. Much has already been written about potato cyst nematode disease, and information about the biology of nematodes and options for control can be found in a recently updated brochure (Molendijk, 2018). A brief description is given below.

G. rostochiensis and *G. pallida* survive in the soil as eggs in 'cysts' (protective shells around the eggs formed from female nematodes). The roots of host plants secrete substances that allow the larvae to leave the eggs and penetrate the roots. The most likely pathway for spread is the movement of infested soil (on plants, machinery, tools, etc.). Measures to control potato cyst nematode disease include:

- adjusting the cultivation frequency (the eggs in the cysts can survive for several years, but a portion of the eggs will die each year);
- using resistant cultivars (each year, the NVWA publishes an official list with resistance data for potato cultivars, as required by Council Directive 2007/33/EC. The problem with the use of resistant cultivars is that, over time, resistance can be broken through the build-up of more virulent populations;
- using potatoes as a catch crop (a catch crop attracts the larvae, but reproduction is prevented by spraying and killing the host plant (catch crop) at the right time);
- using sticky nightshade as a trap crop (a trap crop attracts the larvae, but reproduction is prevented because the crop is not a host plant);
- inundation (inundation, flooding the soil with water, is effective (Molendijk et al., 2017). A potential problem with inundation is that the soil used to construct dykes around the field may not be disinfested);
- anaerobic soil disinfestation (soil disinfestation by mixing organic material in the soil and then covering the soil with a plastic film to restrict oxygen supply);
- soil disinfestation with plant protection products containing metam sodium is an option but is permitted only in a very limited number of cases);
- granular soil-applied pesticides.

4.1.2 EU legislation

Annex VII of Implementing Regulation (EU) 2019/2072 contains special requirements relating to *Globodera pallida* and *G. rostochiensis*. Special requirements apply to imports of rooted plants intended for planting that have been grown outdoors, to potato tubers, to rooted plants intended for planting of *Capsicum* spp., *Solanum lycopersicum* L. and *Solanum melongena* L. and to bulbs, tubers and rhizomes of a number of specific plant species. A range of import bans are in place that are relevant for *G. pallida* and *G. rostochiensis*. These include an import ban for seed potatoes from all third countries except for Switzerland (Annex VI). In addition, special requirements apply to attached soil in imports of plants intended for planting (Annex VII). An EU control directive is also in effect for both nematode species (Directive 2007/33/EC)[18]. Annex VIII of Implementing Regulation 2019/2072, which sets out special requirements for preventing the spread of certain Q-pests within the EU, refers to this directive. The aim of the directive is to obtain a clear picture of the spread of *G. pallida* and *G. rostochiensis* within the EU and to prevent any further spread. To prevent spread, requirements apply to both host plants and a number of non-host plants. This is because the nematodes can be inadvertently transported in attached soil on both host and non-host plants. The strictest requirements in the directive apply to the host plants of nematodes:

- *Solanum tuberosum* L. (potato)
- *Solanum lycopersicum* L. (tomato)
- *Solanum melongena* L. (aubergine)
- *Capsicum* L. (bell pepper, chili pepper)

Before propagating material can be grown for these plants, the field to be used must be officially inspected and declared free of these organisms. Because propagating material for tomatoes, aubergines, bell peppers and chili peppers is not grown in the ground in the Netherlands, this regulation has little relevance for these plants in the Netherlands. However, the nematodes can also be spread in attached soil on non-host plants. Accordingly, for a number of non-host plants, there is also a requirement that the fields to be used for cultivation must be officially inspected and declared nematode-free. However, for these plants ('lightly regulated plants') there is an alternative option, namely that it is sufficient for the harvested product to be soil-free. The 'lightly regulated plants' include dahlia, gladiolus, hyacinth, iris, lily, daffodil and tulip bulbs and tubers, as well as leek, beetroot, cabbage, strawberry, asparagus, onion and shallot plants. No seed potatoes may be grown on land that has officially been designated as infested.

Starch potatoes and potatoes for consumption may be grown on infested land only after official control measures have been implemented. To lift an official designation of infestation, specific conditions (such as a waiting period) must be met before the declaration will be lifted based on the results of a soil investigation. Details can be found on the NVWA website (NVWA, 2018h).

Under Directive 2007/33/EC, EU Member States must also conduct a survey for *G. pallida* and *G. rostochiensis* in the cultivation of 'non-seed potatoes' (potatoes grown for consumption and starch potatoes). Each year, at least 0.5% of the non-seed potato acreage must be investigated for the presence of the nematodes.

4.1.3 Dutch cultivation regulations

In addition to the EU requirements, including the use of fields that are free from the nematodes for cultivation of propagating material of host plants, there are national cultivation regulations intended to reduce the risk of both *Globodera* species (details can be found on the NVWA website):

- Potatoes may not be grown in the same field more than once every three years (1:3) (no potatoes can have been grown in the two preceding years). There are a number of exceptions to this rule:
    - potato cultivation in the 'sand and valley region' in the northeast of the Netherlands (except for NAK seed potatoes);
    - with an exemption issued by the NVWA; or

[18] Council Directive 2007/33/EC of 11 June 2007 on the control of potato cyst nematodes and repealing Directive 69/465/EEC. OJ L 156, 16.6.2007, p. 12–22.

    - through participation in the early digging scheme, which means the potatoes must be dug up before a certain date so that the potato cyst nematode has little chance to reproduce.

- In five areas where a lot of propagating material is grown, there is a ban on growing potatoes (the 'Potato Cultivation Prohibition Areas).
- Farmers who grow potatoes in soil infested with potato cyst nematodes can only sell these potatoes to NVWA-recognised companies. These are companies that dispose of the soil tare (adhering soil that comes loose from the potatoes during handling after harvest) with due regard for phytosanitary principles.
- Outside of the Potato Cultivation Prohibition Areas, tree nursery plants and perennials may only be grown on a piece of land if, based on a soil sample, it is declared free of potato cyst nematode disease or if no potatoes have been grown on it for at least 12 years.

4.1.4 Situation in the Netherlands

G. rostochiensis and *G. pallida* are widespread in the Netherlands, except in the Potato Cultivation Prohibition Areas. In the period 2012–2017, around 10,000 field plots intended for seed potato cultivation were sampled each year, and 6–7% were found to be infested (NVWA, 2018c). The acreage officially designated as infested each year on the basis of these inspections varied from 1,476 to 1,748 ha across the same period.

In the survey of growers of starch potatoes and potatoes for consumption, 120 to 129 field plots were inspected each year (period 2015-2017), and 3.9 to 6.7% of the plots were found to be infested (NVWA, 2016a;2017b;2018c). In these surveys, no plots were inspected in the starch potato area in the northeast of the Netherlands. However, a separate survey in this area was conducted in 2017, with infestations being found in 19 of the 33 plots examined (NVWA, 2018c).

In 2015, it was shown that populations of *Globodera pallida* in the northeast of the Netherlands were reproducing relatively strongly in cultivars that had been known to be 'pallida resistant' (Molendijk et al., 2017). Reports had already been received from Germany of virulent populations of *Globodera pallida*. The virulent populations have so far only been found in the 'sand and valley region' in the northeast of the Netherlands, where there are no restrictions on the cultivation frequency of starch potatoes or potatoes for consumption and starch potatoes are grown at a frequency of 1:2. It was in this area that more than 50% of the plots of land were found to be infested with *G. pallida* and/or *G. rostochiensis* in 2016 (TBM, 2018). The high cultivation frequency (1:2) increases the chance of selection of more virulent populations, compared with the slower pace of rotation elsewhere in the Netherlands. The frequent cultivation of a number of highly resistant or previously highly resistant starch potato cultivars probably also contributed to the build-up of more virulent populations (Molendijk et al., 2017). There is a danger that the more virulent populations could spread further within the Netherlands with movement of plants and soil, which could jeopardise the cultivation of seed potatoes.

4.1.5 Non-European populations

In South America, there are known populations of *G. pallida* to which resistant European potato cultivars are 100% susceptible (Molendijk et al., 2017). The introduction of new genotypes of *G. pallida* could have a significant impact because it would take a long time to develop new resistant cultivars (EFSA-Panel-on-Plant-Health, 2012).

4.2 *Meloidogyne chitwoodi* Golden et al. and *Meloidogyne fallax* Karssen

4.2.1 Short description:

Meloidogyne chitwoodi (Columbia root-knot nematode) and *M. fallax* (false Columbia root-knot nematode) are two closely related root-knot nematodes that each have a very broad range of host plants. *M. chitwoodi* and *M. fallax* infect roots, tubers and/or bulbs in the soil. Damage is primarily known to occur in potatoes, carrots and black salsify in coarse textured soils. *M. chitwoodi* and *M. fallax* cause galls to form on the harvested products of these crops, which can render them unsaleable (Van der Gaag et al., 2011a;2011b). In a number of other crops, such as peas, the damage manifests as retarded growth, but the damage is generally minimal in most host plants. Little is known about the damage to ornamental plants. Elberse & Visse (2008) did research on the host plant status of a number of perennials, including *Hosta*, *Hemerocallis* and *Geranium*, for *M. chitwoodi*. A number of species/genotypes were infected, but no obvious damage (growth retardation) to the plants was observed. In NVWA (2017a), *M. chitwoodi* was identified as an issue for both protected and open-field ornamental horticulture, but it is unclear whether this was due to the organism's quarantine status or because it causes direct damage to plants. It has been reported that root-knot nematodes primarily cause problems in chrysanthemums, but it is not clear whether those problems are caused by *M. chitwoodi* or other *Meloidogyne* species. In the past, other (thermophilic) *Meloidogyne* species have been found in an inventory of root-knot nematodes in chrysanthemum cultivation, of which *M. javanica* was the most frequent; in container tests, *M. javanica* caused growth retardation (Amsing et al., 2003).

An infection with *M. chitwoodi* or *M. fallax* could have serious consequences for the trade and export of reproductive material, since nematodes have quarantine status in the EU and in numerous third countries.

Comprehensive information about the biology of the organisms, the range of host plants, a description of the pathways by which the organisms may spread and an estimate of the impact can be found in (Van der Gaag et al., 2011a;2011b).

4.2.2 EU legislation

Special requirements apply for seed potatoes with regard to *M. chitwoodi* and *M. fallax* (Annexes VII and VIII of Implementing Regulation 2019/2072). Seed potatoes must come from areas or production sites where neither organism is present, or a random sample of tubers must be examined after harvest and found to be free of both organisms. There are also various import bans relevant to the organisms, including a ban on seed potatoes from all third countries except for Switzerland (Annex VI), and special requirements apply to attached soil in imports of plants intended for planting (Annex VII).

4.2.3 Situation in the Netherlands

Both species are present in multiple cultivation areas in the Netherlands. Areas where official findings have been made have the status of 'designated area'. Within these areas, all consignments of seed potatoes must be sampled and tested for *M. chitwoodi* and *M. fallax*. Since 1 January 2019, a number of aspects of this policy have been modified. After a finding, an area is still demarcated with a 1 km-radius within which all consignments must be tested, but after one year, this 'designated area' is limited to the field plot where the original finding was made (which was not previously the case). Each new finding leads to the demarcation of a new '1 km-radius area'. Outside the designated areas, a portion of each consignment must be tested, with an average of one consignment per grower per year. Inspections (and tests) are also conducted on potato end products as part of the annual survey programme. There are more findings in seed potatoes than in end products because seed potatoes are systematically tested in areas where the organisms are officially known to be present, whereas starch potatoes and potatoes for consumption are not (Table 4.1). As a general rule, flower bulbs, perennials and tree nursery plants are inspected visually. An overview of the findings made each year (up to 2017) can be found in the NVWA's annual online report 'Fytosignalering'. Most findings are made in the potato growing industry. In 2017, there was a sharp increase in the number of findings compared to previous years (Table 4.1; (NVWA, 2018c)).

Table 4.1 Number of findings of *Meloidogyne chitwoodi* and *M. fallax* in ware and starch potatoes (End) and seed potato cultivation (Seed), expressed as the number of plots of origin[1] in the period 2013–2017 (source: Table 5.1 in the NVWA's Phytosanitary Detection reports: (NVWA, 2018a)).

Organism	Year									
	2013		2014		2015		2016		2017	
	End	Seed	End	Seed	End	Seed	End	Seed	End	Seed
M. chitwoodi	5	18[2]	9	28	9	28	15	19	12	46
M. fallax	0	1[2]	1	1	1	1	2	4	3	10
Total	5	19	10	29	10	29	17	23	15	56

[1] Field plots from which the potatoes that were found to be infested originated.

[2] Relates to a field plot with both *M. chitwoodi* and *M. fallax*.

Because the range of host plants for both *Meloidogyne* species is so broad and many host plants show few or no symptoms, the chance of spread via plant material is very high. The nematodes can also be spread by movement ofinfested soil. Furthermore, it is suspected that both species are present in more places in the Netherlands and other EU Member States than is officially known, but in many cases do not cause significant damage and may go therefore undetected.

A great deal of research has been conducted on controlling the nematodes. Chemical soil disinfestation is still only possible in limited circumstances and is not 100% effective. Growers can at least partially prevent losses by employing an integrated approach consisting of analysing soil samples to see whether any phytopathogenic nematode species are present and, depending on the results of the analysis, making decisions with regard to a rotation plan, the choice of cultivar and/or crop (resistant cultivars or less sensitive crops), sowing time and the length of the growing period (for example, later sowing for carrots or a shorter growing period for potatoes) and/or using nematicides.

4.3 *Phytophthora ramorum* Werres, De Cock & Man in 't Veld

4.3.1 Short description

The pseudofungus *P. ramorum* causes various types of symptoms on a range of tree nursery plants. On shrubs from *Rhododendron* spp., *Camellia* spp., *Pieris* spp. and *Kalmia* spp., among others, *P. ramorum* causes leaf spots, browning of leaves and spots or cankers on twigs and branches, which can cause the twigs and branches or even the entire plant to wither and die. In *Viburnum* spp., infections often occur at the base of the trunk, resulting in the rapid death of the entire plant. In trees such as beech, *P. ramorum* causes dark, bleeding spots on the trunk (cankers), usually at the base of the trunk but sometimes several metres higher. No spores form in these spots. The organism is found in both cultivated areas and green spaces. To date, the direct damage in the Netherlands has been limited. However, in the United Kingdom, Ireland and the western United States, the organism has caused the large-scale death of a number of tree species. This is probably because climate conditions in those areas are highly favourable for the organism (Sansford CE, 2009; EFSA-Panel-on-Plant-Health, 2011; Walsh et al., 2017).

4.3.2 EU legislation

In the EU, emergency measures are in place to prevent spread and new introductions of *P. ramorum* (Commission Decision 2002/757/EC). Non-EU isolates of *P. ramorum* are listed in Annex II of Implementing Regulation (EU) 2019/2072. The expectation is that EU isolates will eventually be regulated as RNQPs.

4.3.3 Situation in the Netherlands

P. ramorum is present at commercial horticulture sites and in green spaces. In the period 2015–2017, the organism was intercepted 39 times on plants from the Netherlands. In 2002/2003, the former Plant Protection Service conducted a comprehensive survey in natural spaces including parcs; *P. ramorum* was found at 30 locations (2.1% of the inspected locations). Private individuals also sent in 84 samples, of which 10 were found to be infected. Most of the findings were made in the middle of the country, in the provinces Gelderland, Utrecht and Overijssel. *P. ramorum* has also been recorded at several dozen locations where measures have been taken to eradicate the organism or prevent it from spreading. Since 1 January 2014, the NVWA no longer implements official measures when the organism is discovered in nature, and no recent data are available on the spread of the organism in the Netherlands outside of tree nurseries.

4.4 *Ralstonia solanacearum* (Smith) Yabuuchi et al. emend. Safni et al.

4.4.1 Short description

The bacterium *Ralstonia solanacearum* causes brown rot in potatoes. Infected tubers exhibit a brown ring when cut in half. In warm conditions, plants can wilt, but this seldom happens in Dutch conditions. The bacterium is mainly spread via infected seed potatoes and contaminated surface water.

4.4.2 EU legislation

Annexes VII and VIII of Implementing Regulation 2019/2072 contain special requirements for plants of certain species in relation to *R. solanacearum*. There are also various import bans that are relevant to the organism, including a ban on imports of seed potatoes from all third countries except Switzerland (Annex VI). A control directive is also in effect for *R. solanacearum* (Commission Directive 98/67/EC amended by Commission Directive 2006/63/EC). The aim of this directive is to obtain a clear picture of the spread of *R. solanacearum* within the EU and to prevent any further spread. For example, Member States must conduct annual surveys. The directive provides details about sampling and detection methods and measures to be taken in the event of a detection.

4.4.3 Situation in the Netherlands

In the Netherlands, the bacterium is established in surface water, where it is maintained by the presence of host plants on riverbanks, such as the weed *Solanum dulcamara* (bittersweet). The most likely way in which potatoes could become infected is through the use of surface water or through contamination with surface water, such as when the water is blown onto a field plot during a storm. Due to the presence of *R. solanacearum*, there is a country-wide ban on using surface water in seed potato cultivation. For other potatoes, there is a ban on using surface water in areas where the organism is known to be present (the ‘irrigation ban areas’). The number of findings of brown rot can be found in the Phytosanitary Detection reports (‘Fytosignalering’). In the period from 2010 to March 2017, brown rot was recorded on 10 farms in total (NVWA, 2018c).

4.5 *Synchytrium endobioticum* (Schilbersky) Percival

4.5.1 Short description

The fungus *Synchytrium endobioticum* causes warts (bulges) on potatoes (potato wart disease), which renders potatoes unsaleable and significantly reduces yield. The pathogen originates in South America and was introduced to Europe in the 19th century. *S. endobioticum* was first recorded in the Netherlands in 1915. The pathogen can survive in the soil for more than 30 years, but the survival time is suspected to be considerably shorter in actively tilled soil (see below). The pathogen is primarily spread through human actions, in seed potatoes, waste and soil. Wind dispersal is also possible, but the extent to which wind contributes to the spread of the organism in the Netherlands is not known.

Survival time in the soil

Winter sporangia of *S. endobioticum* can survive for a long time. Studies by Schaffnit & Voss (1918) and Köhler (1931) show that winter sporangia can survive in the soil for at least 9 or 10 years. Hartman (1955) describes experiments on growing beds in Pennsylvania in which survival for 15 years was demonstrated, but after 20 years, all ‘units’ were free of wart disease. However, the study contained this quote (Hartman, 1955): “*definite evidence is at hand which shows that* *potato wart has persisted in sods, abandoned gardens, and over-grown weed patches for 25 or more years and in one instance, 30 years"* (no references were given for this statement). Pratt (1976) refers to a study by Holmberg (1944) in Sweden that showed that winter spores were still viable after 16 years 'under grassland', while no spores survived in soil that was tilled annually. Regular tilling of the soil therefore appears to shorten the survival time. Winter sporangia die after germinating, and a lack of oxygen is likely to inhibit the maturation and germination of the sporangia (Esmarck, 1924; Weiss, 1925). Tillage may thus stimulate the germination of spores, contributing to a decrease in the quantity of inoculum in the absence of a host plant.

Strains
There are various strains of *S. endobioticum* that can be differentiated using cultivar tests. The development or introduction of a new strain can have serious consequences for a cultivation area if the potato cultivars common in that area are (very) susceptible to the new strain. Dozens of strains have been described, of which strains 1(D1), 2(G1), 6(O1), 8(F1) and 18(T1) are the most widespread and considered to be the economically most relevant ones for Europe (Busse et al., 2017; Van de Vossenberg, 2019).

4.5.2 EU legislation

Special requirements apply in relation to the organism for potato tubers and rooted plants intended for planting that are grown outdoors (Annexes VII and VIII of Implementing Regulation 2019/2072). There are also various import bans relevant to the organism, including a ban on seed potatoes from all third countries except Switzerland (Annex VI), and special requirements apply to attached soil in imports of plants intended for planting (Annex VII). There is also a European control directive (Council Directive 69/464/EEC of 8 December 1969 on control of Potato Wart Disease), on which the Dutch measures to be taken in the event of a finding are based. The control directive prescribes the minimum requirements that must be met following a detection of *S. endobioticum*:

- infested fields must be demarcated, and a safety zone must be placed around these fields large enough to protect surrounding areas. A field is considered to be infested if symptoms are found on at least one plant (Article 2),
- potato tubers and haulms from an infested field must be treated in such a way as to destroy the organism (Article 3),
- no potatoes may be grown and no plants for planting may be grown, silaged or stored in infested fields (Article 4),
- in the safety zone, only potato cultivars that are resistant to the strain found may be grown. 'Resistant' means that there is no danger of secondary infection and thus reproduction of *S. endobioticum* (Article 5),
- the measures may be lifted only if *S. endobioticum* is no longer found to be present (Article 6).

4.5.3 Situation in the Netherlands

S. endobioticum is present in the north-east and south-east of the Netherlands. In the north-east, strains 2(G1), 6(O1) and 18(T1) are present, while strain 1(D1) is present in the south-east. In the period 2010–2019, three official findings were made, two in the north-east (strain 18(T1)) and one in the south-east (strain 1(D1)).

In the Netherlands, when *S. endobioticum* is detected, a cultivation ban of at least 20 years is placed on the infested field plot (before 2000, it was 5 years). 'Partial release' (being able to grow resistant potatoes for consumption or industrial purposes) is possible after a minimum of 5 or 10 years, if *S. endobioticum* can no longer be found after intensive (after 5 years) or extensive sampling (after 10 years). This 'partial release' is not possible after a finding of strain 18(T1). More details about the measures taken following a finding and the difference between intensive and extensive sampling can be found in an information leaflet on the NVWA website (NVWA, 2015a).

4.5.4 Dutch cultivation regulations: prevention areas

In addition to the measures based on EU legislation that must be taken following a finding, Dutch cultivation regulations apply in a number of areas where *S. endobioticum* has been found in the past decades. These cultivation regulations were instituted by the Dutch potato industry in 2000 via a Product Board Regulation. After the end of the product board system, the cultivation regulations were adopted into Dutch legislation on 1 January 2015. The cultivation regulations state that, in the larger areas surrounding infected areas (‘prevention areas’), only potatoes with a minimum level of resistance to the strains of *S. endobioticum* present in the infested area may be grown. Prevention areas cover the entire potato starch area in the east and north-east and two smaller areas in the south-east of the Netherlands. Three prevention areas, A, B and C are distinguished. The minimum level of resistance for seed potatoes in Prevention Area A is lower than for starch potatoes and potatoes for consumption. In Prevention Area B, where wart disease has only occasionally been recorded (two findings in 1997), a minimum level of resistance applies only to starch potatoes. In Prevention Area C, only strain 1(D1) is present, and many cultivars are available with a high degree of resistance to that strain. In Area C, where the potatoes grown are primarily intended for consumption, the minimum level of resistance for all potato types is the same. Within the prevention areas, there are also smaller areas, core areas, where additional requirements apply for a strain that is only found in those areas, strain 18(T1). A core area has a radius of 1 km around a finding of strain 18(T1). The cultivation regulations are summarised below:

<u>Cultivation regulations in the prevention areas (March 2019)</u>
Requirements apply for the level of resistance of potato cultivars grown in ‘prevention areas’. Resistance is expressed as a number on a scale from 1 to 10, where 10 means complete resistance under laboratory conditions. A cultivar with a resistance of 9 is completely resistant under field conditions, but under laboratory conditions, a low level of development of the strain concerned can be seen.

Area A (strain 2(G1)/6(O1)): minimum resistance of 6 for all potatoes except NAK seed potatoes, for which a minimum of 5 applies.

Area B (strain 2(G1)/6(O1)): minimum resistance of 6 for all starch potatoes

Area C (strain 1): minimum resistance of 6 for all potatoes

Strain 18(T1) core areas:
- 1 km around the finding;
- minimum of 6 for starch potatoes;
- no requirements for potatoes for consumption or NAK seed potatoes.

To date, strain 18(T1) has only been found in Area A (north-eastern Netherlands).

For more details and the most up-to-date regulations, see the NVWA website: https://www.nvwa.nl/onderwerpen/teeltvoorschriften-akkerbouw-en-tuinbouw/inhoud/teeltvoorschrift-wratziekte

5 The ornamental horticulture production chain: risks from known and potential quarantine pests

5.1 Introduction

5.1.1 Definitions of quarantine pests and potential quarantine pests

This document focuses on harmful organisms[19] that have quarantine status in the European Union (EU Q-pests) or that might be eligible for that status (new harmful organisms and potential EU Q-pests) under Regulation (EU) 2016/2031[20] (the Plant Health Regulation). EU Q-pests are the organisms listed in Annex II of Implementing Regulation (EU) 2019/2072. In this document, the organisms for which temporary measures apply via an implementing act of the Commission are also treated as EU Q-pests, since these organisms are also subject to a European control obligation[21]. For the purposes of this document, a potential EU Q-pest is defined as an organism that does not or not yet appear on the list of EU Q-pests and for which no temporary EU measures apply, but which meets the criteria for an EU Q-pest. Potential EU Q-pests are therefore harmful organisms that could possibly be given European quarantine status in the future. This includes organisms designated by the Netherlands as 'NL-provisional Q-pest'. A NL-provisional Q-pest is an organism for which it has been concluded, based on a preliminary risk assessment (quick scan), that the organism meets the criteria for an EU Q-pest. The NVWA takes similar measures in respect of NL-provisional Q-pests to those it takes to prevent the establishment and spread of EU Q-pests. In this report, EU Q-pests are simply referred to as Q-pests.

5.1.2 New harmful organisms and potential Q-pests

New harmful organisms are harmful organisms that do not have quarantine status or NL-provisional Q-pest and are not present in the EU or, if present, are not widely distributed. In principle, all new harmful organisms that are recorded for the first time in the Netherlands are assessed to see if they fulfil the criteria of a Q-pest. In the past, not all new harmful organisms were given the NL-provisional Q-pest status. In some cases, this was because, by the time of the first official finding, the organism was so widespread that statutory measures were no longer deemed likely to be effective. However, findings of new harmful organisms, even if the organisms were not given the NL-provisional Q-pest status, are illustrative of the risks posed by new harmful organisms. Consequently, this document also discusses harmful organisms that have been found in the Netherlands or other EU Member States for the first time since 2000 and which were not subject to any official measures at the time they were first discovered. A number of new harmful organisms are also mentioned that could meet the criteria for a Q-pest. No systematic inventory has been conducted of all new harmful organisms that could be classified as potential Q-pests, due to the huge number of ornamental plants and the even greater number of organisms that can affect these plants worldwide. However, reference was made to existing 'alert lists' and recently conducted inventories of potential Q-pests (see Annex 3 for the methodology followed and sources consulted).

5.1.3 PZ Q-pests and RNQPs

Organisms that have quarantine status only in certain Member States, or certain areas within Member States, known as 'protected zone quarantine pests' or 'Zona Protecta quarantine pests', fall outside the scope of this risk assessment. There are no 'protected zones' in the Netherlands. Regulated non-quarantine pests (RNQPs) are organisms that are already present in the EU, that

[19] Viroids, viruses, bacteria, fungi, pseudofungi, insects, mites, nematodes, gastropods and plants that are harmful to plants.
[20] Regulation (EU) 2016/2031 of the European Parliament and of the Council of 26 October 2016 on protective measures against pests of plants, amending Regulations (EU) No 228/2013, (EU) No 652/2014 and (EU) No 1143/2014 of the European Parliament and of the Council and repealing Council Directives 69/464/EEC, 74/647/EEC, 93/85/EEC, 98/57/EC, 2000/29/EC, 2006/91/EC and 2007/33/EC. OJ L 317 23.11.2016, p. 4–104
[21] Please note that, according to Regulation 2016/2031, only the organisms listed in Annex II of Implementing Regulation 2019/2072 are EU quarantine pests.

are primarily transferred on specific plants intended for planting[22] and whose presence on those plants (above a certain threshold) will lead to unacceptable harm. RNQPs are regulated for specific plants intended for planting, and if the organism is found on these plants (above a certain threshold) the consignment of plants cannot be placed on the market. RNQPs also fall outside the scope of this assessment. No control obligation applies for these organisms. In general, ornamental plant products that are placed on the market must be visually or practically free from pests and diseases (NVWA, 2012b). More background information about the different groups of organisms and the phytosanitary legislation can be found in Annex 3.

5.1.4 Cultivation categories

Known and potential Q-pests are a hazard for ornamental horticulture because they can lead to yield loss (including reduced quality), extra plant protection costs and/or obstacles to the trade and export of floricultural products. Official measures following a finding can also have a significant impact for growers. When discussing known and potential quarantine pests, a distinction is drawn between:

- (I) cultivation in heated greenhouses;
- (II) outdoor cultivation, including cultivation in unheated greenhouses and plastic tunnels;
- (III) cultivation of aquatic and marsh plants;
- (IV) nature (also called 'green spaces', comprising gardens, parks, public green spaces, forests, open water, etc.);
- (V) tropical greenhouses (non-commercial cultivation), offices, homes, sunrooms, etc.

There are clear differences in phytosanitary risks between these categories. For instance, there is a group of organisms that almost exclusively poses a threat to plants grown in heated greenhouses (Category I; primarily cut flowers and pot plants). These are generally tropical and subtropical organisms that cannot become established outdoors in the Netherlands. For some plant types, an unheated greenhouse or plastic tunnel is used to bring forward the growing period. The phytosanitary risks for these types of plants are generally not too different from those for plants grown outdoors, and they have therefore been placed in the same category: (II) outdoor cultivation, including cultivation in unheated greenhouses and plastic tunnels (this primarily concerns summer flowers, tree nursery plants and perennials[23]). Aquatic and marsh plants may have to deal with organisms specific to a water-rich environment and have therefore been placed in a separate category (III). Categories (IV) and (V) are about risks to plants that are not commercially cultivated. The 'nature' category (IV) primarily concerns hazards for the health of plants in forests, parks, private gardens, etc. There can also be an impact, usually a local one, as a result of official measures taken by the NVWA to eradicate or control the spread of the organism. Category (V) is about the phytosanitary risks for plants in tropical greenhouses in zoos, tropical swimming pools, etc., as well as plants in offices and homes. This category mainly deals with organisms that cannot become established outdoors – in other words, different organisms to those affecting plants in Category (IV).

5.1.5 Established and non-established quarantine and NL-provisional Q-pests

The quarantine and NL-provisional Q-pests that are and are not established in the Netherlands will be discussed in separate paragraphs for each cultivation category. This is because the likelihood of an infestation with an established Q-pest is typically much higher than the likelihood of infestation with a non-established Q-pest or NL-provisional Q-pest. Individual organisms are not discussed in detail in this chapter. Details about Q-pests and NL-provisional Q-pests established in the Netherlands can be found in Annex 4. For many non-established Q-pests and NL-provisional Q-pests including those assessed as the most high-risk ones, a short risk assessment can be found

[22] Plants intended for planting: "plants intended to remain planted, to be planted or to be replanted" (Article 2, Regulation 2016/2031). This includes seeds, tissue culture plants, scions, unrooted cuttings, rooted cuttings, root cuttings, rhizomes, bulbs and tubers, plants with roots, plants with a root ball and plants in a pot; in this document, we also use the term 'plants and seeds' to refer to such products, with cut flowers, twigs, fruit and vegetables being considered 'plant products' rather than 'plants'.

[23] BuRO has conducted a separate risk assessment for the flower bulb supply chain, so the cultivation of flower bulbs falls outside the scope of this study.

on the NVWA website[24]. In the short risk assessment, we estimated the likelihood that the organism could enter the country with imports of plants and products (P1), the likelihood that the organism would then reach a place where it could become established (P2) and the likelihood that the organism would in fact become established (P3), on a scale from 1 to 5. We also estimated the likelihood that the organism could still be eradicated through official measures after being discovered (P4), on a scale from 1 to 4. Combinations of these scores give a score for the likelihood of infestation of a cultivated area or green space (P1-P2), the likelihood of an outbreak (P1-P3) and the likelihood that the organism could become established in spite of official eradication measures (P1-P4). Harmful organisms are a hazard because they can cause yield loss and additional plant protection costs, but also because they can lead to barriers for the trade and export of plants and plant products. For each organism, we assessed the potential impact for cultivation (harm from yield loss and increased plant protection costs) and for trade and export (harm from loss of markets and/or extra costs to guarantee that the organism is not present on the plants or products sold). We also estimated the potential impact of the organism for green/nature[25]. An extensive description of the methodology can be found on the NVWA website (NVWA, 2019a).

5.2 Ornamental horticulture in heated greenhouses

5.2.1 Q-pests and NL-provisional Q-pests established in the Netherlands

No Q-pests have been identified that are relevant for ornamental plants and that are established in greenhouse ornamental horticulture. It is possible that the quarantine nematodes *Meloidogyne chitwoodi* and *M. fallax* are present in soil-grown plants in greenhouses. During a 2016 inventory of plant protection issues, *M. chitwoodi* was identified by experts as a ‘troubling development’ for both protected and open-field ornamental horticulture (NVWA, 2017a). However, there have been no known official findings in greenhouse ornamental horticulture. Both nematodes are primarily known to occur in outdoor cultivation and are discussed in Section 5.2 (Outdoor ornamental horticulture). The quarantine bacterium *Ralstonia solanacearum* is established in surface water in the Netherlands. This organism is primarily known as the cause of brown rot in potatoes. In the 1990s and in 2000, the bacterium was found in the cultivation of *Pelargonium* in the Netherlands and in several other EU Member States. The growing sites were suspected to have become infested through imports of infected cuttings (Janse et al., 2004). It is possible that other ornamental plants could also act as host plants. If propagating material is clean (for example, vegetative propagation from parent plants that have been tested and found to be free from *R. solanacearum*), growers do not use surface water and hygiene measures are taken, the likelihood of infection with *R. solanacearum* in ornamental horticulture is low. There have been other outbreaks of *R. solanacearum* in ornamental plants, including *Anthurium*, *Curcuma* and roses. However, these outbreaks involved a different variant of *Ralstonia*, which has been reclassified under the species *R. pseudosolanacearum*. *R. pseudosolanacearum* is not established in the Netherlands.

5.2.2 Q-pests and NL-provisional Q-pests not established in the Netherlands

<u>Findings since 2000</u>

Since 2000, there have been multiple findings of Q-pests in ornamental horticulture that, at the time of their detection, were not known to be established in the Netherlands. There have also been findings of new harmful organisms that were given the NL-provisional Q-pest status (temporarily in some cases) (Table 5.1). As far as is known, of the organisms listed in Table 5.1, *Fusarium foetens* and Potato spindle tuber viroid are now established in greenhouse ornamental horticulture. In many cases of a finding of a Q-pest or NL-provisional Q-pest, the import of infected plants was

[24] https://www.nvwa.nl/onderwerpen/plantenziekten-en-plagen/risicobeoordelingen-quarantainewaardige-organismen

[25] Green spaces/natural spaces: all open spaces in the Netherlands, both public and private, in which no commercial cultivation is taking place. In this risk assessment, the terms ‘green spaces’ and ‘natural spaces’ are used as synonyms. Note that, for the assessment of the risk from invasive exotic plants (Chapter 6), plantings in parks and public and private gardens are excluded from the concept of ‘natural spaces’.

the most likely source of the infestation. Following a comprehensive risk assessment, many NL-provisional Q-pests have been deregulated, which means they no longer have the NL-provisional Q-pest status (Table 5.1). However, the risks from the nematode *Meloidogyne enterolobii* are currently being discussed at the EU level, and this species will probably be given quarantine status. This may have consequences for the import of and trade in pot plants and rooted propagating material for pot plants; the organism has been found more than once in imported consignments (Table 5.1). Economic harm to plants could occur if this organism is introduced to soil-based greenhouse cultivation (Karssen et al., 2009). One Q-pest that is found relatively often is the *Tobacco ringspot virus* (TRSV). This virus is relevant for both greenhouse and outdoor cultivation and will be discussed under 'Outdoor ornamental horticulture', in light of recent findings at outdoor growing sites. There have also been a relatively high number of findings of *Ralstonia pseudosolanacearum* (previously referred to as *Ralstonia solanacearum* race 1), including outbreaks in roses in 2015 and 2016 that had a significant impact (NVWA, 2016f).

<u>Q-pests and NL-provisional Q-pests with a relatively high chance of an infestation</u>
Based partly on information from past interceptions and findings and existing phytosanitary legislation, 16 Q-pests and NL-provisional Q-pests (both individuals and groups of organisms) were identified that are not established in the Netherlands, but for which the likelihood of an infestation (finding) in the Netherlands is assessed as relatively high (Table 5.2). Note that the likelihood of an infestation can change quickly, due for example to changes in regulations, cultivation systems and import and trade flows. For example, the likelihood of an infestation with *Ralstonia pseudosolanacearum* could be significantly reduced by growing tissue culture plants originating from parent plants that have been tested and found to be free from the bacterium or by using reproductive material grown in accordance with a strict certification or other protocol. The likelihood that an infestation or outbreak of most of the organisms listed in Table 5.2 could be eradicated through official measures is relatively high, because the outdoor climate is not suitable for the organisms to become established and/or the organisms spread almost exclusively via reproductive material or contact. However, the costs of eradication measures can be high, particularly if the organism is not discovered immediately and is already present at a large number of growing sites. For the vegetable leafminer *Liriomyza sativae*, *Tomato brown rugose fruit virus* (ToBRFV) and the bacterium *Xylella fastidiosa*, the likelihood of eradication is estimated to be low. For *Liriomyza sativae*, it is estimated that there is a fairly high chance that, by the time it is detected, the species will already have spread within the Netherlands. ToBRFV is a virus that is very persistent, is easily transferred by mechanical means and can also be spread by bumblebees (Levitzky et al., 2019). The virus was recorded in the Netherlands in the autumn of 2019. The virus is primarily a hazard for the cultivation of fruit vegetables (tomatoes, bell peppers and chili peppers), but ornamental peppers (*Capsicum* spp.) are also host plants, and other ornamental plants from the Solanaceae family may be host plants too. Growers can eliminate an infestation by removing (potentially) infected plants and thoroughly cleaning and disinfecting the greenhouse and all spaces and materials that are or may be contaminated. Due to the persistence of the virus, the large acreage used for host plants and the likelihood of new introductions, elimination from the Netherlands will probably be difficult. For the bacteria *Xylella fastidiosa*, which can probably also become established outside greenhouses, the likelihood of eradication primarily depends on the extent to which, at the time of detection, the bacterium has already been spread naturally by cicadas. As long as the *X. fastidiosa* infections are limited to the plants on which it was introduced, the bacterium can be eliminated easily by destroying all infected plants. As soon as cicadas start spreading the bacteria, particularly to plants in nature (outside of commercial cultivation), the likelihood of eradication decreases significantly. Moreover, the likelihood of natural spread in greenhouse ornamental horticulture is assessed to be lower than in open-field ornamental horticulture, because there are probably not many xylem-feeding cicadas in greenhouses. Under Dutch climatic conditions, *X. fastidiosa* probably causes little damage to crops and plants in nature. However, the organism poses a significant risk for the trade in ornamental plants (grown both in greenhouses and outdoors) due to mandatory EU measures following a finding of *X. fastidiosa*, including the demarcation of an area around the infested zone, and due to the relatively high probability of a finding.

5.2.3 New harmful organisms and potential Q-pests

Since 2000, several findings of new harmful organisms have been made for which no official measures applied and for which no official measures were instituted after the finding (i.e. they were not given the NL-provisional Q-pest status). Some of these organisms were eliminated through voluntary measures, while elimination was no longer deemed achievable for others. Examples include:

- *Horidiplosis ficifolii*, a gall midge found at *Ficus* growing sites in 2005;
- *Plantago asiatica mosaic virus*, found in the cultivation of *Lilium* (lilies) as cut flowers in 2009;
- *Thrips setosus*, a polyphagous thrips species found in 2014 at a site where *Hydrangea* was being grown;
- *Contarinia jongi*, a gall midge found in the cultivation of *Alstroemeria* as cut flowers in 2016.

In addition to these official findings, findings of new harmful organisms have also been reported or published by third parties that have not been verified by the NVWA, such as the Asian tramp snail *Bradybaena similaris.* This snail and the other four organisms mentioned are briefly discussed below.

Bradybaena similaris

In the Netherlands, the Asian tramp snail *Bradybaena similaris* was reported for the first time from Burgers' Bush in 2002 (Winter et al., 2009). The presence of the species was not verified by the NVWA. In 2011, the former Plant Protection Service intercepted *B. similaris*, or a closely related species, on *Ficus* plants from China. In light of the finding in Burgers' Bush and other reports in literature, it is suspected that snails are accidentally being imported more often on plants and other products. In the United States, exotic snails have for example been intercepted on tiles, containers and military transports (Robinson, 1999). *B. similaris* is suspected to have originated in Southeast Asia, but it is now also present in North and South America, Africa and Australia, as well as on islands in the Indian and Pacific Oceans (EPPO, 2020c). The snail eats and causes damage to a range of plant species. It is unlikely that this species could become established outside greenhouses in the Netherlands. The species has spread across many parts of the world but, as far as is known, only lives in regions with a warmer climate than we have in the Netherlands. Accordingly, the risk from the species for the Netherlands appears to be limited to tropical greenhouses.

Horidiplosis ficifolii

The gall midge *Horidiplosis ficifolii* was first described in 2001 following a finding on *Ficus* plants imported from Southeast Asia (Harris & Goffau, 2003). The gall midge causes brown spots ('galls') on leaves, which significantly reduce the ornamental value and can make plants unsaleable. In 2005 and early 2006, the former Plant Protection Service regularly found the species in import consignments from China. The organism was probably eliminated from the growing sites where it had been recorded after frequent application of plant protection products (although reintroduction may occur via imports of infected plants). At the time, the risk posed by the organism was assessed as relatively low, since the organism was probably not capable of becoming established outdoors, its only host plants were certain *Ficus* species (*Ficus carica*, the common fig, is not known to be a host plant) and it could be well controlled. However, the risk from the organism could increase if effective plant protection products would be no longer available (Van der Gaag et al., 2006).

Plantago asiatica mosaic virus

Plantago asiatica mosaic virus (PlAMV) was found in lilies in 2009, and its identity was definitively established in 2010. The virus may have been introduced to the Netherlands via imports of lily reproductive material (NVWA, 2012c). At the time, the virus was not known to infect lilies. The virus causes necrotic flecks on leaves and is relevant to both the protected and open-field cultivation of lilies. The virus primarily causes damage at lily forcing nurseries (in cut flower cultivation), with yield losses of up to 80% being reported (EPPO, 2010). Plants may become infected through above-ground contact as well as via infested soil, but there are no indications that nematodes or other vectors are involved in spreading the virus (De Kock et al., 2013). PlAMV was recently identified by experts in the ornamental horticulture sector as a 'troubling development' for lily cultivation (NVWA, 2017a). In 2015, PlAMV was also found in tulips. For now, this appears to be an incidental finding, and PlAMV appears to pose little risk to tulips (NVWA, 2016b).

Thrips setosus
The presence of *Thrips setosus* was recorded in *Hydrangea* spp. in 2014. *T. setosus* causes damage to leaves and flowers that is typical for thrips: silver spots with darker patches. *T. setosus* is relevant to both protected and open-field cultivation of ornamental plants. The organism is polyphagous and a known vector for *Tomato spotted wilt virus*. *T. setosus* was previously only known in Japan and South Korea, and was considered a minor pest in Japan (NVWA, 2014b). Shortly after the first finding, the organism was found at multiple growing sites and on weeds in the vicinity of these sites, and there was also no clear source (such as a recently-imported consignment of plants in which the organism could have been introduced). It was therefore concluded that eradication was not possible, and no official measures were taken. The organism is now widespread in the cultivation of hydrangeas, and growers have to apply plant protection measures to control this new organism (Van Leth, 2016). It is not known how the organism was introduced. The vast majority of hydrangea propagating material comes from Africa, where the organism is not known to be present. In 2011, 2 consignments of hydrangeas, totalling 64 plants, were imported from Japan (no imports of hydrangea plants from Japan or South Korea were recorded in the period 2012–2014). However, the organism is polyphagous and may also have been introduced in imports of other plant species.

