



PBL Netherlands Environmental  
Assessment Agency

# A CLOSER LOOK AT INTEGRATED PEST MANAGEMENT

*Interim assessment of the policy  
document 'Healthy Growth,  
Sustainable Harvest'*





# **A closer look at integrated pest management**

Interim assessment of the policy document 'Healthy Growth, Sustainable Harvest'

PBL Netherlands Environmental Assessment Agency

**A closer look at integrated pest management. Interim assessment of the policy document 'Healthy Growth, Sustainable Harvest'**

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MAIN FINDINGS

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# Main findings

In the policy document ‘Healthy Growth, Sustainable Harvest’ (EZ, 2013), the Dutch Government presented its crop protection policy for the 2013–2023 period.

The government’s ambition is to make the crop protection practice more sustainable and to comply with international standards for the environment, food safety and working conditions by 2023.

The policy document contains interim targets for 2018. The policy aims to achieve these targets by means of so-called integrated pest management (IPM). This involves crop management in which chemical crop protection is kept to a minimum and crop production remains economically viable. Preventive measures, such as the use of resilient crops, form the basis for such a cultivation system. When pests and diseases need to be controlled, non-chemical methods are preferred, such as biological pest control.

The central question in this evaluation is whether the interim targets of the policy document have been achieved and what the policy and private parties have contributed, in this respect. This evaluation also examines a number of options for achieving the targets by 2023.

## The impact of current policies

**Many areas show a positive trend, but most of the targets have not been achieved**

Thanks to the efforts of the agricultural sector, buyers and government authorities, progress has been made in many areas. For example, fewer residues of plant protection products are found in food and the quality of surface water has improved.

Despite these improvements, the interim targets for integrated pest management, water quality, biodiversity and occupational safety have not been achieved. In most agricultural sectors, growers still use mainly chemical plant protection products to control pests and diseases. As a result, and as a result of fragmentation of the landscape, biodiversity in the agricultural area is under pressure. In the case of surface water, the water quality standards are exceeded more often than was intended in the policy document. Finally, growers and the government have not yet paid enough attention to the occupational risks associated with working with plant protection products. The objective of improving the competitive position of Dutch agriculture and horticulture by reducing the number of crop-pest combinations for which no crop protection product or non-chemical method is available (so-called crop protection bottlenecks) could not be tested. This is because these bottlenecks

are not registered in an objective and systematic manner. However, although the costs for growers to comply with the crop protection policy have increased slightly, the differences with other countries have become less.

### As yet, no fundamental steps have been made towards a system based on integrated pest management

Growers in almost all sectors use measures to prevent pests and diseases. The focus is on choosing resistant crops and checking plants and seeds for contamination and infestation. However, not all growers can opt for resistant crops; the market often selects on the basis of other factors such as taste, shelf life and appearance. In addition, there are limitations because traditional cultivation is slow and new techniques, such as CRISPR-Cas, are less socially acceptable.

The fundamental step towards resilient cultivation systems in combination with increased use of natural pest control is made only to a limited degree. In the policy period, the area of field margins has declined, which is unfavourable for natural pest control. As a result of these factors, crops remain vulnerable to pests and diseases and growers are unable to reduce the use of plant protection products. Growers often do not opt for products and techniques with a relatively low risk to the environment or human health. There is no incentive for them to do so. Non-chemical methods such as biological pest control and mating disruption are used more often in greenhouse horticulture and fruit cultivation than in arable farming.

### Ecological quality of surface waters has not improved sufficiently

In 2017, the number of cases in which the water quality standards for surface water under the Water Framework Directive were exceeded were reduced by 15%, compared to 2013. The interim target set in the policy document (50% fewer exceedances) had not yet been achieved by 2017. An important reason for this is that the water quality standards used for the approval of active substances are less strict than the water quality standards under the Water Framework Directive. In addition to the water quality standards in the Water Framework Directive, however, the water quality standards used in the approval of active substances were also exceeded. This may indicate that growers do not always follow the instructions on the label. But there are also shortcomings regarding the Dutch authorisation of plant protection products. Contrary to the approval of active substance at the EU level, it does not consider losses caused by drainage and surface run-off. Moreover, the Dutch authorisation assumes a broader crop-free zone than prescribed in the European approval of substances.

### Biodiversity under pressure in agricultural areas

Both the numbers and species diversity of wild bees and other flying insects have decreased. This decline is probably caused by a combination of factors, including intensification and scaling up in agriculture, the emergence of exotic species such as the Varroa mite, climate change, eutrophication and the use of insecticides.

The availability of natural pest control is important for integrated pest management. It may lessen the pressure on crops caused by pests. For the time being, the conditions for natural pest control do not seem to be improving; the area of flowering field margins has decreased, over the 2013–2018 period. The lack of a financial incentive for farmers that would encourage agricultural biodiversity has been important, in this respect. A different national approach to the Common Agricultural Policy (CAP), whereby priority is given to the creation of field margins, may help.

It is as yet unclear whether the EU decision in 2013 to substantially reduce the use of three neonicotinoids and fipronil has had a positive impact on biodiversity. However, it is clear that the use of other insecticides has increased since 2013. The level of this increase is determined by the available range of plant protection products, with only a limited number of low-risk products available on the market. In addition, growers are less likely to switch to alternatives if conventional and trusted products remain available. They often consider alternatives to be less effective. Moreover, alternatives are often more expensive.

### Food has become safer

The European Commission has set legal levels for the maximum amount of residues of plant protection products that a food product may contain, the MRLs. The share of exceedances of the maximum residue levels in Dutch food has decreased since 2010; the objective of the ‘Healthy Growth, Sustainable Harvest’ policy document, therefore, has been more than achieved. This applies especially to products of non-Dutch origin; the percentage of exceedances in Dutch products was already low. In the case of products originating outside the European Union, however, the number of exceedances varies from year to year. Monitoring, therefore, remains necessary. Regular inspections by the Netherlands Food and Consumer Product Safety Authority (NVWA) of food and food products from outside the European Union have increased slightly.

In addition to the government, buyers such as supermarket chains have also played an important role in improving food safety. Under the pressure of public opinion, they have imposed restrictions on the permitted amounts of residue in food that are more stringent than those prescribed by law. They also perform random checks on their products to look for certain residues of plant protection products. Buyers mainly set certain standards for end products and, to a limited extent, for their own production processes. However, more attention is currently being paid to environmentally friendly cultivation. For example, the agricultural and horticultural acreage under the PlanetProof label is increasing. This label requires growers to apply integrated pest management. Despite the recent increase in the acreage under PlanetProof, the total area under PlanetProof is still less than 10%.

### Too little priority is being awarded to the safe handling of plant protection products

Among growers, working safely with plant protection products still has low priority. Despite the availability of safe plant protection products, they still use products with an acute health risk (i.e. the products with the skull-and-crossbones symbol). This is partly

due to the fact that information on the toxicity of substances is not easy to understand or is difficult to access. In addition, a quarter of the growers do not inform their employees about the risks involved in working with plant protection products.

Lack of information mainly leads to risks for employees who do not handle the spray themselves but do work in recently sprayed crop fields. As a result, they are less aware of the fact that they may not enter the crop field directly after spraying and that they may need to protect themselves. For those who do spray (the so-called operators) this is less of a problem, as they must be in possession of a certificate of professional competence (spray licence) and are therefore better aware of the risks. An additional complication is that employees who work with the crops are often seasonal workers or workers who do not speak the Dutch language. Moreover, the government is not very actively involved, either; since 2013, the Inspectorate of Social Affairs and Employment (ISZW) has hardly carried out any inspections that were specifically aimed at the safe application of plant protection products.

### Costs are higher than in the countries surrounding the Netherlands, but differences have become smaller

The costs for growers to comply with crop protection policies have remained the same or increased slightly since 2010. As a result, growers are less able to control a number of diseases and pests than in neighbouring countries. This was particularly the case in so-called minor crops (i.e. crops covering a small area) and in crops specifically grown in the Netherlands. The costs for growers are slightly higher than in neighbouring countries, but due to harmonisation of the authorisation policy for plant protection products, the differences have been reduced since 2010.

## Options for achieving the main targets

With the current policy effort, it is unlikely that targets will be achieved by 2023. The summary presents a number of options that could increase the likelihood of those targets being achieved by 2023.

### Policy integration is needed in order to bring targets closer within reach

In order to achieve the targets for water quality and biodiversity, the emissions to surface water and the environmental impact on land both need to be reduced. It is also necessary to create habitats for bees and biological pest control species, for example by creating flowery field margins.

Water quality can be improved by implementing emission reduction measures that go further than those set out in the policy document. The condition is that the emission-reducing measures are not, as is currently the case, nullified by easing the authorisation policy. However, emission policy is of little effect for bees and pest control species. The reason is that natural pest control species and pollinators also live on or directly next

to fields where plant protection products are applied. It is therefore necessary for growers to also reduce the environmental impact on and directly around the field. The government could achieve this by setting a cap on the total use of plant protection products in a crop. This cap – if based on the total environmental impact of products – could prevent harmful products from being replaced by other harmful products, as is currently the case. The more limited scope for the use of plant protection products that this creates could encourage growers to look for alternatives such as preventive measures and non-chemical methods. But these do need to be available. That is why more effort is needed from the government and the sector to stimulate research into alternatives.

### Integrated approach is promising yet costly

Region-specific or sector-specific projects are likely to improve water quality and achieve agricultural biodiversity targets. This is especially the case if they increase the awareness of growers through intensive support and by discussing the results of environmental quality monitoring with those growers. In addition, subsidy possibilities may help growers to take measures that go beyond statutory requirements, such as to limit agricultural emissions to surface water. A well-balanced mix of policy instruments is particularly important here. Such projects are expensive and rely on public funding. National and regional government authorities could agree on joint financing. An important success factor in area-specific and sector-specific projects is the joint effort by and support from both the sector and government parties. Monitoring is necessary to be able to assess the effectiveness of projects and, if necessary, to adjust those programmes. It is also important that progress is encouraged by appropriate regulation.

### Increasing the development, transfer and deployment of knowledge

Growers say they experience a lack of effective non-chemical measures to reduce the use of chemical plant protection products. Research may make new measures available. However, this may be hampered by the financing structure for knowledge development in the Netherlands. Because companies in so-called top sectors have to co-finance, the incentive is primarily for research that has a direct added value for companies rather than research that is focused on public values. It is therefore still necessary for the government to continue financing research that focuses on public values, especially if it is aimed at the longer term.

In addition to knowledge development, knowledge transfer is also important. After all, integrated crop management is knowledge-intensive, compared to conventional crop protection techniques. Growers obtain this knowledge mainly from advisors, with the supplier of plant protection products being the most important knowledge provider. The costs of this advice are integrated in the product price. Because suppliers also have an interest in selling their plant protection products, this raises the question of whether such 'free' advice provides a balanced overview of all the aspects of integrated pest management. To stimulate a level playing field with independent knowledge providers, the government could enforce that the costs for advice and products are charged separately (this model is also used in the mortgage sector).

### Problems regarding occupational health and safety call for more government involvement

The policy document 'Healthy Growth, Sustainable Harvest' sees occupational safety as a joint responsibility of employers and employees. However, the document to date has led to only limited improvement in occupational safety. Therefore, government involvement might also be needed. In collaboration with the sector, the government could play a financing and facilitating role in gathering all the information on the safe handling of plant protection products and presenting it in a central location. Although the employer is primarily responsible for good working conditions, more attention must be paid to compliance with the regulation on the safe handling of plant protection products. The inspection and enforcement capacity of ISZW (Dutch Inspectorate of Social Affairs and Employment) could therefore be increased. This could increase the level of compliance with and insight into occupational health and safety regulations. In addition, inspections may also have a learning effect.

### Prevent voluntariness from turning into non-commitment

The policy document relies to a large extent on voluntary action. This evaluation of the practice of plant protection products shows that it is important, in public and private initiatives, to implement coercive measures to prevent voluntariness from turning into non-commitment. The positive experiences with the ban on the use of chemicals on paved surfaces show that regulation can play an important role in the transition to a system that is less based on chemical crop protection. Such a transition calls for a policy that stops the routine use of chemical plant protection products and stimulates new methods and techniques by developing knowledge, providing information and – where necessary and possible – providing financial incentives.



FULL RESULTS

FURTHER RESULTS

# 1 Introduction

Intensive cultivation systems have resulted in highly productive agriculture. Crop selection based on productive properties, cultivation in monocultures and the use of fertilisers have led to crops being vulnerable to diseases and pests. Chemical plant protection products currently play an important role in controlling those pests and diseases. Without them, the productivity level of intensive cultivation systems would fall substantially (Seufert et al., 2012; Boyd, 2018; EPRS, 2019). In addition, food security would decline because the risks of diseases and pests would create uncertainty in food production (Waterfield and Zilberman, 2012). However, EPRS (2019) and Lechenet et al. (2017) show that so-called integrated pest management can reduce the use of such protection products while maintaining crop yield levels.

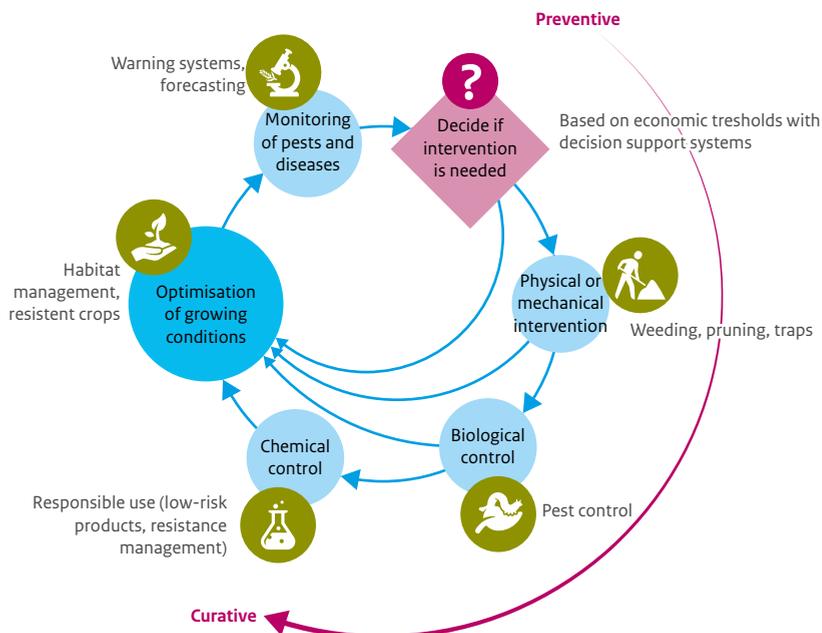
The positive effects of chemical plant protection products are offset by unintended and adverse effects on human health (Alavanja and Bonner 2012; Koutros et al., 2013; Priyadarshi et al., 2011), nature (Goulson et al., 2015; Geiger et al., 2010) and water quality (Betekov et al., 2013). The Netherlands has many crops for which relatively large amounts of plant protection products are used, such as potatoes and ornamental plants. In addition, in many places, intensification has caused the virtual disappearance of good conditions for biological pest control, such as landscape elements that are important habitats for beneficial organisms such as bees and natural pest control species.

## 1.1 Policy document ‘Healthy Growth, Sustainable Harvest’

In the policy document ‘Healthy Growth, Sustainable Harvest’ (EZ, 2013), the Dutch Government presented its crop protection policy for the 2013–2023 period. The document expresses the government’s ambition as follows: ‘A further increase in sustainability and innovation in the use of plant protection products, in response to international requirements in the areas of the environment and water, food safety, human health and working conditions, by 2023 at the latest. At the same time, the government wants to strengthen the economic prospects for Dutch agriculture and horticulture’.

The policy document is largely a continuation of the policy document on Sustainable Crop Protection (LNV, 2004) for the 2004–2010 period, but places greater emphasis on integrated pest management. In this form of crop protection, various techniques and methods are used to control diseases, pests and weeds that would minimise the use of chemicals (Prokopy, 2003) and keep crop production economically viable (Waterfield and

Figure 1  
Main steps of integrated pest management



Source: PBL

Zilberman, 2012). This requires a number of consecutive steps (Figure 1). The document describes objectives in the fields of integrated pest management and the competitive position of Dutch agriculture and horticulture, water quality, food safety and occupational safety (see Table 1).

Public and private parties both participated in the preparation of the *Healthy Growth, Sustainable Harvest* policy document. The parties joined forces in the Sustainable Crop Protection Platform (PDG), which also monitors the policy document's progress. At the request of the Ministries of Infrastructure and Water Management (IenW) and Agriculture, Nature and Food Quality (LNV), PBL Netherlands Environmental Assessment Agency has evaluated the policy and agreements as set out in the policy document; did the implementation go as planned and what effect did the policy have? In this report, we present the interim evaluation for the 2013–2018 period.

Dutch and European crop protection policies have two tracks: the authorisation of plant protection products and policies aimed at the sustainable use of authorised plant protection products. In the 'Healthy Growth, Sustainable Harvest' policy document, the focus is on sustainable use by stimulating integrated pest management, but the

document also recognises the importance of the authorisation of plant protection products. The authorisation policy ensures that a safe and effective range of products is kept available. In addition, harmonisation of the authorisation is important in order to create a level playing field for growers within Europe. The policy document, therefore, also contains a policy to further harmonise the authorisation by influencing European legislation (Figure 2).

## 1.2 Objective

The aim of this study is to assess the extent to which the interim targets for integrated pest management, environmental quality, food safety, occupational safety and economic perspective, as formulated in the 2018 policy document, have been achieved. We also examine the contribution of various policies on target achievement and explore the options available to private and public parties to bring the ultimate objectives of the policy document within reach.

In addition to the policy described in the document, there are other policies that also contribute to achieving its objectives (Figure 2). There are also companies that take initiatives that go beyond what the law prescribes, for example, by setting stricter residue levels for plant protection products in food. In the evaluation, therefore, we also consider the contribution of the related policy and so-called non-statutory measures to the achievement of the objectives. However, the related policy itself was outside the scope of our study.

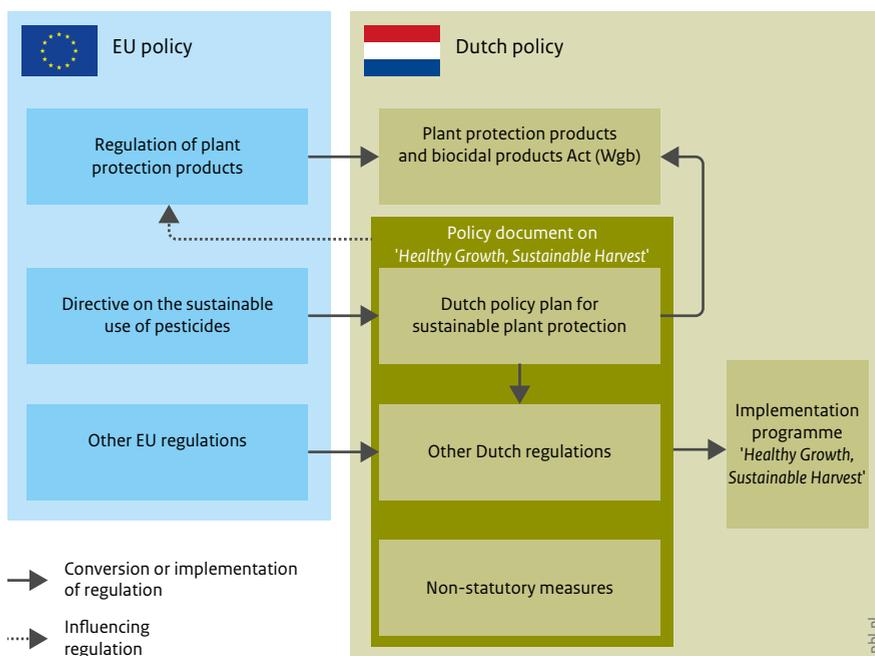
## 1.3 Assessment method

The evaluation is largely based on background studies by knowledge institutions and consultancy firms. The following subjects have been evaluated:

- Availability of an effective package of plant protection products, economy and enforcement: Wageningen Plant Research (WPR) and Wageningen Economic Research (WEcR);
- Integrated pest management: CLM Research and Advice (CLM);
- Environmental quality and biodiversity: National Institute for Public Health and the Environment (RIVM), Institute of Environmental Sciences Leiden (CML), CLM Research and Advice, and Wageningen Environmental Research (WEnR);
- Food safety: RIVM;
- Occupational safety: the Netherlands Organisation for Applied Scientific Research (TNO);
- Policy options for integrated pest management: ORG-ID Advice, Delphy Advice and the Athena Institute of the Vrije Universiteit Amsterdam (VU).

Figure 2

**Relationship between 'Healthy Growth, Sustainable Harvest', Dutch policy plan for sustainable plant protection, and other policies**



Source: PBL

Both quantitative and qualitative research methods were used in the assessment. Monitoring and inventories provided insight into the current state of the physical environment. Models were used to determine trends, to quantify the contribution of policy instruments to target achievement and to project the achievement by 2023. Surveys were used to gain insight into the adoption of integrated pest management by growers. Finally, interviews provided insight into bottlenecks and opportunities to improve the adoption of integrated pest management by growers.

PBL led the project and produced this interim assessment that was based on reports by the collaborating partners (Boon et al., 2019; Leendertse et al., 2019; Spaan et al., 2019; Spoorenberg et al., 2019; Stokkers, 2019; Thijssen et al., 2019; Verschoor et al., 2019; Verstand et al., 2019). In order to place the research in context, we also analysed additional scientific literature. Research structure and main results were discussed during meetings of scientific and societal sounding boards.

# 2 Effects of policies so far

## *There is progress, but most of the interim targets have not been achieved*

The 2013–2018 policy period has seen gains in many areas, but the interim targets for integrated pest management, ecological water quality, drinking water quality, biodiversity and occupational safety have not been achieved (Table 1). The objective for food safety – maintaining food safety at the 2010 level – was amply achieved. The target to improve the competitive position of Dutch agriculture and horticulture by reducing the number of crop–pest combinations for which no crop protection product or non-chemical method is available (so-called crop protection bottlenecks) could not be assessed, as there is no systematic monitoring of those bottlenecks.

For the themes in Table 1, this assessment discusses whether the targets of the Healthy Growth, Sustainable Harvest policy document have been achieved and what the contribution has been from policy and the sector. It first discusses the availability of an effective package of plant protection products (in short, an effective package of products). The authorisation and approval policies are important factors here. Subsequently, it takes a close look at the application of integrated pest management by growers. The following sections discuss the impact of current crop protection on water quality, biodiversity, occupational safety and food safety. The assessment concludes with a section on the factors that influence the plant protection practice of growers.

## 2.1 Use and availability of plant protection products

Plant protection products are used to control pests and diseases and thereby secure crop yields. Plant protection products can only enter the market after a rigorous scientific evaluation. These approval and authorisation policies regulate in which crop a product can be used and how this product should be used (i.e. dosage and application mode). A target of the ‘Healthy Growth, Sustainable Harvest’ policy document is to realise a lasting economic perspective for agriculture and horticulture by reducing the number of crop protection bottlenecks. Such bottlenecks emerge if there are no plant protection products or non-chemical alternatives available for certain pests or diseases. The international approval and Dutch authorisation policies play an important role in achieving this target.

Table 1

## Trend in sustainable crop protection, target achievement and policy contributions

Theme	Interim target 2018	Interim target 2018 achieved?	Trend 2013–2018	Policy contribution
Strengthen competitiveness of Dutch agriculture	Decrease in crop protection bottlenecks by 50%	Cannot be determined	Cannot be determined	Harmonisation of authorisation has improved, but authorisation for small crops remains a point of attention.
Integrated pest management	All growers consistently go through the steps of integrated pest management	Not achieved	Slightly improved	Policy has not sufficiently focused on reducing the use of hazardous substances. More attention needs to be paid to preventive and non-chemical measures.
Ecological water quality	Number of exceedances of standards decreased by 50%	Not achieved	Slightly improved	Emission reduction measures have been delayed. Authorisation policy insufficiently aligned with water quality policy.
Drinking water quality	Decrease of 50% in exceedances of drinking water standards	Not achieved	Unchanged	Authorisation policy solves new groundwater problems, but old substances are still found. Glyphosate remains the most important problem substance in surface water.
Functional agricultural biodiversity	Encouraging field margins and low-risk products	Not achieved	Slightly deteriorated	The policy of encouraging field margins via the voluntary route has not worked. The use of low-risk products remains limited.
Occupational safety	Employers provide information and set agreements on safe working practices, in collaboration with employees	Not achieved <sup>1</sup>	Slightly improved	Not all employers provide information to their employees. The contribution of policy has been limited. There have been no inspections focused on crop protection, after 2015.
Food safety	Number of exceedances of maximum residue limits similar to those in 2010	Achieved	Slightly improved	Residue policies have worked and the number of food inspections from outside the EU has increased.

<sup>1</sup> The occupational safety target is not formally an interim target in the policy document but stems from the existing occupational health and safety legislation.

Source: PBL

***Costs higher than in the countries surrounding the Netherlands, but differences have become smaller***

The costs for growers to comply with the crop protection policy have remained the same or increased slightly since 2010 (Verstand et al., 2019). The reason for this is that the authorisation of some plant protection products has been discontinued without being replaced by effective alternatives. This hampers growers in their efforts to control diseases and pests effectively. The costs for growers are also slightly higher than in neighbouring countries (Belgium, Germany, France and the United Kingdom). One reason for this is that slightly more plant protection products are permitted in those neighbouring countries (1,020 in the Netherlands versus 1,114 on average in neighbouring countries), as a result of which the crops in those other countries are better protected and growers enjoy higher yields. The difference is caused by differences in authorisation, but also by the fact that producers of plant protection products in the Netherlands do not always seek such authorisation.

Due to greater harmonisation of the authorisation policy, the differences between the Netherlands and neighbouring countries have become smaller; however, there is still room for improvement in this harmonisation (see below).

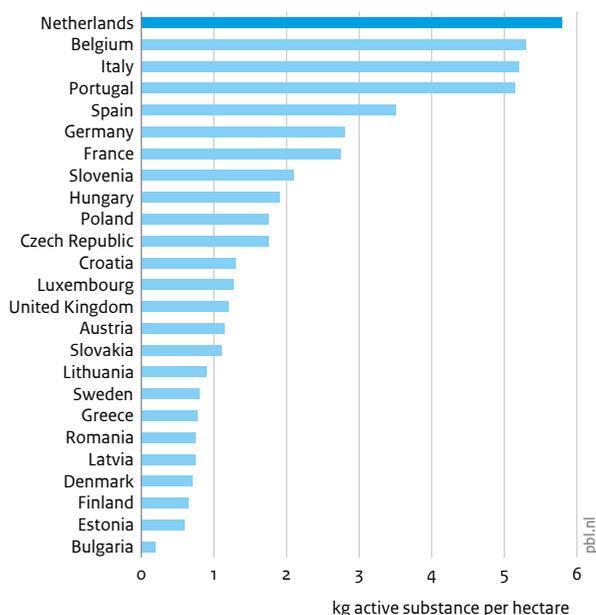
***Crop protection bottlenecks have not been systematically inventoried, but growers are seeing an increase***

If no plant protection product or non-chemical measure is available for a crop–pest combination, a so-called crop protection bottleneck will emerge. The policy document states that the number of crop protection bottlenecks must be reduced by 50% by 2018, compared to 2013. It is not possible to assess this objective quantitatively. The responsible parties (the Coordinators of an Effective Package of Plant Protection Products, or CEMPs) have not monitored the number of crop protection bottlenecks in a harmonised way. Nevertheless, growers in almost all sectors are experiencing an increase in the number of bottlenecks (Spoorenberg et al., 2019). This is especially the case for so-called minor crops, i.e. field crops covering less than 5,000 hectares and protected crops covering less than 1,000 hectares. One of the reasons, according to the growers, is that many broad-spectrum products have been withdrawn from the market and replaced by products that specifically combat a single pest or disease. If the authorisation of a broad-spectrum pesticide ceases to apply, several bottlenecks will immediately emerge. Note, however, that specific insecticides are an essential component of integrated pest management because they do not affect beneficial biological pest control species.

There are also crop protection bottlenecks that have been solved. The CEMPs mention the availability of chemical alternatives as the main reason for a number of bottlenecks having been solved. Only in a limited number of cases do they mention the availability of non-chemical alternatives as a reason for the disappearance of a crop protection bottleneck.

Figure 3

Sales of plant protection products for agri- and horticulture in the EU, 2014



Source: Eurostat

**Product use is intensive in the Netherlands, as compared with other EU Member States**

Compared to other EU Member States, the use of plant protection products per hectare is the highest in the Netherlands, with approximately six kilograms of active ingredient, annually, per hectare of arable land and horticultural land (CBS, 2018; Figure 3). In addition to the high crop production level (stimulated by higher agricultural land prices, compared to other countries, and the high level of technology and knowledge), this is due to the fact that a relatively large number of medium-intensive crop and plant species are grown in the Netherlands (e.g. potatoes, onions, lilies and tulips). The use of plant protection products on covered crops is also considerable per hectare, but the acreage of these crops is relatively small.