Contarinia jongi
At the time of its finding in 2016 in *Alstroemeria* plants grown for the cut flower market, the gall midge *Contarinia jongi* was an undescribed species (NVWA, 2016e). However, the gall midge had previously been found in Australia, and in 2017, a publication appeared in which the species was described (Kolesik et al., 2017). The species causes deformity of *Alstroemeria* flower buds, rending cut flowers unsaleable. It is not known how the species was introduced to the growing site. The species was not found at any other alstroemeria growing sites during a 2016 survey. The grower took measures to eliminate the organism in 2016. The organism could no longer be found at the site in 2017 and, as far as is known, is no longer present in the EU. In principle, it is a potential quarantine pest.

<u>Findings and interceptions of new harmful organisms in other EU Member States</u>
Since 2000, findings and interceptions of new harmful organisms have been made in other EU Member States that are relevant to cultivation in heated greenhouses and that have not yet been found in the Netherlands. Examples include:

- *Singhiella simplex;*
- *Curtobacterium flaccumfaciens* pv. *poinsettiae;*
- *Cathaica fasciola.*

Singhiella simplex.
Singhiella simplex is a whitefly that infests various *Ficus* species (*Ficus carica*, the common fig, is not a known host plant). This species is presumed to have originated in Asia and has been introduced to North and South America, Cyprus and Turkey. The species was recorded on Cyprus in 2014. Cyprus did not take any official measures to control the organism. In 2015, the NVWA intercepted the organism on a consignment of *Ficus* plants from Costa Rica. The NVWA did not take any official measures, because the organism was already present in the EU, Cyprus had not taken any official measures to control the organism and the risk to the Netherlands was assessed to be low. However, the NVWA did issue a communication about this organism (NVWA, 2015b).

Curtobacterium flaccumfaciens pv. *poinsettiae*
The bacterium *Curtobacterium flaccumfaciens* pv. *poinsettiae* infects the poinsettia (*Euphorbia pulcherrima*). The bacterium was found in 2008 and 2014 at growing sites in Slovenia and Germany respectively and, in 2019 in Germany, was given the status 'transient, actionable, under eradication'. It is no longer present in the EU (EPPO, 2019d). Following a short risk assessment (quick scan), the NVWA decided not to take any official measures if it were to be found in the future, since growers could easily reduce the risk themselves by putting hygiene measures in place

and acquiring clean propagating material. The likelihood of natural spread between growing sites is low. The NVWA has previously issued a communication about this organism (NVWA, 2014c).

Cathaica fasciola
In 2017, Germany intercepted the snail *Cathaica fasciola* on wood packaging material used for stones from China (JKI, 2017). The species is known in China and, like most snails, can infest a large number of different plant species. It is possible that this snail species has been accidentally imported from China before. An earlier infestation in the United States was found and eliminated (Robinson, 2015). It is uncertain whether the species is capable of becoming established in the Netherlands, either in greenhouses or outdoors. The risk to plant health from *Cathaica fasciola* does not seem very high, partly because multiple harmful snail species are already present in the Netherlands (NVWA, 2018b). Effective measures to prevent the entry of the organism appear difficult to implement, because the snail could be accidentally imported with a wide range of products and materials, and there are significant import flows from China.

Table 5.1 Official findings of current and former quarantine and NL-provisional Q-pests in ornamental plants in heated greenhouses in the period from 2000 to September 2019; at the time of the finding, these organisms were not known to be present in the Netherlands.

Quarantine or NL-provisional Q-pest[1]	**Plant species/type**	**Year of finding**[2]	**Status as at 14 December 2019**
Aleurocanthus spiniferus (identified at the time as *A. woglumi*)	*Camellia*	2006	Q[3]
Anoplophora chinensis	*Acer*	See Table 5.4	Q
Cnidocampa flavescens	*Acer* bonsai	2000, 2003	No longer NL-provisional Q-pest
Contarinia maculipennis[4]	*Dendrobium*	2001	No longer NL-provisional Q-pest
Darna trima	Palm trees	2005, 2006	No longer NL-provisional Q-pest
Eotetranychus lewisi	*Euphorbia pulcherrima* (poinsettia)	2014	Q[5]
Fusarium foetens	*Begonia*	2000	No longer NL-provisional Q-pest
Helicoverpa armigera	*Chrysanthemum*	2011	No longer a Q-pest
Helicoverpa armigera	*Pelargonium* (geranium)	2012	No longer a Q-pest
Meloidogyne enterolobii[6]	Pot plants: various	Multiple findings in imported consignments of roses and pot plants	No longer NL-provisional Q-pest
Oligonychus perditus	*Juniperus* (juniper)	2000	Q
Platynota rostrana	*Dracaena*	2015	No longer NL-provisional Q-pest
Potato spindle tuber viroid (PSTVd)[7]	*Brugmansia* spp.	2006	RNQP[8](not in ornamental horticulture)
Potato spindle tuber viroid (PSTVd)	*Solanum jasminoides*	2006	RNQP (not in ornamental horticulture)
Potato spindle tuber viroid (PSTVd)	*Solanum muricatum*	2017	RNQP (not in ornamental horticulture)
Ralstonia pseudosolanacearum[9]	*Begonia*	2003	Q
Ralstonia pseudosolanacearum	*Curcuma*	2001, 2014, 2015	Q
Ralstonia pseudosolanacearum	*Rosa* (rose)	2015	Q
Ralstonia pseudosolanacearum	*Anthurium*	2015	Q
Ralstonia solanacearum[10]	*Pelargonium* (geranium)	2000	Q
Rhabdoscelus obscurus	Palm trees	2007	No longer NL-provisional Q-pest

Quarantine or NL-provisional Q-pest[1]	**Plant species/type**	**Year of finding[2]**	**Status as at 14 December 2019**
Ripersiella hibisci	Pot plants, various but particularly *Ficus, Serissa, Zelkova*	At least in 2007, 2012	Q
Scirtothrips dorsalis	Pot plants: various	2011, 2014, 2015, 2016 (2x), 2019	Q[11]
Scyphophorus acupunctatus	*Beaucarnea*	2001 (2x), 2003, 2004, 2006	No longer NL-provisional Q-pest
Scyphophorus acupunctatus	*Yucca*	2001	No longer NL-provisional Q-pest
Spodoptera littoralis	*Begonia*	2011	No longer a Q-pest
Spodoptera littoralis	*Chrysanthemum*	2005	No longer a Q-pest
Spodoptera littoralis	*Pelargonium* (geranium)	2007	No longer a Q-pest
Spodoptera litura	*Ficus*	2008	Q
Tetranychus mexicanus	*Beaucarnea*	2018	NL-provisional Q-pest
Thrips palmi[12]	Pot plants: various	2001	Q
Tobacco ringspot virus	*Bacopa*	2000, 2006	Q
Tobacco ringspot virus	*Celosia*	2008	Q
Tobacco ringspot virus	*Portulaca*	2000, 2006, (2007)	Q
Xylella fastidiosa	*Coffea* (coffee)	2014	Q

[1] Includes organisms with a temporary NL-provisional Q-pest status in the period 2000–2018.

[2] For related findings in different years (findings suspected to have the same original source of introduction into the Netherlands), only the first year is given. Where there is doubt about the relationship between the findings, the year is given in brackets.

[3] At the time of finding, it was only EU-regulated for *Citrus* L., *Fortunella* Swingle and *Poncirus* Raf. plants and hybrids, excluding fruits and seeds. In 2011, the NVWA decided to take official measures upon interception or finding on plants intended for planting that are not regulated in the EU.

[4] Found in 2001 and eradicated by the grower. Declared NL-provisional Q-pest in 2004 following interceptions on cut flowers, deregulated in 2007.

[5] At the time of finding, it was only EU-regulated for *Citrus* L., *Fortunella* Swingle and *Poncirus* Raf. plants and hybrids, excluding fruits and seeds. Infestation in poinsettia was eradicated by the grower.

[6] Listed as NL-provisional Q-pest following interception on rose plants from China in January 2008; national measures lifted in late 2008. The EPPO conducted a Pest Risk Analysis in 2010; the organism is being discussed at the EU level and will probably be given quarantine status.

[7] PSTVd has not been regulated for ornamental plants since 1 January 2018, and in 2018, the status was changed from 'transient' to 'present in ornamentals (*Solanum* spp.)'.

[8] RNQP: regulated non-quarantine pest, an organism that is regulated for specific plants intended for planting (see section 5.1 'Introduction').

[9] *Ralstonia solanacearum* was recently split into three species; the variants that were previously classified as race 1 and race 3 now come under *Ralstonia pseudosolanacearum* and *R. solanacearum* respectively.

[10] The organism is present in surface water in the Netherlands, but the infection in *Pelargonium* most likely entered the country in imports of infected plant material.

[11] At the time of the initial finding in the EU, it was only regulated for *Citrus* L., *Fortunella* Swingle and *Poncirus* Raf. plants and hybrids, excluding fruits and seeds. It has held NL-provisional Q-pest status since 16 April 2009 until 14 December 2019 for all plants intended for planting.

[12] Found in *Serissa* bonsai in 2001; also found in other plants in the 1990s.

Table 5.2 Quarantine and NL-provisional Q-pests, not known to be established in the Netherlands, for which the likelihood of an infestation in heated greenhouses in ornamental horticulture is assessed as relatively high (P1–P2 ≥ 3;5).[1]

Organism	Quarantine status	Plants with a relatively high likelihood of an infestation	Most likely pathway(s)
Aleurocanthus spiniferus	Q	Pot plants (incl. bonsai and container plants)	P4P[2] of various species
Anoplophora chinensis	Q	Pot plants, particularly bonsai	P4P of various species, particularly *Acer*
Chrysanthemum stem necrosis virus	Q	*Chrysanthemum*	*Chrysanthemum* P4P
Eotetranychus lewisi	Q	*Euphorbia pulcherrima* (poinsettia)	P4P of various ornamental plants, particularly *Euphorbia pulcherrima*
Liriomyza sativae	Q	Solanaceae fruit vegetables	P4P, particularly *Ocimum*
Ralstonia pseudosolanacearum	Q	Multiple plant species, particularly *Curcuma*, *Rosa* (rose), *Anthurium*	P4P of various species
Ripersiella hibisci	Q	Plants with a root ball imported as propagating material	P4P of various species
Spodoptera eridania	Q	Plants of which propagating material is imported from North or South America or the Caribbean	P4P of various species
Spodoptera frugiperda	Q	Plants of which propagating material is imported from Africa or the Americas	P4P of various species
Spodoptera litura	Q	Plants of which propagating material is imported from Asia or Oceania	P4P of various species
Tetranychus mexicanus	NL-provisional Q-pest	Plants with propagating material from South America, Central America or the Caribbean	P4P of various species
Thrips palmi	Q	Plants of which propagatingn material is imported from Asia	P4P of various species
Tobacco ringspot virus	Q	Various	P4P of various species
Tomato brown rugose fruit virus	Q	*Capsicum* spp. (ornamental peppers)	Contact/P4P/seed
Tomato ringspot virus	Q	Various	P4P of various species
Xylella fastidiosa	Q	Various	P4P of various species

[1] P1–P2: the likelihood that the organism will enter the country on the plant or product and then make its way to a location suitable for it to become established; '3;5': A score of 3 on a scale from 1 to 5 (NVWA, 2019a).
[2] P4P: plants for planting, other than seeds.

5.3 Outdoor ornamental horticulture, including cultivation in an unheated greenhouse or tunnel

5.3.1 Q-pests and NL-provisional Q-pests established in the Netherlands

Seven Q-pests are established in the Netherlands. They are the pseudofungus *Phytophthora ramorum*, the bacterium *Ralstonia solanacearum*, the fungus *Synchytrium endobioticum* and the nematodes *Globodera pallida, G. rostochiensis, Meloidogyne chitwoodi* and *M. fallax. P. ramorum* is a particular hazard for the tree nursery industry. The other organisms are mainly known for being hazards for potato cultivation, but they are also relevant for ornamental horticulture, particularly outdoor ornamental horticulture. The organisms are briefly discussed below, and more details can be found in Annex 4.

The pseudofungus *P. ramorum* affects many tree nursery plants, including *Rhododendron, Camellia, Pieris, Kalmia* and *Viburnum* spp. The organism is found in both cultivated areas and green spaces. To date, the direct damage to plants and crops in the Netherlands has been limited. However, in the United Kingdom, Ireland and the western United States, the organism has caused the large-scale death of a number of tree species. This is probably because climate conditions in those areas are highly favourable for the organism (EFSA-Panel-on-Plant-Health, 2011). For Dutch growers, the organism has so far primarily been a threat to the trade and export of ornamental plants. In the period 2015–2017, the organism was intercepted 39 times on plants from the Netherlands (NVWA, 2018c). The problem is that infections with this organism may remain latent for an extended period, making it difficult to detect. The organism is present in multiple EU Member States. At present, only the non-EU isolates of *P. ramorum* are listed in Annex II of Implementing Regulation 2019/2072, but emergency measures apply for all isolates (Commission Decision 2002/757/EC). The EU isolates may eventually be given RNQP status.

The bacterium *R. solanacearum* is established in surface water and is primarily known as the cause of brown rot in potatoes. There have been no known findings in outdoor ornamental horticulture, but it is possible the bacterium could infect a number of ornamental plants (see also the section 'Ornamental horticulture in heated greenhouses'). For now, the risk from this bacterium for outdoor ornamental horticulture seems low.

The fungus *S. endobioticum* infects potatoes, but it is also relevant for ornamental horticulture, because no plants may be grown on an infested field plot or in the surrounding buffer zone (safety zone) if they will be harvested with roots or other underground parts. Since 2010, there have been three new findings of *S. endobioticum*, one in the south-east and two in the north-east of the Netherlands, and the risk for ornamental horticulture seems low.

The nematodes *G. pallida* and *G. rostochiensis* cause potato cyst nematode disease. Findings are recorded every year in the potato growing industry (see Annex 4). Because the nematodes can be accidentally transported with attached soil on non-host plants (such as tree nursery plants and perennials), there used to be an EU requirement that propagating material could only be grown on field plots that were free from the disease. This EU requirement has expired. However, due to Dutch export interests, there are Dutch regulations that state that tree nursery plants and perennials may only be grown on land free from potato cyst nematode disease (the soil must be sampled and tested in advance). In five areas where a lot of propagating material is grown, there is a ban on growing potatoes (the 'potato growing ban areas'). The purpose of the ban is to keep the areas free from potato cyst nematode disease. Field plots in these areas do not have to be sampled and tested in advance to check that they are free of the nematodes.

No information has been found about damage to ornamental plants from the nematodes *M. chitwoodi* and *M. fallax*. Both organisms primarily pose a risk for the trade and export of plants, since detection of a Q-pest can lead to rejection of a consignment. The risk is largely determined by requirements that may be imposed by third countries and the EU, now and in the future, in relation to these organisms. In the EU, with regard to *M. chitwoodi* and *M. fallax*, there are currently only special requirements for seed potatoes, but under Article 28(2) of Regulation (EU) 2016/2031, implementing acts will be drawn up for all established Q-pests, containing specific measures to control the spread of these organisms. In the Netherlands, the nematodes are regularly found in potatoes, and it is suspected that both organisms are more widespread than is officially known. The spread of these nematodes is difficult to control due to the large number of host plants. *M. chitwoodi* and *M. fallax* cause no or few symptoms in many plants, allowing them to spread unseen. In 2013, the NVWA conducted a survey in areas of turf. *M. fallax* was found in 9 out of the 35 samples taken (NVWA, 2014a). Turf is not normally sampled and tested for quarantine pests, which means *M. fallax* could be spread through the turf trade.

Table 5.3 Q-pests established in the Netherlands that are relevant for open-field ornamental horticulture (including cultivation in an unheated greenhouse or tunnel) and their main host plants. A short description of these organisms can be found in Annex 4.

Organism	**Host plants (most relevant)**
Bacteria	
Ralstonia solanacearum	Potatoes, tomatoes, aubergines – may have multiple hosts among ornamental plants
Fungi and oomycetes	
Synchytrium endobioticum	Potatoes – relevant for ornamental horticulture due to the ban on growing rooted plants on an infested plot
Nematodes	
Globodera pallida	Potatoes – relevant for ornamental horticulture due to third-country requirements
Globodera rostochiensis	Potatoes – relevant for ornamental horticulture due to third-country requirements
Meloidogyne chitwoodi	Tree nursery plants, perennials (polyphagous organism)
Meloidogyne fallax	Tree nursery plants, perennials, turf (polyphagous organism)

5.3.2 Q-pests and NL-provisional Q-pests not established in the Netherlands

Findings since 2000

Since 2000, there have been several findings in the horticultural industry and nature of new harmful organisms for which temporary or long-term measures were in place or for which measures were imposed after the finding of the organism (Table 5.4). The organisms that were found in nature were also relevant for the horticulture industry. The organisms that now have (or still have) quarantine status were eradicated, with the exception of *Tobacco ringspot virus* (TRSV), which has the status of 'transient'. Plant imports are the most likely pathway by which the organisms were introduced, with the exception of *Anoplophora glabripennis* (Asian longhorn beetle), which most likely entered the country on wood packing material. More details about the pathways and risks posed by these organisms can be found in the short risk assessments on the NVWA website. Due to the large number of findings of TRSV and the suspicion that the virus is present in more places in the Netherlands and other EU Member States than is officially known, a short description of this Q-pest is given below.

TRSV mainly causes yield loss in a number of fruit crops, but in ornamental plants, it causes few or no symptoms (Van der Gaag et al., 2010). This means the virus can be present for a long time and be spread through vegetative propagation without being discovered. For ornamental plants, TRSV, as a Q-pest, is primarily a hazard for the trade and export of plants. The virus is transmitted naturally by nematodes in the *Xiphinema americanum* s.l. group complex. Not all species/populations in this complex can transfer the virus, and as far as is known, no vector populations are present in the Netherlands, but there are some in other EU Member States (Jeger et al., 2018a). However, the spread of these populations within Europe (and on other continents) is uncertain (Van der Gaag et al., 2010), which means the likelihood of introduction of the nematode into the Netherlands is also uncertain. As long as vector populations of the nematode *Xiphinema americanum* s.l. are not present in the Netherlands, the organism can be eliminated relatively easily by destroying the infested consignments.

<u>Organisms with a relatively high likelihood of an infestation in the ornamental horticulture production chain</u>
Nine non-established Q-pests and NL-provisional Q-pests have been identified with a relatively high likelihood of an infestation in outdoor ornamental horticulture (Table 5.5; Figure 5.1). These organisms are briefly discussed below.

- The bacterium *Xylella fastidiosa*, the longhorn beetles *Anoplophora glabripennis* (ALB: Asian longhorn beetle) and *A. chinensis* (CLB: Citrus longhorn beetle) and the Japanese beetle *Popillia japonica* constitute the highest risks for the trade and export of ornamental plants, partly due to the large number of plant species they affect. The anticipated direct damage for the ornamental horticulture sector is limited. Greater damage would be expected in green spaces if the ALB became established, and in the fruit-growing industry if *P. japonica* became established. As the climate continues to heat up, the estimated potential impact of all four organisms is increasing. These four organisms are included in the EU list of priority pests[26] (Commission Delegated Regulation (EU) 2019/1702 of 1 August 2019 supplementing Regulation (EU) 2016/2031 of the European Parliament and of the Council by establishing the list of priority pests). EU emergency measures currently apply to these organisms, with the exception of *P. japonica*. If an outbreak of *X. fastidiosa*, the ALB or the CLB occurs, there is an obligation to demarcate an area around the infested zone. The effect on trade of such a measure could be huge. For the ALB and the CLB, no demarcation is required for isolated cases, provided measures are taken to ensure the organism is immediately eliminated. For *X. fastidiosa*, exceptions to the demarcation requirement apply only in very specific situations. There must be proof that the bacterium "*was recently brought into the area with the plants on which it was found*" or that the bacteria was found at a location that "*is physically protected from vectors*" (Commission Implementing Decision (EU) 2015/789 of 18 May 2015 as regards measures to prevent the introduction into and the spread within the Union of Xylella fastidiosa (Wells et al.)). In addition, an investigation must uncover no indications of natural spread. The most likely pathways of introduction for the four organisms are briefly discussed below, along with the likelihood of eliminating an outbreak.
  - The most likely introduction pathway for X. fastidiosa and CLB is the import of ornamental plants, including from other EU Member States. It might be possible that *X. fastidiosa* is already present at a small number of locations in the Netherlands, in plants that were imported before the EU emergency measures against *X. fastidiosa* were introduced.
  - The most likely introduction pathway for the ALB is the import of products with wood packaging material from China. International agreements state that wood packaging material must be treated in such a way as to prevent harmful organisms from accidentally being transported in it[27], but these agreements have proven to be inadequate. Due to the risk from wood packaging material, from 1 April 2013 to 30 June 2020, EU emergency measures were in place for wood packaging material in certain consignments[28]. These emergency measures have now expired, but an EU requirement to draw up a monitoring plan for wood packaging material and to implement risk-based checks still apply[29]. In addition, the NVWA has for many years carried out inspections at sites where materials with

[26] Priority pests are the Q-pests with the "most serious economic, social or environmental consequences" (Article 6, Regulation 2016/2031). These are organisms to which special provisions apply, "including public information, investigation, contingency planning, simulation exercises, action plans focused on eradication, and co-financing of measures by the EU".
[27] ISPM (International Standard for Phytosanitary Measures) No. 15, Regulation of wood packaging material in international trade. Food and Agriculture Organisation of the United Nations. See: http://www.fao.org/3/a-mb160e.pdf
[28] Commission Implementing Decision (EU) 2018/1137 of 10 August 2018 on the supervision, plant health checks and measures to be taken on wood packaging material for the transport of commodities originating in certain third countries. OJ L 205, 14.8.2018, p. 54–61.
[29] Commission Delegated Regulation (EU) 2019/2125 of 10 October 2019 supplementing Regulation (EU) 2017/625 of the European Parliament and of the Council as regards rules concerning the performance of specific official controls of wood packaging material, notification of certain consignments and measures to be taken in cases of non-compliance.

wood packaging material arrive, as part of its annual phytosanitary monitoring programme. In these inspections, each site and the surrounding area are inspected for the presence of known and potential Q-pests.
  - At present, the most likely introduction pathway for *P. japonica* seems to be accidental importation through air and road transport. The organism may also be spread through trade in plants with attached soil and possibly through fruit. The organism is present on the European continent in the north of Italy, where the infested area is expanding. The likelihood of it spreading to other Member States is considered high. There are currently no specific EU requirements for measures against this organism. The 'accidental importation through transport' pathway is difficult to regulate.
  - Outbreaks of the ALB and the CLB have been successfully eliminated in the Netherlands in the past. The likelihood of timely detection of an outbreak of *P. japonica* when it is still possible to eliminate the beetle seems low. For *X. fastidiosa*, the likelihood of elimination of an outbreak is uncertain. There is no previous experience of outbreaks of the organism outdoors in a climate comparable to that of the Netherlands. As long as no natural spread has taken place, the bacterium can be eradicated relatively easily by destroying the infected plants.
- Over the past few years, several findings of the Q-pest *Tobacco ringspot virus* (TRSV) have been made in the ornamental horticulture sector, and it is suspected that the virus has spread more widely in the Netherlands and other EU Member States than is officially known. As far as is known, TRSV causes few or no symptoms in ornamental plants, which means the virus can enter the country and survive unnoticed. The virus is subject to regulation primarily due to its potential harmful effect on a number of fruit crops. No special requirements apply in the EU for this virus in ornamental plants. The virus can spread via vegetative propagation. As far as is known, its natural vectors – species in the nematode group complex *Xiphinema americanum* s.l. – are not present in the Netherlands. However, *Xiphinema rivesi* is present elsewhere in Europe, and this is known to be a vector for TRSV and three other quarantine viruses. To date, no natural spread in Europe of TRSV or other quarantine viruses has been reported. European populations of *X. rivesi* are not regulated, and there is little information on its spread within Europe. Accordingly, the likelihood of introduction into the Netherlands is uncertain.
- *Tomato ringspot virus* (ToRSV) is related to TRSV. ToRSV is found in the Netherlands less frequently than TRSV, but like TRSV, it can be present and asymptomatic. For this virus, specific EU requirements apply for *Pelargonium, Malus, Prunus* and *Rubus* for third countries where the virus is known to be present, but the virus can infect other plant species and is suspected to be present in more countries than currently known.
- The fungus *Fusarium circinatum* affects pine trees (*Pinus* spp.) and Douglas firs (*Pseudotsuga menziesii*) and can be transmitted via seeds. Within the EU, the fungus is present in Spain and Portugal. The risk from this organism for the Netherlands seems to be low, due to the Netherlands' unfavourable climate.
- The bacterium *Pseudomonas syringae* pv. *actinidiae* affects kiwifruit (*Actinidia* spp.) and is present in multiple EU Member States. The acreage where host plants grow is limited in the Netherlands, but at a local level, the impact of introduction could be high due to the mandatory quarantine measures. The bacterium may eventually be given RNQP status.
- The fruit fly *Strauzia longipennis* affects sunflowers (*Helianthus* spp.). The species was first found in Europe in 2010 in the vicinity of Berlin (Germany) and is expected to spread further.

5.3.3 New harmful organisms and potential Q-pests

Since 2000, there have been several findings in the horticultural industry and natural (green) spaces of new harmful organisms for which no official measures were in place and for which no official emergency measures were instituted. Examples include:

- *Aproceros leucopoda* (elm zigzag sawfly) found on *Ulmus* (elm) in nature, an unofficial 2013 finding published in 2014;
- *Cylindrocladium buxicola* (fungus that causes twig blight in *Buxus*), found in the early 21st century at nurseries and in nature;
- *Cydalima perspectalis* (box tree moth), first recorded in 2008 (unofficial reports of findings in nature date from 2007);

- *Hymenoscyphus pseudoalbidus*, a fungus that causes ash dieback, first recorded in nature in 2010;
- *Thrips setosus*, a polyphagous thrips species found in 2014 at a site where *Hydrangea* was being grown.

At the time of the first finding, these organisms were found or suspected to be so widespread that eradication or containment through official measures was no longer considered possible or effective. These organisms are now all established in the Netherlands. *Thrips setosus* has already been discussed in the 'Ornamental horticulture in heated greenhouses' section. The other four organisms are briefly discussed below.

Table 5.4 Official findings of current and former quarantine and NL-provisional Q-pests in ornamental plants grown outdoors, in unheated greenhouses, in tunnels or in nature in the period from 2000 to September 2019; at the time of finding, these organisms were not known to be present in the Netherlands.

Quarantine or NL-provisional Q-pest	Plant species/cultivation type	Year of finding[1]	Status as at 14 Dec 2019
Aculops fuchsiae	*Fuchsia* – private garden	2015, 2017, 2019	RNQP
Anoplophora chinensis	*Acer* commercial cultivation & nature	2007, 2009[2]	Q
Anoplophora glabripennis	*Acer, Salix* – nature	2010, 2012[3]	Q
Cryphonectria parasitica	*Castanea sativa*	2001, 2010	RNQP
Dothistroma septosporum	*Pinus* – nature	2007[4]	RNQP
Phytophthora lateralis	*Chamaecyparis lawsoniana*	2004	No longer NL-provisional Q-pest
Tobacco ringspot virus	*Hemerocallis*	2006, 2018	Q
Tobacco ringspot virus	*Iris germanica*	2017, 2018	Q
Tobacco ringspot virus	*Phlox subulata*	2010, 2018	Q
Tobacco ringspot virus	*Ajuga*	2019	Q
Tomato ringspot virus	*Iris germanica*	2018	Q
Xanthomonas arboricola pv. *pruni*	*Prunus*	First finding in 2008[4]	RNQP

[1] For related findings in different years (findings suspected to have the same original source of introduction into the Netherlands), only the first year is given.
[2] In 2007 and 2009, an infestation was found in plants in the vicinity of imported lots of *Acer* in Westland and Boskoop respectively. *A. chinensis* has more often been found in imported lots delivered to greenhouses and outdoor growing sites as well as in nature (including private gardens and public green), but without any indication that the species had managed to reproduce (lay eggs) (PD, 2008;2009; NVWA, 2010).
[3] In 2010 and 2012, an infestation was found in trees in nature (including private gardens and public green); the suspected source was wood packaging material. *A. glabripennis* has more often been found in imported wood packaging material and in nature (including private gardens and public green) but without any indication that the species had managed to reproduce (lay eggs) (NVWA, 2011;2013a).
[4] Year of first finding; the organism is now established in the Netherlands, so findings in subsequent years are not noted.

Aproceros leucopoda, the elm zigzag sawfly, was first reported in the Netherlands in 2014, although it had previously been observed in 2013 (Mol & Vonk, 2014). The larvae of the sawfly eat a zigzag trail across elm leaves. The species originates from Asia and, at the time of the report, was already known in several EU Member States (Blank et al., 2010). Damage from larvae eating leaves can be considerable; in 2017, there was a report of a stand of elm trees being stripped bare of leaves (Mol, 2017). It is not known whether the sawfly causes economic harm in tree nurseries.

The fungus *Cylindrocladium buxicola* was recorded in the Netherlands in the early 21st century. The fungus causes twig blight in *Buxus*, and infection can lead to the death of the plant. The fungus was previously recorded in Europe in the 1990s, in the United Kingdom. At the time, it was an undescribed species, and its origin is unknown (Henricot & Culham, 2002). *C. buxicola* can cause considerable damage. For example, following an infection, a box hedge several kilometres long in the garden of Het Loo Palace had to be removed and was replaced with holly (Van Doorn, 2012).

The box tree moth *Cydalima perspectalis* originates from East Asia. The larvae eat the leaves of the plant and can strip an entire plant bare. Following reports of findings in 2007 by amateur entomologists, the species was recorded at nurseries in the Netherlands in 2008 (Van der Straten & Muus, 2010). The species had already been observed in other European countries. Damage is especially visible in private gardens.

The fungus *Hymenoscyphus pseudoalbidus* causes ash dieback. Infections can lead to the complete death of the trees. The fungus is considered a significant hazard for Europe's ash forests. In Europe, the fungus was first described in Poland in the 1990s, and it is now present in many EU Member States. At the time of the initial finding in Europe, the species was still undescribed. It is suspected that the species originates from East Asia (Nielsen et al., 2017).

<u>Findings and interceptions of new harmful organisms in other EU Member States</u>
Since 2000, findings and interceptions of new harmful organisms have been made in other EU Member States that are relevant to outdoor cultivation and that have not yet been found in the Netherlands. Examples include the gall midge *Enigmadiplosis agapanthi* and the downy mildew fungus *Peronospora aquilegiicola,* both first recorded in Europe in the United Kingdom (UK).

The gall midge *Enigmadiplosis agapanthi* was discovered in the United Kingdom (UK) in 2014 and was an undescribed species at the time of finding. *E. agapanthi* infests the flower buds of *Agapanthus*, destroying the ornamental value of the plant (Everatt, 2015). There is a high likelihood that the species will also be observed in the Netherlands within the foreseeable future. The UK has no official measures in place, because the organism is fairly widespread in the UK and there are no good products that growers can use to ensure that plants are entirely free from the organism (Everatt, 2015; DEFRA, 2018).

Peronospora aquilegiicola (which causes downy mildew in *Aquilegia* spp.) was first confirmed in the UK in 2013, but it may have already been present there for several years prior. At the time, it was still an undescribed species, which may have been introduced from eastern Asia (Denton et al., 2015; Thines et al., 2019). An infection can lead to the death of the host plant (*Aquilegia* spp.). The UK has not put any official measures in place. At the time the organism was recorded in the UK, it was already widespread and eradication was no longer possible (Tuffen, 2016).

<u>Inventory of potential Q-pests</u>
See the 'Nature/Green spaces' section below for an inventory of potential Q-pests for trees and shrubs.

Table 5.5 Quarantine or NL-provisional Q-pests relevant for open-field cultivation of ornamental plants, including cultivation in an unheated greenhouse or tunnel and including plants in nature, that are not known to be established at Dutch horticulture sites, but for which the likelihood of an infestation is assessed as relatively high (P1–P2 ≥ 3;5)[1]

Organism	**Status as at 1 July 2020**	**Plants with a relatively high likelihood of an infestation**	**Most likely pathway(s)**
Anoplophora chinensis	Q	Tree nursery plants	P4P[2] of various hardwood species, particularly *Acer*
Anoplophora glabripennis	Q	Tree nursery plants	Wood packaging material
Fusarium circinatum	Q	*Pinus* (pine)	*Pinus* seeds and P4P
Popillia japonica	Q	Tree nursery plants including turf	Accidental importation through air/road transport or fruit; also, imports of plants with soil from other EU Member States in the event of further spread across the EU
Pseudomonas syringae pv. *actinidiae*	Emergency measures (Commission Implementing Regulation (EU) 2020/885	*Actinidia* (kiwifruit)	P4P of *Actinidia*
Strauzia longipennis	Q	*Helianthus*	P4P of *Helianthus*, accidental importation in vehicles, *Helianthus* cut flowers (within the EU, it is present in Germany)
Tobacco ringspot virus	Q	*Hemerocallis, Iris*	P4P of *Hemerocallis*, *Iris* and others
Tomato ringspot virus	Q	Various	P4P
Xylella fastidiosa	Q	Coffee plants and other *X. fastidiosa* host plants that have been imported in the past from regions where *X. fastidiosa* is present.	P4P of various species. Might already be present at a local level in plants imported before the EU emergency measures came into effect in 2015.

[1] P1–P2: the likelihood that the organism will enter the country on the plant or product and then make its way to a location suitable for it to become established; '3;5': a score of 3 on a scale from 1 to 5 (NVWA, 2019a).
[2] P4P: plants for planting, other than seeds (also referred to as 'plants' in this risk assessment).

5.4 Aquatic and marsh plants

5.4.1 Q-pests and NL-provisional Q-pests established in the Netherlands

It is possible that some aquatic and marsh plants could be host plants for the bacterium *Ralstonia solanacearum* or the nematodes *Meloidogyne chitwoodi* or *M. fallax* (Table 5.4). All of these organisms have a wide range of host plants. However, there have been no known infestations of aquatic or marsh plants, and the risk from these organisms for the cultivation of aquatic and marsh plants seems low.

5.4.2 Q-pests and NL-provisional Q-pests not established in the Netherlands

There have been no known outbreaks of (potential) Q-pests that could be related to imports of aquatic plants. However, in the past, the nematode *Aphelenchoides besseyi* was recorded at a nursery with imported aquatic plants. At the time, this nematode was a Q-pest only for *Oryza* spp. (rice) seeds and *Fragaria* (strawberry) plants, and it has been regulated as a RNQP for these species since 14 December 2019. However, there have been interceptions and findings of Q-pests in import consignments of aquatic plants. There is no known list of all aquatic plants imported into the Netherlands, and interceptions of harmful organisms by the Netherlands in the period from 2010 to 24 September 2019 were primarily analysed for:

- a number of known aquatic plants with numerous interceptions in the EU: *Anubias, Bacopa, Hygrophila* and *Vallisneria* (*Bacopa* is also grown as a pot plant, and TRSV was discovered in *Bacopa* pot plants in 2000, see Table 5.1);
- plants categorised as an 'aquatic plant' in the EU's interception database (Europhyt).

The interception information was retrieved from Europhyt on 24 September 2019 and is summarised below.

Interceptions by the Netherlands in Europhyt

- 17 notifications of *Hirschmanniella* spp. on *Vallisneria* spp. in 2018;
- 1 notification of *Radopholus similis* on *Anubias barteri* in 2013 (as of 14 December, *R. similis* is no longer regulated as a Q-pest);
- 1 notification of *Bemisia tabaci* on *Hygrophila* spp. in 2019;
- 1 notification of *Spodoptera litura* on *Hydrocotyle leucocephala* in 2018.

In 2017, the NVWA found *Hirschmanniella caudacrena* in a consignment of *Vallisneria* from Malaysia (NVWA, 2018c). In 2018, the NVWA conducted a survey in which *H. caudacrena* was found in 17 of 36 samples of *Vallisneria* from Malaysia and Indonesia. Interceptions of *Bemisia tabaci* and *Spodoptera litura* are not related specifically to aquatic and marsh plants, but the *Hirschmanniella* spp. interceptions do. The risk posed by *Hirschmanniella* spp. is therefore specifically discussed below.

Hirschmanniella spp.

Hirschmanniella species are root parasites adapted to aquatic environments. EFSA recently carried out a 'pest categorisation' (a short risk assessment to determine whether an organism is eligible for quarantine status or RNQP status) (Jeger et al., 2018b). In this pest categorisation, 29 *Hirschmanniella* species were assessed and divided into 4 groups:

1. species that are known to cause economic damage to plants and are not present in the EU;
2. species that are not known to cause economic damage to plants and are not present in the EU;
3. species that are present in the EU and do not cause damage;
4. *H. gracilis* (not regulated, present in the EU, where it does not cause economic damage, but known to be harmful in rice outside the EU).

The species that are known to cause economic damage (Group 1) are *H. diversa, H. imamuri, H. miticausa, H. mucronata, H. oryzae* and *H. spinicaudata.* They are primarily known to be harmful in regions with a warmer climate than the Netherlands, in rice (*H. oryzae, H. gracilis, H. imamuri, H. mucronata, H. spinicaudata*), Indian lotus (*H. imamuri* and *H. diversa*) and taro (*H. miticausa*), and they pose little risk for the Netherlands. The species that the NVWA found in *Vallisneria* plants, *H. caudacrena*, falls into Group 2 and, in the opinion of the EFSA, does not meet all of the criteria for a quarantine pest. However, the organism does currently have quarantine status, and the

Netherlands has an obligation to work to prevent the introduction into the EU of this and other *Hirschmanniella* species with quarantine status[30]. There are 40 notifications in Europhyt of interceptions of *Hirschmanniella* spp. (in the period from 2010 to 24 September 2019). All or nearly all of these notifications relate to aquatic plants, particularly *Vallisneria*, and aquatic plant imports therefore appear to be the most important potential pathway for these nematodes. Imports of rice plants from third countries are prohibited, with the exception of imports from European countries and countries bordering the Mediterranean. Despite being current practice, visual inspections of aquatic plants at the time of import are insufficient to detect infestations. In response to the many findings of *H. caudacrena* in *Vallisneria*, the Netherlands submitted a proposal to the European Commission in June 2018 to tighten the import requirements for aquatic plants by setting a requirement that the material for export must be tested and found to be free from harmful nematodes. Since 14 December 2019, the EU does require that plants of *Cryptocoryne* spp., *Hygrophila* spp. and *Vallisneria* spp., before export from third countries other than Switzerland, must be tested and found to be free from harmful nematodes. These requirements are expected to significantly reduce the number of infested import consignments.

<u>New harmful organisms</u>
There are no known examples of the introduction into the Netherlands of harmful organisms that cause problems in the cultivation of aquatic plants. There are also no known 'pest alerts' for new harmful organisms specific to aquatic and marsh plants.

5.5 Nature/Green spaces

The organisms in Table 5.5 (Q-pests relevant for outdoor cultivation) can also infest plants in nature. The same applies to the established Q-pests *Ralstonia solanacearum*, *Meloidogyne chitwoodi* and *M. fallax* (Table 5.3). In general, the potential impact of an organism for nature depends on how harmful the organism is to plants (cosmetic damage, growth reduction, death of parts of plants or the whole plant), how widespread susceptible host plants are, the speed of spread and the cost and effectiveness of any control measures. The established Q-organisms and several of the non-established Q-organisms in Table 5.3 do not pose a risk for nature (or at least not a major risk), because the damage they would cause is limited or because host plants are only locally present.

Organisms whose host plants are widespread in nature and that are very harmful to these plants are obviously a hazard. Such organisms include the Asian longhorn beetle (*Anoplophora glabripennis*), the emerald ash borer (*Agrilus planipennis*) and the bronze birch borer (*A. anxius*). The Asian longhorn beetle affects a large number of hardwood species, including a number of widespread species such as *Acer* (maple), *Betula* (birch), *Populus* (poplar) and *Salix* (willow). The likelihood of an outbreak of this beetle via infested wood packaging material is relatively high, but two previous outbreaks have been eradicated (Fig. 5.1; see also 'Outdoor ornamental horticulture'). The emerald ash borer and the bronze birch borer affect ash and birch trees respectively; the trees can die within a few years of an infestation. Strict regulations apply to imports of plants and wood from countries where these organisms are known to be present, so that the likelihood of introduction is low. However, the emerald ash borer is present in western Russia and the Ukraine; it appears to be expanding its distribution area westward, which means the likelihood of introduction into the Netherlands is increasing. Once the organism is present in the EU, measures can only serve to slow its spread, because the organism can travel several kilometres per year by natural means, and the chance of eradication is minimal.

Other Q-pests with a relatively high risk for nature include the longhorn beetle and borer species *Anoplophora chinensis*, *Aromia bungii* and *Saperda candida,* the fungi *Ceratocystis platani* and *Sphaerulina musiva* and the *Rose rosette virus*. The likelihood of an outbreak of these species is assessed as relatively low, with the exception of *A. chinensis*. Like *A. chinensis, A. bungii* and *C. platani* are established in the EU, and further spread of these organisms within the EU may

[30] All Hirschmanniella species have quarantine status, with the exception of *H. behningi*, *H. gracilis*, *H. halophila*, *H. loofi* and *H. zostericola* (Implementing Regulation (EU) 2019/2072 Annex II).

increase the likelihood of an outbreak in the Netherlands in the future. Furthermore, findings of the bacterium *Xylella fastidiosa* and the pine wood nematode *Bursaphelenchus xylophilus* could have an impact at a local level due to the mandatory clear-cut zones (removal of all known host plants) around a finding site. More information about these organisms can be found in the short risk assessments on the NVWA website.

5.5.1 Findings of new harmful organisms, no quarantine measures

Since 2000, several new harmful organisms have been found in nature for which eradication was no longer considered possible. For examples, see the section 'Outdoor ornamental horticulture, including cultivation in an unheated greenhouse or tunnel'.

5.5.2 Inventory of potential quarantine pests

A list of new organisms that are harmful for nature was compiled based on recent alerts (PestLens, 2018; EPPO, 2019c) and a recent inventory of harmful organisms for key tree species in European forests[31] (Table 5.6). The EPPO Global Database (EPPO, 2019b) and the CABI Crop Protection Compendium (CABI, 2019d) were used to compile that inventory. In the EPPO Global Database, it is possible to search for harmful organisms in relation to a specific plant species or genus. In the CABI Crop Protection Compendium, there is also the option of selecting organisms that are absent from a particular region (such as Europe); the search string used in the CABI Crop Protection Compendium was: '[name of plant genus] AND pest NOT Europe'. In the search for potential threats, we only looked at organisms that are not yet present in Europe and are a possible threat for the EU. For a number of the organisms in Table 5.6, an EPPO-PRA[32] was available, and the possibility of quarantine status is currently being debated at the EU level. The organisms in Table 5.6 are also relevant for the commercial cultivation of the host plants concerned. Note that the organisms are known to be harmful in their current distribution area, but for many of the organisms, no risk assessment is available for the EU or the Netherlands. A risk assessment is required to estimate the potential impact for plant health and to determine whether the organism meets the criteria for a Q-pest.

[31] *Abies, Acer, Alnus, Betula, Carpinus, Castanea, Chamaecyparis, Corylus, Crataegus, Cryptomeria, Fagus, Fraxinus, Juniperus, Larix, Ostrya, Picea, Pinus, Populus, Prunus, Pseudotsuga, Quercus, Robinia, Salix, Sorbus, Tilia* and *Ulmus* (De Rigo et al., 2014).

[32] EPPO-PRA Pest Risk Analysis compiled by the European and Mediterranean Plant Protection Organisation (https://www.eppo.int/).