**Dependence on chemical plant protection products remains high**

Sales of chemical plant protection products decreased by approximately 10%, over the 1990–2016 period (Figure 4). Dependence on chemical plant protection products remains high. Average use per hectare in the Netherlands has increased. This is because relatively intensively sprayed crops are increasingly being cultivated in the Netherlands. The acreage for flower bulbs (lilies and tulips), for example, increased by almost 20%, over the 2012–2016 period. However, because the total acreage under cultivation decreased by 5%, the net effect is that the sales of chemical plant protection products decreased slightly, from 10 million

kilograms of active ingredient in 1990 to approximately 9 million in 2016. It must be noted that a decrease in the amount of pesticides applied does not equal a decrease in environmental risk. For example, there is no shift to low-risk products and the use of insecticides has remained constant. Insecticides account for the largest share of the environmental burden.

#### ***No shift towards low-risk products yet***

The range of available plant protection products is constantly changing. This is partly due to the fact that substances become ineffective after 10 to 25 years because pest organisms become resistant to them (Palumbi, 2001). Moreover, the authorisation policy has become stricter. Between 2015 and 2018, the approval of 13 active substances expired. In the same period, more than 40 new substances were approved. The total number of approved substances has therefore increased (EC, 2018).

The new substances include a number of so-called low-risk substances. These are substances which, after evaluation in accordance with the standard authorisation procedure and on the basis of current insights, do not appear to pose unacceptable risks to people and the environment. However, the use of these substances is still limited; in 2016, it was approximately 0.1% of the total use of plant protection products. Not all new substances have a low-risk profile. Among the newly approved substances are about 10 that, according to CLM's environmental yardstick, pose a high risk to human health or the environment (Hoogendoorn et al., 2019).

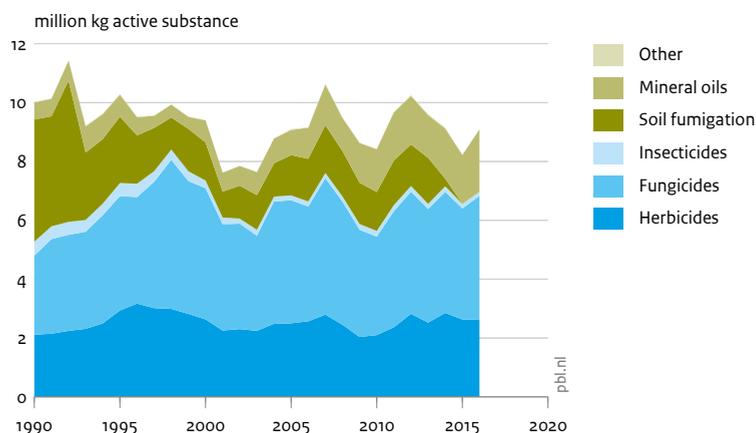
#### ***To date, only one substance has been excluded due to hazard criteria***

The general perception of growers is that the European authorisation of active substances is becoming increasingly strict (Spoorenberg et al., 2019; Bozzini, 2018; EC, 2018). In particular, the introduction of a test for the inherent hazard of a substance has led to much discussion. According to this principle, substances will not be approved if they are inherently carcinogenic, mutagenic or toxic for reproduction (so-called CMR substances). The principle is in fact a far-reaching interpretation of the precautionary principle, because it does not look at the effect of a substance under realistic exposure levels. It was expected that the introduction of this principle would result in the loss of 23 to 188 active substances (EC, 2018). In reality, only one substance (linuron) has so far lost its approval due to the application of hazard criteria. One of the reasons for this is that the re-evaluation of substances has been significantly delayed. However, industry is anticipating the application of hazard criteria; they have not applied for approval for 6 active substances. The approval of these substances will expire in 2021 (EC, 2018).

#### ***Harmonisation of the authorisation policy in the central zone could be improved***

In order to create a level playing field for plant protection in Europe, the European Commission is committed to further harmonisation of the authorisation process. An important aspect, in this respect, is the authorisation of plant protection products in three zones, in which Member States in principle adopt the authorisation in other Member States in the same zone ('mutual recognition'). The Netherlands, together with

Figure 4  
Sales of chemical plant protection products



Source: Nefyto; NVWA; adaptation by PBL

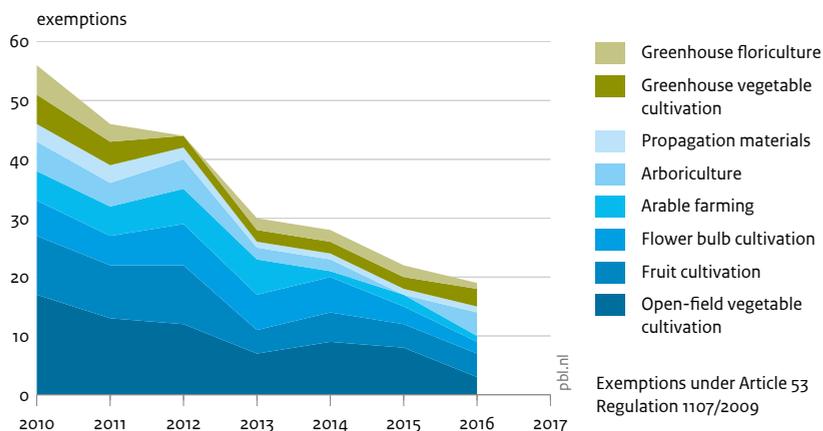
Belgium, the Czech Republic, Germany, Ireland, Luxembourg, Hungary, Austria, Poland, Romania, Slovenia, Slovakia and the United Kingdom, are in the central zone. The number of substances admitted through mutual recognition is steadily increasing. However, legal timelines for authorisation and renewal of authorisations are often not kept (EC, 2018). This may lead to uncertainty for businesses and reduced availability of plant protection products for growers. Furthermore, substances may not have been evaluated against the criteria of the newest guidance documents, which may be an obstacle for assuring a high level of protection for human health and the environment (EC, 2018).

Better harmonisation does not affect the availability of plant protection products for crops specific to the Netherlands, such as flower bulbs and ornamental crops grown in greenhouses. After all, these are relatively small crops at the scale of the central zone. Moreover, the evaluation will not be carried out by other countries. Growers therefore experience the largest number of crop protection bottlenecks for these Dutch crops.

#### ***Differences in exemption policies threaten a level playing field***

A number of countries make frequent use of the possibility to grant an emergency authorisation without a comprehensive risk assessment. The Netherlands grants such exemptions mainly for small crops and for a limited period of time. The Board for the Authorisation of Plant Protection Products and Biocides (Ctgb) and the Netherlands Food and Consumer Product Safety Authority (NVWA) are consulted before exemptions are granted. Year after year, extensions of exemptions take place for products containing neonicotinoids in eastern European countries (EC, 2018). In doing so, these countries are

Figure 5  
Exemptions for plant protection products



Source: Wageningen Plant Research; adaptation by PBL

in fact circumventing EU restrictions or bans on the use of such substances, creating an uneven playing field.

In the Netherlands, several dozen exemptions are granted each year (Figure 5). Most exemptions are granted for minor crops and for a limited time (Ctgb, 2017a). It is striking that – in contrast to the trend in the European Union as a whole – the number of exemptions granted in the Netherlands has decreased. The fact that the number of exemptions is decreasing while the number of identified crop protection bottlenecks is increasing may be because not all the bottlenecks reported by the CEMPs meet the agricultural criteria for an urgently required application (Spoorenberg et al., 2019). Moreover, in order to draft an exemption, a dossier must be created, and costs must be incurred for the application. Often those costs outweigh the benefits.

**Applying non-approved guidance documents may lead to unpredictability of the authorization process**

EU Regulation 1107/2009 explicitly calls for the protection of biodiversity. European guidance documents are necessary for an objective risk assessment. The guidelines currently available do not take enough account of effects on sensitive species and the effects of cumulative exposure, in practice (EFSA PPR Panel, 2014; 2015; 2017). So far, only one guidance document has been updated by EFSA and approved by SCoPAFF. This concerns the guidance document for the assessment of risks to aquatic organisms (EFSA PPR Panel, 2013a). A guideline for the protection of bees is available (EFSA, 2013), but the SCoPAFF has not yet approved it. EFSA has, however, used this guideline in the re-evaluation of three neonicotinoids and the substance fipronil. The use of non-approved guidelines or the absence of guidelines may lead to unpredictability in the authorisation process. For other

groups of species, such as soil organisms, plants and arthropods, up-to-date European guidelines are not yet available.

An important reason why guidelines are not accepted is that Member States cannot agree on the protection goals. Such goals describe, in precise terms, which species should be protected and where (EFSA PPR Panel, 2010). For example, should rare field weeds be protected in each field or is protection in a number of core areas sufficient? What level of bee mortality is acceptable? Due to the lack of consensus on protection goals, the question of what type of agriculture certain Member States in Europe want to perform remains unanswered (Url, 2018). At the same time, the debate on the authorisation of individual substances is becoming more political (Bozzini, 2018).

#### ***Violations in 10% of 20% of companies***

The most recent compliance measurements carried out by the Netherlands Food and Consumer Product Safety Authority (NVWA) show that the level of compliance in fruit cultivation, greenhouse horticulture, arable farming, outdoor vegetable cultivation and flower bulb cultivation varies from 80% to 90% (Figure 6). Compliance is defined in Figure 6 as the percentage of farms that are not subject to an administrative measure (fines) or a civil prosecution procedure, in relation to the sample during a compliance investigation (audit). Conversely, this means that, for 10% to 20% of farms, there are culpable acts for which a fine report or civil prosecution procedure has been imposed. In addition to these far-reaching consequences for farmers, the NVWA also issues warnings. This gives the opportunity to correct matters at certain points (approval after correction). These are usually minor violations, such as a side nozzle that has not been used correctly.

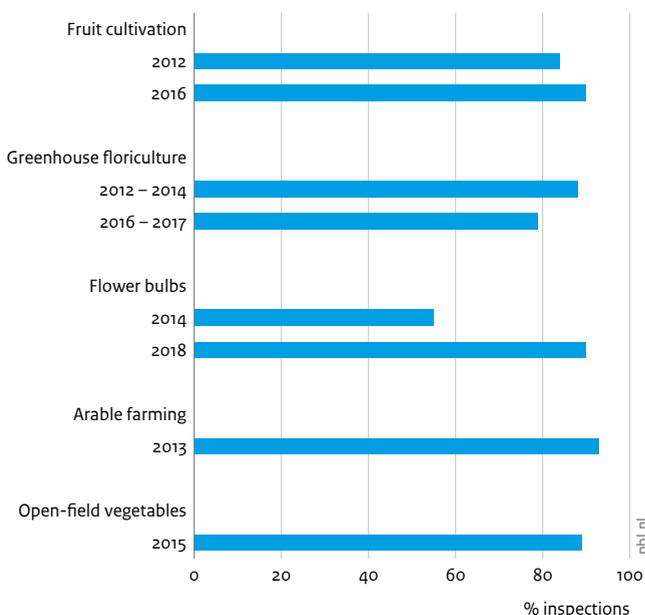
In fruit and ornamental plant cultivation, there has been little change in compliance. Compliance in flower bulb cultivation has improved considerably. In 2014, 45% of farmers were guilty of culpable behaviour. This was the reason for carrying out considerably more inspections before the compliance measurement in 2018. In addition, with the action plan 'Healthy Bulbs, Flowering Sector', the Royal General Association for the Cultivation of Flower Bulbs (KAVB) has worked on a programme to stimulate compliance.

## **2.2 Applying integrated pest management**

The government sees integrated pest management as an important means of making crop protection more sustainable. That is why the policy document includes the aim that, from 2014, all professional users of plant protection products will be working according to the principles of integrated pest management. This form of crop protection includes various techniques and methods to control diseases, pests and weeds, in order to largely limit the use of chemical plant protection products (Prokopy, 2003) and to ensure that crop production remains economically viable (Waterfield and Zilberman, 2012). This requires a number of consecutive steps; whereby chemical crop protection is used only if other crop protection measures are not sufficiently effective or not available (Figure 1).

Figure 6

### Compliance with plant protection regulation



Source: NVWA; Wageningen Economic Research

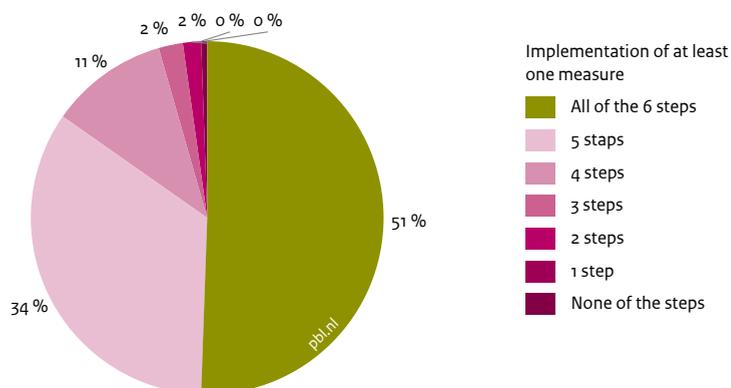
#### ***The fundamental step towards a system based on integrated pest management has not yet been made***

Integrated pest management, therefore, involves systematically going through all the necessary steps: (1) prevention, (2) optimisation of the growing conditions, (3) monitoring diseases and pests, (4) deciding whether pest control is necessary, (5) non-chemical pest control and (6) chemical pest control. When growers apply chemical products, they are to minimise the risks to human health and the environment ('conscious application of chemicals'). A survey among 624 growers carried out by CLM (Leendertse et al. 2019) shows that half of them are not applying one or more of these steps (Figure 7). Strictly speaking, these growers do not follow the principles of integrated pest management.

It should be noted, however, that the differences between the crops are considerable. For example, non-chemical methods are little used in arable farming, but they are common in greenhouse and fruit cultivation. The survey results (Leendertse et al., 2019) indicate that the fundamental step from a system based on the routine use of chemicals to a system based on integrated pest management has not yet been made. This is particularly the case in field crops, where the application of biological pest control is more difficult than in covered crops. The dependence on chemical crop protection is also evident from the barely reduced sales of chemical crop protection products (Figure 4) and the sector's

Figure 7

Percentage of growers who follow the steps of integrated pest management, 2018



Source: CLM

notion that crop protection bottlenecks are mainly solved when chemical alternatives have become available.