Table 5.6 Harmful organisms that do not or not yet have EU quarantine status and are not known to be present in the EU, but are a potential hazard for ornamental horticulture and/or nature in the Netherlands.

Organism	Host plants (examples)	Area of spread (continents/regions)	References
Insects and mites			
Buprestidae (jewel beetles)			
Agrilus auroguttatus	*Quercus* (oak)	North America	(EPPO, 2019b)
Agrilus bilineatus	*Quercus* (oak), *Castanea* (chestnut)	North America, Turkey	(EPPO, 2018b)
Agrilus coxalis	*Quercus* (oak)	North America	(Coleman & Seybolo, 2008; EPPO, 2019b)
Agrilus fleischeri	*Populus* (poplar)	Asia	(EPPO, 2019b)
Chrysobothris femorata	Polyphagous on hardwoods	North America	(EPPO, 2019c)
Cerambycidae (longhorn beetles)			
Aeolesthes sarta	Polyphagous on hardwoods	Asia	(EPPO, 2019b)
Batocera lineolata	Polyphagous on hardwoods	Asia	(NVWA, 2013b)
Massicus raddei	*Quercus* (oak), *Castanea* (chestnut)	Asia	(EPPO, 2019b)
Hemiptera (true bugs)			
Lepidosaphes ussuriensis	Polyphagous on hardwoods	Asia	(EPPO, 2019b)
Hymenoptera (membrane-winged insects)			
Neodiprion abietis	*Abies balsamea* (balsam fir)	North America	(EPPO, 2019b)
Zapatella davisae	*Quercus* (oak)	North America	(Buffington et al., 2016)
Lepidoptera (moths and butterflies)			
Cydia latiferreana	*Quercus* (oak), *Castanea* (sweet chestnut), *Corylus avellana* (hazelnut)	North America	(CABI, 2019d)
Lambdina fiscellaria	Polyphagous, but particularly on *Abies balsamea* (balsam fir) and *Tsuga canadensis* (Canadian hemlock)	North America	(CABI, 2019d)
Lymantria mathura	Polyphagous on hardwoods	Asia	(EPPO, 2019b)
Lymantria obfuscata	Polyphagous on hardwoods	Asia	(CABI, 2018)
Malacosoma americanum	Woody plants in Rosaceae	North America	(EPPO, 2019b)
Malacosoma disstria	Polyphagous on hardwoods	North America	(EPPO, 2019b)

Organism	Host plants (examples)	Area of spread (continents/regions)	References
Phyllonorycter crataegella	Woody plants in Rosaceae	North America	(CABI, 2019d)
Thyridopteryx ephemeraeformis	Polyphagous on hardwoods and softwoods	Asia, North America	(CABI, 2018)
Fungi and pseudofungi			
Fusarium euwallaceae and the vector *Euwallacea* spp. (bark beetles)[3]	Polyphagous on hardwoods	California (USA), Mexico, Israel, South Africa	(EPPO, 2019b)
Pucciniastrum coryli	*Corylus* (hazel)	Asia	(CABI, 2018)
Phytophthora castaneae (Fungi; syn. *P. katsurae*)	*Castanea* (sweet chestnut)	Africa, Asia, the Caribbean, Oceania	(Oh & Parke, 2012) (CABI, 2018)
Phytophthora quercetorum	*Quercus* (oak)	North America	(Balci et al., 2008)
Phytophthora spp.	Various (little is known about these species)	East Asia	(Jung et al., 2020)
Diseases of unknown origin			
Beech leaf disease	*Fagus* spp. (beech)	North America	(EPPO, 2019c)

[1] For a number of organisms for which a risk assessment for the EU or the EPPO area is available, regulation at the EU level is currently under discussion.
[2] The organisms are known to be harmful in their current distribution area, but for many of the organisms, no risk assessment is available for the EU or the Netherlands.
[3] Non-European bark beetles (Scolytinae) including *Euwallacea* spp. are regulated as Q-pests.

5.6 Risks from Q-pests for tropical greenhouses (non-commercial cultivation), plants in offices, homes, sunrooms, etc.

In principle, the organisms in Table 5.2 (Q-pests with a relatively high likelihood of an infestation in ornamental horticulture in heated greenhouses) can also affect plants grown in homes, office buildings, sunrooms, etc. Because these organisms are unlikely to become established outdoors, the most likely way of introduction is that the plants was already infested at the time it was placed in the greenhouse, office etc. The impact for the individual owner may be high, particularly if they have purchased an expensive plant, but the general impact would be limited (incidental and local). The impact would be greater if the introduction of one infested plant leads to infestation of several other plants for example in a tropical greenhouse in a botanical garden or zoo. One example is the thrips *Scirtothrips dorsalis*. *S. dorsalis* causes leaf damage in a range of pot plants and other plant species. In the past few years, there have been multiple findings in the cultivation of pot plants (including bonsai) in the Netherlands, after which the organism was eradicated through the application of plant protection products. In the United Kingdom, the species was found in 2008 in three greenhouses in a botanical garden in southern England. The organism was quickly eradicated in two of the greenhouses. In the third, a tropical greenhouse with large trees and public access, eradication was achieved only after several years (EPPO, 2012b;2019a).

5.7 Pathways for quarantine pests and potential quarantine pests

Ornamental horticulture covers a vast range of plant species, which are associated with a large number of harmful organisms. Ornamental horticulture is also characterised by the high volume and wide variety of plant and flower imports from all continents except Antarctica (Eschen et al., 2017a). As a result, there is a relatively high chance of the introduction of new harmful organisms through the ornamental horticulture production chain. In addition, harmful organisms may be introduced through other production and supply chains and later enter the ornamental horticulture production chain in the Netherlands through either natural or human spread. For most quarantine and NL-provisional Q-pests, imports of plants (plants intended for planting other than seeds) was identified as the most likely pathway, but organisms can enter the country in a number of different ways (Figures 1 and 2). The various pathways by which current and potential Q-pests could be introduced are discussed below, with special attention being given to plant imports due to the relatively high risk.

5.7.1 Trade of plants (plants intended for planting, other than seeds)

For many (potential) Q-pests, trade in plants has been identified as the most likely pathway for introduction. In general, the global plant trade is considered one of the key ways in which harmful organisms are spread around the world (EPPO, 2012c; Liebhold et al., 2012). More specifically, the trade in plants with a root ball (in a pot) is seen as the greatest risk, and plants grown from meristem culture are seen as the lowest (EPPO, 2013; FAO, 2016). The Dutch horticulture industry import large numbers of ornamental plants, with huge variation in terms of species and origin. Plants are imported from countries on every continent except Antarctica. For example, in 2017, around 65,000 lots were imported into or via the Netherlands, involving a total of 1,022 different genera from 55 different countries. These figures are for all plant imports, including flower bulbs and food crop plants, but the majority were ornamental plants.

<u>EU laws and regulations</u>

Each lot of plants, originating from a third country other than Switzerland, must be inspected upon import. Usually, this inspection consists of a visual observation; no samples are taken to test for pathogens. A number of general requirements also apply (not connected to a certain Q-pest) for imports of certain plants from most third countries (Implementing Regulation (EU) 2019/2072, Annex VII, Points 1, 4–6, 10–11, 13, 30):

- If plants with attached growing medium are imported, special requirements apply for the growing medium and the cultivation conditions, to ensure that the growing medium is free from soil-borne Q-pests.
- Plants, other than "*bulbs, corms, rhizomes, tubers and plants in tissue culture*", must be grown in nurseries.
- For trees and shrubs, annual and biennial plants other than Poaceae (grass family)[33], plants of certain ornamental perennial grass species and herbaceous perennial plants of the families Caryophyllaceae (except *Dianthus* L.), Compositae (except *Chrysanthemum* L.), Cruciferae, Leguminosae and Rosaceae (except *Fragaria* L.), the plants must be:
  – grown in nurseries;
  – free from plant debris, flowers and fruits;
  – inspected at appropriate times and prior to export;
  – found to be free from symptoms of harmful bacteria, viruses, viroids and phytoplasmas; and
  – either found to be free from symptoms of harmful nematodes, insects, mites and fungi or have been subjected to appropriate treatment to eliminate such organisms.
- Deciduous trees and shrubs may only be imported in the dormant (leafless) state.
- For bulbs, corms, rhizomes and tubers intended for planting, other than tubers of *Solanum tuberosum*[34], the consignment must not contain more than 1% by net weight of soil and growing medium;
- A range of requirements apply for bonsai trees, including six mandatory inspections per year in the country of origin to check for the presence of Q-pests.

[33] Imports from third countries (except for European and Mediterranean countries) of plants in the Poaceae family are prohibited, except for certain ornamental perennial grasses.
[34] The importing of tubers of Solanum tuberosum intended for planting from third countries other than Switzerland is prohibited.

In addition to these general requirements, for specific plant species/genera (from certain places of origin), special requirements apply with regard to certain Q-pests, and the import of a number of plant species/genera is prohibited (from certain third countries) (Implementing Regulation (EU) 2019/2072, Annexes VI and VII). Special requirements apply for a number of plant species, based on emergency measures against certain Q-pests[35].

Temporary import bans are in place for 35 genera and species of plants, excluding in-vitro material and naturally or artificially dwarfed woody plants, originating from all third countries (Implementing Regulation (EU) 2018/2019). There is also a temporary import ban on plants and plant products of *Ullucus tuberosus*. Based on a risk assessment, these import bans may be lifted (in relation to certain countries or regions of origin) (see 'Risk-reducing measures' below).

<u>Effectiveness of visual inspections</u>
The general requirements for plant imports are considered inadequate to completely prevent the introduction of potential Q-pests in particular. By definition, there are no special requirements in place in relation to these organisms (they are not on the quarantine list). It is likely that only a portion of infested consignments are intercepted through visual inspections, as demonstrated by a US investigation of import consignments (Liebhold et al., 2012). Many organisms cannot be detected through visual inspections. For example, harmful nematodes used to regularly enter the country in attached soil (Den Nijs et al., 2016). Nematodes can only be detected by sampling the soil and/or roots. Visual inspections cannot detect asymptomatic infections either, while all plant pathogens have a latency period after infection in which no symptoms are visible. The bacterium *Xylella fastidiosa* was only discovered in imported coffee plants in the Netherlands after these plants were identified as high-risk plants for this pathogen, following an outbreak of the bacterium in southern Italy. The plants did not exhibit any symptoms, but testing showed they were infected (NVWA, 2016b). A recent EU-regulation requires Member States now to conduct risk-based sampling of imports and test the samples for any latent pathogens that may be present[36], but these tests are focused on specific Q-pests and not on potential Q-pests. Finally, visual inspections are of limited effectiveness in detecting mild infections or infestations or certain hard-to-detect stages, such as eggs of insects and mites. The source of many cases of findings of a Q-pest or NL-provisional Q-pest in the horticulture industry was likely the import of infested plants (Table 5.1). For example, in the period from 2015 to September 2019, there were several findings of *Scirtothrips dorsalis* in greenhouses that had likely been introduced through plant imports, and in the same period, the organism was not intercepted on plants during import inspections (Tables 5.2 and 5.7). Another example is the mite *Tetranychus mexicanus* found on *Beaucarnea* plants in the autumn of 2018 (NVWA, 2019b). This mite is not known to be present in Europe and most likely entered the country in plant imports, which means it was not observed during import inspections.

<u>Attached soil and soil pathogens</u>
In principle, the current requirements for attached growing medium ensure that the growing medium is free from harmful organisms. However, these requirements are insufficient to entirely prevent the introduction of soil pathogens. For example, plants that were grown in natural soil may be imported, provided the soil is removed. But removing the soil does not eliminate any root pathogens that may have already infected the plant. Plants that were grown in natural soil are therefore a greater risk for the introduction of soil pathogens than plants that were grown in clean artificial growing media, with contact with the soil being prevented and clean (pathogen-free) water being used. It is suspected that there are many soil pathogens around the world that are little known or not yet known and that are therefore not subject to specific EU requirements. For example, in a survey in the centre of the area of origin for *Phytophthora ramorum*, 21 new *Phytophthora* taxa were discovered in soil samples from the root zone of woody plants and in river water in Vietnam (Jung et al., 2020). Although little is known as yet about these new *Phytophthora* taxa, the new species and subspecies are a potential hazard for ornamental horticulture and the natural environment in the Netherlands, since the *Phytophthora* genus contains many very harmful

[35] https://ec.europa.eu/food/plant/plant_health_biosecurity/legislation/emergency_measures_en
[36] Commission Implementing Regulation (EU) 2019/2130 of 25 November 2019 establishing detailed rules on the operations to be carried out during and after documentary checks, identity checks and physical checks on animals and goods subject to official controls at border control posts

species. Vietnam is also in the centre of the area of origin of *P. ramorum* (Jung et al., 2020), a pathogen that, after introduction into Europe, caused large-scale death in larch forests in Ireland and the United Kingdom (Webber et al., 2010; Walsh et al., 2017). More recently, the infection of larches in Brittany (France) has been reported (Schenck et al., 2018). In the Netherlands, no large-scale infection of larches or other trees has been reported, but the species does cause problems for the export of and trade in tree nursery products.

<u>Internal EU trade</u>
Q-pests can also be introduced into the Netherlands through the internal EU trade in plants. For example, the longhorn beetles *Anoplophora chinensis* and *Aromia bungii* and the Japanese beetle *Popillia japonica* are established in parts of Italy, and the quarantine bacterium *Xylella fastidiosa* is present in Italy and other EU Member States. These organisms could be accidentally imported with plants or in attached soil (*P. japonica*), and a relatively high number of nursery products are imported from Italy (in 2019, 19% of imports, expressed in euros, came from Italy; plants with GN codes 060220, 060230, 060240, 06029041/046/047/048/050; source: Eurostat). Internal EU trade is not officially registered, unlike imports from third countries. This makes it difficult for the NVWA to get a picture of internal EU trade flows or to inspect random samples of imports as part of its annual phytosanitary survey programme. Specific requirements do apply for certain named organisms, not including *P. japonica*, which should reduce the likelihood of introduction through EU-internal trade of plants.

<u>Existing versus new imports</u>
Certain plants have been imported in large volumes for many years from certain countries without any indications of accidental importation of known or potential Q-pests. The likelihood of introduction of new harmful organisms through this kind of existing trade therefore appears relatively low, provided the plants continue to come from the same production sites and are always grown under the same conditions. Accordingly, the risks from new trade (new imports) appear greater than those from existing trade. The new Plant Health Regulation ((EU) 2016/2031) states: *"The international trade of plants, plant products and other objects with which there is limited phytosanitary experience can potentially involve unacceptable risks of the establishment of quarantine pests which are not yet listed as Union quarantine pests."* With existing import flows, it is more likely that any new harmful organisms that are accidentally imported with the plants will already be known. Targeted preventative measures can be taken against a known harmful organism (e.g. setting special requirements for the plants on which the organism could be accidentally imported). Conversely, the importing of a new plant species or imports from a new location (country/region) could create a new, unknown hazard, and a single infested plant could lead to the introduction of a new harmful organism.

<u>Examples of introductions and outbreaks</u>
Examples of 'new harmful organisms'[37] that were most likely introduced into the EU through plant imports include:
- *Curtobacterium flaccumfaciens* pv. *poinsettiae* (bacterium that infects *Euphorbia pulcherrima* (poinsettia)) (EPPO, 2017a);
- *Cylindrocladium buxicola* (fungus that causes twig blight in Buxus spp.) (EPPO, 2004;2012c);
- *Dryocosmus kuriphilus* (infests *Castanea* (sweet chestnut)) (EPPO, 2012c);
- *Enigmadiplosis agapanthi* (gall midge that infests *Agapanthus*, introduced into the United Kingdom) (DEFRA, 2018);
- *Fusarium foetens* (fungus that kills *Begonia* plants) (Van der Gaag & Raak, 2010);
- *Hercinothrips dimidiatus*, a thrips species found on *Aloe arborescens* in Portugal and the Netherlands (NVWA, 2016c);
- *Horidiplosis ficifolii,* a gall midge that infests *Ficus* species, found at multiple pot plant nurseries and subsequently eliminated (EPPO, 2012c);
- *Meloidogyne ethiopica* (a tropical root-knot nematode) (EPPO, 2011a);
- *Tetranychus mexicanus*, a polyphagous mite species, found at a pot plant nursery in the Netherlands and subsequently eliminated (NVWA, 2019b);

[37] At the time of the first findingf, these organisms did not have quarantine status and were not known to be present in the EU.

- *Ophiomyia kwansonis* (a leafminer that infests *Hemerocallis* spp.) (EPPO, 2013b);
- *Phytophthora ramorum* (oomycete/pseudofungus, polyphagous on woody plants) (Sansford et al., 2010);
- *Phytophthora alni* subsp. *alni* (infects *Alnus*)*, P. kernoviae* (polyphagous) (EPPO, 2012c);
- *Plantago asiatica mosaic virus* (PlAMV; infects lilies, among other species) (EPPO, 2011b);
- *Singhiella simplex* (whitefly species that infests various *Ficus* species) (EPPO, 2014);
- *Thekopsora minima* (rust fungus that infects *Vaccinium* spp.) (EPPO, 2016).

Six of these organisms (*E. agapanthi, H. dimidiatus*, *O. kwansonis*, *S. simplex*, *T. mexicanus*, *T. minima*) were first recorded in the EU in the period 2010–2019 (PlAMV was found in 2009, but its identity was established in 2010). No exhaustive list has been drawn up, but given the high number of findings in the past 10 years, under the system by which the likelihood of introduction of Q-organisms is scored (see 3.5.2 Risk assessments for EU Q-pests and NL-provisional Q-pests), the score for the likelihood of introduction of new harmful organisms on a scale from 1 to 5 must be at least a 3. The likelihood of introduction of new harmful organisms via the 'plants for planting, other than seeds' pathway is therefore assessed as relatively high.

Examples of organisms that already had quarantine status at the time of their initial finding and had probably been introduced into the EU on ornamental plants include *Anoplophora chinensis* (a polyphagous longhorn beetle that attacks woody plants) (EPPO, 2012c) and *Xylella fastidiosa* (a polyphagous bacterium) (EFSA-Panel-on-Plant-Health, 2015b).

Risk-reducing measures

Because plant imports are seen as one of the most important pathways for the unintentional introduction of harmful organisms, this section discusses a number of risk-reducing measures relating to this pathway.

The EU has an organism-focused phytosanitary system. This means the majority of plants and plant products may be imported without a prior risk analysis. Special requirements for a plant or product may be imposed only after identification and assessment of a potential Q-pest that could accidentally be imported with the plant or product. However, the new Plant Health Regulation (Article 42, Regulation (EU) 2016/2031) offers the possibility of instituting an import ban for plants and products that, on the basis of a preliminary assessment, "*present a pest risk of an unacceptable level*". Based on this article, a temporary import ban is currently in place for plants for planting, other than seeds, plants in tissue culture and naturally or artificially dwarfed plants of 35 genera and species from third countries (and a permanent import ban applies to a number of other plants and plant products under the same article)[38]. The import ban on a genus or species from a specific source can be lifted based on a risk assessment. Because many more plant genera and species are imported than the 35 currently listed in the implementation regulation, and because new harmful organisms have been found on a wide range of genera and species over the past 10 years that are not covered by the import ban, the likelihood of introduction of new harmful organisms via plant imports remains relatively high.

As part of its annual phytosanitary monitoring programme, the NVWA conducts surveys at the sites of businesses that import plants. Such a survey is considered both effective and efficient because organisms that might not be detected during the import inspection may be detected during a second inspection, since they may be at a more advanced stage of development and infestations may be more visible. When an organism is detected shortly after import, the chance that the organism will have spread over significant distances is low, so the chance of elimination is relatively high. However, it is not known what percentage of imported lots are inspected during these surveys. For example, plants may be delivered to retailers immediately after import or only remain at a cultivation site for a short period, which means they would be excluded from the survey.

[38] Commission Implementing Regulation (EU) 2018/2019 of 18 December 2018 establishing a provisional list of high risk plants, plant products or other objects, within the meaning of Article 42 of Regulation (EU) 2016/2031 and a list of plants for which phytosanitary certificates are not required for introduction into the Union, within the meaning of Article 73 of that Regulation. OJ L 323, 19.12.2018, p. 10–15.

Risks can also be reduced by making greater efforts to identify new hazards (horizon scanning) and then putting timely measures in place (regulating to reduce the likelihood of introduction). Alerts for new hazards in Europe are issued via the alert systems of the European and Mediterranean Plant Protection Organisation (EPPO) and the European Food Safety Authority (EFSA). Each month, the EFSA publishes the results of its horizon scanning, in which it conducts daily scans of the media and scientific literature for new and emerging risks for plant health. The EPPO publishes monthly reports via the EPPO Reporting Service. These reports are discussed in a European context. The American plant protection service (APHIS-PPQ) also has a system for screening literature for new pests and diseases (‘PestLens’; see also Annex 3). Because some organisms have not yet been described or are not well known as harmful organisms, such an approach has its limitations. For example, an organism may cause very little damage in its area of origin, perhaps because the host plants are not particularly susceptible and/or due to the presence of natural predators, whereas the same organism could cause considerable damage if it were introduced elsewhere. A possible tool for tackling this problem is the ‘sentinel’ approach, whereby European plant species are monitored for pests and diseases in exporting countries. Various recent research projects have investigated this early-warning tool for new harmful organisms (Eschen et al., 2019; Mansfield et al., 2019). However, such projects have practical limitations, since plants are imported from more than 50 countries, regional differences may exist within countries with regard to the presence of harmful organisms, there is a considerable number of European plant species and genotypes and third countries must be willing to take part in the research.

In addition to horizon scanning and placing sentinel plants in exporting countries to identify new hazards in a timely manner, stricter requirements can also be imposed on plant imports. Plants that are collected outside of nurseries, that are grown in natural soil and/or that are particularly large or old are seen as a relatively high risk (EPPO, 2013a). Imports of such high-risk plants can be largely excluded by only allowing plants to be imported if they:

- were at a nursery throughout their production period, with a clear distinction being drawn between nurseries and the natural environment (there is already a requirement for most plants that they must have been grown in nurseries);
- are unrooted, were grown in vitro and/or were exclusively grown in EU-authorised growing media (for the production of bulbs, tubers and rhizomes, cultivation out of the soil is not currently an option; for these products (with a specific origin), an exception may be made on the basis of a risk assessment).

In addition, there may be a requirement that the plants:

- be irrigated with water of which the origin is such, or which is treated in such a way, that the presence of harmful organisms can be entirely or almost entirely excluded (for plants imported with growing medium, there is already a requirement that the water must have been free from Q-pests during cultivation).

Authorised growing media include media for which the chance that harmful organisms may be present is very low (EFSA-Panel-on-Plant-Health, 2015a).

5.7.2 Imports of wood and wood packing material (including wooden products)

Trade of wood and wood packaging material including wooden products is an important potential pathway for beetles (Coleoptera) that infest trees and other woody plants (longhorn beetles, bark beetles, ambrosia beetles and jewel beetles), but also for pathogens that can be spread by these beetles, such as the pine wood nematode, *Bursaphelenchus xylophilus*. Other insects (non-beetles) that have been intercepted in wood in North America include termites and wood wasps (Hymenoptera – Siricidae) (Ciesla, 2004). The likelihood of association with harmful organisms is particularly high for wood packaging material, because the wood used for packaging is usually of lower quality. Trade of wood and wood packaging material is considered the most likely pathway for introduction of a range of beetle species:

- In the United States, in the period from 1985 to 2000, 73% of the 6,825 interceptions of bark and ambrosia beetles (Scolytinae) were in wood packaging material, 22% were on plants (palm trees) and food products and 5% were on other products (Haack, 2001).
- The EU’s interception database (Europhyt, consulted on 1 June 2018) lists 90 interceptions of the Asian longhorn beetle, *Anoplophora glabripennis*, in wood alone (wood packaging material, and once in a wooden object).

- Europhyt (consulted on 1 June 2018) also lists 204 interceptions of Scolytinae (not further specified). All of these interceptions were in wood or wood packaging material including dunnage.

EU-legislation
International agreements designed to prevent the spread of harmful organisms through wood packing material have been in place for a number of years (FAO, 2018). The wood should be treated against harmful organisms. Since 1 March 2005, the EU has also imposed requirements on wood packing material in accordance with the international standard. Despite these requirements, harmful organisms are still often intercepted in wood packaging material from certain countries. Accordingly, from 1 April 2013 to 30 June 2020, EU emergency measures applied to wood packaging material from these countries[39]. These emergency measures have expired, but the EU requirements to draw up a monitoring plan for wood packaging material and to implement risk-based checks still apply[40] (wood packaging material is not subject to regular phytosanitary inspections upon import). In addition, the NVWA has for many years carried out inspections at sites where materials with wood packaging material arrive, as part of its annual phytosanitary monitoring programme. In these inspections, each site and the surrounding area are inspected for the presence of known and potential Q-pests (NVWA, 2018c).

Wood and bark of various wood species are subject to the requirement of a phytosanitary certificate and a mandatory inspection upon import (Implementing Regulation 2019/2072 (EU), Annex XI, Part A). For softwood, with the exception of *Larix* wood, from the European part of Russia, a 'reduced check percentage' applied (until 2020) (Regulation (EC) 1756/2004)[41].

Special requirements apply for wood (including wood chips, sawdust, etc.) of various species (depending on the origin). For example, special requirements apply for softwood species of certain origins due to the risk of *Bursaphelenchus xylophilus* (pine wood nematode) and the risk of non-European species of *Monochamus* spp., *Pissodes* spp. and Scolytidae[42] (all beetles) (Implementing Regulation (EU) 2019/2072, Annex VII). Special requirements apply for some wood species, based on emergency measures against a number of Q-pests[43].

Since 14 December 2019, there has been an import ban on *Ulmus* wood from countries where the beetle *Saperda tridentata* is known to be present (Implementing Regulation (EU) 2018/2019). It is possible that this ban may be lifted, since *S. tridentata* causes little damage to healthy trees (EFSA-Panel-on-Plant-Health et al., 2020).

For isolated bark from certain tree species, a number of import bans apply, and special requirements are laid down in Implementing Regulation (EU) 2019/2072 (Annexes VI and VII) and in emergency measures against certain Q-pests[43].

No phytosanitary regulations apply to wooden products such as wooden furniture and sculptures.

Examples of introductions and outbreaks
Infested wood or wood packaging material is considered the most likely pathway for introduction into the EU of a number of Q-pests with a significant potential impact for the EU:
- *Anoplophora glabripennis* (Asian longhorn beetle);

[39] Commission Implementing Decision (EU) 2018/1137 of 10 August 2018 on the supervision, plant health checks and measures to be taken on wood packaging material for the transport of commodities originating in certain third countries. OJ L 205, 14.8.2018, p. 54–61.
[40] Commission Delegated Regulation (EU) 2019/2125 of 10 October 2019 supplementing Regulation (EU) 2017/625 of the European Parliament and of the Council as regards rules concerning the performance of specific official controls of wood packaging material, notification of certain consignments and measures to be taken in cases of non-compliance.
[41] Commission Regulation (EC) 1756/2004 of 11 October 2004 specifying the detailed conditions for the evidence required and the criteria for the type and level of the reduction of the plant health checks of certain plants, plant products or other objects listed in Part B of Annex V to Council Directive 2000/29/EC. OJ L 313, 12.10.2004, p. 6–9.
[42] Current scientific name: Scolytinae
[43] https://ec.europa.eu/food/plant/plant_health_biosecurity/legislation/emergency_measures_en

- *Aromia bungii* (longhorn beetle that infests *Prunus* fruit trees); and
- *Bursaphelenchus xylophilus* (pine wood nematode that is spread naturally by longhorn beetles in the *Monochamus* genus).

Various bark and ambrosia beetles have also been introduced into Europe, most likely in wood (Kirkendall et al., 2008; EPPO, 2019b):
- *Dactylotrypes longicollis*
- *Gnathotrichus materiarius*
- *Monarthrum mali*
- *Phloeosinus rudis*
- *Phloeotribus limnaris*
- *Xylosandrus crassiusculus*
- *Xylosandrus germanus*
- *Xylosandrus compactus.*

These beetles can infest many wood species, and a number of them (the ambrosia beetles) are also vectors for phytopathogenic fungi. A number of species were first observed in Europe relatively recently, and two of these, *Xylosandrus crassiusculus* and *X. compactus*, are on the EPPO Alert List. The EU's interception database (Europhyt, consulted on 1 June 2018) lists 32 interceptions of *Xylosandrus* species, of which 31 were in wood packaging material and one was in mangos (fruit). Imports of wood materials therefore seems to be the most likely pathway by which the *Xylosandrus* species mentioned above were introduced into Europe. No interceptions of the other genera/species have been notified, but it is possible that a number have been notified as 'Scolytidae' (the current scientific name is Scolytinae). The species seem to mainly be a risk for southern Europe.

5.7.3 Seed imports, including from other EU Member States

Various plant pathogens can be transmitted by seeds and some arthropods are known to have been accidentally imported with consignments of seeds. Of the current Q-pests and NL-provisional Q-pests that are relevant for ornamental horticulture, a number of organisms are known to be transmitted via seeds (of certain host plants):
- *Fusarium circinatum*;
- Scolytinae (non-European) – certain species;
- *Ralstonia solanacearum* species complex (*R. pseudosolanacearum*, *R. solanacearum*, *R. syzygii* subsp. *celebesensis*, *R. syzygii* subsp. *indonesiensis*);
- *Tobacco ringspot virus* (TRSV);
- *Tomato ringspot virus* (ToRSV).

Seed transmission have also been reported for a number of Q-pests that affect plant species that are primarily grown as food crops, but which can also be used as ornamental plants. These include:
- *Black raspberry latent virus* in *Rubus* (blackberry, raspberry) (EPPO, 2020a);
- *Tomato brown rugose fruit virus* in *Solanum lycopersicum* (tomato) and *Capsicum* spp. (sweet peppers and chili peppers) (Anses, 2020).

The five organisms or groups of organisms named above are discussed briefly below in relation to the 'seed pathway'.

F. circinatum causes pitch canker in *Pinus* (pine) and *Pseudotsuga menziesii* (Douglas fir). Due in part to the EU import ban on plants of various softwood species, seeds appear to be the most likely potential introduction pathway from third countries (EFSA-Panel-on-Plant-Health, 2010). The pathogen was first found in Europe (in Spain) in the 1990s. Its presence in Spain was not officially confirmed until 2004, and the species was also later found in Portugal (EPPO, 2019b). The species was most likely introduced into southern Europe through seeds. Moreover, it appears that this organism does not pose a significant risk to the Netherlands due to its unfavourable climate (see the brief risk assessment for *F. circinatum*).

The *Ralstonia solanacearum* species complex contains a number of (sub)species; of these, there have been outbreaks in the past of *R. solanacearum* and *R. pseudosolanacearum* in ornamental plants (see '5.2 Ornamental horticulture in heated greenhouses'). Plant imports and the use of surface water (only for *R. solanacearum*) are considered to be most important potential pathways for these bacteria in the ornamental horticulture production chain. Seeds have been identified as a potential pathway in peanuts (*Arachis*), tomatoes (*Solanum lycopersicum*) and aubergines (*S. melongena*) (EFSA-Panel-on-Plant-Health et al., 2019)

Scolytinae (non-European species have quarantine status) is a broad group of beetles that are primarily known to infest wood. Imports of wood and wooden materials are therefore one of the most important potential pathway for Scolytinae (see 'Imports of wood and wood packaging material (including wooden products)' above), but there are species that infest seeds and can therefore also be spread through seeds, known as 'seed breeders' (Haack et al., 2013; Kirkendall et al., 2015). Examples include *Coccotrypes* species on seeds of palm tree and hardwood species, *Hypothenemus* species on seeds of hardwood species and *Dactylotrypes longicollis* on seeds of palm tree species (Haack et al., 2013). Some exotic species such as *C. dactyliperda, C. carpophagus* and *D. longicollis* are present in Europe and may have been imported with seeds. The potential impact of seed breeders for the EU is unclear. Before 14 December 2019, Scolytinae were only regulated in the EU for plants of softwood species, with fruits and seeds being excluded. EFSA has to date only completed a risk assessment of Scolytinae that infest conifers (EFSA-Panel-on-Plant-Health, 2019).

TRSV and ToRSV are viruses with a wide range of host plants. Seeds transmission has been shown for some host plants. However, plant imports and vegetative propagation appear to be the most likely pathways by which the organisms can enter and spread.

EU legislation
Seeds of a number of species are subject to a mandatory inspection upon import, while for other seeds, at least 1% of import consignments must be inspected (see Annex 3.2).

An import ban is in place for *Vitis* seeds from all third countries except for Switzerland (and for seeds of stolon or tuber-forming species of *Solanum* L. or their hybrids) (Implementing Regulation 2019/2072, Annex VI, Points 10 and 16).

For seeds of the following plant species, special requirements apply in relation to two of the five Q-pests discussed above (with the species belonging to the *Ralstonia solanacearum* species complex being counted as a single Q-pest):
- *Prunus* and *Rubus* seeds in relation to ToRSV (Implementing Regulation 2019/2072, Annex VII, Points 47 and 48);
- *Pinus* and *Pseudotsuga menziesii* seeds in relation to *Fusarium circinatum* (Commission Implementing Decision (EU) 2019/2032).

Special requirements also apply for a number of seeds in relation to certain Q-pests that are primarily relevant for food and animal feed crops (Implementing Regulation 2019/2072, Annex VII, Points 73 and 74).

Examples of introductions and outbreaks
As indicated above, the quarantine pest *F. circinatum* was most likely introduced into Europe through seed imports. Another example is the downy mildew fungus *Plasmopara halstedii*, which has been a RNQP since 14 December 2019. The organism originates from North America and is suspected to have been introduced into Europe with infected seeds (Ahmed et al., 2012). This pseudofungus, which infects sunflowers, has been present in Europe for several decades (since at least the mid-1960s) and has also spread to other continents.

5.7.4 Imports of fruit and vegetables

Harmful organisms relevant to ornamental horticulture may be accidentally imported with imports of fruit and vegetables (including roots and tubers intended for consumption). For instance, the false codling moth (*Thaumatotibia leucotreta*) is regularly intercepted in import consignments of

Capsicum and *Citrus* fruits and can also affect roses. In general, imports of fruit and vegetables are considered a relatively low risk for ornamental horticulture. The organisms that might be accidentally imported are primarily a hazard for the cultivation of fruit and fruit vegetables.

EU legislation
A number of species of fruit and vegetables are subject to mandatory inspection upon import (Implementing Regulation (EU) 2019/2072, Annex XI, Part A). Depending on the import volume, the number of interceptions and the biological properties of the intercepted organisms, a 'reduced check percentage' applies for some fruit and vegetables that are subject to this inspection (Regulation (EC) 1756/2004)[41].**Fout! Bladwijzer niet gedefinieerd.** Where reduced checks apply, only a certain percentage of consignments have to be inspected upon import. All other species of fruit and vegetables are subject to an inspection percentage of 1%, with the exception of five tropical or subtropical fruits (see also Annex 3.2).

Tubers of *Solanum* species and their hybrids are subject to an import ban from most third countries (Implementing Regulation (EU) 2019/2072, Annex VI, Point 17).

A number of species of fruit and vegetables (of certain origins) are subject to special requirements with regard to specific Q-pests listed in Annex VII of Implementing Regulation (EU) 2019/2072 and in a number of emergency measures against certain Q-pests[43].

A temporary import ban is in place for *Momordica* fruit from third countries or regions where *Thrips palmi* Karny is known to be present and where effective risk mitigation measures against that pest are not being taken (Implementing Regulation (EU) 2018/2019).

Examples of introductions and outbreaks
There are few examples known of introductions and outbreaks of Q-pests or new harmful organisms in ornamental plants via fruit and vegetables. The North American fruit fly *Rhagoletis cingulata* may have been introduced into Europe with contaminated fruit. The transport of contaminated fruit has been assessed as the most likely pathway for the spread of the organism over large distances (EPPO, 2020b). In the Netherlands, this fruit fly is primarily found on black cherry trees in nature (Smit & Dijkstra, 2008).

5.7.5 Imports of cut flowers and cut branches

Although there are more interceptions of harmful organisms on cut flowers than on plants (Table 5.7), cut flowers and branches are generally consideredas a less important pathway. This is because, in almost all cases, organisms on cut flowers are in an immature stage when they enter the country; these stages must develop into adults before the organism can form a population, and cut flowers and branches have a limited lifespan (Van der Gaag et al., 2019). In addition, the species intercepted in the Netherlands are primarily tropical and subtropical species, which in most cases could only become established in greenhouses. The organism would have to escape from a living room, office or waste bin and find a suitable commercial greenhouse in which it could become established.

EU legislation
A number of species of cut flowers and cut branches are subject to mandatory inspection upon import (Implementing Regulation (EU) 2019/2072, Annex XI, Part A). Depending on the import volume, the number of interceptions and the biological properties of the intercepted organisms, a 'reduced check percentage' applies for some cut flowers and branches that are subject to this inspection (Regulation (EC) 1756/2004) [41]. Where reduced checks apply, only a certain percentage of consignments have to be inspected upon import. All other cut flowers and cut branches are subject to an inspection percentage of 1% (see Annex 3.2).

For cut flowers of *Chrysanthemum* L., *Dianthus* L., *Gypsophila* L. and *Solidago* L., special requirements apply with regard to the Q-pests *Liriomyza sativae* and *Amauromyza maculosa*. For cut flowers of Orchidaceae, special requirements apply with regard to *Thrips palmi* (Implementing Regulation 2019/2072, Annex VII). For cut flowers (and other plant parts) of *Rosa*, special requirements have been laid down in emergency measures against Rose rosette virus (Commission Implementing Decision (EU) 2019/1739 of 16 October 2019 establishing emergency measures to prevent the introduction into and the spread within the Union of Rose Rosette Virus).

Examples of introductions and outbreaks
Cut flowers have been suggested in a number of cases as the most likely pathway for an outbreak of *Spodoptera littoralis* and *Liriomyza huidobrensis* (Macleod, 1998). These organisms no longer have quarantine status in the EU (although *L. huidobrensis* does have PZ quarantine status for certain regions/countries in the EU).

Table 5.7 Number of interceptions of known and potential quarantine pests on cut flowers (CF) and ornamental plants (OP) in the period 2015–2018 (source: (NVWA, 2016b;2017b;2018c); data for 2018 from Europhyt, 24 September 2019)

	2015		2016		2017		2018	
Organism	**CF**	**OP**	**CF**	**OP**	**CF**	**OP**	**CF**	**OP**
Bemisia tabaci (non-European populations)	7	11	15	31	12	12	16	15
Hirschmanniella spp.								18
Liriomyza spp.			1		2			
Liriomyza sativae			1					1
Liriomyza huidobrensis/trifolii[1]	29		45	5	23	1	23	1
Puccinia horiana[1]						1		
Opogona sacchari[1]				1		1		
Radopholus similis[1]				2				6
Ripersiella hibisci		3		3		1		
Spodoptera spp.				1		2		
Spodoptera eridania		1						
Spodoptera frugiperda			1		3		6	1
Spodoptera littoralis[1]	17	2	17	1	19	2	9	2
Spodoptera litura	1	1	8	1	2		3	4
Thaumatotibia leucotreta	Only regulated for *Capsicum*[4]						92	
Thrips palmi	20		35	1	26		8	
Xiphinema americanum s.l. (non-European species)		1		1				
Other				3[2]	35		4	2[3]
Total	74	19	123	50	88	20	161	50

[1] Since 14 December 2019, the organism is no longer regulated as a Q-pest.
[2] *Aleurocanthus spiniferus* (2x), *Anoplophora chinensis* (1x)
[3] *Paysandisia archon* (PZ Q-pest since 14 December 2019), Pomaceae
[4] Until 2017, national measures applied for *Capsicum* only; regulated as a Q-pest since 1 January 2018.

5.7.6 Imports of other plant products

The quarantine fungus *Tilletia indica* could enter the country with grain. Specific requirements apply for grain from the genera *Triticum* (wheat), *Secale* (rye) and *X Triticosecale* (triticale, a wheat/rye hybrid) from certain countries where the fungus is known to be present (Implementing Regulation (EU), Annex VII, Point 75). This fungus is not relevant for ornamental horticulture.

Cane is imported from various regions, including Asia. Cane imports are a potential pathway for harmful organisms, including the scale insect *Nipponaclerda biwakoensis*. This species of Asian origin causes considerable damage in cane fields in the Mississippi Delta in the USA (NVWA, 2018k). There are no phytosanitary regulations relating to cane. In 2018, the NVWA conducted a survey into harmful organisms in imported cane and mainly found dead insects. No living examples of known or potential Q-pests were found.

5.7.7 Accidental importation through freight traffic, shipping containers, etc.

Organisms may be accidentally imported through freight traffic (including air freight) and in shipping containers. For instance, accidental importation through freight traffic may be the most important introduction pathway into the Netherlands of *Popillia japonica* (Japanese beetle) (Table 5.5).

5.7.8 Travellers' luggage and parcel post

Organisms may also be introduced via plants and products that individuals bring with them from abroad or order over the Internet (Caton & Griffin, 2006; Ramasodi, 2008; Giltrap et al., 2009; Kaminski et al., 2012). In 2008, for instance, the fuchsia gall mite (*Aculops fuchsiae*) was discovered at the home of a person in Germany who had brought in the plants as cuttings from the United States without any phytosanitary checks (EPPO, 2008). A German e-commerce study showed that a high percentage of plants ordered over the Internet did not comply with phytosanitary legislation; harmful organisms were also found (Kaminski et al., 2012). Checks conducted at Amsterdam Airport Schiphol by Customs and the NVWA regularly uncover prohibited plant products in passenger baggage and/or find that the required phytosanitary certificates are missing; Q-pests are also intercepted (NVWA, 2012a;2018c). Checks of parcel post mainly find products subject to an import ban (NVWA, 2012a;2018c). It is difficult to assess the phytosanitary risk posed by travellers' luggage and parcel post due to a lack of data about the species and volumes of plants and plant products that enter the Netherlands and the EU by this pathway and the percentage of luggage and parcel post that is checked. The fact is that many irregularities have been found during checks. The new Plant Health Regulation ((EU) 2016/2031) states: "*Plants moving into the Union from third countries and moving through postal services are in many cases non-compliant with the phytosanitary requirements of the Union. In order to raise awareness, specific rules concerning the information to be provided to travellers and clients of postal services should be set out.*" Member States, seaports, airports and international transport operators are indeed required to make information available to passengers concerning the phytosanitary requirements for their luggage (Article 45). Postal services also have an obligation to provide information (Article 45). Under Article 75, small quantities of plants and plant products may be exempted from the requirement to provide a phytosanitary certificate, but for the time being, it has been decided not to make any exceptions. Accordingly, since 14 December 2019, there has been a requirement to provide a phytosanitary certificate for plants, seeds and plant products in travellers' luggage for which a certificate would be required if they were traded through mainstream channels (fruit from banana, pineapple, date, coconut and durian plants are exempt from this requirement)[44]. Known and potential quarantine pests are regularly intercepted during import inspections of regular consignments of plant products, despite the presence of a phytosanitary certificate. So even though the legislation has been tightened (through the inclusion of a certificate requirement), known and potential quarantine pests can still enter the country in travellers' luggage. The volume of plants and plant products carried by travellers is considerably lower than that in commercial import consignments. In principle, this means the likelihood of quarantine pests entering the country through this pathway is also much lower. However, travellers could buy plant products in shops in third countries without a valid phytosanitary certificate and bring them into the EU. Due to limited information and the fairly recent tightening of the legislation, the risk from travellers' luggage and parcel post relative to the risk from other introduction pathways cannot be properly assessed.