**Growers know most of the measures, but continue to particularly apply chemical crop protection**

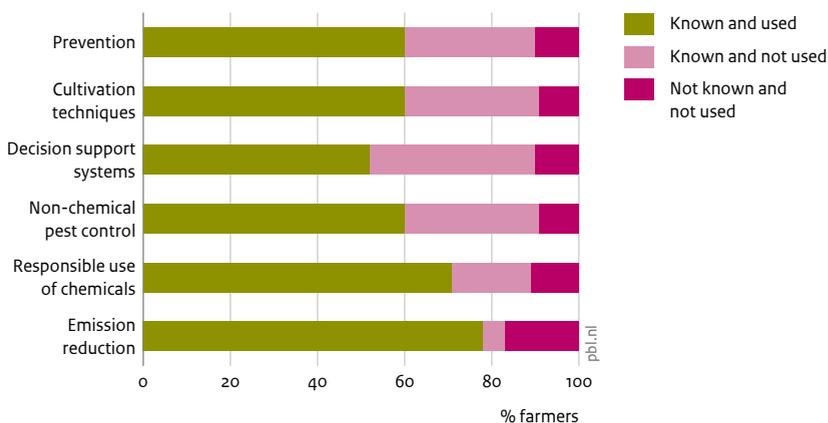
For the evaluation of the Sustainable Pest Management Policy Document (PBL, 2012), the integrated pest management measures that have become available were examined. The survey showed that, on average, 90% of these measures are known to growers (Leenderterse et al., 2019). Growers also apply most of the measures (Figure 8). Most frequently applied are measures aimed at dealing more consciously with the use of chemical substances ('conscious use') such as emission reduction measures and substitution of harmful substances; these are also the measures to which most attention has been paid in the policy document. For example, 90% of arable farmers now use nozzles that reduce spray drift by 90%. Moreover, growers are more likely to opt for selective, rather than broad-spectrum crop protection products.

**Non-chemical measures are mainly applied in covered crops and orchards**

Non-chemical crop protection, such as biological pest control and the use of pheromones (i.e. mating disruption), is common in greenhouse horticulture and fruit cultivation. This is less the case in arable farming. The policy of voluntarily creating field margins has not worked; the total acreage of field margins has decreased. In addition, mechanical weed control is only applied on a small part of the crop area, and glyphosate is sprayed on a large scale to kill the catch crops that are required under the Nitrate Directive, although a good mechanical alternative is available. Growers do this because of the higher costs of mechanical weed control.

Figure 8

**Farmers' knowledge and use of integrated pest management measures, 2018**



Source: CLM

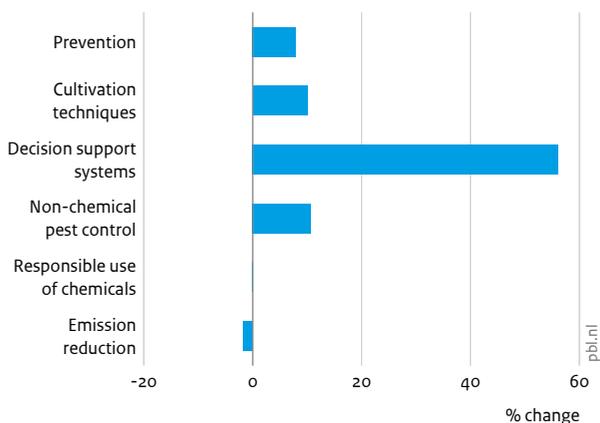
Preventive measures are used for all crops. The focus is on choosing resistant crops and checking the starting material (seeds, bulbs, tubers and planting stock) for possible contamination and infestations. However, not all growers are able to opt for resistant crops; the market often makes a selection that is based on other factors, such as taste, shelf life and appearance. In addition, there are technical barriers in some crops, because traditional breeding techniques are slow and new breeding techniques such as CRISPR-Cas are subject to the strict regulation of genetically modified organisms in Europe (EPRS, 2019).

**Use of decision support systems lags behind**

The use of computer programs that support the grower in setting up a pest control strategy (decision support systems) is still lagging behind (Figure 9), as half of the growers do not use them. Growers say they see little added value in such support systems; the systems do not meet their informational needs, nor do they find them convenient to use (Thijssen et al., 2019). Because the current decision support systems can only predict diseases or pests a few days in advance, growers with large areas and contractors indicate that it is not possible to spray on the basis of a decision support system without risking harvest losses. The spraying capacity is insufficient to rapidly respond to an outbreak of a disease or pest. In such cases, the growers often continue to spray preventively. However, the use of decision support systems has increased since 2010 (Figure 9). Together with the increased use of, for example, GPS systems for targeted spraying, this shows that digital techniques play an increasing role in making crop protection practices more sustainable.

Figure 9

### Change in the application of integrated pest management (IPM) measures, 2010 – 2018



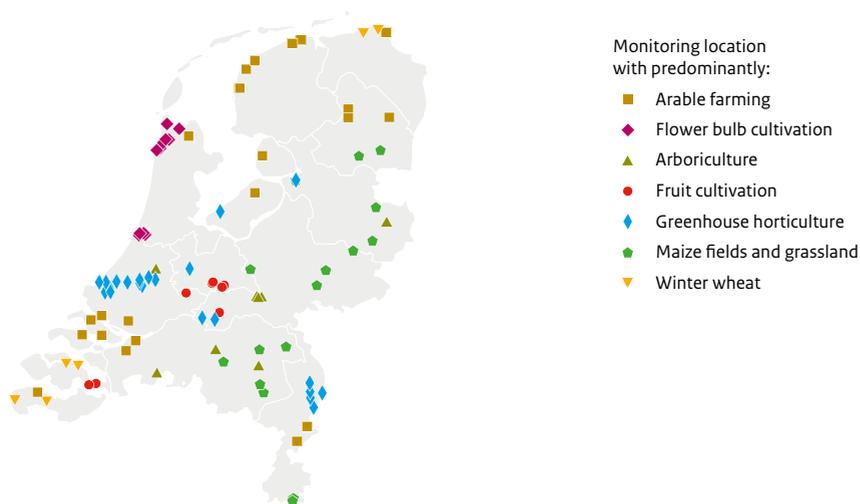
Source: CLM; adaptation by PBL

## 2.3 Consequences of crop protection for ecological water quality

The target of reducing the number of measured exceedances of the water quality standards in surface water by 50% by 2018, compared to 2013, has not yet been achieved, although the water quality has improved. In accordance with the policy document, the assessment will be based on the water quality standards of the Water Framework Directive (WFD). The WFD has two standards: a standard for chronic exposure of aquatic organisms in which the annual average concentration level of a substance in water is tested (the AA-EQS) and a standard for acute exposure of aquatic organisms in which the maximum measured annual concentration is tested (the MAC-EQS). The WFD requires both standards to be met. Both standards have therefore been considered in this evaluation. Contrary to previous evaluations, we now use a monitoring network specifically set up for the evaluation: The National Crop Protection Monitoring Network (LM-GBM; De Weert et al., 2014). This network has been operational since 2013 and contains 96 fixed monitoring points (Figure 10). This makes it easier than before to determine a trend based on the measurements. Trend projections are made robust by considering a three-years moving average instead of annual values, so target achievement is evaluated by comparing the averages for the 2011–2013 and the 2015–2017 periods (Tamis and van 't Zelfde, 2017).

Figure 10

### Monitoring locations in the National Monitoring Network Crop Protection, 2017



Source: [www.bestrijdingsmiddelenatlas.nl](http://www.bestrijdingsmiddelenatlas.nl)

#### ***Number of measured exceedances is decreasing ...***

The number of exceedances of the water quality standards for chronic exposure has decreased by approximately 15% since 2013 (Figure 11, on the left), while for acute exposure, exceedances occurred 30% less often (Figure 11, on the right). The target set in the policy document (50% fewer exceedances in 2018) was not yet achieved, especially with respect to chronic exposure. With the current rate of improvement, the ultimate target for 2023 is also not within reach. For acute exposure, the decrease is mainly due to the reduced use of the substance imidacloprid. The decrease in exceedances of the MAC-EQS is good news for aquatic organisms, as particularly high peak concentrations have a negative impact (EFSA PPR Panel, 2013a).

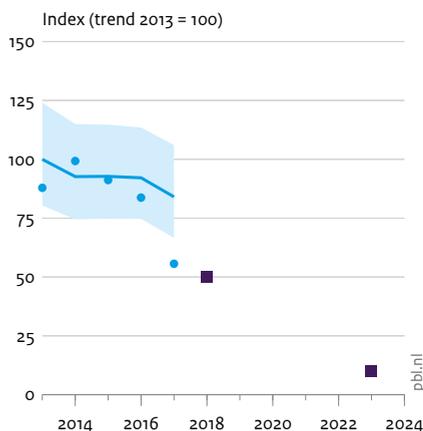
#### ***... but the number of sites where exceedances occur remains almost the same***

The reduction in the number of exceedances has not led to the same reduction in the number of locations with exceedances of the water quality standards (Figure 12). According to the WFD, if at a certain site at least one substance is found above the standard, the entire site is in exceedance (the 'one out–all out' principle). Depending on the extent to which one substance exceeds the standards, the effect on aquatic life may already be significant (Brock et al., 2011; EFSA PPR Panel, 2013a). Most exceedances are found in ditches near tree nurseries, flower bulbs, fruit cultivation and greenhouse horticulture (Tamis and van 't Zelfde, 2019), which is in line with results of the earlier evaluation (PBL, 2012).

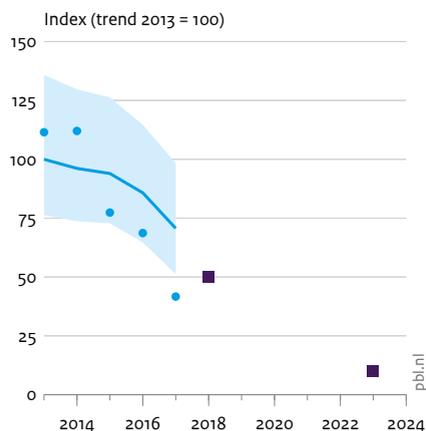
Figure 11

### Exceedances of the Water Framework Directive water quality standards

Chronic exposure



Acute exposure



- Annual value
- Target
- Trend
- Uncertainty trend

Source: [www.bestrijdingsmiddelenatlas.nl](http://www.bestrijdingsmiddelenatlas.nl)

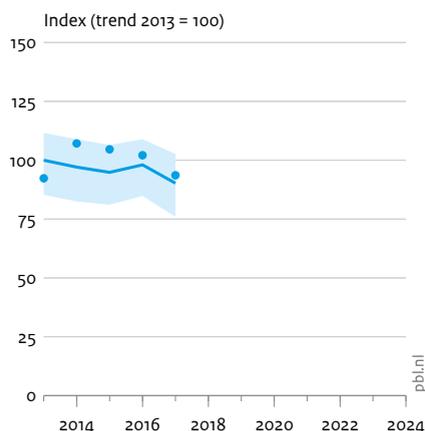
#### **Regulatory acceptable concentrations used for the approval of substances are also frequently exceeded**

An important reason for the measured exceedances is that the approval criteria for active substances are generally less stringent than those related to water quality under the WFD (PBL, 2012). In addition to the WFD standards, the regulatory acceptable concentrations (RACs) for approval are also frequently exceeded (Figure 13). This may indicate that substances are not always used in accordance with regulations. The NVWA has indeed established that 10% to 20% of farmers were in violation, for whom a fine or civil offence investigation was imposed (Stokkers, 2019). But there are also shortcomings in the national approval procedure. Contrary to European procedures, it does not take account of losses through drainage and surface run-off (Tiktak et al., 2012). Moreover, the Dutch authorisation process underestimates the spray drift (Van de Zande et al., 2011). This is because national authorisation assumes that the width of the crop-free zone in arable farming is always 1.5 metres, whereas in reality it is between 0.5 and 1.5 metres (Tiktak et al., 2012). This is not in line with the principles in the European policies that the worst-case situation must be considered (EFSA PPR Panel, 2010). Repairing these shortcomings by the Ctgb may lead to environmental benefits in the short term.

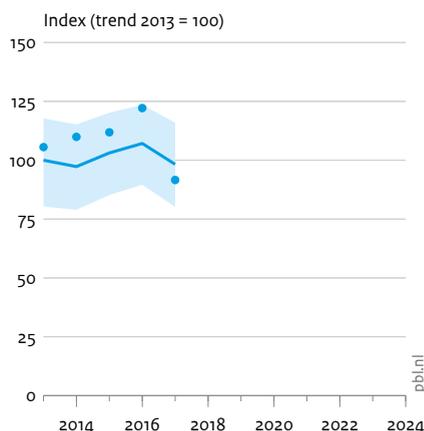
Figure 12

**Locations where Water Framework Directive water quality standards were exceeded for at least one substance**

Chronic exposure



Acute exposure



- Annual value
- Trend
- Uncertainty trend

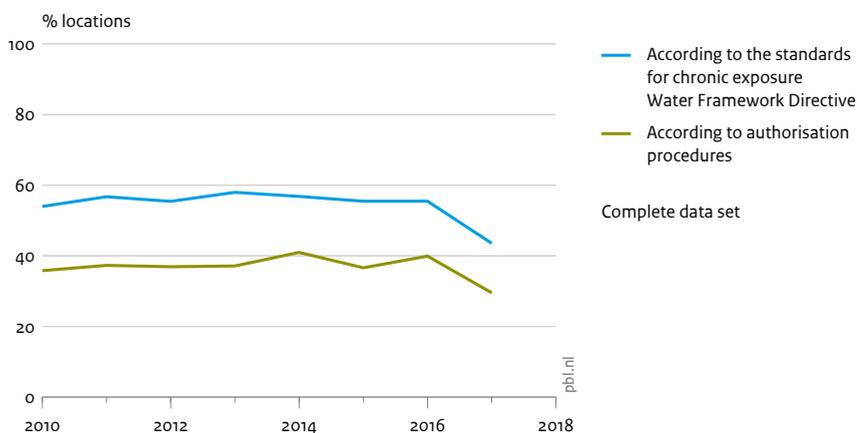
Source: [www.bestrijdingsmiddenatlas.nl](http://www.bestrijdingsmiddenatlas.nl)

**Emissions have decreased but environmental risk has increased**

In addition to the measurements, calculations were made with the NMI-model to determine the trend (Verschoor et al. 2019). These calculations show that emissions of crop protection products to surface water from field crops have decreased by 9%. Despite the reduction in emissions, the calculated environmental risk, expressed in toxic units, has increased on average by 3% for outdoor cultivation (Figure 14). There are, however, significant differences between the crops. In arable farming, the environmental risk increased on average by approximately 40%, while in flower bulb cultivation, the environmental risk decreased by approximately 45%. An increase in the environmental risk of decreasing emissions indicates that the contribution of relatively toxic substances to the calculated environmental risk has increased. One of the reasons for this is that, following restrictions in 2013 on the use of three neonicotinoids, the use of other toxic substances has increased (the so-called waterbed effect). In addition, neonicotinoids used in seed coatings worked directly via the plant and did not have a negative impact on surface water via spray drift. The alternative substances are usually sprayed and thus cause a higher aquatic risk. In greenhouse cultivation on substrate, the use of four toxic substances has been reduced. As a result, the environmental risk has been reduced as well.

Figure 13

### Proportion of locations where standards were exceeded for at least one substance



Source: [www.bestrijdingsmiddenatlas.nl](http://www.bestrijdingsmiddenatlas.nl)

#### **More attention needed for non-testable substances in the measurements**

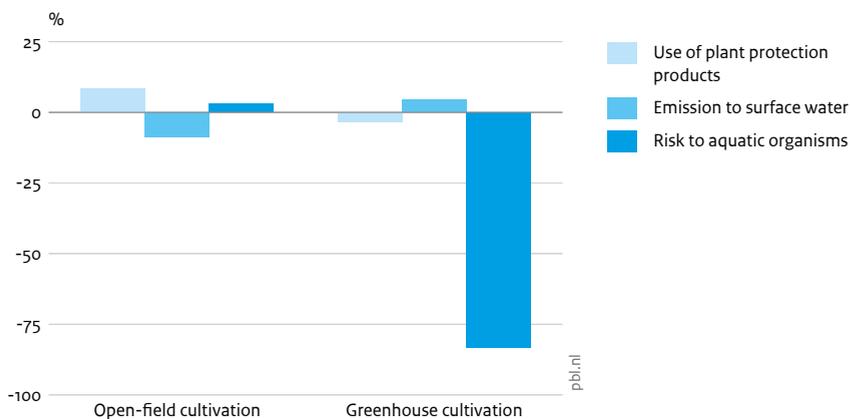
The model calculations present an image that differs from that of the measurements. As mentioned above, the increased calculated environmental risk to surface water is caused by the increased use of toxic substances. This is particularly the case for the insecticides deltamethrin, lambda-cyhalothrin and esfenvalerate. These substances do not appear in the measurements, because in practice they cannot be measured in surface water. These so-called non-testable substances have a water quality standard that is lower than the limit of quantification for this substance. Since these substances account for 90% of the total calculated environmental risk, it is likely that the trend in environmental risk that is based on measurements alone is too optimistic.

#### **Emission reduction is effective as long as this is not accounted for in product authorisation**

The requirements to reduce emissions were tightened up in 2018, which is four years later than the policy document intended. The effects of these emission reduction measures are therefore only visible to a limited extent in the measured water quality. It is now clear that many growers are complying with the obligations as set out in the policy document. By 2018, most growers were using nozzles that reduce spray drift by at least 75% (Figure 15). However, it is still a matter of concern that not all growers comply with the required spraying pressure and boom height, and that some of them spray in too windy conditions or drive faster than is assumed in the determination of drift. In glasshouse horticulture, too, most growers meet their obligations either through individual purification systems or by having joined a collective. In the latter case, this has not yet led to an improvement in water quality, as collectives are granted postponement of their water treatment obligation. Emission reduction measures are effective when these measures are not

Figure 14

### Change in indicators of environmental pollution by plant protection products, 2012 – 2016



Source: RIVM; adaptation by PBL

accounted for in the authorisation procedure. After all, if the emission reduction achieved as the result of such measures would mean that products are authorised that would otherwise not pass the authorisation, then on balance there would be no effect. In this situation, however, the emission-reducing measures can be regarded as a way of retaining an effective package of plant protection products.

#### ***Substituting substances has yielded little environmental benefit***

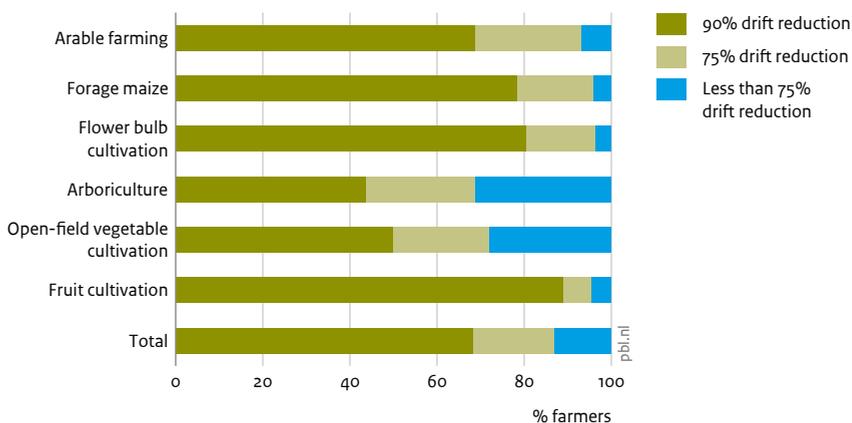
Over the 2013–2018 period, 13 substances were discontinued, and 40 new substances were added. This substitution reduced the calculated environmental risk (expressed in toxic units) by less than 1%. The reason for this small decrease is that growers do not necessarily opt for substances with a lower risk profile when the approval of certain substances is discontinued. The available range of products plays an important role, here. The number of approved low-risk substances is still small. Moreover, growers will be less likely to switch to alternatives such as low-risk products, if conventional and familiar products are available. They often consider alternatives to be less effective. Moreover, the alternatives must be sprayed more frequently and are therefore generally more expensive.

#### ***Voluntary action hampers the effectiveness of emission reduction plans***

The policy document prescribes that, for substances for which it is likely that their application will lead to an exceedance of the WFD standards, the authorisation holder (usually the producer of a product) is to draw up an emission reduction plan. These emission reduction plans are not yet sufficiently effective, for a number of reasons. For example, these plans do not target all substances in the LM-GBM that cause exceedance of the water quality standards. In accordance with the policy document, the emission reduction plans contain a mix of

Figure 15

Percentage of growers using drift reducing nozzles, 2018



Source: CLM

statutory and non-statutory measures (product stewardship). The statutory measures proposed in the plans (restrictions indicated on the label) often turn out not to have been implemented. A possible reason is that the emission reduction plans are prioritised based on exceedances of the standards for the WFD, while restrictions on the label can only be set if exceedances of the approval criteria are seen. In addition, non-statutory measures suggested by industry are only implemented by some of the growers. An example is the application of the farm-yard emission scan ([www.erfemissiescan.nl](http://www.erfemissiescan.nl)), which gives farmers insight into potential emission pathways. Growers who apply this scan appear to act more carefully as a result of improved awareness and thus achieve environmental benefits, but the proportion of growers who applied this scan is only 7% (Rougoor et al., 2018). The government has not indicated what would be the consequence of the voluntary track not yielding sufficient results – which means that, without a consequence, there is a risk that voluntary action may result in non-commitment.

**An integrated approach can be successful, but is also expensive**

Region-specific or sector-specific projects are likely to improve water quality. This is especially the case if they increase the awareness of growers through intensive support and by discussing the results of environmental quality monitoring with growers (Boezeman et al., 2019). In addition, subsidies may help growers to take non-statutory measures; for example, to limit emissions from farm yards to surface water. Example projects include the approach in northern Netherlands of on-site emission scans (*Vermindering Erfemissie Drentsche Aa*), the area-specific approach in Delfland and the ‘Schoon erf, schone sloot’ (clean yard, clean ditch) approach in flower bulb cultivation. The implementation of these projects is expensive for the government, but they have the advantage that growers are

intensively supported and are provided insight into farm processes by means of measurements. Growers can also actually tackle problems through subsidies for, for example, measures to counterbalance farm emissions. Evaluations of such programmes show improvements in water quality but also conclude that, when the project stops, the growers may revert to the national average environmental impact (Hoogendoorn et al., 2018; Van Lienen and Schuerhoff, 2015).

## 2.4 Consequences of crop protection for drinking water extraction

The use of crop protection products within and outside agriculture can lead to exceedances of the drinking water standard in groundwater and surface waters from which drinking water is abstracted. The policy document aims to reduce the number of exceedances by 95%, by 2023, compared to 2013 levels. The intermediate target for 2018 was a 50% reduction. In the case of groundwater, the objective is that groundwater quality must not deteriorate.

### ***Slight increase in the number of exceedances of the drinking water limit at abstraction points***

In addition to protecting aquatic life, the policy document focuses on improving the water quality for the abstraction of drinking water from surface water. The intermediate target for 2018 was to reduce the number of exceedances of the drinking water limit by 50%. The number of exceedances did not decrease during the policy period, so the target was not achieved (Figure 16).

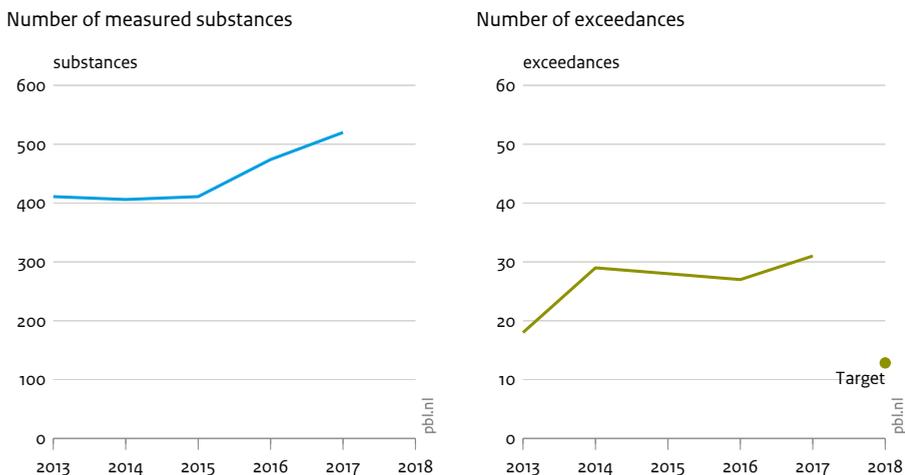
Measurements show that glyphosate is still the main problem substance for drinking water abstraction. Glyphosate is a widely used herbicide that is also used for killing the catch crops that are required by the Nitrate Directive (usually grass or green fertilisers). From the perspective of integrated pest management, this is an inappropriate application, as a good mechanical alternative is available. Due to the large number of yellow-coloured fields in the spring, the application also leads to a negative image for the sector, as evidenced by various discussions on social media and in professional magazines.

### ***Chemical-free weed control on pavements and in public green spaces***

Herbicides including glyphosate are also used outside agriculture. The final evaluation of the Sustainable Crop Protection Policy Document (PBL, 2012) showed that run-off from pavements was one of the largest sources. Plant protection products are now prohibited for professional use on pavements and in public parks and gardens. As a result of the development of new non-chemical techniques in combination with the ban, weed management on pavements and in public green spaces has been chemical-free since 2018. For other applications, Green Deals have been made with the garden sector, the recreation sector and the sports sector. The aim is to reduce the use of these products in these sectors and, in the case of the Green Deal for the garden sector, to provide consumers with better

Figure 16

**Number of measured substances and exceedances of the drinking water limit, at drinking water abstraction locations**



Source: RIVM

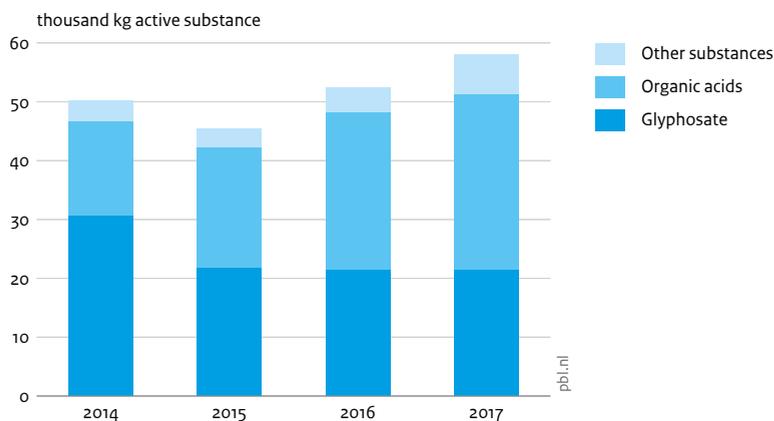
information about the risks. Here, too, regional projects, such as Clean Water for Brabant, show that weed control on sports fields and recreational areas can be achieved without the use of chemicals. In North Brabant, more than 150 fields are now chemical-free. The Green Deal for private use seems to have had a limited effect so far; private use has not decreased (Figure 17) and garden centres hardly inform consumers about alternatives, such as a weed-resistant garden design. In addition, garden centres provide little information on protective measures such as gloves, whereas the Green Deal states that they should.

**Groundwater: partly a legacy of the past**

Two thirds of drinking water used in the Netherlands is abstracted from groundwater. For groundwater, the operational objective is that its quality should not deteriorate. This objective cannot be tested using the monitoring data available in the provincial monitoring networks, as available data are too fragmented. It is advisable to set up a fixed monitoring network for groundwater, as well (Verschoor et al., 2019).

The most frequently found substances in groundwater are herbicides and their metabolites. Many of these substances are no longer permitted. Exceptions are bentazone, glyphosate and mecoprop. For bentazone, instructions for use have been tightened, but effects of this are not yet visible in the measurements due to long travel times.

Figure 17  
Consumer sales of herbicides



Source: RIVM

## 2.5 Consequences of crop protection for biodiversity

The policy document also addresses biodiversity, as a result of the debate on the decline in honeybees and other pollinators. The document sets out the objective of reducing the risks posed by chemical plant protection products to non-target organisms, such as pest control species and pollinators. Measures include restrictions on the use of neonicotinoids, improving guidelines for the assessment of risks to non-target organisms and informing growers about the risks for bees in relation to plant protection products. The document also focuses on the creation of habitats for pollinators and pest control species (so-called functional agricultural biodiversity).