5.7.9 Imports of growing media

Substrate (soil, growing medium) can be a source of harmful organisms (EFSA-Panel-on-Plant-Health, 2015a). The import of soil or a growing medium that consists in whole or in part of soil or solid organic substances is prohibited from third countries other than Switzerland. Growing media consisting entirely of peat or coconut fibre, which have not previously been used as a growing medium or for other agricultural purposes, are exempted from this ban. The presence of harmful organisms in these products is deemed unlikely. Pine bark from Portugal, which is used as a substrate for orchids and is also added to potting mixes for the nursery industry, is a potential

[44] Annex XI, Part C of Implementing Regulation (EU) 2019/2072.

source for the pine wood nematode (*Bursaphelenchus xylophilus*) (Van der Gaag et al., 2013). For this reason, the bark is now steamed in Portugal before being exported. Due to the existing regulations, the risk from substrate as a source of introduction of known or potential Q-pests seems low.

5.7.10 Attached soil (excluding growing medium attached to plants)

The risk from growing medium (including soil) attached to or associated with plants is covered under '5.7.1 Plant imports, including from other EU Member States'. Organisms can also be accidentally imported in soil attached to plant products and a wide range of materials. For root and tuber crops from third countries other than Switzerland, there is a requirement that the consignment or lot must not contain more than 1% by net weight of soil and growing medium (Implementing Regulation (EU) 2019/2072, Annex VII, Points 12 and 14). For "*Machinery and vehicles which have been operated for agricultural or forestry purposes*" from third countries, other than Switzerland, there is a requirement that the machinery or vehicles be cleaned and free from soil and plant debris (Implementing Regulation 2019/2072, Annex VII, Point 2). However, soil can also be found on materials, such as containers, wood, wood packaging material, etc., that have been staying on the ground. There is little information about the extent to which soil (with harmful organisms) enter the country with such materials. The risk therefore cannot be properly assessed. At present, other pathways, such as the import of plants with attached soil, seem to be a greater risk.

5.8 Surveillance and timely detection of outbreaks

Despite the current phytosanitary requirements on the import and internal EU trade of plants and plant products, the chance of outbreaks of known and potential Q-pests does exist. It is important that outbreaks be discovered in a timely manner – that is, before the organism has spread so widely that eradication is no longer achievable or would be very expensive. For many organisms, the likelihood of timely detection of an outbreak through surveys based on a random selection of inspection sites is low. After all, the organism would have to be found while the contaminated area is still small, whereas in many cases the organism is able to establish itself across a large area. For many Q-pests, the likelihood of eradication after introduction is estimated to be very low. These are often organisms that (i) are able to become established in the Netherlands outside of heated greenhouses; (ii) are difficult to detect; (iii) can rapidly spread by natural means; (iv) have a soil-borne phase and/or (v) have a broad range of host plants.

The likelihood of timely detection can be increased by focusing surveys on locations where the chance of introduction is relatively high. EFSA recently created 'pest survey cards' for many Q-pests and published guidelines for conducting surveys in which attention is paid to risk factors that increase the likelihood of the presence of a pest or disease in an area (EFSA et al., 2020c). The NVWA's annual phytosanitary survey programme partly focuses on 'high-risk locations' such as companies that regularly import plants, the vicinity of airports and locations with wood packing material (NVWA, 2018c). Although risk-oriented surveys increase the chance of early detection of known or potential Q-pests, this approach does have limitations. The likelihood of the presence of a known or potential quarantine pest in an import lot of plants is probably very lowl, but the number of import lots is high (around 60,000 in 2018), and it is not known what percentage of those lots are inspected again after import. Lots that have been imported are not placed on hold for a 'post-import inspection', and any lots that are sold to retailers, final consumers or traded to another EU member state immediately after import are not inspected again under the current system. Plants are not quarantined following import, so organisms may have already spread before an inspection is performed as part of the phytosanitary monitoring programme. Known or potential quarantine pests can also enter the country in other ways, and the pathway via which the organism has entered the Netherlands is sometimes fully unclear, as was the case with the outbreak of the gall midge *Contarinia jongi* at an *Alstroemeria* growing site in 2016 (NVWA, 2016e).

Rapid reporting by growers and crop advisers of the suspected presence of a new harmful organism may increase the chance of timely detection. The chance of growers and horticulture workers, who see the plants nearly every day, detecting a new organism at an early stage is much higher than the chance of timely detection by official surveys. During official surveys only a limited number of sites and plants can be inspected, and a location may be visited only once or on a small number of occasions each year. Advisers who regularly visit growing sites can also play a role. A statutory reporting obligation applies for Q-pests and NL-provisional Q-pests. However, the finding of a known or potential Q-pest may lead to quarantine measures that can have a significant impact for a grower. Because financial compensation is not generally paid for eradication measures, growers have no incentive to report an infection at their site (Van Asseldonk et al., 2011). According to experts, this also applies to the nationally regulated weed yellow nutsedge, for which the regulations have not had an adequate effect (NVWA, 2017a).

For the detection of known and potential quarantine pests in nature, existing networks of volunteers and professionals who often visit nature can play a role. The same applies to private individuals who are not directly involved in such networks. In 2012, for instance, a private individual reported the finding of the Asian longhorn beetle (*Anoplophora glabripennis*) in a garden in Winterswijk (NVWA, 2013a). The infestation was confined to a single tree, so the organism could be quickly eradicated. The use of networks of volunteers and professionals raises the chance that large numbers of reports would be received of organisms that do not have and are not eligible for quarantine status. It can take a lot of time to follow up on and respond to reports. This must be taken into account when using volunteers and professionals to detect known and potential Q-pests.

A recent review provided an overview of the various methods that could be used in surveillance for exotic insects in forests (Poland & Rassati, 2019). Every method has advantages and disadvantages, and the development of a cost-effective surveillance programme for timely detection of outbreaks of known and potential quarantine pests would require a thorough analysis of the “trade-offs between surveillance effort and management costs” (Poland & Rassati, 2019).

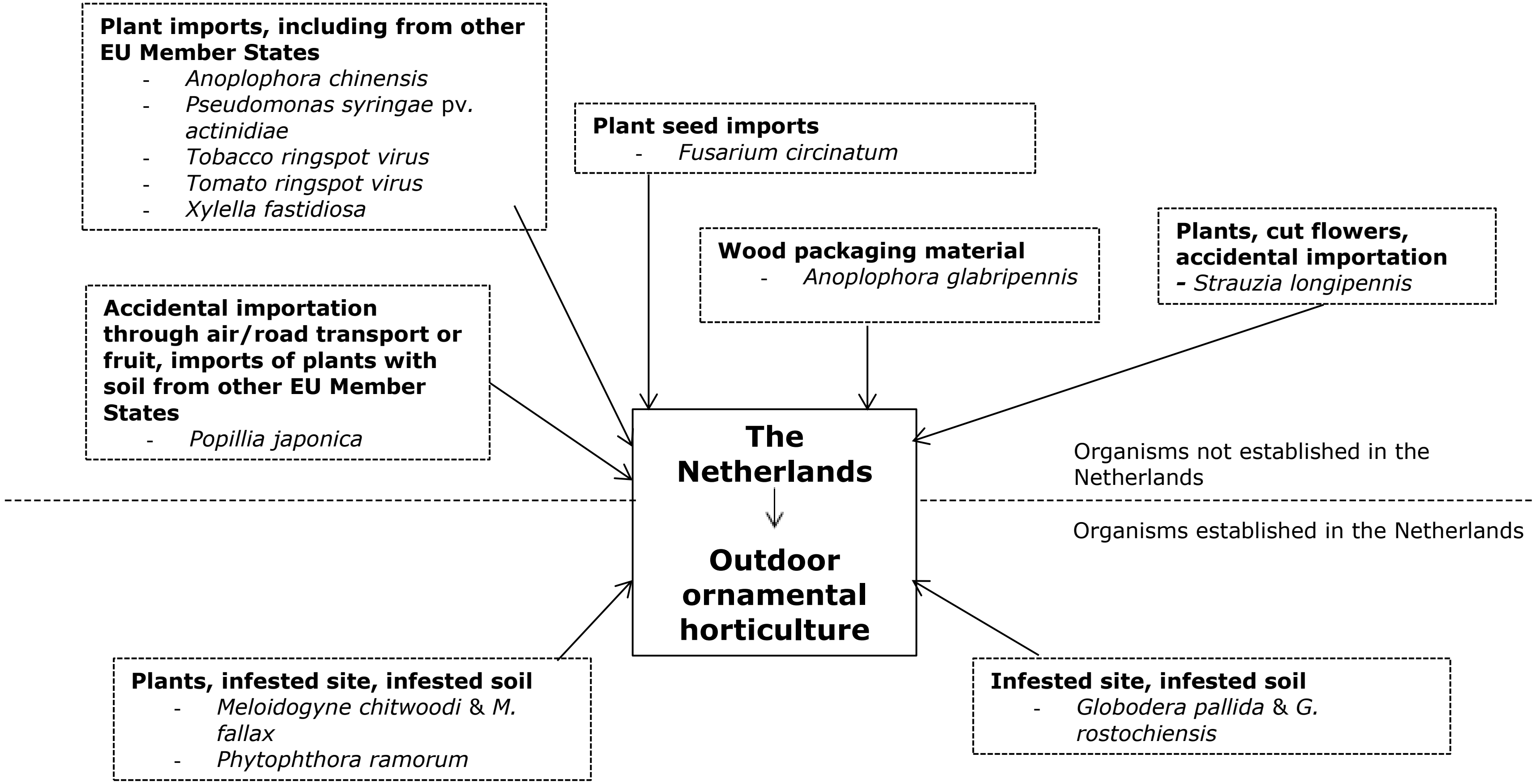

Fig. 5.1 Overview of the most likely pathways by which Q-pests and NL-provisional Q-pests that are relevant to outdoor ornamental horticulture and that were selected due to their relatively high likelihood of an infestation, could be introduced into the Netherlands (non-established organisms) or onto ornamental horticulture growing sites (established organisms). Organisms that are not yet present in the Netherlands may be introduced to the ornamental horticulture sector directly or may initially appear in other crops or in nature and then reach ornamental plants via natural spread or other means.

6 Risks for biodiversity: invasive alien species

6.1 Introduction

An alien species is a plant, animal or other organism that does not naturally appear in the Netherlands and has been brought to our country through the actions of human beings. It is therefore not a species that is native elsewhere in Europe and is advancing into the Netherlands due to climate change, such as the oak processionary caterpillar. The majority of alien species are not a problem, but a small number are. Species that establish themselves in the wild in the Netherlands, multiply rapidly and are harmful for native species are referred to as 'invasive alien species'. In this annex, we distinguish between three categories of invasive alien species:
1) non-native plants that have been or could be imported via the ornamental horticulture production chain;
2) non-native plants, animals and other organisms that have been or could be accidentally imported via the ornamental horticulture production chain;
3) non-native organisms imported for biological pest control purposes to protect food and/or ornamental plants.

Invasive alien species may be imported deliberately, including from other EU Member States. The Netherlands is the largest importer of plants (including pot plants and plant parts that are going to be planted) in Europe. On average in the period 2005–2014, around 850 different plant genera per year were imported into or via the Netherlands from more than 50 non-EU countries (Eschen et al., 2017b). The range of plants depends heavily on what is in fashion (Potting et al., 2013). New species for new markets are often sought on a trial-and-error basis. This results in the import of large numbers of new non-native species, to explore the potential for growing, breeding and trade (Potting et al., 2013; Van Valkenburg et al., 2014). In 2012, 20% of all unique genus-origin-combinations of non-native plants that were imported had not been imported in the four years before. However, the volume represented by this 20% amounted to only 0.2% of the total imports of non-native plants from third countries (Potting et al., 2013). A low percentage of the range of plants are offered for sale for a short period before disappearing from the market; only a very small number of new products expand to a sizeable volume. Due to this wide variation in ornamental plant species, the chance of introduction of invasive plant species is high.

Invasive plant species can also be accidentally imported with ornamental plant imports, either as contaminant or through confusion of species. As well as plant species, non-native animals or microorganisms can also be accidentally imported with plant imports. Due to the scale of imports and the fast turnaround in ornamental plant species and areas of origin, the likelihood of introduction of organisms that were imported accidentally is increasing.

The third category of potentially invasive non-native species in the ornamental horticulture production chain concerns deliberately released animals or other organisms. In the ornamental horticulture production chain, non-native organisms are sometimes used to control pests. Organisms used for biological pest control are natural predators of pests, weeds and organisms that cause diseases. The release or escape of non-native organisms used for biological pest control purposes can have unintended negative consequences for biodiversity.

6.1.1 Approach

Very little data are available on which invasive and non-invasive alien species have entered the Netherlands through the ornamental horticulture production chain and become established in the wild. Accordingly, the NVWA commissioned Radboud University to investigate the extent to which the ornamental horticulture production chain has contributed to the introduction of invasive alien species in the Netherlands and the known and potential effects and risks of these species for the natural environment, public health and other societal interests.

The Radboud University also ascertained which plant species have been imported but have not yet become established in the wild in the Netherlands. To do so, they used data from a 2014 horizon scanning project commissioned by the NVWA (Matthews et al., 2014). They also used import data on plant species that are regarded as potentially invasive. These are species that grow in comparable climate conditions, that have been introduced into other regions, for which a risk assessment has been performed and that are not yet present in the wild in the Netherlands.

Scope
To determine whether a plant is a non-native species, the risk assessment made use of the Standard List of the Flora of the Netherlands 2003 (Tamis et al., 2004). Non-native plant species are all plant species for which the 'indigenous indicator code' is not 'i' (= indigenous origin). The list of non-native species was supplemented with all known non-native species that have since been found in nature in the Netherlands and included in the Dutch National Database of Flora and Fauna (NDFF, 2018). In the assessment of the known and potential impact of non-native species, the emphasis was on the effects on the natural environment (native biodiversity and ecosystems). Effects on ecosystem services (the direct and indirect contributions of ecosystems to human well-being) were also identified. Where there were other harmful effects, such as in relation to human health and safety and damage to buildings, these were also listed. Species that are only a risk for cultivated crops (including forestry) or animal health are outside the scope of this study.

6.1.2 Results

The results described in this annex are drawn from the Radboud University report: Risks from the ornamental horticulture production chain as an introduction pathway for invasive alien species (Pieters et al., 2018), unless otherwise specified.

6.2 Non-native plants imported via the ornamental horticulture production chain

Non-native plants are imported by:
- producers (for cultivation, breeding and seed production);
- wholesalers and retailers;
- consumers;
- owners/managers of botanical gardens.

A total of 2,438 non-native plant species have been observed in the wild in the Netherlands. At least 1,529 of these species are ornamental plants, which means they were sold in the Netherlands, are present in botanical gardens[45] or 'horticultural purposes' is specified in databases as a pathway. Most of these (1,371 species) are not yet established in the Netherlands. A plant is considered to be established if the species can complete its entire life cycle and can maintain itself in more than one place for a number of years without direct human assistance. For 158 ornamental plant species, it has been determined that they have spread to the wild and reproduced there. Ornamental plant species can escape into the wild if their seeds spread from gardens, if people dump plants and garden waste in nature or if they are deliberately released into nature.

At present, 63 (more than 4%) of the 1,529 imported non-native ornamental plant species observed in the Netherlands have become established and are invasive or potentially invasive. Displacement of native species, loss of biodiversity and consequences for the functioning of ecosystems are listed in the available risk assessments as potential effects of these species.

Matthews et al. conducted a horizon scan in 2014 to identify invasive non-native species that could potentially affect the Netherlands. They looked at species that grow in areas with comparable climates to the Netherlands and for which a risk assessment has been conducted, as these species are potentially invasive. Of all the potentially invasive alien species that could become established in the Netherlands in the near future, 35% were related to ornamental horticulture, the aquarium

[45] This refers to the 26 botanical gardens affiliated with the Dutch Association of Botanical Gardens (NVBT).

trade or landscape architecture. There are 26 potentially invasive plant species that have not yet been introduced into the Netherlands or that are present in private or botanical gardens but not yet established in the wild in the Netherlands. NVWA import data show that at least 3 of these 26 potentially invasive plant species were imported in 2017: chocolate vine (*Akebia quinata*), Japanese honeysuckle (*Lonicera japonica*) and pampas grass (*Cortaderia selloana*)[46]. In Europe, chocolate vine is established in France and the United Kingdom (among other countries), where it is considered invasive (CABI, 2019c). Japanese honeysuckle and pampas grass are established in various EU countries and considered invasive in a number of southern Member states (CABI, 2019b;2019a). The imported quantities for individual species are unknown, since it is usually only the genus name rather than the species name that is indicated on the import application.

The horizon scan performed by Roy & et al. (2018) looked at species that grow in regions with a comparable climate and that are invasive in other regions, which are not yet present in the EU but are sold in the EU or are present or kept in areas from which goods are imported or that are visited by travellers. A total of 16 potentially invasive plant species were identified that had 'escape from confinement' as a pathway. These 16 invasive plant species are offered for sale, after which they may escape into the wild and become established in nature in Europe. Of these 16 invasive plant species, 15 are considered to be high risk and 1 presents a medium risk (Roy & et al., 2018) (Table 6.1).

Of the species raised by various horizon scans as possibly being of risk, 37 were prioritised by Tanner et al. (2017). This study showed that *Lonicera maackii* has long been sold in Europe without exhibiting any invasive behaviour (Tanner et al., 2017). A risk assessment for *Cinnamomum camphora* shows that the expected impact of this species is not significant (EPPO, 2017b). FLORON has been commissioned by the NVWA to create a database indicating which of the ornamental plants for sale in the Netherlands are invasive or potentially invasive. It is expected that this database will be available in early 2021.

Table 6.1 List of potentially invasive plant species from a horizon scan by Roy & et al. (2018)

Scientific name	**Pathway**	**Risk category according to Roy et al. (2018)**	**Risk category according to (EPPO, 2017b; Tanner et al., 2017)**
Albizia lebbeck	Escape	High	
Celastrus orbiculatus	Escape	High	
Cinnamomum camphora	Escape	High	Low
Clematis terniflora	Escape	High	
Cortaderia jubata	Escape	High	
Cryptostegia grandiflora	Escape	High	
Gymnocoronis spilanthoides	Escape	High	
Lespedeza juncea ssp. *sericea (= L. cuneata)*	Escape	High	
Lonicera maackii	Escape, release	High	Low
Lonicera morrowii	Escape, release	High	
Lygodium japonicum	Escape	High	
Pinus patula	Escape	Medium	
Prosopis juliflora	Contaminant, escape	High	
Prunus campanulata	Escape	High	
Rubus rosifolius	Escape	High	
Triadica sebifera	Escape	High	

[46] Incidentally, these species are also propagated in the Netherlands.

6.2.1 Effects

Ornamental plant species that have become established in the wild can have a range of effects. They may have an impact on biodiversity and ecosystems, for example, by displacing native plants through their overwhelming presence. In nature areas, such as Natura 2000 areas, the ecological goals could be jeopardised if invasive plants become established. There are various habitat types where, without intervention, invasive alien species could create significant quality issues. One example is swamp stonecrop (*Crassula helmsii*), an aquatic plant that spreads quickly and in some places can threaten the continued existence of the habitat type 'weakly-buffered fens' (Siebel & Reichgelt, 2014). *Cotoneaster* species are another example, which, in the absence of timely intervention, can lead to loss of quality of the Natura 2000 habitat types 'grey dunes' and 'calcareous grasslands'. Native species disappear and the vegetation structure becomes less diverse (Boer, 2014). Plants can also give rise to health problems and cause damage to buildings, pipes and infrastructure.

Invasive plants can have an impact on the entire ecosystem. For example, when invasive aquatic plants become abundant, other aquatic plants are displaced. Ditches can become overgrown with invasive aquatic plants. The plant mass can come loose and accumulate in pumping stations, weirs and other pieces of water infrastructure. This impedes the flow of the water. Sometimes, after heavy rain, the water cannot drain away and flooding occurs. This can cause damage to homes and agricultural crops, for example. A thick layer of aquatic plants can cause significant problems for recreational boats as well. If the plant mass dies, it leads to a lack of oxygen in the water. This has a negative impact on the animals that live in the water and on the animals that feed on these animals.

Examples of ornamental plant species that are established in the wild and are known to have a negative effect on biodiversity include Himalayan balsam (*Impatiens glandulifera*), tree of heaven (*Ailanthus altissima*), water primrose (*Ludwigia grandiflora*), black cherry (*Prunus serotina*) and various *Cotoneaster* species. Himalayan balsam forms dense leaf cover and has a high rate of seed production, allowing it to displace other species (Matthews et al., 2015). Tree of heaven has a strong ability to compete, and through the accumulation of toxins in the soil from fallen leaves, this tree can inhibit the growth and establishment of other plants (Boer, 2012). Through its powerful growth, water primrose displaces the original flora. Cotoneasters form dense stands of trees in which no other species can grow (Boer, 2014).

Established ornamental plant species that have a negative effect on the functioning of ecosystems include parrot's feather (*Myriophyllum aquaticum*) and swamp stonecrop. Due to its fast growth, parrot's feather can displace native species and also has an undesirable impact on the physical and chemical properties of aquatic ecosystems (NVWA, 2016a). Swamp stonecrop has similar effects: by forming floating mats, it displaces native species and reduces the level of oxygen in the water (NVWA, 2018g).

Established ornamental plant species that are known to have a negative effect on human health include giant hogweed (*Heracleum mantegazzianum*) and common ragweed (*Ambrosia artemisiifolia*). Giant hogweed can cause burns when touched (NVWA, 2018i), and the pollen of common ragweed causes hay fever symptoms (Van Vliet et al., 2009). Examples of species that cause damage to buildings, pipes and infrastructure include Japanese knotweed (*Fallopia japonica*) and tree of heaven. Japanese knotweed is an established ornamental plant species that not only has a negative effect on biodiversity by displacing other plant species but can also threaten the stability of dykes; when it grows on road verges and roundabouts, it can jeopardise road safety, and the roots can cause damage to infrastructure, buildings and pipes (Beringen et al., 2019). Tree of heaven seedlings often grow in the gap between walls and pavements, which their roots cause to buckle. In addition to damaging building foundations and road surfaces, tree of heaven's extensive root system can also cause damage to pipes, including sewage pipes (Boer, 2012).

Established ornamental plant species can also have an impact on ecosystem services[47]. In risk assessments of invasive alien species, the negative impact on ecosystem services is often not quantified or is insufficiently quantified (Pieters et al., 2018).

6.2.2 Trend

Over the years, the number of first sightings of ornamental plant species in the wild has exhibited a strong upward trend, which is showing no signs of flattening off (Figure 6.1). One explanation for the sharp increase in first sightings of new ornamental plant species is the globalisation of the trade in ornamental plants. Moreover, a first sighting does not mean that a species has become established. At present, more than 4% of the imported non-native ornamental plant species observed in the Netherlands have become established and are invasive or potentially invasive.

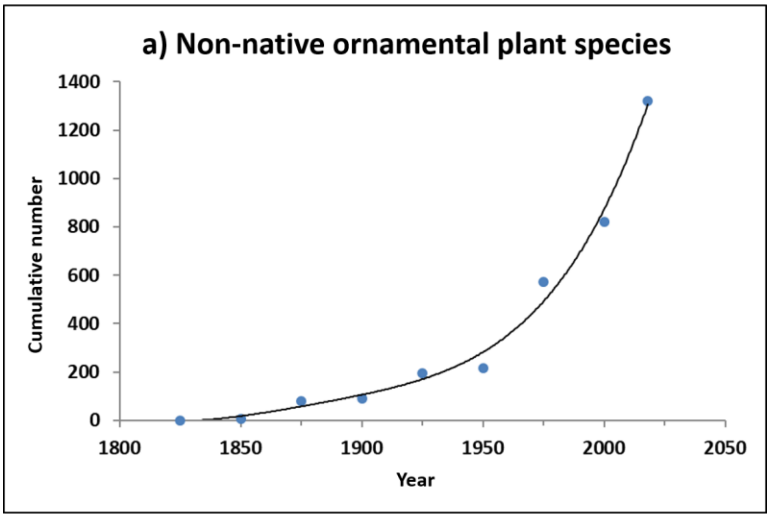

Figure 6.1 Cumulative number of known first sightings of new non-native ornamental plants in the wild (n=1,321). For 208 of the 1,529 species, there is no information about the year of the first sighting (Pieters et al., 2018).

Due to continuous innovation in the sector, globalisation and climate change, it is expected that more non-native species will escape into the wild in the future. The likelihood that planted species may escape into the wild, become established and ultimately become a nuisance depends in part on introduction pressure and species characteristics such as winter hardiness. The climate is currently unsuitable for a number of species, particularly since they cannot survive the winter. However, due to climate change, the climate may well become suitable for these species in the future. The impact of climate change could perhaps be even more pronounced for organisms that were imported accidentally, because deliberately imported species intended to be grown in gardens are selected for properties such as winter hardiness.

6.3 Non-native plants, animals and other organisms that were imported accidentally via the ornamental horticulture production chain

The study conducted by Radboud University (Pieters et al., 2018) shows that, within the ornamental horticulture production chain, plants, animals and other organisms that were imported accidentally are primarily introduced with imports of ornamental plants (such as pot and container plants), propagating material and seeds. In the Netherlands, 658 species have been observed in the wild that have one or more pathways indicating transport within the ornamental horticulture

[47] Ecosystem services are services for the benefit of humans that arise from natural resources in ecosystems or that are related to the functioning of ecosystems. Examples include pollination, water supply and recreation in nature areas.

production chain and that were not deliberately introduced into the Netherlands as ornamental plants; these are known as 'species that were exclusively imported accidentally'. They include both aquatic and terrestrial plants and animals. Of the 658 species that were imported accidentally, 115 have become established in the Netherlands. The invasiveness of 95 of the 115 species has been assessed. Approximately 40% (41 of the 95 species) are on a list of high-risk species and are considered invasive or potentially invasive. For the species for which risk assessments are available, the adverse effects on biodiversity are often estimated to be low, but generally with a high degree of uncertainty.

6.3.1 Effects

An example of a species established in the wild that was accidentally imported and has a negative impact on biodiversity is the Portuguese slug (*Arion lusitanicus*). Due to its rapid spread and potential impact on the native red slug (*Arion rufus*), this slug is considered to be a potentially invasive alien species (Soes & de Winter, 2011).

An example of an established species that was imported accidentally and has a negative impact on the functioning of local ecosystems is the Argentine ant (*Linepithema humile*). These ants are often detected during import inspections of imported plants. The ants 'farm'[48] aphids on plants, thereby weakening the plants (NVWA, 2015c). The Argentine ant displaces other ant species, such as the native common black ant (*Lasius niger*), because these ants are more active in daytime than the common black ant; they even forage in winter, day and night and throughout the year, allowing them to keep significant food sources out of reach of the common black ant. Because they are less good at spreading seeds than native ants, this has negative consequences for the number of plant species. They also displace pollinators and can collect so much nectar that very little is left for bees. In the Mediterranean region, the Argentine ant behaves like an invasive alien species, with enormous populations in nature areas and significant effects on flora and fauna (Boer & Brooks, 2009). With the influence of climate change, this issue may move into northern regions. It had been thought that the Argentine ant could not survive the Dutch winter, but in Capelle aan den Ijssel, the ants survived the cold winter of 2008/2009 outdoors (Boer & Brooks, 2009).

Species that can be accidentally imported and are known to have a negative effect on human health include the Asian tiger mosquito (*Aedes albopictus*) and the hay fever plant, common ragweed (*Ambrosia artemisiifolia*). The Asian tiger mosquito is a risk to public health because it is a vector for a range of diseases, such as dengue fever and chikungunya. The likelihood that the tiger mosquitoes that have been found in the Netherlands to date could transmit viruses of specific infectious diseases is negligible (RIVM, 2019c). The NVWA has control measures in place for this tiger mosquito, to prevent it from becoming established. See also Annex 7, which describes the risks of the ornamental horticulture production chain as an introduction pathway for organisms that are harmful for public and animal health. Common ragweed can cause severe hay fever symptoms (Van Vliet et al., 2009). The plant produces allergenic pollen in autumn, a period in which few other allergenic plants are flowering, extending the hay fever season by two months.

The invasive garden ant (*Lasius neglectus*) is an example of an established species that was imported accidentally and can have an effect on human safety. This ant is attracted by electrical fields; in other countries, large numbers have been found in electrical cabinets, wall sockets, switches, alarm systems, etc., which can lead to a short circuit through the accumulation of dead ants. In the Netherlands, too, electrical cables are repeatedly cited as finding sites (Van Loon, 2009). This ant also causes damage to paving through its burrowing (Van Loon, 2009).

An example of a species that is not yet established in the Netherlands and that may be accidentally imported with pot plants is the New Zealand flatworm (*Arthurdendyus triangulatus*). This flatworm is a predator of earthworms and can considerably reduce the biomass of earthworms, mainly that of the most common species, the common earthworm (*Lumbricus*

[48] 'Farming' aphids means that the ants stimulate aphids to release honeydew, a sweet liquid that aphids secrete if the sap that the aphids extract from plants contains more sugar than the aphids need (this process is known as 'milking' aphids). Ants sometimes fight off the aphids' natural predators.

terrestris). Field experiments show a reduction of this earthworm of 75%. Because earthworms are an important source of food for a range of animals, both birds and mammals, this has a significant impact on biodiversity. Earthworms also fulfil a range of functions in the soil such as breaking down plant debris and improving soil aeration and drainage through the tunnels they create. The presence of earthworms in agricultural soil generally promotes higher yield (van Groenigen et al., 2014). In Northern Ireland, the yield reduction of grassland from 0.8 New Zealand flatworms per m^2 has been estimated at 7.4% (Murchie, 2017). In 2019, the species was placed on the Union List.[49]

6.3.2 Trend

The number of first sightings in the wild of species that have been accidentally imported via the ornamental horticulture production chain is increasing (Figure 6.2). Here, too, it should be remembered that a first sighting does not mean that a species will become established. The likelihood that species will become established and invasive is highest for imports from temperate climate zones.

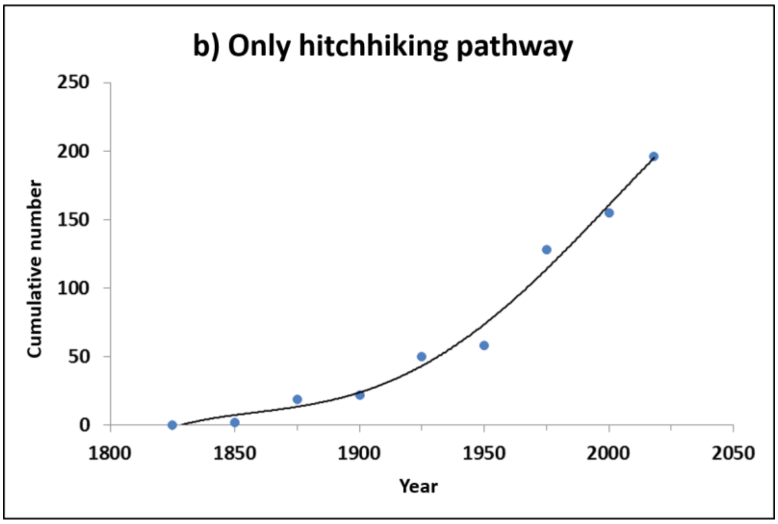

Figure 6.2 Cumulative number of known first sightings of species that were exclusively imported accidentally (hitchhiking pathway) in the ornamental horticulture production chain (n=196). For 462 of the 658 species, there is no information about the year of the first sighting (Pieters et al., 2018).

6.4 Non-native organisms imported for biological pest control purposes to protect food crops and/or ornamental plants

Organisms used for biological pest control are the natural enemies of weeds, pests and organisms that cause diseases. The use of organisms for such purposes is increasing, in terms of both the number of species and the number of organisms, due to efforts to reduce the use of chemical plant protection products. Biological pest control has been in use for more than 120 years, but attention has only turned to the possible risks in the past few decades. Compared to countries such as Australia, New Zealand, Canada and the United States, Europe was much slower to turn attention to the possible risks that might be posed by the organisms used for biological pest control (Loomans, 2007).

In the past, some biological pest control organisms that have escaped or been released have had undesirable effects on biodiversity, such as the harlequin ladybird (*Harmonia axyridis*). This ladybird was released to control a range of aphid species in both greenhouse and open-field cultivation. It appears to be able to survive Dutch winters outdoors and displace native ladybird

[49] Commission Implementing Regulation (EU) 2019/1262 of 25 July 2019 amending Implementing Regulation (EU) 2016/1141 to update the list of invasive alien species of Union concern.

species. The sudden invasiveness of this species is probably caused by the use of offspring from a certain strain, which has been used in Europe and came from Asia via North America (Pieters et al., 2018).

In the Netherlands, there has been a 'white list' since 2005 (see also Section 6.7) for species that are already in use, and new native and non-native organisms may only be used for biological pest control purposes if permission is given by the competent authority (the Netherlands Enterprise Agency (RVO)). The likelihood of establishment, the ability to spread, the host specificity and the observed direct and indirect effects on other species are key criteria in deciding whether permission should be given (Loomans et al., 2013).

In the search for suitable new natural predators, research projects primarily look at whether they effectively control the pest under cultivation conditions; less attention is given in the first instance to the effects on non-target organisms (personal communication from A.J.M. Loomans, 2019, NVWA). Research (usually a long-term study) into possible undesirable effects is not generally started until after the announcement that a potential new organism for biological pest control has been found. This means pressure can arise for the rapid approval of the species.

Importing, transporting and researching non-native species is permitted, provided measures are taken to ensure the potential biological pest control organisms do not escape. There are international guidelines for the import and transport of and research into biological pest control organisms and other useful organisms (IPPC, 2005, amended in 2017). These guidelines have not been incorporated into legislation in the Netherlands. However, it is illegal in the Netherlands to release animals or their eggs into the wild (Nature Conservation Act (*Wet natuurbescherming*), Section 3.34(1)). Locations that are not contained provide an opportunity for animals to escape into the wild and are implicitly covered by this ban. Because there is no obligation for people to report that they are working with non-native species, there is no way of monitoring how well these species are contained.

The study by Radboud University (Pieters et al., 2018) shows that there are currently 38 species offered for use in biological pest control in open-field and/or greenhouse cultivation in the food crop and ornamental horticulture production chains. The 38 species comprise 11 parasitic wasps, 11 predatory mites, 5 nematodes, 4 beetles, 4 flies, 2 bugs and 1 net-winged insect. Of these 38 species, 20 are most likely native, including 2 with cosmopolitan distribution. The remaining 18 species are probably non-native. Of these 18 species, 9 are listed in the Dutch Species Register (NSR) as 'alien species observed in the wild in the Netherlands' or as 'expected alien species'.

Only a few of the organisms currently permitted to be used for biological pest control have become established in the Netherlands. The non-native organisms permitted to be used for biological pest control in the ornamental horticulture production chain (and in other production chains) have no undesirable effects. The only possible exception is the predatory bug *Orius laevigatus*. It appears on the white list, but it has also been identified as potentially invasive, because it competes with native bugs from the same genus and thus could have a negative impact on biodiversity. The bug was first found outside of greenhouses in 2004 or 2005.

Although the risks from the use of organisms for biological pest control transcend national borders, the European Union does not currently have a harmonised assessment and approval policy for organisms to be used for biological pest control (Hunt et al., 2008; Mason et al., 2017). If such organisms are released in a country where they are not regulated, they could spread naturally or through human actions to a neighbouring country where they are banned due to the risk of undesirable side effects in nature.

6.5 The ornamental horticulture production chain as a pathway, now and in the future

The study by Radboud University (Pieters et al., 2018) shows that, of the 2,438 non-native plant species observed in the wild in the Netherlands, more than 60% (1,529) were or are sold in the Netherlands and/or are connected to the ornamental horticulture production chain in some other way, such as through imports for botanical gardens.

In other countries, too, a significant portion of their non-native plant species were introduced through the ornamental horticulture production chain. More than 30% of the top 100 invasive species (Lowe et al., 2000) and around 40% of the introductions of non-native plant species in Europe are related to the trade in ornamental plant species (Padilla & Williams, 2004; Gooijer et al., 2010; Martin & Coetzee, 2011). An analysis of the introduction and establishment of non-native species in four countries in north-western Europe (Belgium, France, Great Britain and the Netherlands) shows that 57% of the invasive plant species were deliberately introduced, and for 73% of those 57%, the species were imported for ornamental horticulture (Zieritz et al., 2017).

Of the 2,500 non-native species listed in the British Flora, nearly half (1,195 species) were introduced through ornamental horticulture (Stace & Crawley, 2015). In the Czech Republic, 53% of the non-native plant species had been introduced for ornamental purposes (Pyšek et al., 2002). In Australia, 65% of the plant species that became established between 1971 and 1995 were introduced for ornamental purposes (Groves & Hosking, 1998). In South Africa, 86% of the non-native species with known pathways are related to ornamental horticulture (Faulkner et al., 2016).

From the horizon scan performed in 2014, it appears that there are 31 plant species that have a high risk (with a high degree of certainty) for biodiversity in the Netherlands (Matthews et al., 2014). The majority of these are already present in private and botanical gardens or sporadically present in nature. The most likely pathways for these species are those related to ornamental horticulture (including the aquarium trade) and landscape architecture.

According to a rule of thumb known as the 'rule of 10', 10% of non-native species survive introduction, 10% of those are able to become established and 10% of that group will sooner or later become harmful (Williamson & Fitter, 1996). The study by Radboud University (Pieters et al., 2018) shows that, based on the available information on establishment status, it can be stated that around one-tenth of all non-native plant species brought into the Netherlands via the ornamental horticulture production chain have indeed become established. And out of all non-native ornamental plant species (n=2,438), around 2.6% are both established and invasive or potentially invasive (n=63). This percentage is higher than it should be under the 'rule of 10'. The reason why a higher percentage of ornamental plant species is invasive is probably because a portion of those species were selected and imported with the goal of surviving in gardens and ponds. Another relevant factor is that the species that are sold are often easy to propagate and thus can easily reproduce by themselves in the wild.

Not all cultivation categories have an equal chance of becoming invasive. Non-native species grown in heated greenhouses, such as various pot plants, are usually not able to become established in the Netherlands and are almost never problem species. Species grown outdoors, such as tree nursery plants and perennials, have a much greater chance of becoming established, since the majority of these species are selected for their winter hardiness.

Marsh and aquatic plants, too, have a high chance of becoming established in the wild. There was a good reason why the Dutch government, the Association of Regional Water Authorities and actors from the ornamental horticulture industry signed the Aquatic Plants Agreement in 2010 (LNV, 2010). In that document, the partners agreed that they recognised the importance of biodiversity and intended to protect it from the introduction of invasive aquatic plant species. An evaluation of the agreement shows that 2–3% of consumers surveyed indicated that they sometimes intentionally released surplus plants into surface water (Verbrugge et al., 2013). The release of surplus pond and aquarium plants into the natural environment is an important pathway for introduction into the wild.

For plants that were imported accidentally, the likelihood that the plants will be invasive is highest for imports from comparable climate zones. Species from tropical regions will not be able to become established, because they generally cannot survive the Netherlands' cold winters. However, one effect of climate change may be that more species that were imported accidentally will be able to become established in the future.

6.6 Management measures

Invasive alien species have economic consequences. In addition to the costs of control and eradication, there are also costs that arise directly from the effects on nature, public health, security and infrastructure. In the Netherlands, these costs have not been quantified for non-native ornamental plant species (Pieters et al., 2018).

Control of invasive alien plants is often difficult and not always successful. For many species of aquatic plants, fragments of the plants can escape during control operations and become established elsewhere. In addition, for species such as Japanese knotweed and swamp stonecrop, a small piece of the plant can grow into a new plant.

Control of organisms that were accidentally imported with ornamental plants is also often difficult and expensive. Examples of species against which control measures have been taken include ants (such as the Argentine ant and the invasive garden ant) and the Asian tiger mosquito.

Little information is available about the cost of controlling invasive ornamental plant species. To preserve biodiversity and water flow, aquatic plants have to be removed from various locations. This means higher costs for water boards and other public authorities. The extra maintenance costs for waterways that have become overgrown with non-native aquatic plants amount to around €2 million per year (UVW, 2017). Control of the small water primrose on Tiengemeten island cost around €150,000 (Withage et al., 2017), but this did not remove the plant species completely.

The likelihood of inexpensive eradication is highest with early intervention. The Netherlands has an effective detection system that relies on volunteers who quickly report new sightings of ornamental plants in the wild. However, for many new non-native species not on the Union List, whether they will turn out to be a problem species is unknown, because there is no reliable estimate of any possible negative long-term effects. As a result, it is difficult for landowners to assess whether a new non-native species will become a problem species and should therefore be controlled as soon as possible. After all, most species are not invasive. By the time it becomes clear that a non-native species is having a negative impact on biodiversity, control may have already become a difficult and expensive task.

A number of invasive plant species against which land and/or water managers have implemented expensive control measures are offered for sale. These sales mean that the species could be re-introduced into the wild. Examples include the rugosa rose (*Rosa rugosa*), a variant of the very difficult-to-control Japanese knotweed (*Fallopia japonica* var. *compacta*) and swamp stonecrop[50].

The well-known saying that 'Prevention is better than cure' is certainly applicable to invasive alien species. Preventing introduction is a key pillar in national and international policy with regard to invasive alien species. Knowledge about invasive alien species, their effects and the importance of early intervention is still insufficient among various stakeholders. A survey conducted in 2015 revealed that, in the secondary vocational 'green education' sector, few learning resources about invasive alien species were available, even though it is highly likely that the students will encounter these pest species in their future careers (Verbrugge & Rutenfrans, 2015). In 2014, invasive alien species were mentioned rarely or not at all in Natura 2000 management plans, even though invasive alien species represent a growing threat to biodiversity and the cost of controlling them continues to rise (Siebel & Reichgelt, 2014).

[50] Swamp stonecrop is often sold under the incorrect name *Crassula recurva*.

6.7 Legislation

Regulation (EU) No 1143/2014 of the European Parliament and of the Council of 22 October 2014 on the prevention and management of the introduction and spread of invasive alien species came into effect in the European Union on 1 January 2015. The purpose of this regulation was to limit the introduction, spread and impact of invasive alien species in Europe. A unified approach is desirable, because an invasive species may spread into neighbouring countries, whether on its own or through human actions.

Central to the regulation is a list of species with negative effects that make joint action at the Union level desirable: this is known as the Union List. The initial list of 37 species came into effect on 3 August 2016 and was supplemented with 12 more species in 2017 and 17 in 2019. The intention is for the Union List to be expanded in the next few years. Possession, trade, cultivation, transport and import of plants and animals on the Union List is prohibited. Member States must implement eradication measures against species that are newly established and control measures against populations that are already present in the wild.

In 2019, there were 36 plant species on the Union List. Before being placed on the list, a number of them were being traded as ornamental plants. Examples include Chilean rhubarb (*Gunnera tinctoria*), giant hogweed (*Heracleum mantegazzianum*), groundsel tree (*Baccharis halimifolia*), common milkweed (*Asclepias syriaca*) and a number of water and waterside plants such as American yellow skunk cabbage (*Lysichiton americanus*), parrot's feather (*Myriophyllum aquaticum*) and common water hyacinth (*Eichhornia crassipes*).

Not all of the plants on the Union List that were previously traded as ornamental plants have an impact on the natural environment in the Netherlands. Species such as Chilean rhubarb and common water hyacinth are frost sensitive and therefore do not form large, thick stands of plants here. However, because these species have a significant impact in nature in other EU Member States and there is free movement of goods within the EU, the trade and import of these plants is banned in all EU Member States.

The Union List also includes a number of species that have been imported accidentally, such as Santa Maria feverfew (*Parthenium hysterophorus*), mile-a-minute weed (*Persicaria perfoliata*), Japanese stiltgrass (*Microstegium vimineum*) and alligator weed (*Alternanthera philoxeroides*). All of these plant species have been accidentally imported with pot plants. Only Japanese stiltgrass is capable of becoming established in the Netherlands.

The Nature Conservation Act took effect on 1 January 2017, replaced three acts, namely the Nature Conservation Act 1998 (*Natuurbeschermingswet 1998*), the Forestry Act (*Boswet*) and the Flora and Fauna Act (*Flora- en Faunawet*). The Act states that, by virtue of a general order in council, it is prohibited to plant or sow designated non-native plant species (Section 3.34(4)). No species have currently been designated.