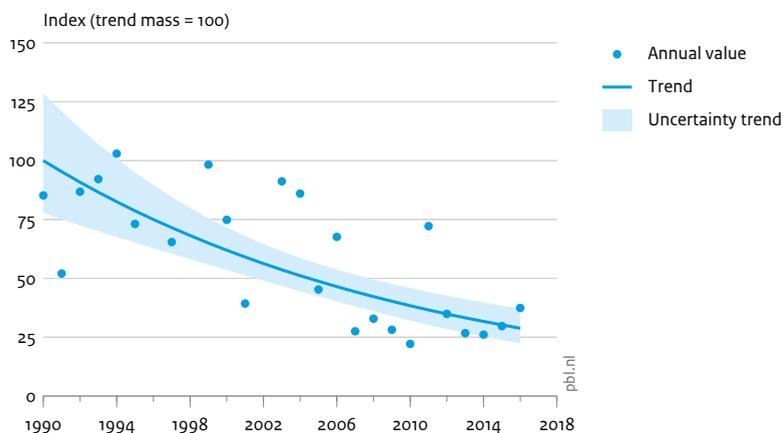
### ***Populations of wild pollinators and other beneficial insects are still declining***

The honeybee mortality rate in winter, in the Netherlands, has remained above the European average of 10%, in recent years. Exceptions were the years 2014, 2016 and 2019. In addition, the numbers and species diversity of wild bees and other flying insect species are decreasing (Goulson et al., 2015; Hallman et al., 2017; Figure 18) and many of these species are now limited to nature reserves. The decline in the populations of insects and other arthropods is caused by a combination of factors, such as intensification and scaling-up in agriculture, climate change, the use of insecticides and the emergence of exotic species such as the Varroa mite (Goulson et al., 2015; Blacquière et al., 2012).

### ***Restrictions on neonicotinoids not necessarily lead to lower bee mortality***

Due to the risks to bees, the European Commission has imposed precautionary restrictions on the use of three neonicotinoids since 2013; the restrictions were tightened even further

Figure 18  
Mass flying insects



Source: Hallmann et al. 2017; adaptation by PBL

in 2018. From the monitoring data it cannot yet be deduced whether this decision has led to a reduction in bee mortality (Blacqui re et al., 2017). What is clear is that the use of alternative toxic crop protection products has increased. Low-risk products, such as micro-organisms, are not available for pest control in field crops (NVWA, 2017). Therefore, alternatives are chosen that do not always have a lower risk profile than the neonicotinoids they are intended to replace (Ctgb, 2017b).

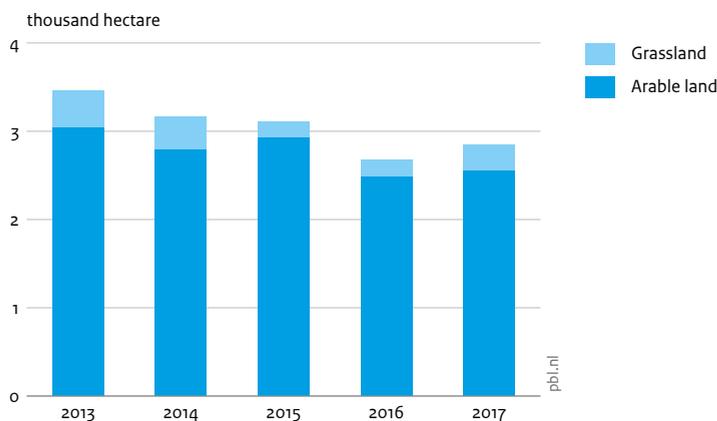
#### **Compensation necessary to stimulate field margins**

Field margins – if well managed – lead to greater numbers and diversity of pest control species, which can lead to less pest pressure in crops. The policy document, therefore, focuses on voluntary implementation of field margins. However, this measure did not work: during the policy period (2013–2017), the total area of field margins decreased slightly (Figure 19).

In addition to the lack of a coherent agricultural nature policy, the absence of a subsidy mechanism seems to have been important, in this respect. Farmers incur costs for the construction and management of field margins and these costs outweigh the avoided costs of spraying (Daniels, 2015; De Geus et al., 2011). The Dutch implementation of the Common Agricultural Policy (CAP) will not lead to more field margins, either. Since 2014, the CAP has made greening compulsory for everyone who wants to receive the basic payment (pillar 1). Arable farmers can choose between various types of greening measures. It appears that growers usually opt for measures that have little added value for biodiversity (e.g. green manure) rather than for field margins. Negotiations are currently underway (2019) on the implementation of the CAP for the 2021–2027 period. The Netherlands could

Figure 19

### Area of field margins with flower or grass/herb mixtures



Source: RVO.nl

press for a higher financial reward for farmers who contribute to functional agricultural biodiversity. The new structure of the Agricultural Nature and Landscape Management (ANLb) under the current CAP also offers possibilities. In this new set-up, collectives will carry out the management, which could lead to greater coherence between measures. In addition, management quality will improve, as farmers in the collectives will learn from each other's experiences (Van Alebeek, 2015).

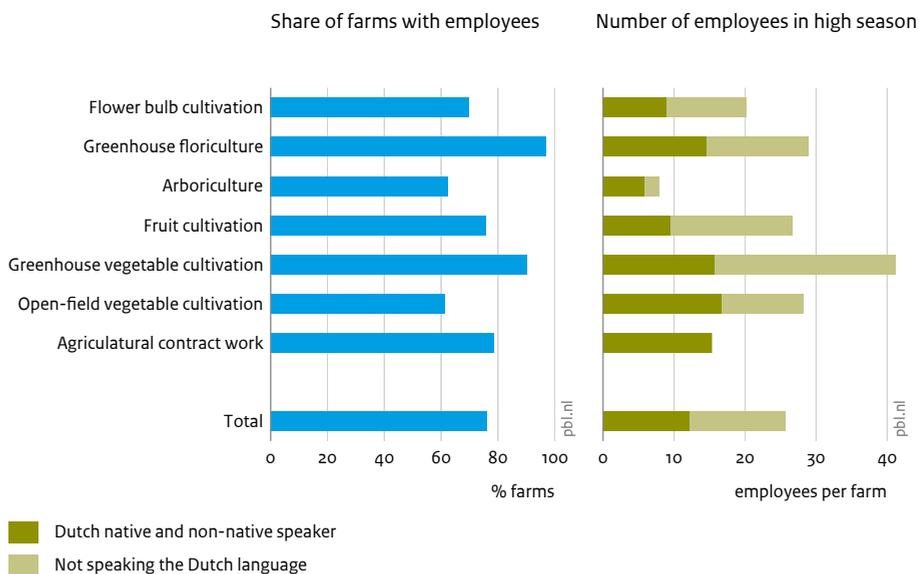
## 2.6 Consequences of crop protection for occupational health and safety

The ambition of the policy document is that employers, buyers and employees who may be exposed to plant protection products have sufficient knowledge about the risks of handling these products, in order to prevent high-risk exposure. Employers must inform their employees of those risks. Employers are obliged to make an inventory of these risks and to establish safe and healthy work conditions in consultation with employees.

### *In practice, joint responsibility does not seem possible*

When companies use plant protection products, they are obliged to inform their employees of the risks involved. Under the Dutch Working Conditions Act (*Arbowet*), employers are obliged to inventory these risks in a so-called risk inventory & evaluation (RI&E). In consultation with employees, they must then establish safe and healthy work conditions to prevent high-risk exposure from occurring. This joint responsibility cannot

Figure 20  
Farm employees, 2018



Source: TNO

be implemented in practice in the agricultural sector; more than 50% of the employees do not speak Dutch, are not permanently employed or work mainly in the peak season (Figure 20). Moreover, not all employers inform their employees. The above factors make it difficult to make agreements between employer and employee.

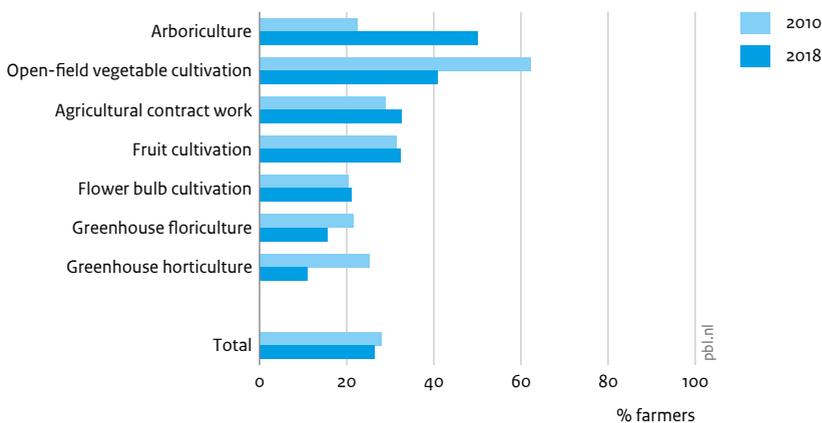
The role of the government in improving occupational health and safety has been limited. According to the policy document, the government should pay more attention to methodologies to improve the RI&Es, especially with regard to the risks for young people and the application of multiple substances at the same time and in quick succession. To date, however, the government has taken no or hardly any action on this subject. In addition, over the past five years, the Inspectorate of Social Affairs and Employment (ISZW) has carried out hardly any inspections specifically aimed at the safe application of crop protection products.

### **Improving occupational safety has little priority**

Among growers, working safely with crop protection products still has a low priority. For example, only a small proportion of growers indicate that they have recently adapted their crop protection to improve occupational health and safety (Spaan et al., 2019). In addition, growers have seldom drawn up an exposure assessment and action plan to reduce the risks associated with working with crop protection products. The exposure assessment

Figure 21

### Percentage of growers who do not educate employees about crop protection



Source: TNO

and such a plan are compulsory components of the RI&E. Drawing up and discussing an action plan with employees increases awareness of the risks arising from, for example, accidents or working with multiple substances at the same time, and thus contributes to occupational safety. In practice, however, the RI&E is mainly a theoretical exercise that leads to little or no improvement in occupational safety.

#### ***Use of products with an acute toxicity label has increased***

Companies that do adapt their crop protection measures mainly focus on the direct protection of employees. Few growers have started using other crop protection products for reasons of occupational safety. This is evident from the figures on the use of substances that can pose an acute health risk (i.e. products with a skull-and-crossbones symbol on the label). Even though more specific and safer products have become available since 2010, the use of products with the skull-and-crossbones label has increased by approximately 20%. This is contrary to the occupational health and safety strategy, which requires the use of toxic substances to be reduced as much as possible. Moreover, it is not easy for growers to implement the first step of this strategy. Easy-to-understand and comparative information on the toxicity of pesticides is not publicly available and is also partly obsolete due to the rapid development of new pesticides.

#### ***Information to employees needs to be improved***

Plant protection products are used on almost all farms. Here, employers must provide their employees with information about the use of these products. A survey among those farms (Spaan et al., 2019) shows that this still does not happen in a quarter of the cases (Figure 21).

Lack of information about health risks is particularly relevant for employees who work with sprayed crops but do not spray those crops themselves. Many employers are not aware of the risks to which these employees are exposed. Those who do spray (the operators) must be in possession of a certificate of professional competence (a so-called spray licence) and are therefore more aware of the risks. Although they are potentially most at risk, they often do protect themselves, either through personal protective equipment such as gloves, or by using an enclosed cabin during spraying work. On most farms, the owner is also the one who carries out the spraying work. Suppliers can also contribute to the improvement of occupational safety by making 'safe-by-design' products available. Examples are sealed and closed filling systems that prevent the operator from coming into contact with crop protection agents when filling the tank.

## 2.7 Consequences of crop protection for residents

The policy document *Healthy Growth, Sustainable Harvest* not only calls for the protection of employees, but also of people living near agricultural fields. The reason for this is that there is concern among local residents about the use of crop protection products in their immediate vicinity. A consortium of knowledge institutes, led by the Dutch National Institute for Public Health and the Environment (RIVM), has therefore investigated the extent to which people living near bulb fields are exposed to crop protection products. The choice for bulb cultivation was made because the use of crop protection products in such crops is relatively high. During this study, air and dust samples were collected from homes within 250 metres of bulb fields and urine samples from local residents were also taken. For control purposes, such samples were also collected at a greater distance from bulb fields.

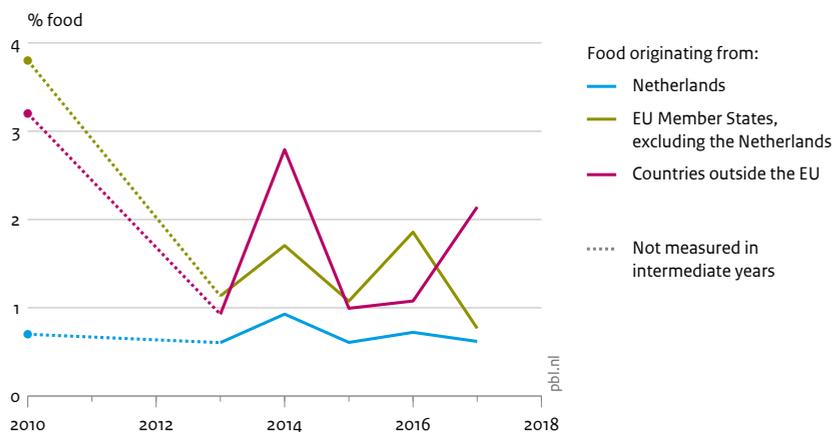
### ***Residents are exposed, but health-related limits are not exceeded***

The research shows that residues of crop protection products used on the bulb fields were found in the soil around houses in the neighbourhood. There were also residues in the dust on doormats and inside the houses. Residues were also found in the urine of both adults and children living near flower bulb fields. This was also the case for people who lived more than 500 metres from agricultural fields. Higher concentrations of pesticides were measured in the samples from bulb growers and their families than in those from other local residents. The exposure of local residents may be due to the use of pesticides in the environment, but other sources, such as food, may have contributed, as well. Of the crop protection products studied, the measured levels in air and urine did not exceed any health-related limits (Montforts et al., 2019).

The results from the study show that exposure to individual substances is not underestimated in the current authorisation assessment. However, RIVM points out that the assessment method can be improved by taking into account the total exposure to several plant protection products at the same time. Previous research by RIVM showed that there were no health problems associated with bulb cultivation. However, there were

Figure 22

### Exceedances of the maximum residue levels of plant protection products in food



Source: RIVM

indications of health problems in other crops. For this reason, RIVM proposes a broad health study, which should also look at conditions not yet investigated, such as effects on cognitive development or related to autism. Attention should also be paid to vulnerable groups such as young people (Montforts et al., 2019)

## 2.8 Consequences of crop protection for food safety

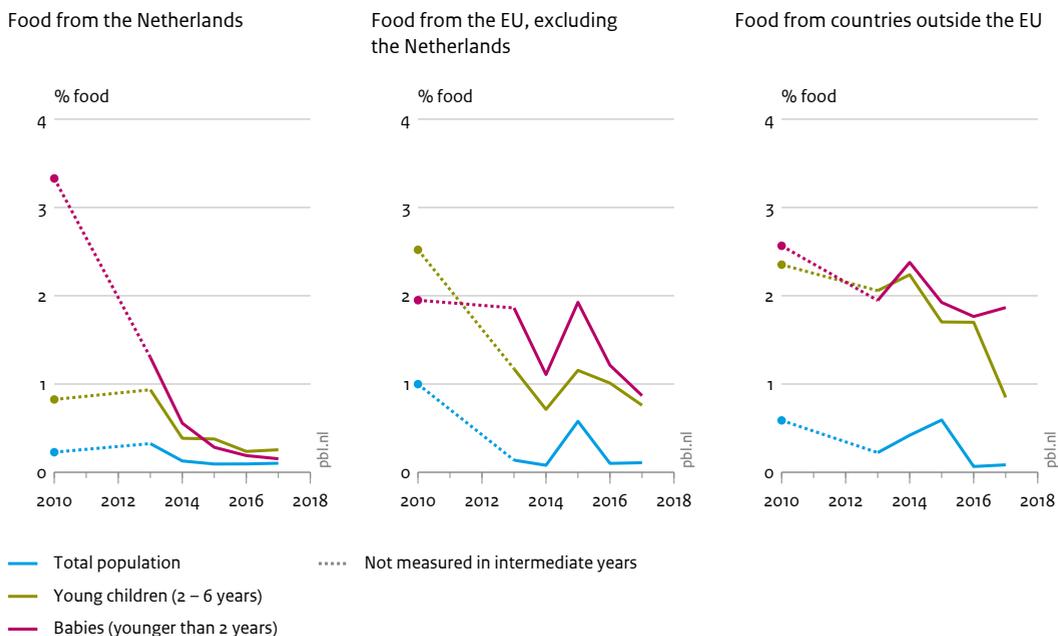
In order to protect the health of consumers, there are statutory limits on the maximum amount of residues of crop protection products that food may contain, the so-called Maximum Residue Levels (MRLs). The aim of the *Healthy Growth, Sustainable Harvest* policy for food safety is for exceedances not to go beyond the 2010 level. The MRLs have been established based on good agricultural practice and are usually stricter than is necessary from the point of view of public health. Therefore, exceeding the MRLs may not mean that there is a public health problem. Because MRL exceedances are found relatively often in products from countries outside the European Union, the policy document also focuses on increased monitoring of imported products. Finally, the document also looks at the possible effects of exposure to several substances at the same time and at informing consumers about the risks of plant protection products in relation to food.

### ***The percentage of foods that exceed the maximum residue levels has decreased***

The percentage of non-compliance with the MRLs has decreased since 2010 (Figure 22). This applies to products of non-Dutch origin; the percentage of exceedances of the MRLs for Dutch products was already low (less than 1%). The number of exceedances of foods

Figure 23

**Exceedances of the acute reference dose (ARfD)**



Source: RIVM

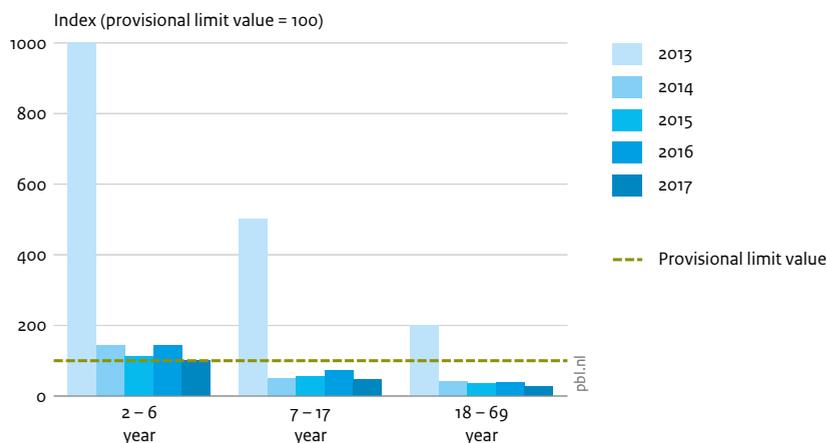
from countries outside the European Union varies between 1% and 3%. That is why the policy document sets the goal of stricter monitoring of these products. This goal meanwhile appears to have been achieved.

Over the 2013–2017 period, the MRLs for a number of toxic substances have been lowered. In general, agricultural practice reacts quickly to such stricter standards. The tightening of statutory standards therefore remains an efficient mechanism for reducing the amount of residue from crop protection products. This is partly because non-statutory requirements in the supermarket chains are usually linked to the statutory maximum residue levels; depending on the chain, the non-statutory standard is between 33% and 70% lower than the statutory standard.

Figure 22 is based on the average Dutch consumption pattern. Individuals may have different consumption patterns. Less is known about the consumption patterns of specific groups among the Dutch population, including those with a non-Western background. It would be advisable to devote more attention to this aspect.

Figure 24

### Acute cumulative exposure to plant protection products with a neurochemical effect



Source: RIVM; adaptation by PBL

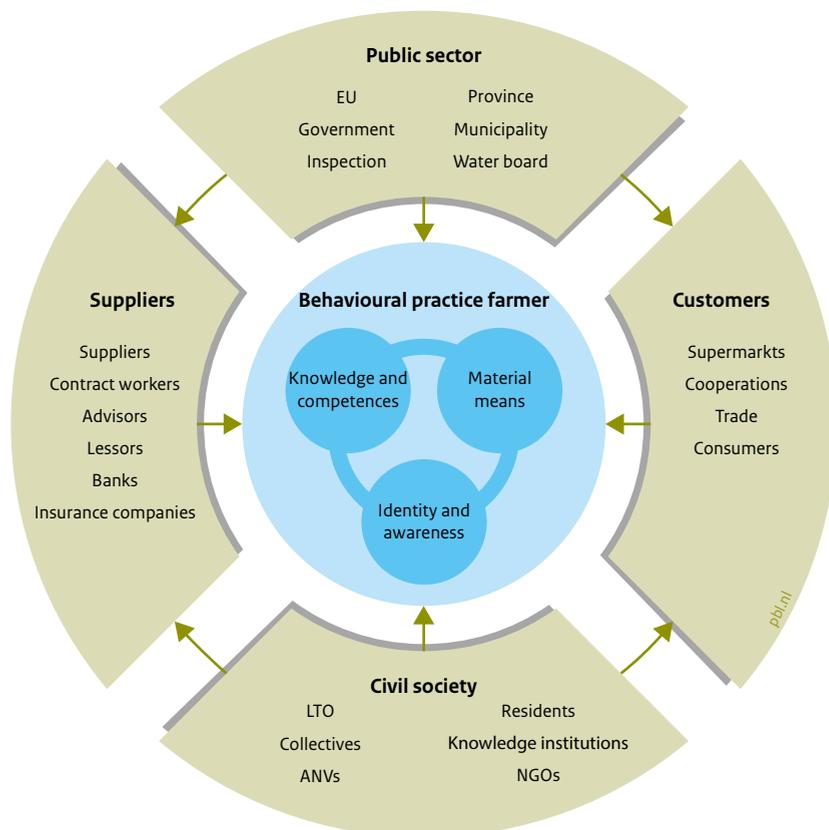
#### Food safety has improved

As indicated above, exceeding MRLs does not automatically mean that there is a public health problem. The number of exceedances, therefore, has only limited influence on the level of protection achieved. Therefore, RIVM also investigated the total number of exceedances of the health limits related to acute exposure (the so-called Acute Reference Dose or ARfD). This was done for different age groups (Boon et al., 2019). Because young children and babies consume more per kilogram of body weight, separate exposure calculations have been carried out for these groups. The number of exceedances of the toxicological acute exposure limit value (ARfD) appears to have decreased since 2010 (Figure 23). On balance, it can be said that food safety has improved for all age groups and that the objectives of the food safety policy document have been achieved.

#### Health risks due to cumulative exposure low to negligible

People are exposed to multiple substances daily. To assess whether the level of exposure to multiple substances is safe, the exposure to substances with the same health effect must be added together. There is no generally accepted method for calculating this 'cumulative' exposure. However, provisional methods and standards are already available for some groups of substances (EFSA, 2013b). In accordance with the objective in the policy document, the RIVM has mapped out the situation for four groups of substances with the same effect on the basis of the methods and standards now available in draft form. It appears that, for the investigated substance groups, the cumulative exposure for all age groups is below the limit value provisionally established by EFSA; the risk due to cumulative exposure is therefore negligible. Only for the group of substances with a harmful effect on the nervous system, the calculated cumulative exposure for young children is close to the

Figure 25  
Parties influencing the plant protection practices of farmers



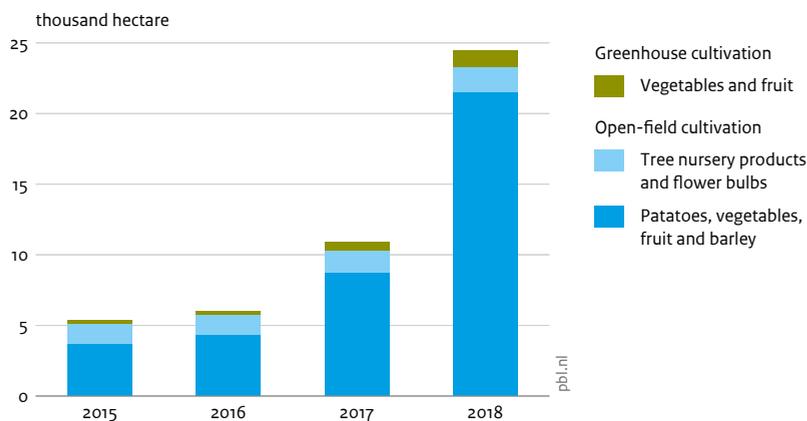
Source: PBL

provisionally established limit value; a risk for young children (children aged 2 to 6) can therefore not be excluded (Figure 24). It should be noted, however, that the calculations in accordance with generally accepted principles in the approval policy are based on a conservative scenario. The actual cumulative exposure is therefore very likely lower than the calculated exposure (Boon et al., 2019).

## 2.9 Factors affecting the crop protection practice

As a result of specialisation, economies of scale and intensification, growers are highly dependent on the means of production, techniques, services and requirements of other parties. This means that the influence of third parties on plant protection practices is substantial (Figure 25).

Figure 26  
Agriculture and horticulture area under PlanetProof label



Source: SMK

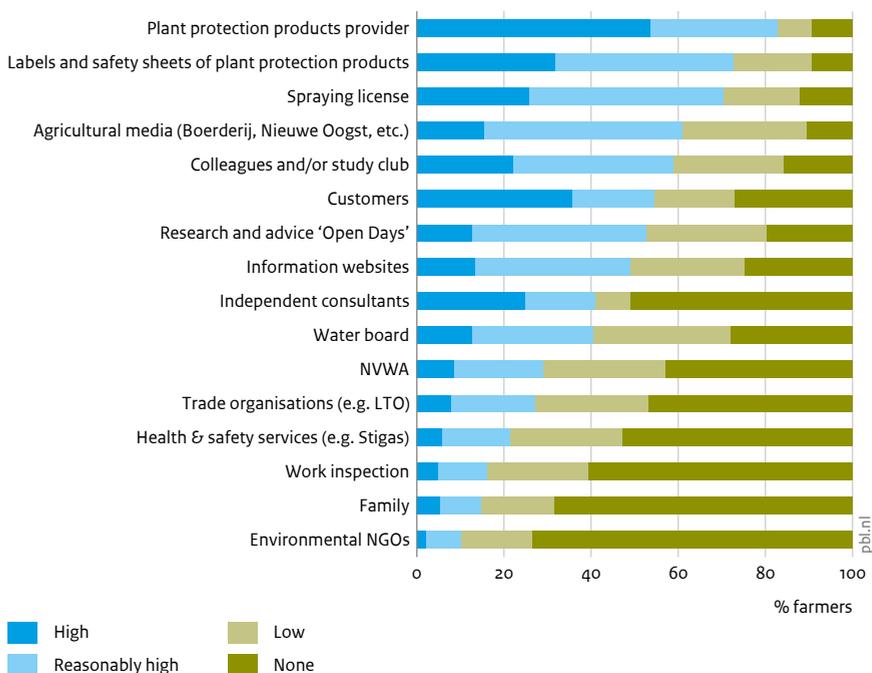
### ***Market requirements aimed at the presence of residues or diseases predominate ...***

The marketing chain plays an important role in the grower's practice. Buyers place demands on the end product and, to a limited extent, on the production process. Factors that are important to buyers are price, shape, taste and appearance. Resistance of crops is less important to buyers; they can distinguish themselves less with it (Thijssen et al., 2019). Only for products that are close to consumers do buyers also impose non-statutory requirements on the amount of residue. They do this, among other things, in order to prevent negative perceptions in public opinion and thus to prevent additional and unpredictable regulations (Hees et al., 2016; Lamichhane et al., 2018). Strict phytosanitary requirements apply to export products such as flowers, plants and plant propagation material; this is a major obstacle to reducing the use of pesticides, because it increases the chances of not meeting these strict phytosanitary requirements.

### ***... but requirements for environmentally conscious cultivation are on the rise***

The importance of environmentally friendly cultivation seems to be slowly gaining ground. In 2018, for example, a number of purchasing firms made the label (On the Way to) PlanetProof compulsory for potatoes, vegetables and fruit. The agricultural and horticultural acreage under PlanetProof is increasing rapidly, but, in the Netherlands, it is still less than 10% (Figure 26). In addition to non-statutory maximum residue levels, PlanetProof also imposes requirements on how growers should implement integrated pest management. This means that, unlike the government, PlanetProof operationalises the rules for cultivation practice. Not all purchasing firms participate in PlanetProof, but often they do follow certain strategies to lower pesticide use, such as phasing out products with a relatively high risk for people and the environment (Thijssen et al., 2019).

Figure 27  
Influence of knowledge sources on farmers, 2018



Source: CLM

### Still too few effective measures available

Growers say they experience a lack of effective measures to reduce the use of chemicals. According to growers, there is particularly a shortage of resistant crop varieties, technologies such as decision support system and low-risk substances (Thijssen et al., 2019). Research can make new measures available. However, the financing structure of knowledge development is an obstacle to this. Because companies in the so-called top sectors have to co-finance, there is an incentive for research with a direct added value for participating companies and less for research that only leads to results in the longer term and benefits society. The Schaaf Committee (2017) also notes that it is difficult to finance agricultural research aimed at public values with private funds. It therefore remains necessary for the government to continue to fund research that serves public interests, especially if it is aimed at the longer term. An example of such research is the knowledge impulse Green Crop Protection, in which the WUR is working on the development and testing of new cultivation systems.