There is no national list of non-native species of which the import is banned, other than species regulated under phytosanitary legislation (quarantine or NL-provisional Q-pests) and of course EU Regulation 1143/2014.

Since 2005, the Netherlands has had a white list of organisms used for biological pest control purposes. This means that new native and non-native organisms may only be used for biological pest control purposes if permission is granted by the competent authority (Loomans, 2015). The list of approved organisms is set out in the Nature Conservation Regulation (*Regeling natuurbescherming*) (EZ, 2016). For approval to be granted, the organism must undergo an environment-focused risk assessment, as described by Van Lenteren et al. (2006). Factors that determine the risk of damage to native flora and fauna by organisms used for biological pest control include the capacity of the organisms to become established and to spread, the range of the host plants/prey and the direct and indirect impact on species that are not the target of the pest control (Van Lenteren et al., 2003; Van Lenteren et al., 2006). Exemptions may be requested from the Netherlands Enterprise Agency for the use of other organisms (RVO, 2019). Between 2005 and 2014, exemptions were granted in the Netherlands for 22 organisms to be used for biological pest control (Loomans, 2015).

There are international guidelines for the export, transport, import and use of organisms for biological pest control and other useful organisms, written by the International Plant Protection Convention (IPPC): ISPM3 (International Standard for Phytosanitary Measures 3) (IPPC, 2005, amended in 2017). One of the aims of these guidelines is to prevent harmful effects to the environment, including to non-target organisms.

Although the risks from the use of organisms for biological pest control transcend national borders, the European Union does not currently have a harmonised assessment and approval policy for organisms to be used for biological pest control (Hunt et al., 2008; Mason et al., 2017). If such organisms are released in a country where they are not regulated, they could spread naturally or through human actions to a neighbouring country where they are banned due to the risk of undesirable side effects in nature.

7 Risks for public and animal health: the ornamental horticulture production chain as an introduction pathway for organisms that are harmful to the health of humans and animals

7.1 Introduction

In the Netherlands in 2005, it was found that the Asian tiger mosquito, a vector for a range of viral diseases in humans, could be accidentally imported with ornamental plants. Partly due to this fact, it became clear to Dutch authorities that plant imports not only involve phytosanitary risks but also risks for public and animal health. Accordingly, in the context of its risk assessment of the ornamental horticulture production chain, BuRO also assessed the risk from ornamental plants as an introduction pathway for organisms that are harmful to the health of humans and animals. These organisms, as described in this chapter, include organisms that cause direct harm after ingestion or after a bite or sting, such as vectors for pathogenic organisms. The risks from the ornamental plants themselves or plants that are accidentally imported are discussed in other annexes of this ornamental horticulture production chain assessment. The focus of this chapter is on risks for the Netherlands.

7.2 Approach

BuRO conducted a literature review in Scopus and performed additional research into literature on the Internet, using Google. We used various combinations of search terms (ornamental plant, cut flower, horticulture, lucky bamboo, importation, biological invasion, vector, dispersal vector, disease vector, vector of introduction, route of introduction, introduction, introduction pathway, pathway, stowaway, hitchhiker, insect nuisance, non-quarantine species, non-native pests of livestock, public health, human health, animal health, arthropod, chiggers, Trombiculidae, snail and slug). We also used available quick scans (initial risk assessments) drafted by NVWA experts following the interception of organisms on ornamental plants that could potentially be harmful for animal or public health.

7.3 Results

7.3.1 General

The literature review produced few publications and reports on organisms that had (likely) moved with import of floricultural products. In light of the results of the literature review, ornamental plants do not seem to be a significant pathway for the introduction of organisms capable of causing direct health damage in animals or humans. According to Engelkes and Mills (2011), the reason, at least for arthropods that prey on other arthropods and for vectors such as ticks and mosquitoes, is that these organisms do not feed on plant material. Nevertheless, ticks, for example, rely on vegetation for finding a host, and mosquitoes regularly drink nectar.

Insofar as any literature was found on the subject, these organisms primarily cause health damage in humans and rarely affect animals. One possible reason for this is that the likelihood of organisms that were accidentally imported with ornamental plants coming into contact with people is greater than the chance of them encountering animals.
Little research has been done into either direct or indirect health damage caused by invasive alien species (Mazza et al., 2014). Moreover, in a 2015 review article, Schindler et al. (Schindler et al., 2015) observed that European research into the impact of non-native species on human health is limited to a small number of species. Most of the articles analysed in this review cover allergenic Asteraceae (mainly *Ambrosia*; 31 of 77 relevant publications) and vectors from the order of Diptera (flies and mosquitoes; 25/77) (Table 7.1). There were no publications about Gastropoda (slugs and snails), for example, and few were found (2/77) that dealt with Acari (ticks and mites). Below, we discuss the organism groups for which examples have been found (publications, reports, findings by the NVWA) of introduction with ornamental plants.

Table 7.1 Taxonomic classification of non-native species with an impact on human health in Europe, based on an analysis of 77 articles (Schindler et al., 2015)

Taxonomic group	Number of non-native species	Original articles	Reviews	Total number of articles
Vascular plants[1] (Tracheophytes)	28	27	4	31
Flies (Diptera)	6	17	8	25
Mammals (Mammalia)	2	3	1	4
Other arthropods (Arthropoda)	4	1	2	3
Ticks and mites (Acari)	7	2		2
Amphibians (Amphibia) and reptiles (Reptilia)	7	1	1	2
Birds (Aves)	53	1	1	2
Ants, wasps and bees (Hymenoptera)	1	1		1
Jellyfish (Cnidaria)	1	1		1
Multiple taxonomic groups	*N/A*	*2*	*4*	*6*

[1] The risk from imported ornamental plants and plants that could be accidentally imported with these imports is assessed in other annexes to the risk assessment for the ornamental horticulture production chain.

7.3.2 Organism groups (by taxonomic order) with examples of introduction of harmful organisms

Ticks

Association of ticks with imported plant material has been described twice by the former Plant Protection Service. In 2006, the African tick, *Rhipicephalus simus*, was intercepted on a consignment of cut flowers in the goldenrod species (*Solidago*) from Zimbabwe. *Rhipicephalus simus* is a potential vector organism for *Rickettsia africae* and *Rickettsia conorii*, the pathogens (in humans) for African tick-bite fever and Boutonneuse fever respectively. *R. simus* can also transmit a number of tropical diseases to cattle, dogs, cats and other pets. The suitability of the Dutch climate for *R. simus* to become established was not assessed at the time. In 2009, the tick *Haemaphysalis bispinosa*, which is widespread in Southeast Asia and Australia, was intercepted on fan palms (*Livistona*) from Sri Lanka. *H. bispinosa* primarily acts as a vector for veterinary pathogens: *Babesia motasi* and *B. ovis* in sheep, *B. equi* in horses and monkeys and *B. canis* and *B. gibsoni* in dogs. Furthermore, *Borrelia burgdorferi*, the pathogen for Lyme disease, has been found in *H. bispinosa* in China. Since *H. bispinosa* is seldom found on people, it is not clear whether this tick could transmit Lyme disease to humans. In view of its origin in the humid tropics, the Plant Protection Service assessed the risk of *H. bispinosa* becoming established in the Netherlands as low.

The literature review did not reveal any indications that the import of plant material had led to the introduction of ticks outside of their natural distribution area. The scarcity of literature about the importation of ticks with plant material is likely a consequence of the absence of a trophic relationship between ticks and plants, as mentioned in the introduction. Similarly, Pfäffle et al. (Pfäffle et al., 2013) found no indications in the literature that ticks could be introduced without a host. The key introduction pathway for ticks to new regions is the transport of ticks with vertebrate hosts (Pfäffle et al., 2013; Dergousoff et al., 2016). A low likelihood of introduction[51] for ticks

[51] For the purposes of this document, 'introduction' is defined as the entry and establishment of an organism, in accordance with the definition in International Standard for Phytosanitary Measures No. 5.

through the import of plant material also means that the likelihood of establishment of non-native tick-borne diseases via this pathway is low. This does not alter the fact that the personnel involved in phytosanitary import inspections are at risk of being exposed to tick-borne diseases. This risk does not appear to be significant, because the chance of a tick being present seems low; to date, there have only been a handful of known findings of ticks on imported ornamental plants.

Conclusions on ticks
There have been at least two known interceptions of ticks on imported ornamental plants, but it is uncertain whether ticks could actually spread to new regions through the plant trade. The import, including from other EU Member States, and natural spread of vertebrate animals is seen as the most important pathway for the introduction and spread of ticks.

Spiders
The international transport of plants is an important introduction pathway for spiders. This primarily concerns reproductive material and, to a much lesser extent, cut flowers (Nentwig & Kobelt, 2010). There are many anecdotal examples of plants purchased in supermarkets, from florists or at fairs that have been found to contain spiders or cocoons (Nentwig & Kobelt, 2010). For many spider species, synanthropy, the ability to thrive alongside humans, is a precondition for expanding their distribution area (Nedvěd et al., 2011). Nedvěd et al. (Nedvěd et al., 2011) do not consider spiders to be invasive in the European situation and therefore believe that control measures are not necessary for most non-native species. Almost half of the 47 non-native spider species established in Europe are found in buildings and/or the urban environment. One-third of the non-native species are found in greenhouses, botanical gardens, zoo buildings or other relatively warm buildings. Five species have been able to become established in natural habitats (Nentwig & Kobelt, 2010).

Of the spider species listed in the review article by Nentwig and Kobelt (Nentwig and Kobelt, 2010), three are poisonous for humans. These are the Chilean recluse spider, *Loxosceles laeta*, the Mediterranean recluse spider, *Loxosceles rufescens*, and the redback spider, *Latrodectus hasselti*. According to the Dutch Species Register (http://www.nederlandsesoorten.nl, consulted on 2 April 2018), the latter two species have also occasionally been unintentionally imported into the Netherlands, but no reproduction has taken place here. However, these species could reproduce in buildings.

There is a relatively large amount of information available about the unintentional import of *Latrodectus* species (widow spiders) into the Netherlands. *Latrodectus* species, including the black widows (*L. mactans* and *L. hesperus*) and the redback spider (*L. hasselti*), are spiders with a powerful venom that poses a health risk for both humans and animals. Widow bites are very painful and can cause severe symptoms such as muscle pain, muscle cramps, abdominal cramps, sweating and tachycardia, but they are seldom lethal in humans. Black widows are found in the wild in North and Central America, and the redback spider is found in Australia.

Until 2016, 14 verified findings of *Latrodectus* species were recorded in the Netherlands (Noordijk et al., 2013; Noordijk, 2016). According to Noordijk (Noordijk, 2016), there is one known finding of a *Latrodectus* species on imported indoor plants. In 2014, three female redback spiders (*Latrodectus hasselti*) were found in a container with torpedo parts from Australia, one of which had a cocoon containing hundreds of eggs and several recently hatched juveniles (Noordijk, 2016). At present, it seems that *Latrodectus* species are unable to become established in the wild in the Netherlands, because our summers are not sufficiently hot and dry (Noordijk, 2016).

Another spider that bites people, albeit without serious consequences, is *Steatoda nobilis*, the noble false widow. Instances of accidental introduction with plants have been described for this species (Nentwig, 2015). *S. nobilis* originated in the Canary Islands and Madeira, but it is now also found in a number of areas on the European continent. To date, it has been sighted three times in the Netherlands (http://www.nederlandsesoorten.nl, consulted on 12 August 2018). The bite of *S. nobilis* is painful and can cause swelling similar to that from a bee or wasp sting.

The personnel involved in phytosanitary import inspections run a low risk of being bitten by non-native spiders.

Conclusions on spiders
There are several pathways by which non-native spiders could be introduced into the Netherlands, one of which is the import of ornamental plants. Spiders that are harmful for humans and animals primarily live in hot regions. Accordingly, the likelihood of these spiders becoming established in the Netherlands seems to be low, due to the unfavourable climate conditions. However, occasional instances of reproduction indoors cannot be excluded.

Insects

Diptera/true flies (flies, mosquitoes and midges)
In 2010, there were seven known non-native species of Diptera in Europe, including the Asian tiger mosquito, that could have a negative impact on the health of humans and animals (Skuhravá et al., 2010). Only the Asian tiger mosquito, *Aedes albopictus*, is known to be able to be accidentally imported with ornamental plants. The Asian tiger mosquito originated in Southeast Asia, but it can now also be found in Africa, North and South America, Europe and Oceania. The Asian tiger mosquito is a hazard for people because the species can transmit a range of diseases to humans. The tiger mosquito is a proven vector of the chikungunya and dengue viruses and, based on an experimental study, is considered a competent vector for 22 other viruses transmissible by arthropods. In southern European countries, the Asian tiger mosquito is now a serious nuisance due to its aggressive biting behaviour (ECDC, 2016). The chikungunya virus is established in several central Italian regions, and multiple cases of the disease have been reported (http://www.who.int/csr/don/15-september-2017-chikungunya-italy/en/). The Asian tiger mosquito is also a potential vector for important veterinary viruses, a number of which are zoonotic. The Invasive Species Compendium (CABI) lists bluetongue virus, Rift Valley fever virus and West Nile virus as examples of viruses that can infect both humans and animals and are transmitted by the Asian tiger mosquito (Eritja, 2009).

As well as viruses, the Asian tiger mosquito (*A. albopictus*) also acts as a vector for *Dirofilaria repens* and *D. immitis* (ECDC, 2016). *Dirofilaria* are nematodes of Canidae, a family of dog-like carnivorans, with larval stages in the blood. Occasionally, people are also infected by *Dirofilaria*.

Like other invasive mosquito species, the Asian tiger mosquito is a container breeder. This means that females of these species lay their eggs in small amounts of water, including in holes in trees and in pot plant watering funnels. Eggs may also be laid in pools of water in rubbish and materials such as waste plastic and used tyres.

In California in 2001, Asian tiger mosquitoes were found for the first time in a consignment of 'lucky bamboo' (*Dracaena* spp.) from southern China (Madon et al., 2002). The lucky bamboo stalks were transported in a small quantity of water in which tiger mosquito eggs had been laid. In 2005, Asian tiger mosquitoes were found in the Netherlands for the first time. As with the findings four years earlier in California, they were found in a consignment of lucky bamboo from southern China (Scholte et al., 2007). The international trade in used car and aircraft tyres is considered the key pathway for the introduction of invasive mosquitoes into new regions[52].

The distribution area of the tiger mosquito in East Asia includes regions with temperate, subtropical and tropical climates (https://animaldiversity.org/accounts/Aedes_albopictus/). The strains that live in each of the various climate zones are adapted to the prevailing climate conditions in that zone. That means that the geographical origin of any Asian tiger mosquitoes that are introduced influences their chance of becoming established in the Netherlands. For tropical strains of the tiger mosquito, such as those that were accidentally imported with Chinese lucky bamboo, the likelihood of establishment is low. For other strains, it appears to be more nuanced. The NVWA's Vector Monitoring Centre (CMV) assumes that, for most strains that enter the Netherlands, there will be a certain mismatch between their climate adaptation and the prevailing

[52] M. Braks, personal communication, 1 May 2018

climate in this country. This means that it may occasionally be possible for strains that enter the country to overwinter here, as appears to have been the case in Weert in the winter of 2017/2018, but permanent establishment is not yet in the offing. Due to climate change, the mismatch is steadily shrinking, and the risk of permanent establishment is increasing[53]. The CMV monitors the presence of Asian tiger mosquitoes in high-risk locations (companies that import used tyres and lucky bamboo) and implements control measures when mosquitoes are found. The mismatch referred to in the previous paragraph works to the advantage of control efforts. Speed is of the essence, since there is a chance that a temporary population could adjust to the Dutch climate.

Lepidoptera (butterflies)
Pine and oak processionary caterpillars (*Thaumetopoea pityocampa* and *Thaumetopoea processionea*) can cause health damage when either humans or animals come in contact with their stinging hairs. These caterpillars start producing stinging hairs in the third larval stage (from April or May for the oak processionary species). In the sixth larval stage, a caterpillar has approximately 600,000–700,000 stinging hairs that are released on contact as a defence mechanism. The stinging hairs are approximately 0.2 to 0.3 millimetres long and are arrow shaped and barbed. The stinging hairs can easily penetrate the superficial layers of the skin, eyes and upper respiratory tract and attach themselves by means of their barbs. Furthermore, if a stinging hair is lightly touched, its tip will break off, releasing the protein thaumetopoein from the inner, hollow part of the stinging hair. The protein plays a role in the onset of health symptoms (Hagens & Mulder, 2013). The health symptoms that arise following contact with stinging hairs are diverse. In addition to localised symptoms affecting the skin, eyes and upper respiratory tract, symptoms of a general nature can also occur, such as fever and a general malaise (Hagens & Mulder, 2013). Animals are also sensitive to the harmful effects of the stinging hairs. Symptoms in animals include lesions on lips and the mucous membranes of the mouth and throat if the stinging hairs enter the mouth, as well as inflammation of the eyes. Animals rarely experience skin disorders due to their thick coats. Animals could also be exposed to stinging hairs through feed that is contaminated with stinging hairs (Jans & Franssen, 2008; Hagens & Mulder, 2013).

Pine and oak processionary caterpillars are thermophilic species that originated in southern and central Europe. Their geographic expansion to northern areas is largely ascribed to climate change (Moraal, 2012; Robinet et al., 2012). In the Netherlands, the oak processionary caterpillar was first described as a nuisance in 1878. This related to an isolated incident in the region between Nijmegen and Heesch. After that, the caterpillar was not seen in our country for more than a century. It was not until 1987 that the caterpillar was sighted in the Netherlands again, in the vicinity of Reusel (west of Eindhoven) (Stigter et al., 1997). Since the early 1990s, the oak processionary caterpillar has been spreading across the entire Netherlands at a rate of 4.5 kilometres a year (Kuppen, 2016). The pine processionary caterpillar has not yet been sighted in the Netherlands. It is expected that it will eventually be introduced into the Netherlands through natural spread. Over the past few years, the pine processionary caterpillar has been marching northwards through France at an average rate of 5.6 km per year (Robinet et al., 2012). Besides natural spread, both species are also spread through the transport of plants. That was almost certainly the case with the pine processionary caterpillars that unexpectedly turned up in the Paris area (Robinet et al., 2012). The introduction of the pine processionary caterpillar to the UK in 2005 was attributed to the import of infested oaks from the south of the Netherlands (Townsend, 2008). In both cases, the transport of trees with moth pupae in the root balls was considered the likely pathway of introduction (Evans, 2008; Robinet et al., 2012).

Conclusions on insects
The international plant trade is one of the pathways by which insects that can have detrimental health effects on people and animals are introduced into our country. Examples of introductions:

- The oak processionary caterpillar is now established throughout the Netherlands, probably as a result of natural spread.
- The pine processionary caterpillar, which causes harm to people and animals that is similar to that caused by the oak processionary caterpillar, is not yet present in the Netherlands. This European species is marching northwards and is currently present in northern France.

[53] A. Stroo, personal communication, 1 September 2018

It is expected that the species will eventually reach the Netherlands through natural spread and/or through the transport of infested plants and become established here.
- Asian tiger mosquitoes occasionally overwinter in the Netherlands, but permanent establishment is not yet in the offing. The Asian tiger mosquito is the subject of active control measures by the NVWA.

<u>Molluscs</u>

Gastropoda
In 2011, the former Plant Protection Service intercepted the snail *Bradybaena similaris*, or a closely-related species, on *Ficus* plants from China. This snail is suspected to have originated in Southeast Asia, but it is now also present in North and South America, Africa and Australia, as well as on islands in the Indian and Pacific Oceans (EPPO, 2012a). In the Netherlands, the species was observed for the first time in Burgers' Bush in 2002 (De Winter et al., 2009). The species is primarily known to be harmful to plants, but it is also known to be one of the intermediate hosts of the rat lungworm *Angiostrongylus cantonensis* (Walden et al., 2017). In humans, *A. cantonensis* can cause the severe neurological illness eosinophilic meningitis. People can become infected through the consumption of inadequately cooked snails, through accidental consumption of snails with raw vegetables or through consumption of vegetables that are contaminated with slime from infected snails (CDC, 2016). In monkeys, dogs and horses too, *A. cantonensis* causes a neurological illness (Duffy et al., 2004).

It is not known whether *B. similaris* is still present in Burgers' Bush, but it is unlikely that it could become established outdoors. The species has spread across many parts of the world, but as far as is known, it only lives in regions with a warmer climate than the Netherlands. The likelihood of the species becoming established in the Netherlands therefore appears to be limited. There are other non-native snail species that are known carriers of the rat lungworm, including *Cathaica fasciola*, which can be accidentally transported all over the world in all sorts of products and materials. *C. fasciola* was intercepted on wood packaging material in Germany in 2017 (NVWA, 2018b). Given the findings of snails on a range of materials, the import of ornamental plants is only one of many pathways by which the rat lungworm and other pathogens transmissible by snails could enter the Netherlands and other European countries.

In 2008, Majoros et al. described the detection of a population of *Biomphalaria tenagophila* in the waters of a thermal spring in Romania (Majoros, Fehér et al., 2008). *B. tenagophila* originated in South America and has colonised Africa (Pointier, David et al., 2005). The origin and method of introduction of *B. tenagophila* into Romania is unknown, but Majoros et al. suspect the trade in aquarium plants might be the source (Majoros, Fehér et al., 2008). *Biomphalaria* species do not occur naturally in Europe. Moreover, the international trade in aquarium plants is considered the most important pathway for the international spread of planorbida water snails, which includes *Biomphalaria* species (Pointier, David et al., 2005). Planorbids (planorbida snails), which include *Biomphalaria* species, can act as an intermediate host for parasitic flukes (trematodes) of the genus *Schistosoma*. The definitive hosts of *Schistosoma* are mammals, including humans. Adult *Schistosoma* parasites live in the blood vessels of the intestines or bladder. In humans, chronic infections can lead to bladder cancer.

In a number of southern European countries, there are native planorbida freshwater snails that could be suitable intermediate hosts for *Schistosoma* (Berry et al., 2014). On Corsica, more than hundred people were infected with *Schistosoma* after swimming in a creek. It is presumed that *Schistosoma* was introduced to the creek when a person who had become infected in the tropics swam there. As a result, native snails became infected, and they in turn infected swimmers (Boissier et al., 2016). Given that potentially suitable intermediate hosts of *Schistosoma* are naturally present in fresh water in southern Europe, human or animal shedders constitute a higher introduction risk than the introduction of non-native freshwater snails that may or may not be infected with *Schistosoma*.

Conclusions on snails

- A number of non-native herbivore snail species are known vectors of human and animal pathogens.
- The international plant trade is one of the pathways by which snails and pathogens could enter the Netherlands. The accidental introduction to the Netherlands of the rat lungworm (*Angiostrongylus cantonensis*), which can cause meningitis in humans, with infected tropical snails is a very minor risk due to the low likelihood of the snails becoming established. Freshwater snails may also be accidentally imported through the import of aquarium plants. These snail species may be carriers of flatworms in the genus *Schistosoma*, which are pathogenic to humans.
- Since there are native freshwater snails in southern Europe that could be a suitable intermediate host for *Schistosoma*, the likelihood of introduction of *Schistosoma* via a human or animal shedder is higher than the likelihood of introduction via non-native water snails that also act as intermediate hosts for *Schistosoma*.

8 The risks from plant protection products and biocides in the ornamental horticulture production chain for humans, the environment and nature

8.1 Introduction

The majority of the exogenous chemical compounds found on ornamental plants are intentionally introduced into the supply chain as plant protection products or biocides. The focus of the assessment of the chemical risks in the ornamental horticulture production chain is therefore on the use and residues of these products on floricultural products. The study is limited to the risks from the active substances in plant protection products and biocides and therefore does not examine any risks from adjuvants[54] or basic substances[55]. The risk assessment of organisms used for biological pest control purposes is discussed in Annex 7.

In this annex (Annex 8), Section 2 describes the legal frameworks for the authorisation and use of plant protection products and biocides. Section 3 discusses the authorised products, statistics on the use of plant protection products and compliance with laws and regulations. Section 4 describes how plant protection products are applied, and at which links in the supply chain. Due to the strong international character of the supply chain, this section also addresses the use of plant protection products in third countries. Section 5 discusses the toxicological properties of plant protection products with the aim of obtaining a hazard profile of the products used. Section 6 contains a risk assessment for public health, the environment and nature. This section also discusses the risks of the development of azole-resistant *Aspergillus fumigatus* and genetically modified plants.

8.2 Legal frameworks

8.2.1 European and Dutch legislation on the use of plant protection products and biocides

Dutch plant protection and biocides policy is determined by European regulations and directives. The Plant Protection Products Regulation (Regulation (EC) No 1107/2009) sets out rules for the authorisation and placing on the market of plant protection products and for the use and control of such products within the EU. The equivalent regulation for biocides is the European Biocidal Products Regulation (Regulation (EU) No 528/2012). There is also the Sustainable Use Directive (Directive 2009/128/EC), which provides a framework for the sustainable use of plant protection products, including the encouragement of integrated plant protection. Another European regulation that determines plant protection policy is the Residues Regulation (Regulation (EC) No 396/2005), which sets out harmonised maximum levels of pesticide residues for food and animal feed (so not for ornamental horticulture). The Water Framework Directive (Directive 2000/60/EC) with its framework for water policy in Member States, which was later supplemented by Directive 2013/39/EU with regard to priority substances, is also important. In addition, the Control Regulation (Regulation (EU) 2017/625) describes the official controls performed to ensure compliance with the requirements for the use of plant protection products.

The most important Dutch legislation in this context is the Plant Protection Products and Biocides Act (Wet gewasbeschermingsmiddelen en biociden: Wgb) and the underlying decree and underlying scheme. In 2011, the Wgb was amended to take account of Regulation (EC) No 1107/2009. The Wgb contains rules for the authorisation, placing on the market and use of plant protection products and biocides. There is also the Environmental Management Act (*Wet milieubeheer*), along with the Activities (Environmental Management) Decree (*Activiteitenbesluit milieubeheer*), which contains regulations for sustainable use of plant protection products, for

[54] An adjuvant may be added to a plant protection product to improve its effectiveness. Adjuvants require administrative registration; the legislation for the assessment of these substances needs to be more detailed.
[55] A basic substance is one that is already on the market for use for another purpose (for example, in cosmetics or food). Any risks have therefore already been identified. Basic substances may be used for plant protection, but they cannot be sold as plant protection products. There is a list of 'permitted basic substances'.

example with regard to the storage of plant protection products and the protection of surface water.

The maximum amount of residue that may be found on food (i.e. this does not apply to ornamental plants) is expressed in maximum residue levels (MRLs). The Pesticide Residues (Commodities Act) Regulation (*Warenwetregeling Residuen van bestrijdingsmiddelen*) applies to residues of pesticides that do not fall within the scope of the previously mentioned European Residues Regulation (Regulation (EC) No 396/2005).

Dutch policy with regard to plant protection is described in the Second Memorandum on Sustainable Plant Protection 2013–2023, 'Healthy Growth, Sustainable Harvest'. This document describes the ambition for further increasing the sustainability of plant protection while strengthening the economic prospects for agriculture and horticulture in the Netherlands. Integrated plant protection is an important approach within this policy. This approach involves a combination of measures such as preventing harmful organisms, mechanical or biological forms of control and the use of low-risk chemical products. The goal is to limit the dependence of agriculture on the use of chemical plant protection products. In terms of the goal of strengthening economic prospects, the memorandum aims for maximum use of Article 51 of Regulation (EC) No 1107/2009 with regard to minor uses (see Section 1.1.2). The interim evaluation of the Second Memorandum on Sustainable Plant Protection was published by the Netherlands Environmental Assessment Agency (Planbureau voor de Leefomgeving: PBL) in June 2019.

8.2.2 Authorisation procedure for plant protection products and biocides

The safety of active substances in plant protection products in relation to humans, animals and the environment is assessed at a European level by the European Food Safety Authority (EFSA), based on a harmonised European assessment framework. For biocides, the European Chemicals Agency (ECHA) is responsible for assessing the active substances. Approval of an active substance is only possible if there is at least one safe application. Following approval of an active substance by the European Commission, it is determined at the national level whether a product based on the approved active substance is authorised.

For authorisation assessments of plant protection products, Europe is divided into three zones (northern, central and southern). The Netherlands is in the central zone, together with twelve other Member States. For each zone, the authorisation assessment is conducted by one of the Member States in accordance with the European assessment framework. The assessment then applies to the other Member States in the same zone; they can simply accept the authorisation (within 120 days). Member States may set additional risk-reducing measures if warranted by specific national circumstances (such as leaching into groundwater, wind speed and the abstraction of drinking water from surface water). For the Netherlands, for example, various products are subject to additional measures in the form of spray-free zones to protect surface water. For greenhouse cultivation, treatment of storage rooms, post-harvest treatments and products for seed treatment, the EU is treated as a single zone, and one Member State will conduct the assessment for the entire EU.

For biocides, individual Member States assess the products and their applications. If a product is authorised by one Member State, other Member States may adopt this authorisation ('mutual recognition'). Alternatively, an application for Union authorisation may also be submitted, by which authorisation can be obtained for the entire EU at once. For products that meet specific requirements (such as not containing substances of concern), a simplified authorisation procedure may be followed. In the Netherlands, the Board for the Authorisation of Plant Protection Products and Biocides (College voor de toelating van gewasbeschermingsmiddelen en biociden; Ctgb) is responsible for the authorisation of plant protection products and biocides.

The authorisation of a plant protection product applies for specific applications (such as crop treatment) for specific areas of application (such as the protected cultivation of floristry plants; this may be narrower or broader) and is based on an assessment of whether the product is effective and whether the product is safe for people, animals and the environment. For plant protection products, the list of areas of application (Definition list of areas of application for plant protection products (DTG)) is used. An existing authorisation for a product may be expanded to cover a so-called 'minor use', in accordance with Article 51 of Regulation (EC) No 1107/2009. The authorisation holder for the plant protection product concerned or a third party such as the Dutch Federation of Agricultural and Horticultural Organisations (Land- en Tuinbouw Organisatie: LTO) may submit an application for a minor use. Every Member State applies its own interpretation of the European criteria for 'minor uses'. In the Netherlands, 'minor uses' apply for plants that are grown on a small scale; this means cultivated areas of less than 5,000 ha for open-field cultivation and less than 1,000 ha for protected cultivation. Examples of minor uses in large-scale cultivation include use on specific soil types or use to control a rare pest. The criteria have resulted in a list of minor uses. Since 2018, most ornamental plants fall into the 'minor crops' group (Ctgb, 2018c). The definitive new list of minor uses was published on 1 August 2019. This version defines the procedures to be followed for applications relating to the protected cultivation of pot plants (Ctgb, 2019c). For the authorisation of a minor use, there is no requirement to provide information about effectiveness, since it is assumed that this was already demonstrated for the existing authorisation, and no additional risk assessment is performed if the minor use falls within the scope of the use that has already been authorised ('risk envelope approach').

Finally, in emergency situations and if no other method of control is possible, an exemption may be granted at a national level under specific conditions for an unapproved product for a maximum of 120 days, pursuant to Article 53 of Regulation (EC) No 1107/2009 (section 38 of the Plant Protection Products and Biocides Act).

The Ctgb establishes legal instructions for use for each product, which must be displayed on the label. These instructions indicate the types of cultivation and the period of the year in which the product may be used, how it must be administered, in what dosage and with what personal protective equipment. Authorisations for active substances (EU level) and products (zone level) are reassessed after 10 years. For low-risk plant protection products, the reassessment is performed after 15 years. Some plant protection products that were authorised under the old directive (Council Directive 91/414/EEC) are still on the market. These are products that have not yet been assessed at a European (zone) level, but they are covered by Regulation (EC) No 1107/2009. Ultimately, all products will at least be assessed at the zonal level.

For biocides, if the active substance of a product has not yet been assessed at the European level under Regulation (EU) 528/2012, existing national law applies. In 2017, the Ctgb further harmonised its policy for biocide authorisations with European directives, which means the use of biocides in agriculture cannot be specifically aimed at protecting plants or plant products (because that would make them plant protection products); they can only be used for general hygiene. This applies only to new registrations or re-registrations, which means this change is being phased in gradually (Ctgb, 2018f).

Basic substances are substances that are already marketed for a different purpose (such as cosmetics or food). Any risks have therefore already been identified. Authorised basic substances, which have been placed on the list of authorised basic substances, may be used for plant protection, but they cannot be sold as a plant protection product and are authorised for an unlimited period (Ctgb, 2020b). The assessment of basic substances falls outside the scope of this supply chain analysis.

8.2.3 Supplementary non-statutory requirements for plant protection products

In the ornamental horticulture production chain, the purchasers of plants and flowers increasingly request quality labels indicating that the plants were grown in a sustainable way (Rabobank, 2017). The certification schemes for these private quality labels require the use of plant protection products that pose a risk to the environment or public health to be limited, based on their own lists of plant protection products, which are more stringent than the regulations, such as (MPS, 2019) and (SMK, 2020). The use of plant protection products by participating growers is checked through laboratory tests of random samples collected from growers' plants.

8.3 Authorisation and use of plant protection products and biocides

8.3.1 Authorised plant protection products and biocides in the Netherlands

In October 2018, approximately 390 plant protection products were listed in the Ctgb authorisation database (Ctgb, 2018e) for the application in 'ornamental horticulture'. In total, these products contain 170 unique substances or unique combinations of such substances. As well as chemical active substances, authorised products contain 15 microbiological preparations, consisting of fungi or bacteria, as the active component. Most products contain a single active substance, but in a number of cases, products contain a combination of two active substances. These products are collectively authorised for over 2,200 applications. Due to updates, the precise numbers are subject to constant change. These more than 2,200 applications are specific to the 'ornamental horticulture' area of application, but many of the active substances also have broader authorised applications such as arable farming, public green spaces and private gardens, or related areas of application such as fruit or herb crops. The functions for which the products are authorised include herbicides, fungicides, insecticides, acaricides, growth regulators, bactericides, slug and snail control products, elicitors[56], virus control products (to prevent virus transmission), a mole control product, nematicides and repellents. Of the more than 2,200 applications, most act as a fungicide (35%), herbicide (29%) or insecticide (21%).

In 2019, the Ctgb changed the crop group classifications (DTG[57]) to include the agricultural and risk characteristics of the plants. The list of minor uses was also adjusted, and most ornamental plants now fall into the 'minor crops' group, which means expansion of existing authorisations to these plants is now easier. Changes were also made to the 'extrapolation document of effectiveness and phytotoxicity in ornamental horticulture', making it easier to expand authorisations for ornamental plants based on existing studies for other types of cultivation (Ctgb, 2018c). Figures from the 'minor uses service desk' from 2017 show that, in that year, a total of 25 products were authorised for small-scale cultivation (LNV, 2018). Given the recent changes for ornamental horticulture, no specific information is available yet on the effects of the increased scope for authorisation of the range of products for the ornamental horticulture sector.

A biocide is intended to prevent or destroy harmful or unwanted organisms, but it may not be applied to plants to control plant pathogens. These products are divided into 22 product types (PTs) based on the application of the product (Ctgb, 2018a). The product types are assigned to four main groups: disinfectants, preservatives, pesticides and other biocides. Most biocides used in the ornamental horticulture production chain fall into the disinfectant or pesticide groups. In the Ctgb authorisation database, biocides are divided into product types for which specific plant groups are sometimes indicated. Biocides authorised for the ornamental horticulture sector are primarily based on the following active substances or active substance combinations: hydrogen peroxide, hydrogen peroxide and peracetic acid, hydrogen peroxide and acetic acid or hydrochloric acid and sodium chlorite (Ctgb, 2018e). A search for 'agriculture' application information produces multiple applications of ethanol and pest control products with various active substances, including deltamethrin, alphachloralose, carbon dioxide, imidacloprid, brodifacoum and hydrogen cyanide. A number of these active substances are also approved as active substances in plant protection products.

8.3.2 Use of plant protection products and biocides in the Netherlands

The use of plant protection products in ornamental horticulture and other forms of cultivation is illustrated in Figure 8.1. In the graph, ornamental horticulture is represented by greenhouse flowers, tree nurseries, flower breeders and flower bulbs and tubers (CBS Statline). The use of plant protection products is highest (in kilogrammes of active substance per hectare) in the cultivation of flower bulbs and tubers; a separate supply chain risk assessment has been performed for this cultivation category, which means it falls outside the scope of this risk

[56] Products of chemical or non-chemical origin that are used to increase the resistance of the plant to plant pathogens.
[57] DTG: definition list of areas of application for plant protection products (in Dutch: Definitielijst Toepassingsgebieden Gewasbeschermingsmiddelen).

assessment for the ornamental horticulture production chain. The use of plant protection products, in kilogrammes of active substance per hectare, is higher for greenhouse flowers than for other types of cultivation (29.5 kg active substance per ha in 2016), despite the fact that the use per hectare decreased by 25% between 2012 and 2016 (Figure 8.1). The use of plant protection products among tree nurseries and flower breeders is considerably lower, at 7.4 kg active substance per hectare. Given the relatively small acreage used for greenhouse flower cultivation and for tree nurseries and flower breeders (0.4% and 2.2% respectively of the total acreage for all cultivation sectors), these sectors' contribution to the total plant protection product use in the agriculture and horticulture industries is small (1.5% and 2.2% respectively in 2016).

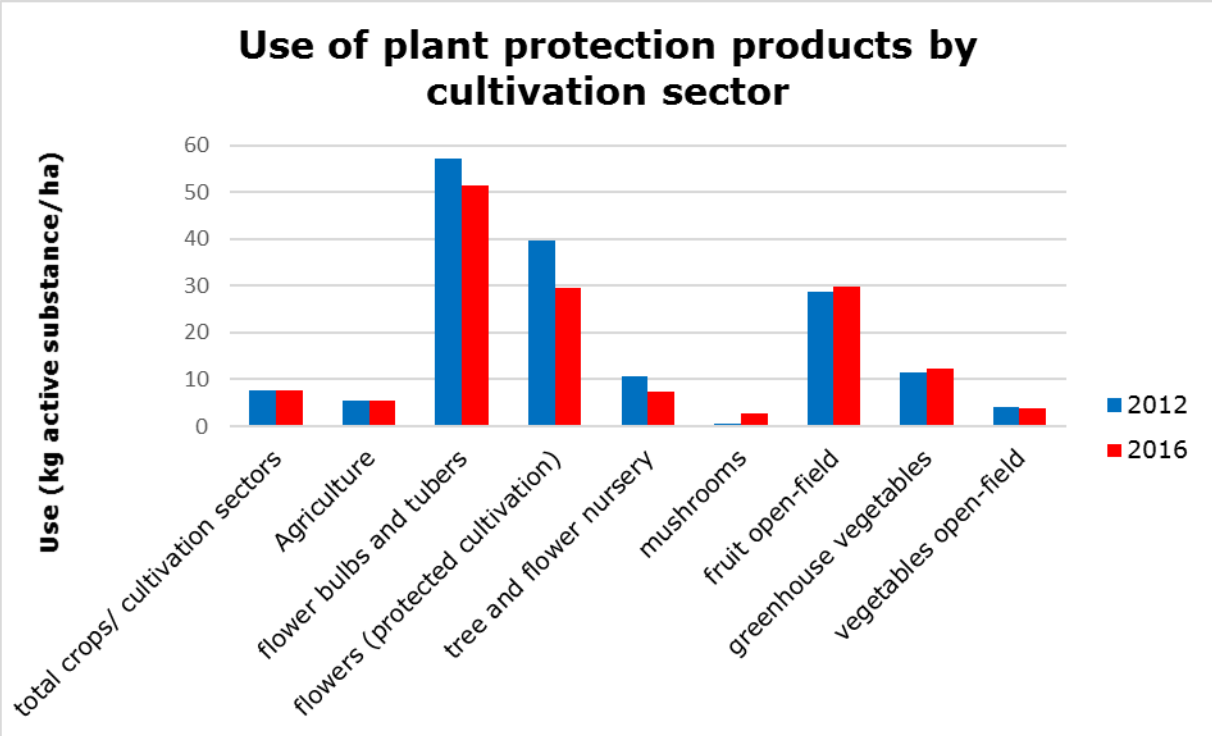

Figure 8.1 Total use of plant protection products by cultivation sector expressed in kg active substance per ha, based on CBS Statline data for 2012 and 2016. These statistics include the use of chemical products and microbiological preparations.

The use of plant protection products is further divided into various applications: control of fungi and bacteria, weed control and defoliants, control of insects and mites, control of slugs and snails, plant growth regulators and sprout inhibitors, and other plant protection products. Figure 8.2 illustrates the use of plant protection products for the CBS categories of 'greenhouse flowers' and 'tree nurseries and flower breeders'. For both of these groups of ornamental plants, control of fungi and bacteria is the most important application, based on the use of active substance per hectare. Only one active substance is authorised for use as a bactericide (aluminium sulphate), and only for the application on cut flowers (to extend their storage life). This means this application primarily relates to the use of fungicides, some of which may also have a bactericidal effect. For greenhouse ornamental horticulture, the groups 'plant growth regulators and sprout inhibitors'[58] and 'control of insects and mites' are also significant in terms of the quantities applied per hectare. Conversely, the use of plant protection products among tree nurseries and flower breeders is mainly limited to 'weed control and defoliants'[59] (as well as 'control of fungi and bacteria').

[58] Plant growth regulators and sprout inhibitors fall into the same CBS group; only plant growth regulators are relevant for ornamental horticulture.
[59] Weed control products (herbicides) and defoliants fall into the same CBS group; only herbicides are relevant for ornamental horticulture.

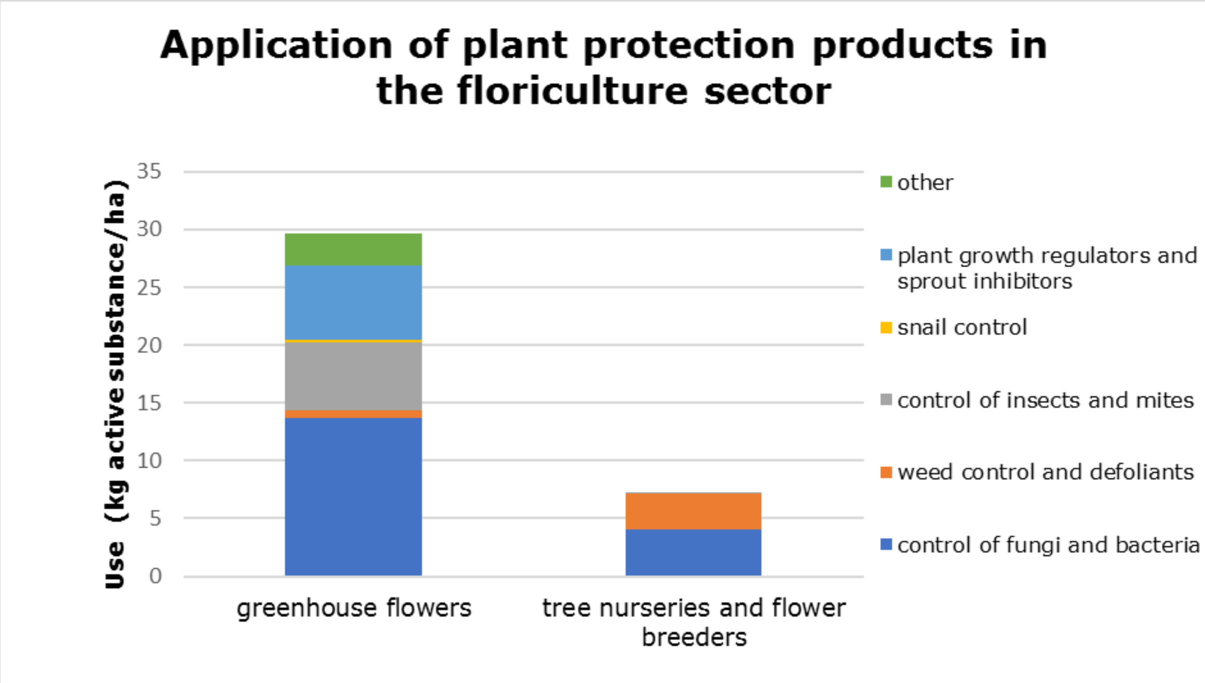

Figure 8.2 Use of plant protection products in the ornamental horticulture sector (excl. flower bulbs and tubers) by application, expressed in kg active substance per ha, based on CBS Statline data from 2016.

Looking at the total use of plant protection products by plant type per hectare in the cultivation sectors of 'greenhouse flowers' and 'tree nurseries and flower breeders', three groups in the dataset have relatively high usage (Figure 8.3). The total use of plant protection products is highest for three cut flower crops grown in greenhouses, namely roses (81.8 kg active substance/ha), chrysanthemums (76 kg active substance/ha) and gerberas (40.5 kg active substance/ha). For other ornamental plants, the use of plant protection products per hectare is significantly lower.

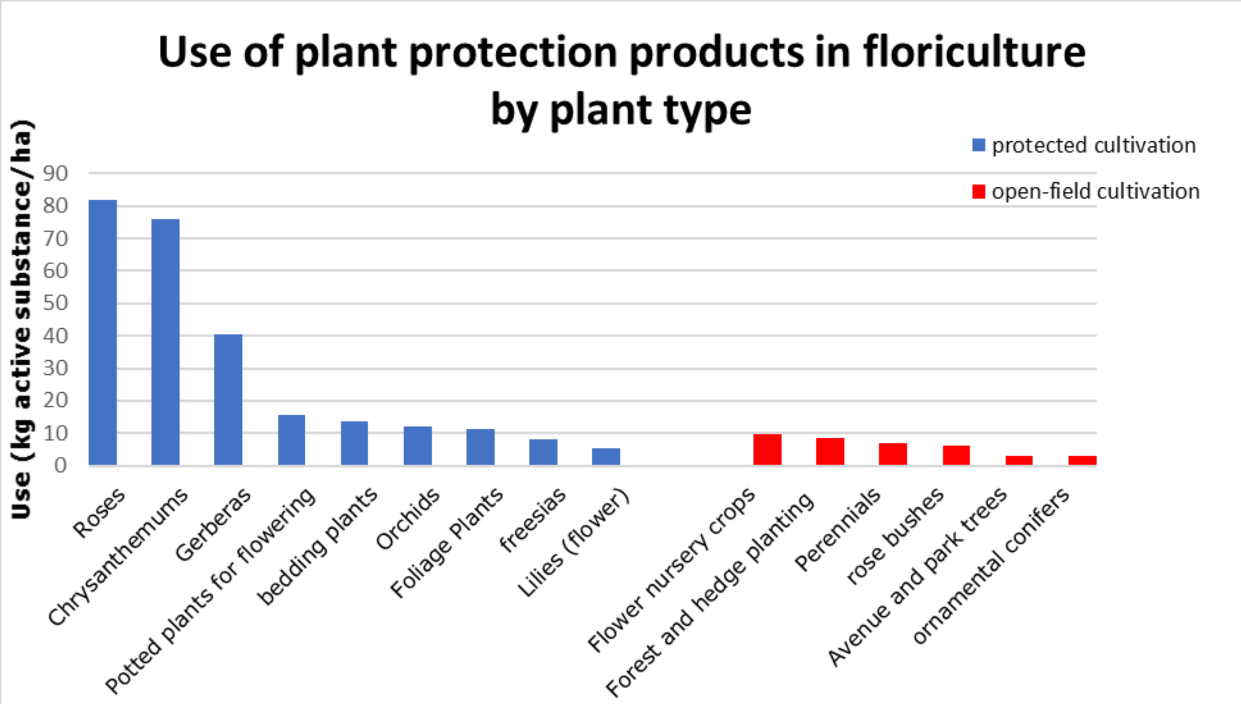

Figure 8.3 Total use of plant protection products per plant type in the cultivation sectors of 'greenhouse flowers' and 'tree nurseries and flower breeders', expressed in total kg active substance per ha, based on CBS Statline data from 2016. The plant groups (excl. flower bulbs and tubers) are divided into greenhouse cultivation (blue) and open-field cultivation (red), and sorted by the quantity of active substance used per ha.

In 2017, the LTO compiled an inventory of the active substances in the biocides applied in various agricultural sectors (Ctgb, 2017). The active substances from this inventory, relevant to ornamental horticulture are those that are applied in the tree nursery sector (formaldehyde, didecyldimethylammonium chloride (DDAC), hydrogen peroxide + peracetic acid and sodium-p-toluene sulphonchloramide) and in flower cultivation (DDAC, hydrogen peroxide + peracetic acid and sodium hypochlorite). Products used in the greenhouse horticulture sector, which is much broader than greenhouse ornamental horticulture, are formaldehyde, DDAC, hydrogen peroxide with peracetic acid, hydrogen peroxide alone, pentasodium bis(peroxymonosulphate) bis(sulphate), sodium hypochlorite and ethanol. No quantitative information is available on the use of biocides in the ornamental horticulture production chain. For the active substance formaldehyde[60], the authorisations are being re-evaluated or have been withdrawn.

8.3.3 Compliance in the use of plant protection products

Over the period 2012 to 2014, the NVWA compiled a report regarding compliance with regard to the use, administrative requirements and storage of plant protection products in greenhouse ornamental horticulture. The audit results showed that compliance in the greenhouse ornamental horticulture sector was generally low. Compliance was particularly low in the cultivation of cut roses, chrysanthemums and orchids. The lack of compliance mostly involved the use of unauthorised products or not following the instructions for use of authorised products. The NVWA also noticed that many samples contained low concentrations of unauthorised active substances (NVWA, 2015d). The report did not elaborate on the origin of these residues, and it is therefore not clear whether these products were applied during cultivation or were residues on imported propagating material.

In 2016, a large number of pre-announced inspections were conducted to promote compliance in greenhouse ornamental horticulture. These inspections involved sampling as well as administrative audits. The inspections showed 78% compliance for cut flowers and 80% for pot plants. Reports on

[60] https://www.ctgb.nl/actueel/nieuws/2015/10/02/formaldehyde-nog-toegestaan-ondanks-nieuwe-classificatie

findings were also drawn up for the unauthorised use of products, most of which related to a product not authorised for use in the specific cultivation. Excessive or too-frequent application of products and the use of expired or foreign products were also noted. The use of active substances not authorised for use in cultivation was also observed in a number of cases. These figures cannot be directly compared to the 2015 report due to differences in the setup of the inspections (NVWA, 2016d).

The figures from 2017 for greenhouse ornamental horticulture fit within the picture of the previous years, and the NVWA concluded that attention was still required with regard to the use of unauthorised products (NVWA, 2017c).

In 2016 and 2017, the NVWA also carried out inspections to check compliance with laws and regulations in open-field ornamental horticulture. The general picture was comparable with the period from 2009 to 2011. Compliance in this sector with regard to the use of chemicals was higher for plants at tree nurseries and perennials than for floristry plants. However, the use of products that are not authorised for use in cultivation or are not (or no longer) authorised for use in the Netherlands was observed. This mostly related to herbicides, fungicides and insecticides and in a few cases to growth regulators (NVWA, 2019c).

The reason for the low compliance with laws and regulations with regard to the use of plant protection products in the ornamental horticulture sector may be due to the limited range of products and the lack of controls such as residue measurements that are applied to products intended for consumption (NVWA, 2015d;2017a). The stringent export requirements were also suggested as a reason. The interim evaluation of the Memorandum by the PBL shows that, throughout the period 2010–2017, growers had a poor opinion of the range of products, giving an average score of 4.9 out of 10. The PBL also indicated that authorisations through 'mutual recognition' for specific Dutch cultivation types, such as protected ornamental horticulture, are not applicable, because these cultivation types are considered minor at a European level, and these specific products have not been assessed in other countries (PBL, 2019). These applications often fall into the 'minor uses' category in the Ctgb's authorisation framework. It is not yet known whether the 2018 expansion of the scope for authorisation described earlier has led to an expansion of the range of products for ornamental horticulture.

In the period from 2010 to 2016, the number of temporary exemptions for products under Article 53 of Regulation (EC) No 1107/2009 decreased significantly, in contrast to the European trend, from approximately 55 to fewer than 20 per year (PBL, 2019). In 2016, there was one exemption for greenhouse ornamental horticulture and one for tree cultivation.

8.3.4 Summary of legislation, authorisation and use

- The assessment of active substances and products is performed in accordance with the European Plant Protection Products Regulation (Regulation (EC) No 1107/2009) and the European Biocidal Products Regulation (Regulation (EU) 528/2012). Active substances are assessed at the European level, while products containing those active substances are assessed at the level of the Member States, with Member States imposing additional risk-reducing measures if warranted by specific national circumstances.
- Approximately 390 plant protection products are authorised for ornamental horticulture in the Netherlands, containing around 170 unique active substances or combinations thereof, with more than 2,200 authorised applications. The key groups in terms of use, expressed in kg of active substance per hectare, are fungicides (35%), herbicides (29%) and insecticides (21%).
- In 2018, in collaboration with the NVWA, the Ctgb amended the authorisation guidelines for plant protection products for the ornamental horticulture sector to make it easier to expand the range of products.
- In the ornamental horticulture sector, and particularly in greenhouse flower cultivation, the use of plant protection products (in kilogrammes per hectare) is higher than in other types of cultivation.

- For biocides, very little data are available on the use of active substances and products in the ornamental horticulture sector.
- In inspections by the NVWA between 2012 and 2017, a low level of compliance with laws and regulations was observed in greenhouse ornamental horticulture. There were significant differences between cultivation types in terms of compliance. The limited range of products was cited as a possible explanation for these statistics. The possible impact on the product range of the recent changes in authorisation guidelines is not yet known.
- The number of exemptions for the use of unauthorised products under Article 53 of Regulation (EC) No 1107/2009 is decreasing, in contrast to the European trend.

8.4 Introduction of plant protection products and biocides into the ornamental horticulture production chain

8.4.1 The importance of chemical plant protection in the supply chain

The wide variety of plants and pests in this sector, the relative sensitivity of ornamental plants to pests and diseases and the stringent aesthetic requirements requested by the sales market create extra challenges for plant protection (Bethke & Cloyd, 2009; LTO, 2015). Third countries will often not accept any traces in export products of organisms used for biological pest control, and to meet this requirement, chemical plant protection products are often used alongside biological pest control (EZ, 2013). Key benefits of chemical plant protection products include constant availability, rapid effectiveness, reliability and consistency of effect, increased productivity and quality of the crop, reduced spread of invasive pests and transmission of plant pathogens, relatively low costs and the possibility of use in combination with natural predators (Bethke & Cloyd, 2009). For Dutch export products, effective pest control is very important. According to Council Directive 98/56/EC of 20 July 1998 on the marketing of propagating material of ornamental plants, propagating material that is placed on the market must be practically free from harmful organisms and associated symptoms. The Dutch basic standards for ornamental horticulture state that, in consignment inspections, propagating material must be visually free from viral diseases, bacterial diseases, fungal diseases, insects (including eggs), nematodes and weeds. Floricultural products intended for end users must be practically free from harmful organisms (NVWA, 2012b). In addition, the plants must be free from Q-pests and must meet the applicable country-specific requirements of the importing country upon export. In its interim evaluation of the Memorandum, the PBL concluded that the stringent phytosanitary export requirements for flowers and plants were impeding efforts to reduce the use of chemical plant protection products (PBL, 2019).

8.4.2 Applications at the various links in the supply chain within the Netherlands

Due to the wide range of plants and significant differences in the use of plant protection products within the ornamental horticulture sector, this section will not exhaustively examine the specific applications for all defined subchains. By way of illustration, the use of plant protection products and biocides for a number of cultivation types will be discussed in general terms.

In a 2015 report, Wageningen University & Research (WUR) identified the applications of plant protection products in various links of the supply chain for the cultivation of bulb flowers (for this supply chain analysis, only the information about forced bulbs was used, because the links concerning the dry sale of bulbs fall outside the scope of this document), trees and perennials in pots (for both protected and open-field cultivation). For forced bulbs, plant protection products are introduced into the supply chain through the following actions: space treatment, dipping treatment of planting material, potting mix treatment and potentially crop treatment. The list of applications for the cultivation of trees and perennials in pots is very similar. During both propagation and breeding, plant protection products are applied through plant spraying, drench treatment and space treatment (for greenhouse cultivation only). Dipping treatment may also be applied in the open-field cultivation of perennials. A detailed analysis of around 20 plant types shows that plant spraying during bulb forcing is primarily used to control lice and insects, while dipping treatment is used to control fungi (prior to potting up). For the cultivation of trees and perennials, plant spraying is primarily used to control insects, fungi, mites and nematodes. For root rot fungi, a drench treatment with fungicides is applied. In isolated cases, a fungicide dipping treatment may be applied to perennials in outdoor cultivation (WUR, 2015). A more recent report on protected substrate and soil cultivation describes the following methods of application of plant protection products: dripping, drenching, space treatment, spraying, sprinkling, wound treatment and post-harvest treatment (WUR, 2018c). Note that, due to changes in authorisations, it is possible that certain application methods, such as space treatment for certain cultivation types, are no longer applied.

Another method of applying bactericides is to add them to a vase growing medium for cut flowers. In addition to professional application in the production chain, these products are also applied by consumers. The primary goal in adding these products is to inhibit bacterial growth in the vase growing medium, which might otherwise negatively affect the lifespan of the cut flowers (Knee, 2000; de Witte et al., 2014).

The main reason for the use of biocides in ornamental horticulture is disinfection to ensure clean propagating material, tools, packaging, spaces (both at the start and during the use of the space), pipes and water and thus prevent the spread of harmful organisms that could be spread via mechanical transfer (Ctgb, 2017). Biocides are thus applied at many stages in the supply chain. Since 2017, products used on tools, floors, machinery, etc. to disinfect against plant pathogens have been considered plant protection products.

To reduce the use of plant protection products, pilot studies for integrated plant protection have been set up, as a collaboration between the government and the industrial, trade and cultivation sectors (LTO, 2015). The second memorandum, 'Sustainable Healthy Growth, Sustainable Harvest', also focuses on integrated plant protection (EZ, 2013). This policy is in line with the European Directive on the sustainable use of pesticides (Directive 2009/128/EC), which states that Member States should encourage integrated plant protection in practice. The goal of integrated plant protection is to limit the use of chemical products as much as possible. In this systemic approach to cultivation, the use of plant protection products is assessed across the entire supply chain, instead of assessing the individual applications. It is a way of controlling pests and diseases by using a combination of measures and products, with chemical products being used only if non-chemical means and measures have proven insufficient. In relation to sustainable pest control, two pilot studies have been launched for greenhouse ornamental horticulture, one relating to the cultivation of chrysanthemums and the other to the growing-on of young ornamental plants (LTO, 2016). In June 2019, the PBL concluded in its evaluation of the Memorandum that integrated plant protection was still not being fully applied throughout the country. However, the PBL did note that non-chemical pest control, an important component of integrated plant protection, is now being generally applied in greenhouse cultivation. In greenhouse flower cultivation, the use of biological pest control increased between 2012 and 2016 from 45% to 70% of the cultivated acreage. However, the use of biological pest control for this cultivation type is still lower than for greenhouse vegetable cultivation (95% of the acreage) (PBL, 2019).

8.4.3 Application in third countries

For the purpose of the risk assessment for the ornamental horticulture production chain, there are several reasons why it is important to understand the use of plant protection products in third countries and possible residues that could be found on imported products:

- The ornamental horticulture production chain has a strong international orientation (NVWA, 2018c), but no systematic overview has been compiled of the use of products in third countries and possible residues on floricultural products. Foreign growers are often part of a Dutch parent company.
- The NVWA conducts 80,000 to 95,000 physical import inspections on this import flow each year (NVWA, 2018c). These phytosanitary inspections focus on the presence of organisms and therefore do not provide an insight into residues of plant protection products and biocides on these products.
- Workers and processors in the sector as well as consumers could potentially come into contact with residues via dermal contact.

- There may be residues on imported propagating material that are later found in checks by Dutch growers.
- Persistent residues could enter the environment, for example after composting of plant material or when imported floricultural products are planted outdoors.
- Edible flowers or flower parts are added in food to or used to decorate prepared food. These flowers have to be specially grown for this purpose and thus meet the requirements for food crops. However, the extent to which consumers add ornamental plants to prepared food is not known, since they are not aware of the different requirements imposed on edible flowers as opposed to ornamental flowers.

The use of plant protection products in export countries is discussed below. The use of products in other EU Member States is covered by European legislation, but differences with the Dutch situation may exist here too, such as differences in national legislation and in the structure of monitoring activities. These differences will not be discussed any further in this supply chain risk assessment.

<u>Regulations and use of plant protection products in third countries</u>
The Netherlands imports floricultural products from a large number of third countries. It is within the current analysis not feasible to describe the regulations of every country, to the extent that such information is even available. We therefore decided to discuss the regulations and use of plant protection products in two key export countries, Ethiopia and Kenya. Both are relevant countries for the Dutch market on which information is available, albeit limited information. This section does not aim to be comprehensive, but it does serve to indicate the possible introduction of residues of plant protection products that could appear on imported products.

Ethiopia
In Ethiopia, cut roses, cuttings and summer flowers are the main products grown (Joosten, 2007; Mengistie, 2016). The available literature on the use of plant protection products in the ornamental horticulture sector in Ethiopia is described in an academic thesis from Wageningen University & Research (Mengistie, 2016). Of the floricultural products exported from Ethiopia, 70% are destined for the Dutch market or for the European market after transiting through the Netherlands. In Ethiopia, the ornamental horticulture sector is one of the heaviest users of plant protection products. For example, 212 plant protection products with various active substances are applied in the cultivation of roses (Sahle & Potting, 2013; Mengistie, 2016). Ethiopia lacks specific legislation for the ornamental horticulture industry and conducts too little monitoring of compliance with existing legislation on plant protection products. However, many Ethiopian growers comply with private international quality standards (certifications) relating to environmental and working conditions. Examples of these standards include national certifications awarded by the Ethiopian Horticulture Producer Exporters Association (EHPEA) and various international standards including Fairtrade. An inventory of 29 flower breeders (a representative selection from a total of 84 flower breeders in Ethiopia) showed that 11 companies were controlled by Dutch owners or by owners from other EU Member States. According to Ethiopian regulations (Pesticide Registration and Control Proclamation (PRCP) No. 674/2010), all plant protection products must go through a registration procedure. This legislation complies with key international agreements such as the Stockholm Convention (on persistent organic pollutants), the Rotterdam Convention (on the international trade in hazardous substances, including pesticides) and the Basel Convention (on hazardous waste). However, the government allows flower growers to import their own unregistered plant protection products if they deem it necessary for their business. These imported products include active substances classified by the World Health Organisation (WHO) as ‘hazardous’ or that appear on the ‘negative pesticide list’ and therefore cannot be used in the EU. Aside from the use of products that present significant intrinsic hazards, there are also possible risks to health and the environment from incorrect use, a common phenomenon in Ethiopia. Incorrect use of products occurs due to a lack of knowledge, particularly among the workers employed by small-scale growers who actually apply the products. As a consequence, high residue concentrations are found in food (in the case of food crops) and drinking water (Mengistie, 2016).

Kenya

For Kenya, no recent information could be found about the regulatory system for registration of plant protection products or monitoring of the use of these products. A study from the 1990s showed that plant protection products that were a cause for concern were being used in the agricultural industry in Kenya, including in the cultivation of ornamental flowers. The available information was summarised in an academic thesis from Wageningen University & Research, which was discussed in the scientific journal The Lancet (Kigotho, 1997; Ohayo-Mitoko, 1997). Of the plant protection products used at that time in Kenya, 42% were classified by the WHO as toxic or potentially toxic. This included both registered products and illegal imports of products that were not authorised in the country of production, such as aldrin, dieldrin, DDT, heptachlor, paraquat, captafol, dicofol and phosphine. Only 60% of the products used in Kenya had been registered by the authorities (Kigotho, 1997). However, the thesis concluded that, compared to other African countries, Kenya had a reasonably well-developed pesticide management system, particularly concerning legislation and registration. There was also political awareness about the hazards to public health and the environment connected with the use of plant protection products. In Kenya, the Pest Control Products Board (PCPB) is responsible for monitoring plant protection products. This monitoring is primarily based on import licences; once the products are in the country, there is little monitoring of their use and application. The study was based on data that are now more than two decades old, so the current situation may be different. In addition, no data specific to ornamental horticulture could be derived from this study. In 2016, the Ministry of Economic Affairs and Climate Policy launched a Dutch initiative to make plant protection in East African countries safer and more sustainable. The project started in Kenya, because this country has the best-developed registration system. At present, the agricultural industry in Kenya still relies on high-risk chemicals. The object of the project is to support integrated plant protection and alternative working practices (biological control or low-risk chemical products) (WUR, 2019).

These examples show that the use of plant protection products in countries that export floricultural products to the EU may deviate significantly from European legislation and that there is little monitoring of that use. This means that residues may be present on imported floricultural products, posing a risk for workers, consumers and the environment in the Netherlands. The Netherlands has turned its attention to the registration and use of plant protection products in third countries. In July 2019, 12 parties from the flower sector and the Ministers of Agriculture, Nature and Food Quality and Foreign Trade and Development Cooperation signed an agreement to make the cultivation of ornamental plants by Dutch companies in third countries such as Kenya, Ethiopia and Colombia more sustainable. This agreement covers matters such as reducing the use of hazardous products (IMVO, 2019).

<u>Residues from plant protection products on floricultural products from third countries</u>
There is a limited number of sources that provide insight into the residues of plant protection products on cut flowers from key exporting third countries. An older study from the United States measured residues of plant protection products on imported cut flowers from South and Central America (Morse et al., 1979). In this study, residues were measured on carnations and chrysanthemums. A total of 105 samples from 43 growers were analysed: 102 samples from Colombia, 2 from Nicaragua and 1 from Guatemala. These samples were taken on three different dates. This study also mentioned that the primary focus of import inspections of ornamental plants is to prevent pests and diseases, which encourages the use of pesticides. A total of 16 pesticides were detected, including 8 organophosphates and 8 chlorinated hydrocarbons. The detected amounts varied between plant types and sample dates. High residue concentrations (> 5 mg/kg) were found in samples from 40% of growers. The insecticide Azodrin was found in concentrations of over 400 mg/kg, in samples originating from a single grower. The most residues of plant protection products were found on the chrysanthemums. Given that these data are somewhat dated, it is difficult to assess whether this study and the chemical compounds detected are representative of residues of plant protection products currently to be found on cut flowers from South American countries. Of the 16 residues found, currently only 1 substance (malathion) is authorised for use in the EU (EC, 2019b).

In a fairly recent Belgian study, residues of plant protection products were measured on roses, gerberas and chrysanthemums. The samples were collected from florists and supermarkets in major Belgian cities (Toumi et al., 2016b) (Toumi et al., 2016a). In the bouquets sampled (50 roses, 20 chrysanthemums and 20 gerberas), a total of 107 active substances (> 0.01 mg/kg) were found, with total residue concentrations of up to 97 mg/kg. Fungicides were detected the most frequently and in the highest concentrations. The information relating to roses is analysed by country of origin; Table 8.1 summarises this information and describes the uncertainties in the data. Of the roses analysed, 60% originated from outside the European Union. Fewer residues were found on the chrysanthemums and gerberas than on the roses. For the chrysanthemums and gerberas, only samples from the Netherlands and Belgium were part of the data set, meaning that this study does not provide any information about residues on products from third countries.

Table 8.1 Residues measured on cut roses in the Belgian market, originating from various countries (Toumi et al., 2016a).

Country of origin*	Number of samples	Average number of AS** per sample	Average concentration of total AS found (mg/kg)	Number of different AS detected
EU: Belgium	8	10.1	27.7	38
Colombia	2	19.0	31.8	24
Ecuador	9	14.8	18.8	60
Ethiopia	3	12.3	22.9	29
EU: Germany	1	22.0	92.0	22
Israel	2	16.0	29.6	27
EU: the Netherlands	11	10.5	20.6	54
Kenya	9	15.6	26.5	48
Unknown (supermarket product)	5	15.8	28.2	36
Total	50	13.6	26.0	97

* Because this information was obtained by questioning the florists, the authors of the article believe there is an element of uncertainty around the reported origins. There may also have been a transit country involved, in which case the country of origin given in the table is not the country where the flowers were grown.
** AS = Active Substances

What is remarkable is that, with the exception of the sample originating in Germany, the quantities of residue are in the same order of magnitude (20 to 32 mg/kg), while the number of different active substances varies significantly between countries (22 to 60 substances). For all countries, an average of 10 to 22 different substances were found on each sample. However, based on these data, it is not possible to compare the use of plant protection products between European and third countries, because the data for the European countries include data for products that transited through those countries but originated in third countries. A comparison of the residues found with the European Pesticide Database shows that approximately one-third of the products are not authorised for use in the European Union (Toumi et al., 2016b; EC, 2019b).

8.4.4 Summary of the introduction of plant protection products and biocides into the supply chain

- Plant protection is very important for ornamental horticulture due to the intrinsic susceptibility of the plants to pests and diseases and the quality and phytosanitary requirements imposed on the products.
- Plant protection products are introduced into the supply chain through crop treatment, drench treatment, space treatment (for greenhouse cultivation) and in some cases dipping treatment. After harvest, bactericides are applied to the plant food of cut flowers to prolong their life.
- Disinfectants (biocides and plant protection products) are used throughout the cultivation process, for example for disinfecting propagating material, tools, packaging, spaces, pipes and

water to prevent the spread of harmful organisms. This does not include applications to the plant itself.
- The ornamental horticulture production chain has a significant international orientation, but the available data about residues on floricultural products from third countries are limited and/or out of date. However, the available data about residues on cut flowers indicate that the products have been intensively treated with multiple products at the same time. Many substances were also found that are not authorised in Europe. The available data from Kenya and Ethiopia show that hazardous products are sometimes used in these countries and that the products are not always applied correctly. However, increased attention is being given to improving ornamental horticulture conducted by Dutch companies in third countries and making it more sustainable.
- Residues of plant protection products are not measured during import inspections for phytosanitary and other purposes.

8.5 Hazard profile of plant protection products for public health and the environment

8.5.1 Hazard profile of active substances in plant protection products authorised in the Netherlands

In addition to its intended effect of controlling pests, the active substance in a plant protection product can also have undesirable or harmful effects. Although these effects are taken into account in the authorisation procedure for the products, levels in excess of environmental quality standards may still be measured and workplace safety may still be inadequate (EZ, 2013; Health Council, 2014). Suggested reasons include inadequate compliance with rules such as the use of the Risk Identification & Evaluation (RI&E) methodology as required by the Working Conditions Act (*Arbowet*), insufficient consideration being given in the authorisation evaluation to possible risks for neighbouring residents, passers-by and sensitive populations (such as unborn children) and not sufficiently taking account of the cumulative effects of simultaneous exposure to multiple substances or exposure to the same substance from multiple sources (EZ, 2013; Health Council, 2014; RIVM, 2019c). It has also been suggested that the RI&E methodology used to safeguard the health of workers is not entirely definitive, since it does not take young workers into account, for example (EZ, 2013). A good level of knowledge about the risks among employers, those applying plant protection products and other workers is also important to prevent risky exposure. For a number of cultivations within the ornamental horticulture sector, compliance with laws and regulations with regard to authorised products and legal instructions for use is low (NVWA, 2015d;2016d). Incorrect use may lead to a level of exposure to plant protection products that was not taken into account during the authorisation procedure.

Assessing risks from cumulative effects is a developing field. The EFSA and the National Institute for Public Health and the Environment (Rijksinstituut voor Volksgezondheid en Milieu: RIVM) are coordinating a research programme to develop a methodology to assess the cumulative effects on health of different substances with the same toxicological properties. So far, so-called 'cumulative risk assessment groups' of plant protection products have been defined for two toxicological effects: neurotoxicity and effects on the thyroid. Within these groups, the effects of various substances are added together. Groups are currently being defined for other endpoints. An online tool for cumulative exposure (Acropolis) is also being developed (RIVM, 2015; EC, 2019a). The RIVM and the EFSA have assessed the cumulative effects of four groups of plant protection products with comparable toxicological properties that are applied to food. These calculations show that the risks of cumulative effects are negligible (EFSA et al., 2020a; EFSA et al., 2020b; RIVM, 2020). A recent study shows that 'mixture effects' must also be assessed in order to assess the harmful effects on insects (Willow et al., 2019).

In 2016, CLM Research and Advice, part of the independent expertise and consultancy firm CLM, created a hazard profile of all the active substances authorised for use in the Netherlands. This CLM classification is based on the intrinsic properties of the substances and not on the actual risk from using the product in accordance with the legally mandated instructions for use. In its assessment, CLM divides substances into three classes based on the hazard (the intrinsic properties of the substance) for humans, the environment and biodiversity: green (average or low hazard profile), orange and red (increased or high hazard profile). With regard to hazards for humans, CLM used the WHO list on acute toxicity, the list of CMR substances (substances that are carcinogenic, mutagenic or reprotoxic) from the Dutch Ministry of Social Affairs and Employment and the EU list of 'candidates for substitution'. In relation to the hazards for nature and the environment, CLM referred to a range of sources with regard to drinking water supplies, water and soil life and beneficial organisms (CLM, 2016). According to this analysis, of the 238 authorised substances in 2016, 45% had no risk or only a minor risk (green category) and 55% had an increased risk (orange and red categories). The CLM classification of the active substances authorised for use in ornamental horticulture in 2018 is illustrated in graph form in Figure 8.4: 35% of the active substances fall into the green category, 50% fall into the red or orange category (increased hazard profile) and 15% were not assessed by CLM in 2016.

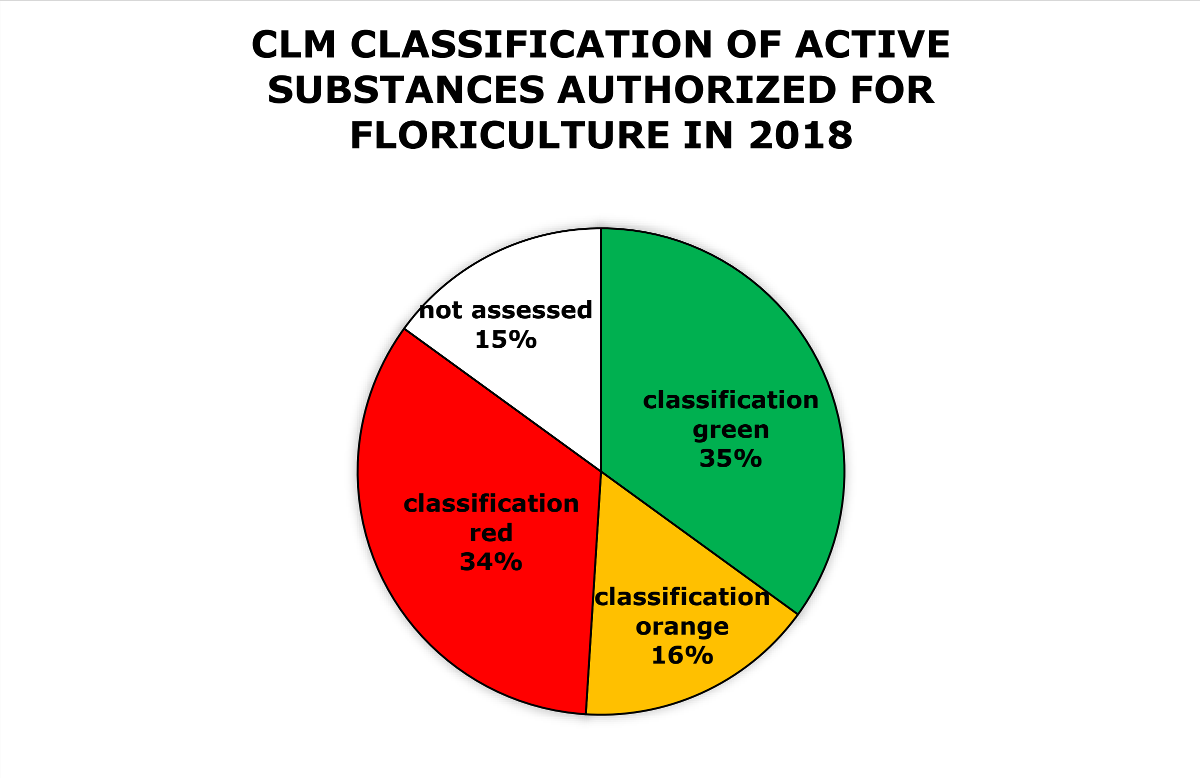

Figure 8.4 Hazard categorisation of the active substances authorised in 2018 (Ctgb authorisations database, October 2018) for ornamental horticulture, divided according to the CLM methodology in 2016. Individual active substances (n = 171) are divided into the green category (low or average hazard profile) or the orange or red categories (increased hazard profile). Of the substances that are now authorised for ornamental horticulture, 15% were not assessed by CLM in 2016.

This category allocation corresponds to the allocation of all substances authorised in 2016, as reported by CLM at the time. In other words, according to the CLM classification, the percentage of hazardous substances authorised in the ornamental horticulture production chain was not higher than the percentage of hazardous substances in relation to all authorised substances. The ornamental horticulture production chain is very diverse, which means an analysis of authorisation of the most hazardous substances (red category) for the different subchains provides more insight into the hazard profile for authorisations for specific plant types (Table 8.2). This analysis reveals several small differences. For all subchains, the percentage of authorisations with a 'high hazard profile' is not too different from the average for all substances assessed by CLM.

Table 8.2 Percentage of active substances authorised by the Ctgb (October 2018) that fall into the red hazard category, by subchain.

Subchain	Percentage of active substances from the red hazard category*
Flower bulbs	43%
Perennials	38%
Tree nursery plants	36%
Cut foliage and cut flowers	33%
Pot plants	33%
Forced shrubs	32%
Breeding and seed production	31%
Marsh and aquatic plants	27%
All substances assessed by CLM	34%

* Hazard category allocation taken from CLM (CLM, 2016)

In 2019, CLM updated the hazard assessment, using updated versions of the sources listed above. Substances that are no longer authorised (n = 13) were removed from the list and newly authorised and reauthorised substances (n = 42) were assessed (CLM, 2019). Of the newly assessed substances, 11 were authorised for use in ornamental horticulture. Four of these substances are based on microorganisms (*Bacillus thuringiensis* subsp. *israelensis*, *Trichoderma asperellum* ICC 012, *Trichoderma gamsii* ICC 080 and *Trichoderma asperellum* T34) and fall into the green hazard category, along with the chemical active substances acibenzolar-S-methyl, propaquizafop and terpenoid blend QRD 460. Flupyradifurone, isoxaben, penthiopyrad and sulfoxaflor were reauthorised and placed in an increased hazard category (red or orange). This shows that substances with an increased hazard profile are still being authorised according to this classification system (CLM, 2019). An increased hazard profile (based on the intrinsic properties of the substance) is not the same as saying that this is a high-risk substance, because risk also depends on the degree of exposure.

8.5.2 Hazard profile of residues detected on cut flowers

Many plant protection products are non polar and therefore have the potential to enter the body via dermal absorption (Morse et al., 1979; Toumi et al., 2016b). Both of these studies refer to possible health effects in people who come into contact with residues of plant protection products on a daily basis (including contact allergy, irritation, neurological effects and cancer). The detected substances are more toxic if ingested orally, but this route of exposure only occurs occasionally (for example, through hand/mouth contact).

Of the 107 residues measured on roses, gerberas and chrysanthemums on the Belgian market, several fall into substance classes that are generally toxic, such as organophosphates (12 substances), pyrethroids (8 substances) and carbamates (7 substances). In the study referred to, the hazard allocation is based on the classification of the substances according to the CLP Regulation (Regulation (EC) No 1272/2008) (Toumi et al., 2016b;2016a). This regulation focuses on the identification and communication of hazards from chemical substances and mixtures, so translation to actual health hazards from possible residues is difficult. However, the study mentions that Acceptable Occupational Exposure Limits (AOELs) have been set for the vast majority of the substances detected. Of the residues detected on roses, gerberas and chrysanthemums, 19, 3 and 6 respectively have an AOEL of between 0.001 and 0.01 mg/kg body weight/day, according to the EU Pesticides Database. This shows that, from a toxicological point of view, there are reasons to limit occupational exposure to these products to a level below these values.

8.5.3 Summary in relation to hazard profiles of plant protection products in ornamental horticulture

- Undesirable and harmful effects from plant protection products are taken into account in the authorisation procedure. The assessment of cumulative effects from different products is a developing field. Initial calculations from the RIVM and the EFSA show a negligible risk when cumulative effects are taken into consideration. Multiple factors, such as poor compliance with legally mandated instructions for use and incomplete harmonisation between authorisation requirements and set standards, can lead to environmental quality standards being exceeded in some cases, resulting in inadequate levels of workplace safety.
- The goal of integrated plant protection is to reduce the risks from plant protection products. Non-chemical pest control, an important part of integrated plant protection, is already frequently applied in greenhouse cultivation in particular.
- Relatively speaking, for the ornamental horticulture production chain overall, the percentage of authorised products with an increased hazard profile is no higher than in other sectors.
- A number of the active substances found on roses, chrysanthemums and gerberas in scientific studies have toxicological properties such that their ingestion into the human body, even in low amounts, could lead to negative effects on human health. However, the internal exposure is unknown in most scenarios. A risk assessment is described in Section 1.5 for consumers of rose petals and for florists.

8.6 Risk assessment of plant protection products for humans, nature and the environment

8.6.1 Risk assessment for consumers from dermal exposure

For food crops, legal Maximum Residue Limits (MRLs) have been set. Because ornamental plants are not classified as food crops, no MRLs have been determined[61]. For ornamental plants, the Ctgb assesses whether exposure to 'transferrable residue' is safe for workers who come into contact with ornamental plant products (section 5.3). In terms of consumer safety, it is assumed that, if the 'transferrable residue' does not constitute a risk for workers, the risk for consumers who purchase the ornamental plants must be negligible, since consumers have much less intensive contact with the substance and at a later time (Ctgb, 2018b). If plant protection products are used in accordance with the instructions, residues on ornamental plants are therefore considered safe for consumers.

Despite the lack of residue standards for ornamental plants, growers can take the initiative and commission commercial parties to determine residue concentrations. Measurements of residue concentrations are requested by purchasers in connection with certifications and trade requirements. Other examples of where such measurements can be useful include auditing of working conditions and identification of external sources (Eurofins, 2018).

The NVWA's Office for Risk Assessment & Research (BuRO) has performed two risk assessments on the risks for consumers with regard to residues of plant protection products on ornamental plants. In the 2014 assessment, 25 residues of plant protection products found on ornamental plants in Dutch garden centres were evaluated. The residue concentrations came from an earlier study by the environmental organisation Greenpeace. The exposure calculations were based on a conservative assumption, namely complete absorption via the skin of all residue present on the leaf or petal. Subsequently, the exposure was compared to the Acceptable Daily Intake (ADI) of the chemical substance. The calculations showed that these health based guidance values were not exceeded for any of the 25 substances, with a maximum ratio between the exposure scenario and the ADI of 0.03 (BuRO, 2014). In a 2017 follow-up study, Greenpeace again looked at residue concentrations on ornamental plants in garden centres. This update showed a slight drop in the number of plant protection products found. However, more residues that are banned in the EU were detected compared to the earlier study (Greenpeace, 2017).

[61] With effect from 1 January 2020, specific MRLs apply for plant protection products in pollen and bee products. These MRLs will be taken into account in the authorisation of plant protection products for ornamental plants.

A 2009 risk assessment by BuRO focused on two pesticides found in high concentrations on cut roses grown in greenhouses (BuRO, 2009). The high concentrations of fipronil and dodemorph found were explained by excessive use. The authorisation of fipronil was withdrawn in 2007 for environmental reasons, but the previously referred scientific study from Belgium showed that fipronil is still frequently found on imported products (Toumi et al., 2016b). Exposure calculations were performed for workers who apply the products, for workers in greenhouses and florists and for consumers who put the flowers into vases or eat the rose petals. The exposure was then compared with the ADI, the AOEL and the limit value for acute toxicity (ARfD or Acute Reference Dose). The results show that the risks are negligible for consumers who put the flowers into a vase, because the health limit values are not exceeded in this scenario (BuRO, 2009). The risk from eating rose petals is discussed in Section 1.5.2.

A systematic risk assessment of residues on imported products is not possible, due to a lack of data. Since it is unknown which biocides and what quantities are applied in ornamental horticulture, the risks to consumers of any residues of biocidal products cannot be assessed.

8.6.2 Risk assessment for consumers from oral exposure

<u>Consumption of ornamental plants</u>
Floricultural products are not intended for consumption, nor are they sold as such. However, consumers may deliberately or unintentionally consume a floricultural product, or part of one, thus being exposed via the mouth (orally) to plant protection product residues. Below, we assess the risk from ingestion of the petals of cut roses. The use of plant protection products on cut roses is higher than for other ornamental plant types, and a wide range of different products are used (Fig. 8.3). It is therefore assumed that the consumption of rose petals is a worst-case scenario for any health risks that may result from plant protection products due to the consumption of ornamental flowers. It is important to differentiate such consumption from the consumption of flowers or petals grown specifically for that purpose, which have to meet the requirements for food crops. The following risk assessment does not apply to those products.

BuRO's risk assessment for fipronil and dodemorph residues on roses shows that the health risk to adults from consumption of the petals is low. However, based on the concentrations of fipronil and dodemorph found in the study, there is a risk if young children were to eat the rose petals. This assessment was based on standard portions (3.5 g rose petals), as described in specialized cookbooks (BuRO, 2009).

Based on the measured residue concentrations on cut roses from the Belgian market (Toumi et al., 2016b), BuRO has now performed an additional risk assessment. A systematic risk assessment of residues on domestic or imported cut flowers is not possible, due to a lack of data. First, the 97 residues found were prioritised, based on the ratio between the highest residue concentration found and the ADI (taken from the EU Pesticides Database). For 13 substances, this ratio was over 500: acephate, benomyl, clofentezine, dicofol, dodemorph, fipronil, fluopyram, iprodione, methamidophos, methiocarb-methomyl and thiodicarb (concentration based on the sum of these two substances), procymidone, spiroxamine and thiacloprid. It was assumed for the purpose of the calculation that the residue was evenly distributed over the entire flower; the calculation was also based on the residue concentrations of the total homogenate of the flower. BuRO then calculated the minimum number of petals (at a weight of 0.4 grammes (RIVM-RIKILT, 2009)) that would be required to exceed the ADI for an adult (70 kg) and for a young child (12 kg). The smallest number of petals required before the ADI is exceeded was for procymidone: a daily consumption of 14 petals for an adult and 2 petals for a young child. It can be concluded that health risks cannot be excluded for a child who eats rose petals from cut flowers every day. For an adult, the risks are minimal if a few rose petals are used to decorate a dish of food, for example. If larger quantities are consumed, for example in salads, health risks for an adult can also not be excluded. Despite the fact that there are no consumption data for edible flowers, it is likely that the consumption of flowers would form only a very small part of the overall diet, which means the contribution to chronic health effects would probably be lowl. In terms of acute health effects, we also calculated the minimum number of rose petals children and adults would have to eat to exceed the health limit value for acute effects (ARfD). For procymidone (largest ratio between the residue concentration found and the ARfD), this number was only 10 rose petals for children and 60 rose petals for adults. Procymidone has not had European approval as an active substance since 2008, but it may still be in use outside of Europe. Any cumulative effects of substances were not taken into account in these calculations. Note that, if roses are grown specifically for consumption and treatment with plant protection products is much less, the MRLs for food crops apply and the risks are managed.

Consumption of subsequent crops
Oral exposure to plant protection products applied to ornamental plants can also potentially occur via subsequent crops grown on the same soil or substrate, if the subsequent crop is intended for consumption. This route of exposure is particularly important for substances (or degradation products) that remain in the soil for a long time. The data requirements for active substances, as described in Commission Regulation (EU) No 283/2013 of 1 March 2013 setting out the data requirements for active substances, in accordance with Regulation (EC) No 1107/2009 of the European Parliament and of the Council concerning the placing of plant protection products on the market, include an investigation of the metabolism and extent of the presence of residues in subsequent crops if there are indications that persistent substances could appear in the subsequent crop (and if that crop is a food crop). Restrictions can then be imposed in relation to the choice of the subsequent crop and the setting of MRLs for the subsequent crop so that any risks for the consumer can be controlled. There are known examples of rotation between ornamental and food crops, particularly in outdoor cultivation. In open-field ornamental horticulture, compliance with the use of plant protection products is generally higher than in greenhouse ornamental horticulture (overall picture: 82% in 2017) (NVWA, 2018d). It seems probable that the growing of a crop for consumption after an ornamental crop in a greenhouse only happens occasionally, such as when a growing site is being restructured. In this situation, the growing system (such as the substrate) is also often replaced.

Consumption of honey
Consumers may also be exposed to plant protection product residues from ornamental plants through the consumption of honey. Bees can collect nectar from ornamental plants to which plant protection products have been applied. Due to the absence of a suitable methodology, the standard MRL of 0.05 mg/kg was used until recently. On 1 January 2020, specific MRLs for pollen and bee products came into force. These MRLs are now being taken into account in the authorisation of plant protection products for ornamental plants (Ctgb, 2019b). In its technical guidelines[62] for the setting of MRLs, the European Commission indicated that the consumption of honey only makes up a very small part of the overall diet (less than 5 grammes per person per day), which means honey's contribution to chronic effects must be small. The MRLs primarily have to be evaluated in the context of possible acute health effects, even if the standard value of 0.05 mg/kg will be maitained.

8.6.3 Risk assessment for workers, processors and those applying plant protection products

Occupational exposure to plant protection products can occur during use of the products (for the people who apply the plant protection products) and for workers who come into contact with the treated plants. The exposure of these groups is typically the highest. In its authorisation assessment of plant protection products and biocides, the Ctgb evaluates the risks for those applying plant protection products and for other workers. For ornamental plants, the Ctgb assesses whether exposure to 'transferrable residue' is safe for workers who come into contact with the plants. The exposure of a worker who touches the plants is based on a worst-case scenario: it is assumed that the content of the residue does not decrease in the period following the application of the product (even though it usually does, due to chemical breakdown and irrigation). Thus,

[62] Technical guidelines for determining the magnitude of pesticide residues in honey and setting Maximum Residue Levels in honey, SANTE/11956/2016 rev. 9, 14 September 2018.

when the products are used according to the instructions and according to existing standards, the risks for workers, processors and those applying plant protection products are negligible. However, the Health Council of the Netherlands has concluded that, in practice, safety in relation to occupational exposure is not always adequate (Health Council, 2014). Possible causes include a failure to follow the instructions for use in practice and too little attention being given in the authorisation procedure to specific substance properties or sensitive groups. Likewise, the possible cumulative effects (addition or synergy) of products are not systematically taken into account in the authorisation assessment. The Health Council of the Netherlands refers to Dutch and international literature describing links between exposure to plant protection products and diseases such as skin conditions, effects on fertility, cancer (including in offspring) and Parkinson’s disease. However, the underlying information in the Health Council’s report dates back a number of years. It is possible that the current situation concerning the use of plant protection products may be different (Health Council, 2014). The relationship between reproductive toxicity for female workers and exposure to plant protection products is discussed in the literature. Greenhouse workers in particular face a higher risk, because the exposure to plant protection products is often higher and of longer duration compared to exposure in other forms of cultivation. Studies from a range of countries suggest a link between the exposure of female workers and reproductive toxicity (Figà-Talamanca, 2006).

From BuRO’s risk assessment on two plant protection products found on cut roses grown in greenhouses, it appears that a combination of excessive use and inadequate personal protection creates a scenario of risk for workers, processors and those applying plant protection products to the flowers (BuRO, 2009).

Based on the PBL’s interim evaluation of the Second Memorandum ‘Healthy Growth, Sustainable Harvest’, it seems that the interim target for workplace safety, which is about employers providing information and recording safety agreements with their employees, has not been achieved (PBL, 2019). Issues include language barriers and short employment periods. According to the PBL’s analysis, working safely with plant protection products is not given a sufficiently high priority. However, the number of companies engaged in greenhouse ornamental horticulture that did not give their employees any training on plant protection products decreased from over 20% to around 15% between 2010 and 2018.

In the scientific literature, there is a risk assessment based on residues of plant protection products measured on the gloves of Belgian florists available (Toumi et al., 2017). In the 20 measured samples, 12 to 68 different residues were detected per sample, with total concentrations of 1.3 to 113.5 mg per kg body weight per day. In total, 111 different substances were detected, mainly insecticides and fungicides. The potential dermal exposure at the P90 percentile of the residue concentrations and at the maximum detected concentrations exceeded the AOELs for three and five substances respectively, which means health risks cannot be excluded. Based on an assumption of 75% dermal absorption, the dermal exposure was converted into exposure for the body as a whole. This calculation showed that, for the P90 and at the maximum concentration detected, the AOEL was exceeded (up to 393%) for one and three substances respectively. If the use of gloves is taken into account, the exposure is approximately 90% lower and the health risks are limited.

Because too little is known about what biocides are used in the ornamental horticulture production chain, the risks for workers and those applying biocides cannot be assessed for these substances.

8.6.4 Risk assessment for neighbouring residents

A risk assessment for people living in the vicinity of greenhouses was carried out in 2001 (Alterra, 2001). In this study, the risks from 24 plant protection products were assessed for people living up to 30 metres downwind of a greenhouse. For three substances (dodemorph, heptenophos and dienochlor), harmful effects could not be excluded for various reasons. The conclusion was that further study into these substances was required, but only dodemorph is currently still authorised for the cultivation of roses (Ctgb, 2018e). This study also examined the combined use of substances with the same mode of action, but the analysis did not result in the identification of additional harmful effects from combined exposure.

Before 2014, the risk to neighbouring residents was not separately assessed in the Ctgb's authorisation assessment, with the exception of residents in the vicinity of greenhouses. It was implicitly assumed that the assessment of the occupational exposure risks was sufficient to protect neighbouring residents. Nevertheless, there was societal concern about the use of large quantities of products on agricultural land. In 2014, the Health Council of the Netherlands issued a report that recommended further research into exposure to plant protection products of residents in the vicinity of agricultural land (Health Council, 2014). This was due to the unique nature of neighbouring residents as a risk group. Differences between neighbouring residents and workers may arise due to the length of exposure, the level of exposure (peak exposure versus long-term exposure to lower concentrations), sensitive groups such as children and pregnant women and whether personal protective equipment is used. Since 2014, in response to this report, the Ctgb has explicitly assessed the exposure of neighbouring residents using two available models. In addition, based on a new EFSA model, it has conducted a reassessment of existing authorisations to identify the risks for neighbouring residents and bystanders including children. For this reassessment, the provisional EFSA model (as described in (EFSA, 2014a)) was used for the exposure calculations. Based on the intensity and method of application (spraying in an upwards direction), 116 products were included in the reassessment. From this evaluation, the Ctgb drew the conclusion that the evaluated products were safe and that a review of the assessments of these products was not necessary. Since 1 January 2016, the EFSA model is routinely used in the assessment of products and substances as a basis for the risk assessment for neighbouring residents and bystanders (Ctgb, 2015b;2018g). In 2015, the EFSA issued guidelines that described a harmonised approach for exposure calculations for neighbouring residents, bystanders and passers-by (EFSA, 2014b).

In response to the report of the Health Council of the Netherlands, the RIVM coordinated a study into exposure and health risks for residents living in the vicinity of agricultural land (RIVM, 2018a). The exploratory health study, which examined various cultivation types, was published in July 2018 and concluded that, in general, there was no clear relationship between health and living in the vicinity of agricultural land. However, a number of specific relationships (unrelated to ornamental horticulture) require further investigation (RIVM, 2018b). The exposure of neighbouring residents was examined by measurements in urine, outdoor air and samples from surfaces inside homes, soil and vegetation in the vicinity of sites where flower bulbs were grown. A small number of swipe samples from hands and samples of indoor air were also taken. Residues of the plant protection products that had been applied were found in samples from outdoor air around houses, in dust on doormats and in household dust. Residues were also found in urine samples from neighbouring residents (adults and children), including in situations where the residents lived more than 500 metres from the agricultural site in question. The study shows that the current authorisation frameworks do not underestimate the exposure for neighbouring residents, based on the fact that the measured exposure is below the health based guidance values. However, there is scope for further refinement of the model, for example by assessing the combined effects of different substances. The studies provide various leads for follow-up studies, for example into vulnerable groups or other health effects such as cognitive development (RIVM, 2019c).

8.6.5 Risks from plant protection products for nature and the environment

<u>Environment</u>
Products enter the environment through the application of plant protection products, for example through accumulation in the soil or through spray drift, leaching or run-off from the growing site into surface water or groundwater (PBL, 2019). The substances found in groundwater are primarily substances that are no longer authorised, but of which residues can still be found in the soil from previous usage (EZ, 2013; RIVM, 2016). Residues from plant protection products can cause environmental problems, such as issues related to the drinking water supply (CML, 2012; RIVM, 2016). To protect the environment, a range of environmental quality standards have been drawn

up, such as the Maximum Permissible Risk (MPR) levels, the Negligible Risk (NR) levels and various environmental quality standards (EQSs) for surface water and groundwater (specific requirements apply for drinking water collection points), soil, sediment and air (RIVM, 2019a). If a standard is exceeded, a negative effect on the environment and living organisms cannot be excluded.
For tree nurseries and bulb forcing nurseries, specific emission pathways have been identified by which plant protection products can enter surface water (WUR & CLM, 2012).
At forcing nurseries, the products enter ditch water through rainfall, leaching and the discharge of condensation, drain water and filter coil water. These emission pathways also apply to protected tree nurseries. For outdoor tree nurseries, the main emission pathways are droplet drift from spraying, rainfall, leaching from drains or soil and run-off from individual fields and the site as a whole. In container fields, the main emission pathways are droplet drift from spraying, rainfall, leaching, run-off and the discharge of drainage and tank water. In these cultivation types, various voluntary and legally mandated measures are taken to prevent emission, such as drift reduction measures, limiting point emissions and filtering of waste water (WUR & CLM, 2012). For greenhouse substrate cultivation, emissions are primarily into surface water; with soil cultivation, emissions are primarily into the greenhouse soil (WUR, 2018c). Since 1 January 2018, there has been a legal obligation to treat discharged water in greenhouse cultivation in such a way as to remove 95% of the plant protection products present (WUR, 2017).

Measurements show that the emission of plant protection products has significantly decreased over the years. For example, data from the National Monitoring Network for Plant Protection Products in Agriculture and Horticulture (LM-GBM) show a clear decrease in emissions to surface water for tree nurseries (65% reduction) and greenhouse ornamental horticulture (36% reduction) over the periods 1997–1999 and 2008–2010 (CML, 2012). Calculations for greenhouse horticulture over the period 2004–2016 show that the burden on aquatic life from plant protection product emissions decreased by up to 90% in this period (Table 8.3) (WUR, 2018b). The vast majority of the environmental impact from these types of cultivation was caused by the use of insecticides (WUR, 2018c). According to this study, the quantity of active substances used (in kg/ha) in cut flower cultivation in the period 2004–2016 decreased by 60% (WUR, 2018d). Given the obligation to filter discharged water, which took effect on 1 January 2018, it is expected that emissions to surface water will continue to decrease.

Table 8.3 Environmental impact in environmental impact points[63] per hectare (EIPs/ha) for ornamental plants in greenhouse horticulture in 2004 and 2016 (WUR, 2018b)

Plant type	**Environmental impact 2004 (EIPs/ha)**	**Environmental impact 2016 (EIPs/ha)**
Cut flowers, chrysanthemums (aquatic life)	2,134	188
Cut flowers, chrysanthemums (soil life)	2,635	1,355
Cut flowers, roses	49,330	1,568
Pot plants	1,205	48
Bedding plants	TBD	70

Despite these calculated decreases in environmental impact, levels that exceed the standards are still being measured. In 2016, for example, excessive levels of a number of products that had been applied in the cultivation of bulbs and trees were observed in surface water (Deltares, 2017). For tree nurseries, levels that exceeded the standards were observed for thiacloprid, metazachlor, deltamethrin, indoxacarb, imidacloprid and linuron. For flower bulb cultivation, the relevant substances were imidacloprid, ETU, pirimiphos-methyl, captan, esfenvalerate, azoxystrobin, carbendazim, deltamethrin, pyraclostrobin, pendimethalin, thiophanate-methyl and pirimicarb.

[63] The environmental metric developed by CLM assigns environmental impact points (EIPs) to plant protection products. This involves examining the effects on aquatic life and soil organisms as well as the likelihood of leaching in connection with the contamination of groundwater.

Figures from 2017 show that the extent of noncompliance with the standards (SOM index) was slightly lower for tree nurseries. However, there were changes from 2016 in terms of the products that exceeded the standards: in 2017, additional instances of excessive levels were found for methoxyfenozide, carbendazim, thiamethoxam and thiophanate-methyl. There were no further instances of the standards being exceeded for imidacloprid or linuron. For flower bulb cultivation, the SOM index was lower than in 2017, primarily because fewer active substances exceeded the standard: imidacloprid, carbendazim, pyraclostrobin, pendimethalin, esfenvalerate and pirimiphos-methyl (Deltares, 2018b).

In 2013, the government set a target of having virtually no exceedances of the surface water quality standards by 2023, with an interim target of a 50% reduction by 2018. To achieve these targets, additional measures are required so that emissions in protected cultivation are completely or almost completely removed using water treatment technology. For open-field cultivation, drift from sprayed plant protection products must be restricted even further and cultivation-free zones must be expanded. Point emissions must also be reduced (EZ, 2013). A different target applies for groundwater: the quality may not deteriorate in the period from 2013 to 2023.

The PBL's interim evaluation of the Memorandum showed that, in spite of an improvement in water quality, the interim target for the abstraction of drinking water from surface water (50% decrease in exceedances of surface water quality standards by 2018) was not achieved. The majority of exceedances were recorded in ditches near tree nurseries, flower bulb crops, fruit orchards and greenhouses. Glyphosate made a significant contribution to the standards being exceeding (PBL, 2019). Glyphosate-based products authorised for use in ornamental horticulture have an expiry date of no later than 1 January 2020 (Ctgb, 2018e). The reassessment procedure for glyphosate as an active substance started on 15 December 2019 and should be completed by December 2022 (Ctgb, 2019b).

Most of the residues found in groundwater come from products that are no longer authorised. Three active substances found in groundwater are an exception to this rule and are still authorised, including bentazon and glyphosate, which are authorised for use in ornamental horticulture. The third substance, mecoprop-P, is not authorised for use in ornamental horticulture (Ctgb, 2018e; PBL, 2019). Of course, authorisation is not an indication of how the active substances are actually used in practice.

A complicating factor in determining water quality and exceedance of standards based on measurements is the uncertainty caused by so-called difficult-to-measure substances. If the reporting limit of a substance is higher than the standard, the measurement is said to be 'unverifiable'. There is an increasing trend of unverifiable measurements, which means statements about changes in water quality and instances of standards being exceeded that are based on measurements involve a degree of uncertainty (PBL, 2019).

If the standards are exceeded, it may be due to incorrect use of products (failure to follow the legal instructions for use). However, the PBL also indicates that the national authorisation procedure gives insufficient consideration to specific emission pathways, meaning that the rate of emissions into the environment may be underestimated and that exceedance of standards could also occur with appropriate use (PBL, 2019). The emission models used for the product authorisation procedure and water quality standards are therefore insufficiently aligned (RIVM, 2019b).

Since 2018, stricter requirements have applied in relation to implementing emission reduction measures. This has led to the widespread use of nozzles (reducing drift by at least 75%). Most protected cultivation sites are also equipped with water treatment facilities or are connected to a collective system, which defers the water treatment obligation (and therefore will not yet lead to decreased emissions). Since the strict requirements have only applied since 2018, any effect on water quality cannot yet be measured. The Memorandum also encourages the creation of wider field margins, partly to support populations of natural predators. This voluntary approach has not produced the desired result, as the area occupied by field margins in the Netherlands has actually decreased slightly between 2013 and 2017 (PBL, 2019).

In theory, plant protection products may also enter the environment through the composting of floricultural products that contain persistent residues. This may apply particularly to imported floricultural products, which could contain possible residues of very persistent active substances that are no longer authorised in the EU. The Fertiliser Policy Implementing Regulation (*Uitvoeringsregeling meststoffenbeleid*) and the Fertilisers Act Implementing Decision (*Uitvoeringsbesluit meststoffenwet*) set maximum levels for organic micropollutants in fertilisers, including several persistent, banned plant protection products such as aldrin, dieldrin, endrin, isodrin, HCB, HCH, DTT, DDD and DDE. However, it is unclear to what extent the composting of floricultural products contributes to organic micropollutants in fertilisers.

Nature

The effects of plant protection products on nature, such as insects, aquatic life and soil life, etc., fall outside the scope of this risk assessment. However, due to the recent awareness of the negative effects of plant protection products (particularly neonicotinoids) on bees, these effects are briefly discussed below.

Neonicotinoids are used against pest insects, but they also have harmful effects on beneficial insects such as bees. In 2013, the EFSA issued a specific guideline for assessing the risks to bees from plant protection products (EFSA, 2013). This guideline has not yet been adopted at a European level. A number of elements of the draft guideline are currently being updated. The guidelines were updated in 2018 with evaluations of three neonicotinoids: clothianidin, imidacloprid and thiamethoxam (CIT). These substances are subject to restrictions on their use within the EU (EFSA, 2015;2018a;2018e;2018d;2018b). In April 2018, the EU Member States endorsed the proposal of the European Commission to ban all outdoor use of these neonicotinoids[64]. An earlier study on the monitoring of imidacloprid in surface water in a number of bulb, greenhouse and arboriculture regions in the Netherlands found that no decrease or only a slight decrease in levels was detected after additional treatment measures were imposed for this substance on 1 May 2014 (CML, 2015). Measures such as water treatment facilities are used to filter active substances from discharged water. In 2015, the NVWA observed that the required water treatment facilities were present at only a handful of greenhouse ornamental horticulture sites. The cost of such facilities was cited as a possible explanation for the low compliance with this measure (NVWA, 2015d). After the requirements were tightened in 2018, most sites did implement the measures (PBL, 2019). In its interim evaluation of the Second Memorandum the PBL concluded that, given the recent introduction of the latest legal restrictions on use, any effects such as reduced bee mortality would not yet be visible. However, it is possible to discern a shift towards the use of alternative products, most of which do not have a lower risk profile (PBL, 2019).

The 2014 risk assessment by BuRO, which included 25 plant protection products detected on ornamental plants from Dutch garden centres, described the uncertainty about the hazards for bees from specific systemic pesticides (neonicotinoids). The most likely way in which bees could be exposed is via nectar and pollen from flowering plants that are grown in greenhouses before being planted in gardens (BuRO, 2014). A 2017 follow-up study showed that the number of substances harmful to bees on these types of plant products is decreasing (Greenpeace, 2017). In addition to curtailment of the use of neonicotinoids, grower education and encouragement of non-chemical pest control, the government suggested other measures in its Second Memorandum on Sustainable Plant Protection such as encouraging or widening cultivation-free zones that could be designed for functional agrobiodiversity (EZ, 2013). In addition, recent academic research shows that, with regard to harmful effects on insects (the ichneumon wasp was used as a model in the study), it is important to examine the cumulative effects of mixtures of plant protection products, since there may be synergy between the various effects (Willow et al., 2019).

The illegal use of plant protection products can also lead to harmful effects for bees. In 2016 and 2019, the NVWA reported incidents of mass mortality of honey bees caused by the use of the

[64] Commission Implementing Regulation (EU) 2018/783 of 29 May 2018 amending Implementing Regulation (EU) No 540/2011 as regards the conditions of approval of the active substance imidacloprid.

unauthorised plant protection product fipronil in the cultivation of cherry laurel trees (RIVM-WFSR, 2017;2019).

8.6.6 Other risks

Development of azole-resistant *Aspergillus fumigatus*
Aspergillus fumigatus is a fungus that generally appears on rotting plant material and produces numerous spores. These spores are present everywhere in both indoor and outdoor air, and people inhale them continually. The fungus is an opportunistic pathogen for humans that can cause a severe burden of disease in immunocompromised people, which in some cases can lead to death (Verweij et al., 2009). People become infected by inhaling the spores, which then grow in the airways and can cause infections. Infections can be controlled with azole antifungals (such as triazoles and imidazoles). However, just as bacteria can become resistant to antibiotics when exposed to non-lethal concentrations, *A. fumigatus* can become resistant to azoles (Händel et al., 2015). Azoles are used not only as antimycotic medication, but also as fungicides in agriculture and in timber processing. It has been shown that, in many cases, the azole resistance of isolates of *A. fumigatus* that cause infections in humans was formed through exposure to azoles (Rietveld AG, 2017). Resistance as a consequence of exposure to azole fungicides is an important source of *A. fumigatus* resistance in healthcare, because cross-resistance between the various azoles is very common (Azevedo et al., 2015).

An increase in *A. fumigatus* resistance has been observed in connection with the storage of wood waste and with compost heaps containing remnants of flower bulbs and other plant material. In the case of the remnants of flower bulbs, a link can be made with the use of various azole fungicides during cultivation (Rietveld AG, 2017). The use of a range of azoles is also authorised in ornamental horticulture (including tebuconazole, prothioconazole + penconazole, propiconazole + difenoconazole, etoxazole and metconazole) (Ctgb, 2018e). Composting of plant waste from the ornamental horticulture production chain could therefore also create a risk for the development of azole resistance by *A. fumigatus*. However, no studies on this topic are currently available. In a letter to Parliament dated 24 October 2019, the Ministry of Agriculture, Nature and Food Quality emphasised the importance of identifying possible sources of this development of resistance (Minister van LNV, 2019).

Genetic modification
In genetic modification, the DNA of an organism (in this case an ornamental plant) is changed with the aim of giving the organism a new or adapted characteristic. Strict legal frameworks apply to working with genetically modified organisms (GMOs) and placing them on the market. A permit is required for the cultivation and import of live GMOs in ornamental horticulture; these activities are covered by Directive 2001/18/EC. An authorisation must be submitted to one European Member State, and the market authorisation then applies for the entire European Union. The procedure consists of an environmental risk assessment (RIVM, 2019d). In the Netherlands, the RIVM's GMO Office assesses the safety of applications and grants permits on behalf of the Ministry of Infrastructure and Water Management (RIVM, 2019e). A list of GMOs with market authorisation is publicly available on the website of the Joint Research Centre (JRC). This database lists five Dutch authorisations for placing on the market (i.e. not for cultivation) of imported carnations with a modified flower colour (JRC, 2019). This shows that genetic modification is indeed applied in ornamental horticulture. Authorisations are currently limited, and any risks are assessed within a strict legal framework. The Human Environment and Transport Inspectorate (ILT) is responsible for monitoring compliance with laws and regulations in relation to GMOs. In 2014, on behalf of the ILT, the RIVM conducted a survey of global developments of successfully genetically modified ornamental plants and the possible illegal import of these products. In general, the risk to public health and the environment from the products identified was low. One modified (glyphosate-resistant) plant (*A. stolonifera*) was identified that could potentially pose a risk to biodiversity, but illegal imports of this plant are unlikely (RIVM, 2014).

8.6.7 Summary of the risk assessment of plant protection products and biocides for humans, nature and the environment

- For floricultural products, there are no legal maximum residue limits (MRLs) set for plant protection products and biocides. Since 1 January 2020, specific MRLs apply for pollen and bee products that will be included in the authorisation of plant protection products for ornamental plants.
- The risks for consumers who come into contact through their skin with residues of plant protection products on ornamental plants are negligible.
- Ornamental plants are not intended for consumption. However, if ornamental plants are eaten, health risks related to the residues of plant protection products cannot be excluded.
- The risks for consumers from exposure to residues of plant protection products through a subsequent crop appear to be minimal.
- Workplace safety in the sector in relation to the use of plant protection products and biocides by workers, processors and those applying plant protection products and biocides is still not adequate. Possible causes include failure to follow the legal instructions for use, inadequate training, not recording agreements and sensitive groups not being taken into account in the authorisation assessment.
- There are not enough data to be able to perform a risk assessment for biocides, either for consumers or for people exposed in the course of their work.
- There are not enough data to be able to perform a risk assessment for residues of plant protection products on imported products from third countries.
- A recent study examined exposure to plant protection products and health risks for people living in the vicinity of agricultural land. This study showed that neighbouring residents were exposed to plant protection products, but no clear harmful effects on health were identified. However, a follow-up study and further refinement of the authorisation framework were recommended (for example, by assessing combined exposure).
- Active substances of plant protection products have been found in surface water. In the groundwater, the main residues found are from substances that are no longer authorised. Although emissions of plant protection products are decreasing, levels that exceed the standards are still being observed, and the interim targets in the Second Memorandum have not been achieved. When the standards are exceeded, negative effects on certain organisms cannot be excluded. More stringent requirements for emission-reducing measures were imposed in 2018, but their effect on water quality cannot yet be assessed.
- Standards may be exceeded because the legal instructions for use were not followed, but also due to insufficient harmonisation between the authorisation procedure and water quality standards.
- An increasing quantity of unverifiable substances has created uncertainty in trend analyses of water quality and instances of the standards being exceeded.
- The extent to which residues of persistent plant protection products enter the environment through the composting of floricultural products is unknown. There are legal limits for a number of persistent plant protection products in fertilisers.
- Recently, awareness has been raised to the risks posed by plant protection products for biodiversity, particularly the effects on beneficial insects such as bees. Due to these risks, the use of a number of insecticides has been curtailed at the European level.
- Given the use of azole fungicides in ornamental horticulture, the development of azole resistance by *A. fumigatus* through the composting of plant waste from the ornamental horticulture production chain is a possible scenario; however, not enough data are available to test this hypothesis.
- Genetic modification is used in the ornamental horticulture sector industry; authorisations are assessed within a strict legal framework. The current risk from illegally imported, genetically modified ornamental plant products for public health and the environment is assessed as low.

9 Toxicity and allergenicity of ornamental plants

9.1 Introduction

Plants are grown for a variety of purposes, such as for the production of food, animal feed and fuel, but also for use in medicines and herbal remedies, as insecticides or as ornamental plants for decoration. The Dutch Wikipedia page on ornamental plants provides the following definition of ornamental plants: "An ornamental plant is a plant (or cultivated plant) that is grown for its ornamental value. The plant's value is solely decorative. Ornamental plants can have ornamental value in a number of different ways, such as through their flowers, fruit or scent." In addition to decorative purposes, ornamental plants and ornamental trees can also perform a function, such as separating two spaces or providing shade.

The division of the ornamental horticulture production chain into subcategories, such as cut flowers, pot plants, tree nursery plants and perennials, is less relevant for the description that follows, and these divisions have therefore been ignored. The same applies to the different links in the chain (breeding, propagation, production and post-production trade). The risk for animal and human health is primarily connected with the final link in the chain, namely post-production trade. With regard to animal health, the health of farm animals falls outside the scope of this assessment.

The risks posed by each of the following will be discussed in turn:
- edible plants;
- dyeing and processing of ornamental plants;
- toxicity of ornamental plants; and
- allergenicity of ornamental plants.

9.2 Edible plants

The distinction between crops or plants grown and sold for consumption and those grown for their ornamental value is not always entirely clear. Some people use plants or flowers from the garden in salads and soups. This use of plants is not considered in this assessment. However, there are also restaurants that use flowers such as roses and pansies to decorate dishes. Herbs, cresses (freshly sprouted seedlings) and other plants are sold, usually wholesale, and are then in principle grown to be eaten. To date, they have not been consumed in large quantities.

9.2.1 Novel edible plants

'Edible' means something is suitable for eating and not toxic. This term is not defined by law. It can be assumed that food that is offered for consumption is edible. Article 2 of Regulation (EC) No 178/2002 defines 'food' or 'foodstuff' as "any substance or product, whether processed, partially processed or unprocessed, intended to be, or reasonably expected to be ingested by humans." In addition, Article 3 of Regulation (EU) 2015/2283 of the European Parliament and of the Council of 25 November 2015 on novel foods, amending Regulation (EU) No 1169/2011 of the European Parliament and of the Council and repealing Regulation (EC) No 258/97 of the European Parliament and of the Council and Commission Regulation (EC) No 1852/2001 defines 'novel food' as "any food that was not used for human consumption to a significant degree within the Union before 15 May 1997".

It is not always clear whether edible plants can be considered novel foods (Sprong et al., 2014). The assessment of whether a food was used for human consumption to a significant degree within the Union before 15 May 1997 must be based on information provided by food business operators, which can be supported if necessary by other information available in Member States. If food business operators are not sure of the status of the food they wish to place on the market, they must consult the Member States. The European Commission may decide, on its own initiative or upon a request by a Member State, by means of implementing acts, whether or not a particular food falls within the definition of novel food. Novel foods should be safe, and their use should not mislead consumers. The European Food Safety Authority (EFSA) assesses the food safety risks based on the submitted dossiers. Approved novel foods or novel ingredients may only be placed on the market if they are included in the Union list of novel foods authorised to be placed on the market within the Union. Approved novel foods are subject to the same legislation as all other foods, including the general labelling requirements laid down in Regulation (EU) No 1169/2011.

EFSA has published guidance describing the data required for a safety assessment of a novel food. EFSA assesses the safety of the novel food for its proposed use (EFSA NDA Panel et al., 2016; EFSA, 2018c).

A number of edible plants that are often grown and traded in the ornamental horticulture production chain are subject to a European statutory labelling requirement in the context of the quality of fruit and vegetables: fresh and chilled thyme, basil, lemon balm, mint, oregano/wild marjoram, rosemary and sage belong to the fruit and vegetable sector according to Regulation (EU) No 1308/2013.
For rose hips and flowers, leaves and roots for dried herbal tea (such as jasmine, chamomile, hibiscus, red bush and ginseng root), Regulation (EC) No 396/2005 lays down maximum residue levels of pesticides in or on food and feed of plant and animal origin.

9.2.2 Assessment of the chemical risks from edible plants

The risk assessment for substances that are deliberately or accidentally added to foods, whether or not they are considered novel foods, is based on safe human doses, which are usually calculated by extrapolating from animal testing data using safety factors. The safe dose is the quantity of a substance that a human can ingest every day throughout his or her life without any noteworthy health risk. This amount is usually referred to as the Acceptable Daily Intake (ADI) or the Tolerable Daily Intake (TDI). The ADI is used for authorised substances such as plant protection products. The TDI is used for substances that are not deliberately added to food, such as environmental contaminants. For the assessment of acute health effects, the ARfD (Acute Reference Dose) is used. This is the maximum quantity of a substance that someone could safely ingest during a short period of time, usually 24 hours. The likelihood of a health effect increases if the ADI or TDI is exceeded, but this does not mean that there will always be a health effect.

European legislation is based on the principle that consumer exposure to undesirable chemical substances should be as low as possible. For many substances, a maximum permissible concentration has been set, the MRL (Maximum Residue Limit) or ML (Maximum Limit). MRLs are used for substances that can be found as residues in foods, such as plant protection products. MLs are used for substances that can enter foods unintentionally, such as environmental contaminants. MRLs and MLs are legal standards established for each substance/food combination. MRLs for residues of plant protection products in food are set on the basis of what is achievable while applying good agricultural practice; in doing so, due consideration is given to toxicological benchmarks. Contaminant standards (ML values) are based on the ALARA principle (as low as reasonably achievable).

9.2.3 Research

In Denmark, the National Food Institute conducted a study into the safety of wild plants as food. One hundred and fifty restaurants and local food producers (of jam, for example) were visited in mid-October 2016, and their use of plants picked in the wild or from gardens was investigated. The flowers of 23 plants were examined more closely, using data from the literature. Nine flowers contained substances with toxic or potentially toxic effects following consumption, two contained unidentified toxic substances and four were flowers from plants with potentially toxic substances in parts other than the flower or in related species (Egebjerg et al., 2018). Examples of the toxic substances found include thujone in yarrow, coumarin in woodruff and erucic acid in nasturtium. Ingestion of 18, 7 and 40 grammes of fresh flowers respectively was enough to exceed the associated ADI or TDI. Due to a lack of data, the researchers were unable to derive a safe intake limit for the other substances in the flowers studied (Egebjerg et al., 2018).

9.2.4 Labelling (consumer information)

The Association of Dutch Flower Auctions (VBN, www.vbn.nl) reports that edible flowers, plant parts and fruits are being cultivated and traded in the ornamental horticulture sector in increasing numbers. This includes edible herbs, cut flowers and plants with edible fruit. In a document entitled 'Specifications for edible plants', the VBN provides guidelines for supplying edible products, including the necessary certification, possible edible floricultural products and labelling. The VBN states that, when trading edible products, suppliers must comply with the MRLs set at a European level for plant protection products. When trading a product that has both an edible and a non-edible variant, the supplier must indicate this using the grading code S77 (edible/not edible) along with one of the following codes: Code 1 Suitable for consumption; Code 2 Edible plant; Code 3 Edible fruit; Code 4 Edible flowers; Code 6 Produces edible fruit; Code 9 Not for consumption. An example of a potentially edible product that may be traded as 'not for consumption' is *Capsicum annuum* (ornamental pepper). The VBN has drawn up a list of flowers and plants that are potentially edible and for which the grading code S77 must be used (VBN.nl).

On 13 March 2015, FloraHolland published guidelines for the use of uniform symbols for the care of pot plants by consumers. FloraHolland proposed that a number of symbols be used, including to indicate that a plant is or is not suitable for consumption. It quite rightly pointed out that suppliers are liable for any harm if consumers are not warned. Dutch flower auctions advise their suppliers and buyers to include the following text on the packaging or on a stick-in or hanging label: *"This product is intended exclusively for decorative purposes and is not intended for internal consumption. Incorrect use, consumption, contact and/or hypersensitivity could result in harmful consequences for people and/or animals", or the abbreviated text: "Intended for decoration, not for consumption*".

These initiatives should be seen as guidelines that are not covered by legislation and therefore cannot be enforced by the NVWA. It is not known what percentage of the plants and parts of plants sold to private individuals are clearly labelled as being suitable or unsuitable for consumption.

9.2.5 Monitoring

The NVWA is responsible for monitoring compliance with the legislation on edible plants. European Regulation (EC) No 396/2005 determines the maximum residue levels of plant protection products in or on food and requires Member States to implement two control programmes: the EU-coordinated control programme (EUCP) and a National Control Plan. The EUCP involves taking random and representative samples of a product or product group to obtain a picture of residues of plant protection products on the products. Each year, the EUCP stipulates around 10 products that must be sampled. The National Control Plan must be implemented in a risk-based way, based on reports from the RASFF system and country/product combinations for which excessive levels have been found previously on a regular basis. In addition, each EU Member State must conduct mandatory checks on imports of food of non-animal origin at the external borders of the EU (Commission Regulation (EC) No 669/2009. To this end, a list of countries and products is drawn up every six months on the basis of previous results. Products that do not comply with the legal requirements are not permitted to enter the EU.

No MRLs or MLs are specified in the legislation for edible flowers. Edible flowers, plants and parts of plants are also not included in any national control programme, since it is not clear whether they should be considered 'food'.

9.2.6 Conclusions

- The purpose for which plants are grown and traded must be clear. Different rules apply for plants offered for consumption and for ornamental plants.
- Flowers and plant parts offered for consumption that were not used for human consumption to a significant degree before 15 May 1997 are classified as novel foods and must be approved by the European Commission for trade on the European market (Regulation (EU) No 2015/2283). The supplier/seller must check whether the product is a novel food.

- Flowers, plants and parts of plants offered for consumption are food and must comply with all European rules on food safety.
- Voluntary guidelines for labelling of edible plants are provided by the Association of Dutch Flower Auctions. It is not known what percentage of the flowers and plants that are sold are clearly labelled as being suitable or unsuitable for consumption. Consumers are not always aware of whether a particular ornamental plant is edible or not.

9.3 Dyeing and processing of ornamental plants

An important industry branch responsible for the emission of volatile organic compounds is the flower dyeing sector (Limburg, 1992). Cut flowers and indoor plants (such as orchids) are dyed by being dipped in a container of dye. To dilute the dye, and because flowers often have a waxy layer, a solvent is required. Previously, volatile substances such as acetone were used for this purpose, in concentrations of up to 90%. Exposure to these substances can lead to brain and skin disorders, but as far as we know, flowers are no longer dyed in this way.

Since November 1990, dried flowers may only be dyed with water-based dyes. For cut flowers with large vascular bundles, such as chrysanthemums, freesias and tulips, the stems can be placed in a vase containing dye. In addition to dipping flowers in dye or allowing them to draw up the dye through their stems, spraying flowers and treating them with glitter are also options. Another popular method of colouring flowers is to inject dye into the stems.

Preserving flowers also seems to be a growing trend. Roses in particular, but increasingly other flowers, plants and even mosses as well, are being treated to make them keep for more than a year without needing to be watered and with minimal maintenance. Flowers can be preserved using a variety of methods, but the most common commercial form at the moment is dehydration (drying) followed by dyeing the flower or applying a pigment.

Flowers can be dehydrated in a number of different ways. The usual commercial method is to replace the water in the flower (with or without the stem and leaves) with another liquid, usually oils, glycol, glycerine, etc. Dehydration often leads to loss of colour, or there may be a desire to present the flowers in unnatural colours. In these situations, the next step is a dyeing process. Preserved flowers are sensitive to moisture and touch. They are often sold in packaging that is intended to be used as a holder. In the Netherlands, preserved roses can be purchased in a range of colours[65]. Fresh roses are chemically treated with ethanol, polyethylene glycol, boric acid, glycerine and dyes for six to eight days. The result is a coloured, preserved (‘premium stabilised’) rose that will last for one to two years. After stabilisation, the roses are placed in small pots without their stem. Alternatively, they can also be sold with the stem attached.

Some suppliers provide a bottle of fragrance and specify that their product should be sprinkled with it, so that the scent of fresh flowers will linger in the room throughout the lifespan of the preserved flowers.

To date, no RAPEX notifications have been made about preserved flowers. Nor could we find any publications (search terms: preserved flowers (roses), Konservierte Blumen (Rosen)). Patents have been granted in relation to preservation, but these provide no further information about consumer risks.

Preserved flowers are not suitable for consumption. Suppliers also state on their websites that their products are non-toxic and not harmful for the environment. The properties of the preservation fluids and dyes used are not known in detail and are considered to be corporate secrets.

Flowers and plants preserved as described above may be considered products that fall under the general product safety regulations. Below is a short list of the risks from this perspective:

[65] http://www.roseamor.com

- chemical, short-term risk: transfer of substances through skin contact – corrosive or allergenic. This is not expected with ordinary, appropriate dye. Brief skin contact only, of limited extent and duration;
- chemical, long-term risk: sensitising or CMR[66] substances. Evaporation is not expected. Skin contact is likely to be limited in terms of extent and duration;
- release of substances if heated: given the properties of the fluids and dye in preserved flowers, limited heating of the flowers (<150 °C) should not lead to harmful emissions;
- physical/mechanical: cutting, bumping – the preserved product is brittle, fragile and has no sharp edges. Contact will damage the product but not injure the person;
- fire: preserved flowers in which water has been replaced with oils will not lead directly to an increased fire risk, given the flashpoint of the oils used. If different processes are used to dehydrate the flowers in which no replacement fluid is used, the flowers could potentially catch fire. However, this appears not to be the case for the bulk of the commercially preserved flowers placed on the market.

The biggest risk would be expected if the flowers were eaten and the oil entered the body. However, the flowers are not intended for consumption, nor is it expected that the usually brightly coloured flowers would be eaten accidentally. There are currently no indications that further research is required into the risks from preserved flowers, although not all information is known.

Conclusion
Dehydrated, coloured, dyed, sprayed or treated flowers and plants are unfit for consumption. No other risks are known.

9.4 Toxicity of ornamental plants

A large number of plants can cause harmful effects when eaten by humans or animals. The toxicity may be caused by various toxic substances such as alkaloids and glycosides. It is often not clear whether one or multiple toxins are responsible for the toxic effects after ingestion of a plant (Poppenga, 2010).

The toxicity of ornamental plants for humans is discussed below. However, instances of farm animals being poisoned occur frequently as well. This happens when the animals eat plants in the meadow or eat hay that is contaminated with toxic plants (Cortinovis & Caloni, 2013). Some plant poisonings of pets occur because they have eaten house or garden plants (Cortinovis & Caloni, 2013). In 2017, the Dutch Poisons Information Centre (NVIC) was consulted in 1,624 cases of exposure of animals to plants. This is comparable to the number of reported cases of exposure of humans to plants (1,846 in 2017). Of all reports, 12% were about the exposure of animals to *Vitis vinifera* (grapes), followed by *Persea americana* (avocado) (6%), *Lilium* spp. (lily species) (6%), *Allium* spp. (garlic species) (4%), *Taxus* spp. (yew species) (4%), *Hydrangea* spp. (3%), *Solanum* spp. (nightshade species) (3%), *Prunus* spp. (3%), *Dracaena* spp. (2%), *Spathiphyllum* spp. (2%) and *Anthurium* spp. (1%). What is striking is that plants that are edible for humans top the list (grapes and avocados) (NVIC, 2018).

The US Food and Drug Administration has a searchable database, the FDA Poisonous Plant Database[67], which contains publications from the scientific literature describing the toxic properties and effects of plants and plant parts.

[66] Carcinogenic (causing cancer) and/or Mutagenic (inducing changes in hereditary characteristics) and/or Reprotoxic (harmful to the reproductive process or to the offspring).
[67] https://www.accessdata.fda.gov/scripts/plantox

9.4.1 Poisonings: hazard identification

Information about poisonings due to the ingestion of ornamental plants by humans (and also animals) is available in the annual reports of the Dutch Poisons Information Centre (NVIC). Medical professionals can obtain information from the NVIC about poisoning cases and how to treat them. In 2017, the NVIC was consulted about 1,846 cases of exposure of people to plants (NVIC, 2018). In 2016, they were consulted 2,531 times, and there were 1,857 cases in 2015. The majority of cases involved young children who had eaten a plant in the living room or garden. In 2017, there were 30 reports of cases in which one plant was mistaken for another, with people eating a poisonous plant instead of an edible plant. People thought they had picked an edible plant in the garden or in the wild, but it turned out to be a poisonous species.

The 12 plants or genera about which the most reports were made on average between 2013 and 2017 in relation to children aged 12 years or younger are listed in Table 2 (NVIC, 2017;2018).

Table 2. The plants or genera with the highest average number of reports over the period from 2013 to 2017 in relation to children aged 12 years or younger (NVIC, 2017;2018).

Plant/genus	Average number of reports
Taxus spp. (yew species)	79
Spathiphyllum spp.	50
Prunus spp.	49
Hedera helix (ivy)	40
Zamioculcas spp.	37
Arum spp.	37
Anthurium spp.	32
Ilex spp. (holly species)	31
Solanum spp. (nightshade species)	30
Lonicera spp. (honeysuckle species)	28
Ligustrum spp. (privet species)	27
Ranunculus spp.	24

The plants with the highest number of reports relating to children aged 12 years or younger were yew species (82 cases of exposure in 2016 and 102 in 2017), followed by *Spathiphyllum* and *Prunus* species. Most of the reports regarding *Prunus* species related to the cherry laurel (*Prunus laurocerasus*).

In 2015, there were 22 reports about exposure of persons aged 13 or over to *Prunus* species, including the ingestion of bitter almonds (*Prunus dulcis* var. *amara*) and apricot kernels (*Prunus armeniaca*). In 2017, there were 11 reports about 14 people who may have eaten too many apricot kernels or bitter almonds. Apricot kernels and bitter almonds contain cyanogenic glycosides that are converted in the body into toxic cyanide. In some reports, the kernels were mistaken for ordinary nuts, but apricot kernels and bitter almonds are also eaten deliberately as an alternative cancer therapy.

With regard to *Solanum* spp. (nightshade species), the reports primarily concerned black nightshade (*Solanum nigrum*) and Jerusalem cherry (*Solanum pseudocapsicum*). Black nightshade grows as a weed in gardens, including vegetable gardens, and fields. Black nightshade berries are the same size as peas and can therefore easily be mistaken for peas. In the Netherlands, the Jerusalem cherry is primarily kept as an indoor plant and has bright orange toxic berries.

In addition to reports of the ingestion of toxic plants and plant parts, there were also reports of the effects of plant parts coming into contact with the skin or the eyes. These primarily related to plants from the arum (*Araceae*) and spurge (*Euphorbia* spp.) families. Plant species from the arum family include *Spathiphyllum* spp., *Arum* spp., *Zamioculcas* spp. and *Anthurium* spp. These plants contain irritating substances, primarily in the sap.

In the US, more than 100,000 incidents are reported to poisoning centres each year involving exposure to toxic plants (Froberg et al., 2007). As in the Netherlands, these often involve the ingestion of small quantities with minimal toxicity. Severe effects can occur following deliberate ingestion due to the supposed medicinal properties of the plant, ultimately leading to toxicity.

9.4.2 Toxic substances in plants

Froberg et al. (Froberg et al., 2007) and Furbee and Wermuth (Furbee & Wermuth, 1997) describe the most important substances with toxic properties and the plants that contain them: toxalbumins (ricin, abrin), cicutoxins, glycosides that affect the heart, grayanotoxins (in rhododendrons and azaleas, among others), veratrum alkaloids, aconitine (in monkshood, for example), nicotine and related substances (pyridine and piperidine alkaloids), anticholinergic substances (in the *Solanaceae* family, among others: atropa, satura and hyoscyamus produce hyoscyamine (atropine), other plants produce scopolamine), saponin glycosides, catechol phenols and non-catechol phenols, and oxalates.

Hundreds of pyrrolizidine alkaloids have been identified in more than six thousand plants from the Boraginaceae, Compositae and Leguminosae families. Approximately half of these pyrrolizidine alkaloids are toxic. As well as hepatotoxic effects, pyrrolizidine alkaloids also have genotoxic and carcinogenic properties (EFSA CONTAM Panel, 2011). Due to the multitude of plants and the widespread distribution of these toxic plants, they constitute a threat to the health of humans and animals (Stegelmeier et al., 1999).
Kristanc and Kreft (Kristanc & Kreft, 2016a) have identified European medicinal and edible plants that are associated with subacute and chronic toxicity and have created a list of plants with hepatotoxic, neurotoxic and immunotoxic effects (Kristanc & Kreft, 2016b). The main effects are liver toxicity from pyrrolizidine alkaloids, nephrotoxicity from aristolochic acids, lathyrism (a neurological disease) related to the neurotoxin swainsonine, thiamine depletion, thyroid abnormalities and the immunosuppressive effect of cannabinoids. Neurotoxins often induce acute toxicity. Neuroactive alkaloids such as tropane alkaloids and nicotine bind to receptors of neurotransmitters such as acetylcholine and serotonin. Some alkaloids can inhibit enzymes that break down neurotransmitters such as cholinesterases and monoamine oxidases.
The authors describe plant species with chronic hepatotoxic potential and their active substances (Kristanc & Kreft, 2016b). A large number of such species exist.

9.4.3 Hazard characterisation

The NVIC keeps a database with extensive information about plants, toxic effects of the substances in these plants, clinical pictures and descriptions of acute poisoning cases (https://www.vergiftigingen.info). Several examples are given below, along with information from the NVIC database or website.

Taxus
The leaves of the yew tree (*Taxus baccata*), particularly older leaves, contain the highest concentrations of taxine: up to 2%. The hydrocyanic acid concentration in young leaves is 20 mg per kg fresh weight; in older leaves, the concentration is approximately double this amount. Systemic effects arise within one to three hours after ingestion. Initial effects may consist of dizziness, dry mouth and mydriasis (dilation of the pupil of the eye) (usually within one hour after ingestion) and may be followed by abdominal cramps, hypersalivation and vomiting. Reddish-purple spots may also appear on the skin. The patient may then become weak and develop convulsions and may become comatose. During severe cases of poisoning, the patient can die within 30 minutes to 24 hours after ingestion of the plant material, as a result of heart and/or respiratory failure.
The felling and sawing of yew wood can cause severe contact dermatitis, while the inhalation of yew sawdust can cause headaches. A severe acute anaphylactic reaction occurred following the ingestion of 4–5 leaves by a 15-year-old. The leaves, seeds and bark of yew trees, but not the berries, contain a complex blend of more than 350 different yew pseudo-alkaloids. Most yew pseudo-alkaloids are polyhydroxy diterpene esters. These are taxine-derived alkaloids (taxines,

syn. taxicines). Other yew pseudo-alkaloids, the taxanes, have a skeleton derived from pentamethyl tricyclo-pentane decane (taxane) (NVIC database).

Prunus
The pits or kernels of *Prunus* species contain cyanogenic glycosides. These are compounds that are released via thorough chewing or grinding of the pit and can be converted to cyanide in the gastrointestinal tract. Ingestion of a large number of chewed or ground pits or kernels can lead to symptoms of poisoning. Mild cases of poisoning mainly cause gastrointestinal complaints, sometimes accompanied by headaches and confusion. Severe cases of poisoning can lead to coma, respiratory depression and heart failure (NVIC, 2016). These pits and kernels are sometimes eaten as an alternative cancer therapy. However, if large quantities of bitter almonds or apricot kernels are ingested, it can cause a very severe case of cyanide poisoning.

Solanum
Solanum species contain solanum alkaloids. Ingestion of large quantities of solanum alkaloids can cause poisoning symptoms such as gastrointestinal complaints and neurological effects (headaches, dizziness, confusion, hallucinations) (NVIC, 2016).

Chrysanthemum
Poison from chrysanthemums is extracted from the flowers and used in insecticides, among other products. This poison (pyrethrum) has a lethal effect on insects. However, the active substance is quickly broken down when it comes into contact with sunlight. Some chrysanthemum species do not contain toxic substances and are edible for humans.

Ricinus communis
The fruits (seeds) of *Ricinus communis* (castor bean) contain a strong poison, ricin. In addition to ricin and the less toxic agglutinin, the plant contains another toxic substance: the piperidine alkaloid ricinine. The number of seeds that will cause mild to severe symptoms after ingestion varies from a few seeds to 30 seeds (Worbs et al., 2011). Symptoms include abdominal pain, diarrhoea, vomiting, muscle pain, cramps, circulatory problems, shortness of breath and dehydration.
Worbs and colleagues (Worbs et al., 2011) compiled a list of poisoning cases of humans and animals and concluded that accidental poisonings in humans had resulted in death in 1.5% of the cases. Poisoning occurs when people or animals chew seeds, releasing the toxins for absorption into the body.
Ricinus is also allergenic and can lead to severe anaphylactic reactions (Froberg et al., 2007). The most important allergenic proteins are 2S albumins (Worbs et al., 2011).

In summary, if irritants from plants come into contact with the skin or eyes, symptoms may arise such as redness, pain, inflammation and blistering of the skin, eye irritation, eye infection, corneal damage and temporary blindness. Substances in certain ornamental plants can lead to severe symptoms of poisoning when ingested by humans.

9.4.4 Herbal products and medicinal plants

Due to the presence of bioactive substances, many plants have been used for medicinal or other purposes since ancient times. Many herbal remedies are well known. The clinical use of digitalis (digoxin) in atrial fibrillation is a long-standing practice (Aronow, 1992). Oleanders contain cardenolides, which affect the hearts of humans and animals. These cardiotonic properties (i.e. improving the efficiency of the heart) can be harnessed for therapeutic purposes (Langford & Boor, 1996). The mechanism of action of cardenolides is similar to that of the digitalis glycosides (Langford & Boor, 1996).

Chinese *Aconitum* species, such as monkshood, are used in traditional Chinese medicine. The toxic substances are alkaloids, and the concentration determines the application (Bisset, 1981). Another example of a toxic alkaloid is coniine, a nicotinic acetylcholine receptor antagonist that shuts down the nervous system and leads to death from asphyxiation. The most famous victim of coniine ingestion is Socrates, who was forced to drain a poisoned chalice containing hemlock (*Conium* *maculatum* L.). There is renewed interest in this substance due to its medicinal use as a painkiller (Hotti & Rischer, 2017). In general, little is known about the toxicity of medicinal plants (Alonso-Castro et al., 2017).

Van Ingen and colleagues (Van Ingen et al., 1992) describe five cases of yew poisoning and point to the availability of Taxol®, a drug that contains the active substance paclitaxel, which is extracted from the bark of *Taxus brevifolia*. Paclitaxel belongs to a group of anti-cancer drugs called taxanes. These substances inhibit the growth of cancer cells[68].

9.4.5 Conclusions

- Substances in certain ornamental plants can lead to severe symptoms of poisoning when ingested by humans or animals.
- Ornamental plants are not intended for consumption by people or animals. Severe effects can occur following ingestion due to supposed medicinal properties or deliberate ingestion of toxic substances from the plant. Children are a risk group due to their inquisitive behaviour.

9.5 Contact with ornamental plants

Plants in our living environment can contribute to the onset of asthma and allergies. Proteins in pollen can act as allergens (Traidl-Hoffmann et al., 2003). A number of ornamental plants (including ornamental trees) produce pollen grains with allergenic[69] properties and thus constitute a potential risk to human health. Pollen allergy or hay fever, also known as allergic rhinitis[70], is one of the most common allergies. The Dutch College of General Practitioners (NHG) describes allergic rhinitis as immunoglobulin E (IgE)-mediated inflammation (an immunological reaction) of the nasal mucosa due to hypersensitivity to allergens (Dutch College of General Practitioners, second amendment, 2019). Allergic rhinitis is a risk factor for the development of asthma. Approximately 15–40% of patients with allergic rhinitis also have asthma (Leynaert et al., 2000).

According to the NHG, the most significant allergens are tree pollen (particularly birch pollen; present in the air from February to late July) and grass pollen (in the air from early April to November). Birch pollen can lead to cross-reactivity to nuts and apples, while grass pollen can lead to hypersensitivity to carrots. As well as its allergenic effect, pollen can also have pro-inflammatory and immunomodulating effects.

Contact with plants or plant parts such as stinging nettle can lead to a non-immunological reaction (Schempp et al., 2002). Stinging nettles contain histamine, acetylcholine and serotonin. The leaves and stems of the plant are covered with stinging hairs that break off easily. When someone comes into contact with these stinging hairs, the hairs emit the substances listed above, which cause a burning or stinging sensation and a skin rash.

In 2007, the Health Council of the Netherlands published a report (Health Council, 2007) about the extent of the role of environmental factors, including pollen, in the onset and increase of asthma and allergies. Asthma is a chronic condition that is associated with hypersensitivity of the airways to stimuli and a chronic inflammatory response by the airways[71] (Dutch College of General Practitioners, 2019).

9.5.1 Allergenicity

The consumption of ornamental plants can lead to new food allergies. An allergy to inhaled pollen manifests in the lungs, nose or eyes. The symptoms of hay fever can therefore include sneezing, a

[68] Medicines Evaluation Board (MEB) Medicines Information Bank: https://www.geneesmiddeleninformatiebank.nl/en
[69] An allergen is a substance that triggers an allergic reaction.
[70] Rhinitis is the scientific term for inflammation of the nose and nasal mucosa.
[71] Asthma is a lung condition characterised by attacks of acute bronchial obstruction based on increased sensitivity of the airways to allergic (IgE-mediated) and non-allergic stimuli (exertion, smoke, fine particles, mist, cold, viral infections), with a chronic inflammatory response as a pathological substrate (NHG Standard Asthma in Adults).

runny nose, red eyes with an itchy or burning sensation, a swollen throat, watery eyes, swollen eyelids, poor sleep, headaches and concentration problems (van Dijk et al., 2009). The symptoms can vary from year to year in both strength and type, depending on the amount of pollen in the air. If the pollen comes into contact with the mucous membranes of the eyes, nose, mouth, throat or windpipe, the mucous membranes become stimulated and irritated. Hay fever/rhinitis or asthma can have a significant impact on quality of life due to sleep issues and restrictions on daily activities and sport, and there is no cure.

9.5.2 Prevalence

Based on the registers from five general practices, the number of people with asthma in the Netherlands in 2003 was estimated at nearly 520,000 (Health Council, 2007). In 2015, there were an estimated 613,500 people with asthma who had received care for their condition from a general practitioner or whom the general practitioner knew were receiving care (Volksgezondheidszorg.info, 2019).

In the Dutch general practice registers, the prevalence of patients with hay fever/allergic rhinitis in 2017 was 51.9 per 1,000 patients (NIVEL, 2019). The condition is slightly more prevalent among women than among men: 53.1 and 44.1 per 1,000 patients respectively. The incidence increases until the age of 19 to 24 years, after which it gradually decreases. Rhinitis is probably under-reported by general practitioners. In studies in the general population into the prevalence of allergic rhinitis (diagnosed on the basis of a questionnaire and a positive skin prick test[72]), the prevalence was found to be between 230 and 300 per 1,000 patients (Blomme et al., 2013; Gronhoj Larsen et al., 2013).

9.5.3 Exposure

Green spaces in cities are important concepts in urban planning. City parks contribute to citizens' well-being and quality of life. The same is true of plants in offices, which are intended to improve the indoor climate[73]. However, some trees and plants cause allergic reactions in sensitive people, impacting their quality of life.

Examples of studies into the allergenicity of plants in green spaces

A comparative study of the ecological and aerobiological properties of urban ornamental flora in four Andalusian cities (in southern Spain) showed that more than a hundred allergenic ornamental plant species were present (Velasco-Jimenez et al., 2015). The researchers recommended that, when new city parks and gardens are being created, the planners should ensure variability of species and avoid excessive use of any one species.

Maya-Manzano et al. (Maya-Manzano et al., 2017) assessed the concentration and distribution of *Platanus* pollen in the air in five cities on the Iberian Peninsula. The researchers found differences in pollen concentrations that were related to the degree of ripeness of the pollen, the distance from the spore falls and the number of plane trees.

Cariñanos et al. (Carinanos et al., 2016) characterised the most important tree species that contributed to the pollen spectrum during the year in a number of cities in southern Spain. These researchers used an index to quantify the allergenicity of city parks in southern Spanish cities. The index was applied to 26 green spaces in 24 Spanish cities. The percentage of allergenic species in each park was calculated and varied from 6% to 17%. Using this index value, 12 parks were considered to be unhealthy throughout the entire year. The researchers recommended that measures be taken to control pollen emissions, prevent high allergen concentrations and improve city air quality.

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[72] A skin prick test is used to determine whether there are any indications that the person is hypersensitive to particular substances. A strip of plaster with numbers on it is applied to the forearm. Beside each number, a drop of liquid is applied and the skin is lightly punctured.

[73] https://www.wur.nl/nl/Dossiers/dossier/Effect-van-natuur-op-gezondheid.htm

In Serbia, a study was conducted into the toxic and allergenic plants to which children from eight primary schools and six kindergartens/preschools were exposed. The study identified 21 allergenic plant species, mainly from the genera *Acer*, *Tilia*, *Betula*, *Populus*, *Platanus*, *Celtis*, *Aesculus*, *Thuja*, *Ulmus*, *Robinia* and *Quercus*, represented by 675 specimens (Mrđan S, 2017). Based on an allergen index devised by the researchers, most of the species examined were highly allergenic.

Cypress trees (*Cupressus sempervirens*) have grown in southern Europe since ancient times, but it was not until 1945 that an allergy to cypress pollen was first reported. The first cases in France were published in 1962. There appears to be an upwards trend in sensitivity that corresponds to the increasing use of cypresses as ornamental plants and as windbreak and hedging plants. In Italy, for example, the prevalence of cypress allergies increased from 10% in 1991 to 35% in 1994. Part of that increase can probably be attributed to improvements in diagnosis. Timely pruning before pollination is one of the possible measures for reducing the amount of pollen (Charpin et al., 2005). An Italian study at 12 research centres involving 3,057 patients who were sensitised to pollen found positive skin tests for a range of Cupressaceae and Taxodiaceae species in 18% of the people studied. This percentage varied from 9.2% in northern Italy to 20.1% in southern Italy (Fiorina et al., 2002). Sick trees produce two to three times more pollen than healthy trees. Pruning hedges and hedgerows in the autumn removes the male cones (Charpin et al., 2005) and reduces the amount of pollen in the air.

Indoor plants
The relationship between having indoor plants and the risk of being sensitised to pollen was studied in 59 people with atopic rhinitis and 15 control subjects. None of the control subjects had a positive skin prick test, but 78% of the people with allergic rhinitis had a positive reaction to at least one plant. The most frequent sensitisation was observed for *Ficus benjamina*, yucca, ivy and palm trees (Mahillon et al., 2006). Indoor plants can therefore be a potential source of allergens for people with allergic rhinitis.

The prevalence of sensitivity to *Ficus benjamina* and the relationship with a latex allergy was investigated by Hemmer et al. (Hemmer et al., 2004) in 2,662 patients with a positive skin prick test for airborne allergens (atopic people), 2.5% reacted to *Ficus benjamina*. Sensitivity to *Ficus benjamina* was associated with a positive skin prick test for fresh fig (82%), dried fig (37%), kiwifruit (28%), papaya (22%), avocado (19%), banana (15%) and pineapple (10%). Thiol proteases play a role in this ‘Ficus-fruit syndrome’ (Hemmer et al., 2004).

Aydin et al. (Aydin et al., 2014) studied 150 patients with asthma and/or allergic rhinitis and 20 healthy control subjects. They performed skin prick tests with standardised inhalation allergens from the leaves of 15 ornamental plants. The tests were positive in 80 patients (47%), predominantly allergic people, people with allergic rhinitis and a food sensitivity and people with exposure to plants in their home, but not in patients with a pollen and latex allergy. The most sensitising ornamental plants were *Yucca elephantipes* (53%), *Dieffenbachia picta* (51%) and *Euphorbia pulcherrima* (48%). There was a significant correlation between owning *Saintpaulia ionantha*, crotons, *Pelargonium* or *Y. elephantipes* plants and having a positive skin prick test for these plants. Atopy and food sensitivity were risk factors for the development of sensitivity to indoor plants.

Cut flowers
Allergic reactions can occur following contact with ornamental plants. Sesquiterpene lactones are found in sunflowers (*Helianthus annuus* L.), among other plants. Touching a sunflower can trigger the release of enough sesquiterpene lactones to sensitise a human. These substances have been responsible for cases of contact dermatitis in sunflower growers since 1906 (Hausen & Spring, 1989). Contact dermatitis caused by *Artemisia* and *Chrysanthemum* species has also been attributed to sesquiterpene lactones (Mitchell et al., 1971).

Lee et al. (Lee et al., 2007) studied the sensitisation and cross-allergenicity of pollen from chrysanthemums, dandelions and wormwood (mugwort), which all belong to the Compositae (Asteraceae) family, in 6,497 patients who had had skin prick tests over a 10-year period (1995–2005). Sensitivity to a single plant was seen in some cases, but in most cases, sensitisation to chrysanthemums or dandelions was seen in conjunction with sensitisation to wormwood (5% of the population).

Marsh and aquatic plants
No scientific literature on marsh or aquatic plants and allergies could be found.

Cosmetics
Plant extracts are used in cosmetics for their fragrance or their supposed positive properties. Examples include arnica, chamomile, yarrow, citrus extracts, ivy, aloe, lavender, peppermint, etc. (Schempp et al., 2002; Aburjai & Natsheh, 2003).
These plants contain sesquiterpene lactones or terpenes with a sensitising effect. Schempp et al. (Schempp et al., 2002) discussed various forms of phytodermatitis, including plant dermatitis, phototoxic and photoallergic dermatitis, allergic dermatitis and airborne contact dermatitis.

Agriculture and horticulture workers
Monso et al. (2002) studied the prevalence of work-related asthma and sensitisation to allergens in the workplace at a total of 39 greenhouse flower and/or ornamental plant growers. Sensitisation to flowers or fungi was found in 13 out of 38 growers, and one-quarter of the growers who were sensitised to flowers or fungi in the workplace had asthma. This means that 8% of the growers had asthma, which was nearly twice the prevalence in the general Dutch population (Monso et al., 2002).

Goldberg et al. (1998) studied whether ornamental plants cause skin reactions and allergic symptoms in 292 allergic city dwellers, 75 flower growers and 44 students. Skin prick tests for 11 species of plants belonging to the Asteraceae, Ranunculaceae, Liliaceae, Scrophulariaceae and Gentianaceae families were carried out. Positive reactions to the pollen of various ornamental plants were found in 17% of the allergic people and 23% of the students. The incidence among flower growers was significantly higher at 52% and even up to 83% for flower growers who were also sensitive to other allergens. All plants tested triggered a positive skin prick reaction in all groups of participants. However, in the flower grower group, approximately half reported worsening of their allergic symptoms. This was not the case in the other groups

De Jong et al. (1998) described 14 patients with symptoms caused by flowers. The symptoms varied from allergic rhinoconjunctivitis and asthma to urticaria (nettle rash or hives). Most of the patients worked in the flower industry. Skin prick tests were performed with pollen extracts from the 17 different flowers that are grown and sold the most in the Netherlands. Blood tests were also performed for mugwort, chrysanthemum and goldenrod. Cross-sensitisation to pollen from various members of the Compositae family (such as chrysanthemum and goldenrod) and pollen from the Amaryllidaceae family (alstroemeria and daffodil) was observed. Mugwort can be used as a screening test for a possible flower allergy. All patients were found to be sensitised to mugwort pollen. The researchers described 13 different flowers that caused an allergy (De Jong et al., 1998).

Groenewoud et al. (2002) studied the prevalence of work-related allergies to chrysanthemum pollen in 104 workers in greenhouses in the Netherlands in March and April 2000. Chrysanthemums are major cut flowers for Dutch exports. The number of allergic symptoms among workers in this industry also appears to be increasing. Skin prick tests were performed with pollen extracts from seven different members of the *Chrysanthemum* genus. Blood tests (radioallergosorbent tests; RASTs) were then performed to confirm the IgE-mediated reactions. Sensitisation to *Chrysanthemum* pollen was found in 20% of the workers. Respiratory atopy[74] and sensitisation to pollen in the air appeared to be closely related to sensitisation to *Chrysanthemum*. This could be evidence of cross-sensitisation.

[74] Atopy is a person's predisposition to make IgE immunoglobulins (antibodies) that specifically target innocuous substances present in the environment, such as house dust mites or pollen from grass or trees. Atopic diseases include hay fever, allergic asthma, rhinitis and conjunctivitis.

Exposure and allergy potential
Thompson & Thompson (2003) used the term 'urban jungle' for the plants, animals, insects and other organisms that live in urban areas. A key component of the urban jungle is the urban forest – the collection of trees, shrubs and other plants. In the selection and design of landscapes, the potential for triggering allergies was (and is) seldom considered. A person who is in the vicinity of a flowering tree may be exposed to 10,000 particles of pollen per cubic metre or more. A pair of alder trees can produce approximately 14 billion pollen grains in a 2-week period. Studies into the spread of pollen show that 99% falls within nine metres of the plant or tree. Approximately 30 pollen grains per cubic metre of air are required to cause an allergic reaction. An average person inhales 10 cubic metres of air per day. This results in the inhalation of 300–500 pollen grains per day, enough to cause an allergic reaction. The tree species that produce the most pollen are trees with catkin inflorescence. Catkins are highly suitable for being spread by the wind.

Radauer & Breiteneder (2006) created a classification system for plant pollen allergens based on their proteins (among other factors). Protein families were determined using the Allergome database, the Protein Families Database of Alignments and Hidden Markov Models. The taxonomic distribution of the pollen allergens was obtained from the Integrated Taxonomic Information System. This allowed the pollen allergens to be divided into 29 of the 7,868 protein families. Expansins, profilins and calcium-binding proteins can be found in the major families of pollen allergens. The allergens from food crops were prolamins, cupins or profilins (Radauer & Breiteneder, 2006). The database was last updated in September 2018 and included 17,929 protein families[75] (Finn et al., 2014). The classification of pollen allergens into protein families may help with the prediction of cross-reactivity, the design of more extensive diagnostic equipment and the assessment of the allergy potential of new proteins (Radauer & Breiteneder, 2006).

Pollennieuws[76] is a Dutch website that reports the daily pollen forecast for the Netherlands and related news items. The site also features a pollen calendar, showing the plants that can cause an allergic reaction and the months in which the most pollen is released. Up-to-date information about pollen load, the level of symptoms, forecasts and pollen counts can also be found at hooikoortsradar.nl.

The Ogren Plant Allergy Scale (OPALS, created in 2000) measures the allergy potential of garden and landscaping plants as well as trees. The scale was updated and expanded in 'The Allergy-Fighting Garden'[77]. More than five thousand plants have been evaluated against the scale. The safest, least-allergenic plants are given a score of 1, while the most allergenic get a score of 10. An example of a pollen-free tree with a score of 1 is the 'Autumn Glory' cultivar of the red maple. The most allergenic species is one of the pepper trees (without berries) with a score of 10.

9.5.4 Climate change
Since the industrial revolution, the emission of gases with a greenhouse effect and their concentration in the atmosphere have increased, with a steep rise in the past few decades. This has resulted in changes to the climate, which have affected biological systems and human health, among other things. A number of researchers have studied the impact on allergens and allergies. The specific plants or fungi and the extent of exposure to these allergens are determined by the local climate. Climate change has already had a significant effect on the distribution and quantity of allergens outdoors (Peden & Reed, 2010).

The increased CO_2 concentration and corresponding increase in temperature have affected the growth of plants. In the northern hemisphere, this has led to longer pollination periods and the emergence of certain neophytes or non-native species (plants that have become established in a country where they did not previously exist) with allergenic properties, such as *Ambrosia artemisiifolia* (common ragweed) (Behrendt & Ring, 2012). Ragweed is a highly allergenic plant that flowers late in the season (see www.pollennieuws.nl). Ragweed pollen concentrations in the

[75] http://pfam.xfam.org
[76] http://www.pollennieuws.nl
[77] http://www.allergyfree-gardening.com/opals.html

air were studied in France by Laaidi et al. (Laaidi et al., 2003) from 1987 to 2001. They found a statistically significant daily and yearly increase in the pollen concentration since 1987.

Lake et al. (Lake et al., 2017) attempted to quantify the effect of climate change on pollen allergies in humans using several models and a number of scenarios for climate change and the spread of the invasive plant species *Ambrosia artemisiifolia* in Europe. Estimates are that sensitisation to ragweed in Europe will more than double, from 33 to 77 million people in the period 2041–2060. The increase will occur in countries with an existing ragweed problem (such as Hungary), but the biggest increase will be seen in countries where the exposure to ragweed is still low, such as Germany and France. A higher pollen concentration and a longer pollen season may strengthen the severity of the symptoms. Rasmussen et al. (Rasmussen et al., 2017) studied three allergenic ragweed species (*Ambrosia* spp.) in Europe and their potential effect on health. Using models, the researchers estimated that, by 2100, the distribution would increase across northern and eastern Europe and that there would be 27–100% more 'high allergy risk' areas. To prevent this, measures must be taken to combat the spread of ragweed and reduce existing populations. In 2011, the Netherlands Food and Consumer Product Safety Authority (NVWA) started a campaign to eradicate the plant, in collaboration with other organisations.
Ragweed is given as an example here because it has been the subject of a relatively large amount of research. However, ragweed is not planted deliberately and is not considered an ornamental plant.

Bock et al. (Bock et al., 2014) studied the effect of climate change on the flowering periods of 232 plant species on the island of Guernsey. The researchers found flowering periods were starting significantly earlier, by an average of 5.2 days per decade since 1985. The length of the flowering periods was ten days shorter per decade on average. The earlier and shorter flowering periods could lead to a potentially serious effect on pollinators and thus threaten biodiversity and the agriculture and horticulture industries. On the other hand, a shorter pollen season could be an advantage for allergic people (Beggs, 2004). However, Katelaris and Beggs (Katelaris & Beggs, 2018) claim there is sufficient evidence that rising air temperatures and increasing CO_2 concentrations have resulted, in some plant species, in increased pollen production and allergenicity and an earlier and longer pollen season.

Accordingly, the effects of climate change may have an impact on plant growth, with pollen being produced at different times (Behrendt & Ring, 2012) and plants flowering earlier (Bock et al., 2014). For some plants or tree species, the pollen season may be longer; for others, it may be shorter.

9.5.5 Conclusions

- Ornamental plants in homes and in green spaces contribute to citizens' quality of life and well-being, and many people spend a lot of time in the vicinity of ornamental plants.
- Ornamental plants, and particularly their pollen, can cause allergic reactions.
- Hay fever is one of the most common allergies. Hay fever is a form of allergic rhinitis that is characterised by an allergy to the pollen of grasses, plants and trees. Around 5–30% of people suffer from allergic rhinitis. The amount and type of pollen from ornamental plants and the exposure to that pollen determine the allergenic effect on humans.
- The symptoms of hay fever include sneezing, a runny nose, red eyes with an itchy or burning sensation, a swollen throat, watery eyes, swollen eyelids, poor sleep, headaches and concentration problems. The symptoms can vary from year to year in both strength and type, depending on the amount of pollen in the air.
- Allergy-free and low-allergen ornamental plants exist. Within a species, sterile cultivars can occur that do not produce pollen. These are usually not labelled as such. In the future, serious thought will have to be given to allergy-free or allergy-friendly landscapes with non-allergenic or low-allergy alternatives and measures to control pollen emissions.
- The effects of climate change can have an impact on plant growth, with plants flowering earlier and pollen being produced at different times and for longer or shorter periods than in the past.

- Allergic reactions can also occur following contact with ornamental plants. This can be a particular problem for people who work in the ornamental horticulture sector or when plant extracts are incorporated into cosmetics.
- Eating ornamental plants can lead to new food allergies.

10 Glossary for the ornamental horticulture production chain risk assessment

10.1 Plant health

Term	Definition
Active substance	Component or components in a plant protection product that are responsible for the effect (Ctgb, 2015a).
Biocides	Substances or mixtures that: - contain or generate one or more active substances; and - are intended to destroy, repel, render harmless or prevent harmful or unwanted organisms, ranging from bacteria and viruses to fungi and rats (Ctgb, 2018a). Biocides are divided into 22 product types, split across 4 groups. One of those groups is disinfectants (Ctgb, 2018d).
Containment	The application of phytosanitary measures in and around an infested area to prevent spread of a harmful organism (FAO, 2016a).
Cultivar	A unit within a cultivated plant species, also known as a ‘variety’ (see (Waller et al., 2002)).
Damage	Reduction of the normal growth and/or development of plants as a result of the presence of a harmful organism on or in the plant (Zadoks & Schein, 1979).
Designated area (*Meloidogyne*)	Area where there has been an official finding of *Meloidogyne chitwoodi* or *M. fallax* , designated (demarcated) by the NVWA (NVWA, 2018f).
Dipping bath	A container of liquid (to which a solution or dilution of one or more plant protection product(s) may be added) in which to dip planting material or seed potatoes, with the aim of rendering harmless any harmful organisms that may be present in or on the planting material or seed potatoes or protecting the planting material or seed potatoes from an ongoing infestation or infection with harmful organisms.
Disinfect	To remove harmful organisms or render them harmless, with the aim of preventing infection or preventing the spread of infection (Ctgb, 2015a).
Disinfectants	Chemicals with a disinfectant effect. This group of biocides comprises five product groups: 1. biocides for human hygiene; 2. disinfecting agents for private use and for public health care and other disinfecting biocides; 3. biocides for veterinary hygiene purposes; 4. disinfectants for use in food and animal feed; 5. disinfectants for drinking water (Ctgb, 2015a).
Effective package of products and measures	An effective package of products and measures means that sufficient products and measures are available to control diseases, pests and weeds on a cultivated site in a way that is effective from an agricultural technology standpoint (which also means it must be cost-effective), including responsible resistance management (NVWA, 2018e).
Export control	Official procedure for export of consignments to countries outside the European Union to establish that the requirements of the importing country have been met.

Term	**Definition**
Export loss	Economic value of reduced export of products due to the presence of a harmful organism within the territory of the exporting country.
Fungicide	A chemical that kills fungi – an anti-fungal agent (Ctgb, 2015a).
Genetic resources	Genetic resources are genetic material of actual or potential value. Genetic material means any material of plant, animal, microbial or other origin containing functional units of heredity (UN, 1992).
Genus-origin-combination	A criterion for classifying plant lots of the same taxonomic genus imported from the same country or region
Harmful organism	Any species, strain or biotype of plants, animals or pathogens injurious to plants or plant products (Regulation 2016/2031); FAO, 2016a).
Herbicide	A product to kill or control weed (Ctgb, 2015a).
Hitchhiking	The movement of a harmful organism via means or materials other than host plants or natural spread.
Host	An organism (individual or species) in or on which another organism or a virus finds the elements and conditions it needs for growth (and reproduction). If the host is a plant, the preferred term is 'host plant' (Bos et al., 1985).
Host plant	See: Host
Import control	Official procedure for import of consignments from countries outside the European Union to establish that the requirements of Regulation 2016/2031 are met. The procedure comprises physical inspections, document checks and identity checks.
Incidence	The percentage or the number of units of a lot, area or sample infested by a harmful organism (FAO, 2016a).
Infest/infect	The establishment and spreading of a parasite or phytophagous organism in or on the host (Bos et al., 1985).
Infestation/infection	Infesting/infecting or being infested/infected. Infestation by a pathogen is known as 'infection' and does not necessarily result in damage or disease symptoms (Bos et al., 1985).
Insecticide	A substance that kills insects and arthropods – a chemical or non-chemical product for the control of insects (Ctgb, 2015a).
Inspection	Official visual assessment of plants, plant products or other objects to establish whether harmful organisms are present (FAO, 2016a). During an inspection, samples may also be taken so that a test can be conducted to detect the presence of one or more harmful organisms.
Integrated pest management (IPM)	The careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimise risks to human health and the environment (Directive 2009/128/EC and the Plant Protection Products and Biocides Act (Wgb)). The definition in Directive 2009/128/EC continues: "Integrated pest management emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms."
Integrated plant protection	See: integrated pest management

Term	Definition
Interception	The detection of a harmful organism in a consignment during import control (FAO, 2016a).
Introduction	The entry of a harmful organism in an area, resulting in the long-term presence of the organism in the area (FAO, 2016a). Introduction refers to both the entry and establishment of a harmful organism in an area (FAO, 2017).
IPPC	International Plant Protection Convention, an international treaty under the Food and Agriculture Organisation of the United Nations for international cooperation with the aim of preventing and controlling the introduction and spread of harmful organisms.
Laboratory test	A test performed in a laboratory.
Loss	The economic value of damage (Zadoks & Schein, 1979).
Metabolite	Chemical conversion product created by the metabolic degradation of the parent substance (Ctgb, 2015a).
Nematicide	A substance that kills nematodes – a nematode control product (Ctgb, 2015a).
Neonicotinoid	A group of active substances (insecticides) related to nicotine.
NL-provisional Q-pest	A harmful organism that is not listed in Annex II of Commission Implementing Regulation 2019/2072 and for which no temporary measures have been established by an implementing act of the Commission, but for which official phytosanitary measures are in place in the Netherlands, usually in response to a previous finding or interception of the organism or a request from a company or institution for permission to work with an organism from outside the European Union.
Notification of interception	A 'notification of interception' is sent by an importing country to an exporting country if an exported consignment does not comply with the requirements set out in the phytosanitary certificate, for example if the consignment proves to be infested by harmful organisms (FAO, 2016b).
Official	Established, authorised or performed by the national plant protection organisation' (FAO, 2016a). The NVWA is the national plant protection organisation of the Netherlands.
Package of plant protection products	The set of plant protection products authorised by the Ctgb for the Netherlands for a defined activity (such as the cultivation of lilies, the cultivation of floristry plants (protected cultivation) or the Dutch agriculture and horticulture industries).
Pathotype	A unit within a species (mainly used for fungi) that is distinguished not on the basis of morphological characteristics, but on the formation of symptoms in a set of plant cultivars of one or more host plant species (see (Bos et al., 1985)).
Pest	See: Harmful organism.
Phytophagous organism	An organism that feeds on living plant tissue (Bos et al., 1985).
Phytosanitary certificate	An official paper document or its official electronic equivalent, consistent with the model certificates of the IPPC (International Plant Protection Convention), attesting that a consignment meets phytosanitary import requirements (FAO, 2016a).
Phytosanitary measure	Any legislation, regulation or official procedure having the purpose to prevent the introduction or spread of quarantine pests, or to limit the economic impact of regulated non-quarantine pests (FAO, 2016a).

Term	Definition
Plant-organism-combination	The specific combination of one species of harmful organism and one species of host plant, for example to formulate a tolerance limit for the degree of contamination of a consignment of that host plant.
Plant passport	An official label indicating that the phytosanitary standards and the special requirements for the movement of plants within the EU, laid down in Regulation 2016/2031, have been met and which, to that end, is: - standardised at the community level for different types of plants or plant products; and - prepared by the responsible official body in a Member State and issued in accordance with the implementing rules governing the details of the procedure for issuing plant passports (Regulation 2016/2031).
Plant pathogen	A harmful organism that is not an animal.
Plant protection product	A product, in the form in which it is supplied to the user, consisting of or containing active substances, safeners or synergists, and intended for one of the following uses: a) protecting plants or plant products against all harmful organisms or preventing the action of such organisms, unless the main purpose of these products is considered to be for reasons of hygiene rather than for the protection of plants or plant products; b) influencing the life processes of plants, such as substances influencing their growth, other than as a nutrient; c) preserving plant products, insofar as such substances or products are not subject to special community provisions on preservatives; d) destroying undesired plants or parts of plants, except algae, unless the products are applied to soil or water to protect plants; e) checking or preventing undesired growth of plants, except algae, unless the products are applied to soil or water to protect plants (Regulation (EC) No 1107/2009).
Potato cultivation prohibition area	Demarcated areas in the Netherlands where large amounts of propagating material are grown and where the cultivation of potatoes is prohibited (NVWA, 2018j).
Quarantine pest (EU quarantine pest)	A harmful organism with an established identity that is not present in the EU or if present not widely distributed, is capable of entering into, becoming established in and spreading within the territory and its entry, establishment and spread would have unacceptable consequences and is listed in Annex II of Commission Implementing Regulation (EU) 2019/2072 (Regulation 2016/2031, Article 4), or for which temporary measures apply via an implementing act of the Commission (Regulation 2016/2031, Article 30). Note that, according to Regulation 2016/2031, only the organisms listed in Annex II of Commission Implementing Regulation 2019/2072 are EU quarantine pests.
Range of host plants	The list of known host plants of an organism.
Regulated non-quarantine pest (RNQP)	A non-quarantine pest that is regulated for propagating material (and other plants for planting) of certain plant species that is placed on the market (FAO, 2016a).
Regulated organism	A quarantine pest, NL-provisional Q-pest or regulated non-quarantine pest (FAO, 2016a).
Residue	Residual amount of the active substance of a plant protection product or a harmful metabolite thereof, which is found on or in a product, plant, water or the soil after application of the plant protection product (Ctgb, 2015a).

Term	Definition
Resistance (against harmful organisms)	Genetically determined reduced susceptibility of a plant population to damage by a harmful organism.
Resistance (against plant protection products)	Genetically determined reduced sensitivity of a population of a harmful organism to a plant protection product.
Soil disinfectant	A plant protection product for soil or soil treatment specifically intended to control the harmful organisms in the soil. This product is often primarily aimed at controlling nematodes (Ctgb, 2015a).
Spread	Expansion of the geographic distribution of a harmful organism in an area (FAO, 2016a).
Symptom	A sign indicating the presence of a harmful organism.
Test	An official assessment, other than a visual assessment, of plants, plant products or other objects to assess whether harmful organisms are present (FAO, 2016a).
Thrips damage	Thrips damage is damage resulting from the boring and scraping action of the conical jaws of insect species in the *Thrips* genus on plant leaves.
Tolerance level	Incidence of a pest specified as a threshold for action to control that pest or to prevent its spread or introduction (FAO, 2016a).
Variety	See: cultivar
Visual assessment	Physical examination of plants, plant products or other objects with the naked eye, a magnifying glass, stereoscope or microscope to detect harmful organisms, without carrying out tests (FAO, 2016a).
Yield loss	See: damage
Zero tolerance	For a harmful organism or a residue: the requirement that the organism or the substance must not be found in a lot or sample.

10.2 Cultivation

Term	Definition
Breeding	All actions that lead to improvement of the genetic characteristics of cultivated plants.
Consumer	End user of an end product. The final stage in a production chain.
Consumption	End use of the product, which may take a range of forms: food, placement of plants in a private garden or private protected space, processing of plants for decoration, etc.
Crop rotation	The chronological order in which plants in a growing plan are grown on a single piece of land.
Disease finding	Finding and removing diseased plants in a crop.
Dry sale	Flower bulbs intended for garden use by the consumer or for planting in public spaces.
End use	See: consumption
End product	Harvested product of a crop, intended for consumption.
Food plant	Plant intended for use as food.
Forcing	Commercial process in which flower bulbs (primarily tulips) are brought into bud or bloom, with the aim of selling the flower bulbs in a pot or selling the flowers as cut flowers. Forcing is performed at a forcing nursery.

Term	Definition
Growing plan	The distribution of plants across the available plots on a farm.
Ornamental plant	A plant intended for planting for decoration, including turf intended for planting.
Planting material or seed potato	See: propagating material
Pre-treatment	Treatment of propagating material prior to the cultivation of end products. See: dipping bath
Propagating material	Plants or plant material intended for use as seeds, seed potatoes or planting material. A synonym of reproductive material.
Propagation	Production of new propagating material (seeds, seed potatoes or planting material) for the cultivation of end products. Propagation techniques include seed cultivation, producing cuttings, grafting, in-vitro culture and tissue culture.
Reproductive material	See: propagating material
Residual flow	By-products and waste generated at a stage in a production chain.
Subsequent crop	The next crop to be grown on a particular plot after the current crop has been harvested.
Tissue culture	Tissue culture is a method of propagating plants under sterile conditions and is often used to produce clones of a plant.

10.3 Medical

Term	Definition
Burden of disease	The burden of disease is the extent of the loss of health within a population caused by disease. The burden of disease is expressed in DALYs (Disability-Adjusted Life Years). DALYs quantify the loss of health and are made up of two components: the years of life lost due to premature mortality and the years lived with a disease.
Immunocompromised	The group of immunocompromised patients consists of: - patients with congenital immunodeficiencies; - patients with longstanding neutropenia; - patients with an HIV infection and a low CD4 count (<200); - patients who have had an allogeneic haematopoietic stem cell transplant; - patients taking immunosuppressive medication, for example after an organ transplant (Van der Eerden, 2011).
Opportunistic pathogen	A microorganism present on or in a human body without causing any harm and that presents no health risk unless the body’s immune system fails (O'Toole, 2017).

10.4 Other

Term	Definition
Environmental quality standard	Environmental quality standards focus on the protection of general environmental quality within statutory frameworks.

Term	Definition
	There are environmental quality standards for substances in surface water, groundwater, sediment, soil and the air.
Handling	Treatment of the product without significant alteration. This includes washing and packing.
Third country	A country that is not a member of the European Union.
Third-country requirement	Requirements imposed by third countries on consignments from other countries.

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