***In addition to knowledge development, knowledge transfer is also important***

Integrated pest management is knowledge-intensive, because growers need to understand the biology of pest controlling species and pests, as well as the direct and indirect effects of crop protection products. In addition, resistance levels, measures and the range of products are constantly evolving. Therefore, in addition to the development of new measures, knowledge transfer is also important. Growers attach great importance to the knowledge of advisors, with the supplier of crop protection products being the most important free source of knowledge (Figure 27). The supplier also has an interest in selling pesticides, which raises the question of whether this free advice gives a balanced picture of all the possibilities of integrated pest management. Independent advisors, provided they are well informed about the possibilities of integrated pest management, may be able to present such a picture, but this carries a price tag for the grower.

***Collectives can play an important role in lifelong learning***

According to more than half of the growers, learning from colleagues via study groups is important for acquiring knowledge (Figure 27). So far, the focus of this type of study group has mainly been on specific aspects, such as the reduction in emissions from the farm yard through the application of the farm yard emission scan (*erfemissiescan*). Integrated pest management, on the whole, is rarely an issue. In order to reach the other half of the growers, knowledge meetings on integrated pest management could be held as part of spray licence courses. This offers the opportunity to reach more growers (both the front runners and those in the middle).

# 3 Quantitative outlook

This chapter uses model calculations to show what environmental gains can be achieved with additional emission reduction measures, with the consistent implementation of the principles of integrated pest management and with the substitution of relatively high-risk products. These are measures that are explicitly mentioned in the policy document. We consider both the effects on aquatic life and the effects on functional agricultural biodiversity. The models used are the NMI model to calculate the risks for aquatic organisms (Kruijne et al., 2011; Verschoor et al., 2019) and the ALMaSS model to predict the effects on non-target terrestrial species (Topping et al., 2015). As there are no models available for other themes, such as occupational safety and food safety, it was not possible to make a quantitative outlook for all themes.

## ***More far-reaching, drift-reducing measures needed to achieve the objectives of the policy document***

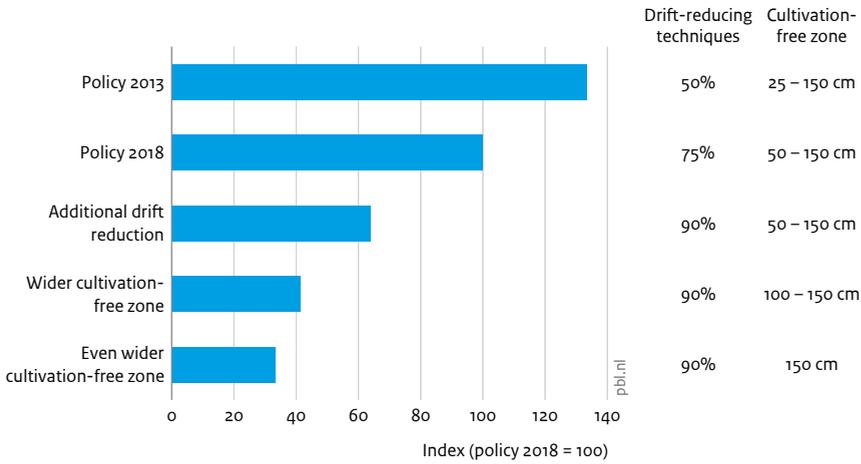
With a compulsory cultivation-free zone of 1.5 metres for all crops in combination with 90% drift reduction, the environmental impact will decrease by 0% to 52%, compared to the current situation, depending on the crop (Figure 28). The relatively small improvement in some cases is due to the fact that many growers already use 90% drift reducing techniques (Verschoor et al., 2019). In addition, the crop-free zone in intensively sprayed crops, such as flower bulbs, sugar beets and potatoes, has already been set at 1.5 metres. More far-reaching measures than those proposed in the policy document are needed in order to achieve the objectives by means of emission reduction measures. An example is 95% drift reducing techniques in combination with the further expansion of the crop-free zone to 3 metres. Compared to drift-reducing measures, broadening the cultivation-free zone is a relatively expensive measure, especially since there are many fields in the Netherlands adjacent to ditches. The costs of drift-reducing measures in arable farming amount to 3 euros per hectare, the costs of extending the crop-free zone to 3 metres are – depending on the type of crop – between 30 and 70 euros per hectare (Van Eerd et al., 2014). However, the broadening of the crop-free zone – if it is set up as a field border for functional agricultural biodiversity, as well – also offers possibilities for pollinating species and biological pest control species. This is less the case for drift-reducing measures (see below).

## ***Integrated pest management can further reduce environmental impact***

In addition to drift-reducing measures, consistent implementation of the principles of integrated pest management offers opportunities to reduce the environmental impact of surface water. This is evident from sample calculations for five crops (potatoes, tulips, asparagus, apples and tomatoes). These calculations are based on the requirements set for the PlanetProof certification label (SMK, 2018). PlanetProof was chosen as an example because this label makes the principles of integrated pest management compulsory and

Figure 28

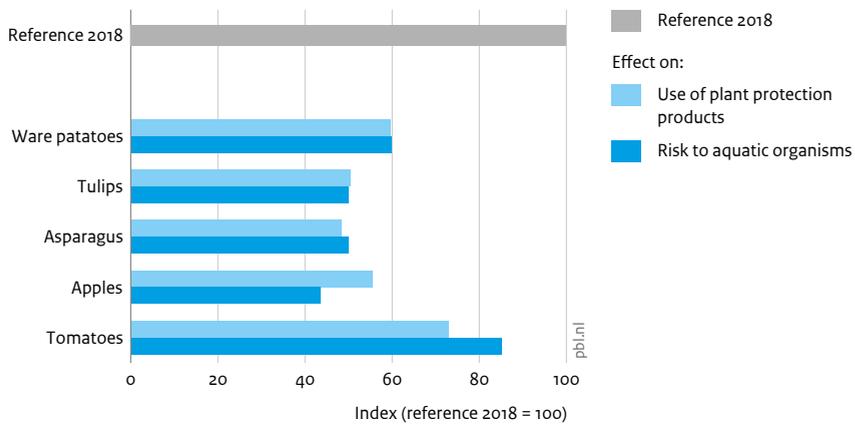
Effect of emission-reducing measures on the calculated aquatic risk



Source: RIVM; adaptation by PBL

Figure 29

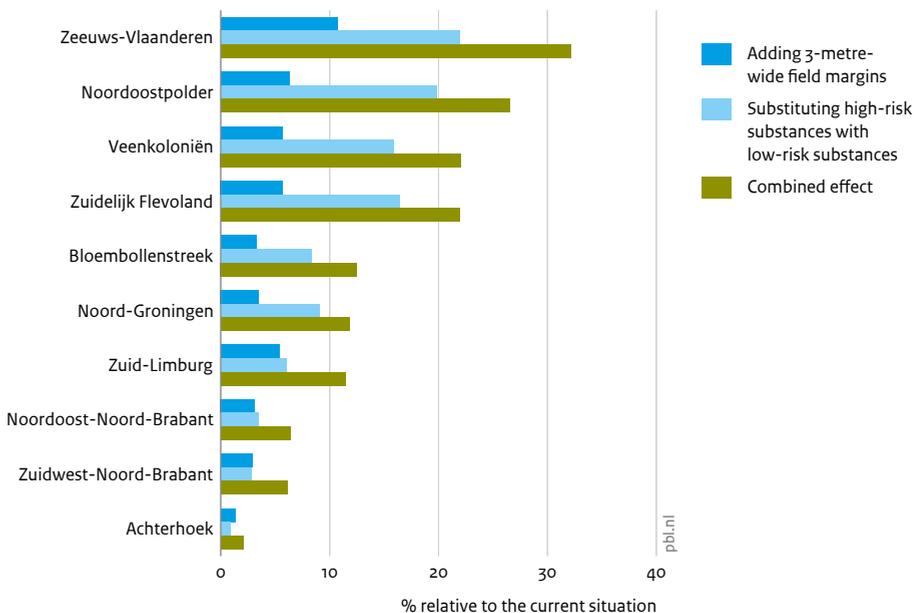
Effect of integrated pest management on the calculated aquatic risk



Source: RIVM; adaptation by PBL

Figure 30

Dispersion of ground beetles due to integrated pest management measures



Source: University of Krakow

rules of conduct have been defined for the grower (Chapter 3). Growers who work according to the PlanetProof scheme can reduce the use of plant protection products by 25% to 50% (Figure 29). This corresponds reasonably well with figures from practice and the international literature (Lechenet et al. 2017). The calculated reduction in risk to aquatic organisms is 15% to 56%, depending on the crop. This reduction is mainly achieved because integrated pest management reduces the need for high-risk products or even makes their use unnecessary. Reduced pesticide use is possible through the application of preventive measures, economic damage thresholds where growers only intervene when the expected yield losses caused by pests exceed the costs of treatment and non-chemical crop protection methods (Leendertse et al., 2019).

### ***Increasing agricultural biodiversity requires less use of high-risk products and improvement in landscape structure***

Calculations with the ALMaSS model (Ziółkowska and Topping, 2019) show that drift-reducing measures have little effect on the occurrence of the *Bembidion lampros* beetle. This ground beetle plays an important role in natural pest control and is comparable to other ground beetles in terms of behaviour. Exposure is still too high in field margins adjacent to the sprayed field, even with a 90% drift reduction. In addition, the sprayed fields themselves are the habitat of many insects. In order to promote functional agricultural biodiversity, it is therefore important to – first and foremost – reduce the risk for non-target species such as pest control species (Figure 30). This can be achieved by substituting high-risk substances with substances that pose a low risk to non-target species (so-called selective substances).

In addition to reducing environmental impact, the creation of field margins is an effective measure to stimulate functional agricultural biodiversity (Figure 30; Ziółkowska and Topping, 2019; EFSA PPR Panel, 2015). The effect is the strongest in areas that currently contain few landscape elements. In landscapes that contain many hiding places for pest control species (such as in the Dutch *Achterhoek*) the effect is less pronounced. The benefits for biodiversity can also be achieved through crop diversification in strip farming. It should be noted, however, that field margins are still necessary in such systems and that such edges are well managed. Poor management can be counterproductive because pests can also develop in field margins (Karp et al., 2018).

# 4 Options for achieving the main targets

Under current policy, targets are unlikely to be achieved by 2023. This concluding chapter presents a number of options for increasing the probability of targets being achieved by 2023. Here, four themes are considered: (1) better integration of policy domains, aiming at the simultaneous achievement of water quality and agricultural biodiversity targets, (2) the use of a balanced mix of policy instruments, (3) the strengthening of knowledge development, knowledge transfer and access to knowledge, and finally (4) possibilities to achieve more sustainable crop protection via the supply chain.

## 4.1 Better integration of policy domains

An important reason for exceeding maximum residue levels in surface water is that the authorisation procedure for plant protection products and the policy on water quality are not in line with each other. In addition, each product is authorised individually, whereas, in reality, several products are used in parallel. Some of these products may even contain the same active substance. Finally, emission policy aimed solely at water quality does not necessarily lead to more functional agricultural biodiversity (Chapter 3). A system-based approach in which the water quality policy, the policy for functional agricultural biodiversity and the authorisation policy are more integrated increases the chances of achieving all targets.

### ***Ensure that the authorisation does not consider additional emission measures***

With additional generic emission policies, water quality can still be improved, provided that rules are complied with. The advantage of generic measures is that substance-specific restrictions are no longer necessary. This promotes simplicity and transparency of the instructions for use. Emission-reducing measures are effective, as long as the authorisation does not take the additional emission reduction measures into account. After all, if the emission reduction achieved as the result of such measures would mean that products are authorised that would otherwise not have been authorised, then on balance the emission effect would be limited or even zero. In this situation, however, emission-reducing measures can be regarded as a way of retaining an effective package of plant protection products (i.e. a mitigation measure).

### ***Avoid a one-sided focus on water quality in emission policy***

Reducing spray drift alone is not enough to bring agricultural biodiversity targets closer within reach. This also requires limiting the use of high-risk products for non-target species. In addition, field margins are a prerequisite. Combining field margins and crop-free zones offers perspectives for both functional agricultural biodiversity, and aquatic life; however, on the condition that crop-free zones are then at least 3 metres wide (Bos et al., 2014). In addition, the management of those field margins also requires attention. After all, annual field margins have to be sown again, each year, and multiannual field margins require weed management.

### ***Plead for quick reassessment of WFD-problem substances***

An important reason for the measured exceedances is that the European approval criteria are generally less stringent than the water quality standards according to the WFD (PBL, 2012). These approval criteria are especially less stringent because, for the approval, a temporary effect on the most sensitive organisms is considered acceptable; this is not the case for the exceedance of the water quality standards (Brock et al., 2011). Partly for this reason, EFSA has published a new guideline for the assessment of effects on aquatic organisms (EFSA PPR Panel, 2013a). It is expected that reassessment of substances with this new guideline will bring the approval standard and the WFD standards closer together (Brock et al., 2011). This offers possibilities for improving water quality, as the approval of many substances will have to be renewed and re-evaluated from 2019 onwards. The Netherlands could plead in Brussels for WFD problem substances to be given high priority in the reassessment.

### ***Align Dutch product authorisation with the emission policy***

In addition to water quality standards, approval standards are also frequently exceeded. This may be a sign of shortcomings in the Dutch authorisation procedure. It is advisable to solve these shortcomings as soon as possible. For example, unlike the European procedure, the Dutch procedure does not take account of losses due to drainage and surface run-off. In addition, the contribution of spray drift is underestimated by a factor of 1.2 to 2.5 (Van de Zande et al., 2012). This is partly due to the fact that, for many crops, the authorisation is based on a wider crop-free zone than is required under the Dutch emission policy.

### ***Cap on the total use of plant protection products may prevent a waterbed effect***

The total environmental impact per crop is not taken into account in the approval of substances and the authorisation of products. As a result, there is a risk that the use of other high-risk products will increase when a product's authorisation expires. This is also referred to as a waterbed effect. In addition, the so-called stacking effect plays a role. Substance labels often prescribe a maximum number of sprays. Since instructions for use apply to each product, another product containing the same active ingredient may be sprayed, adding the same substance more frequently, intentionally or unintentionally.

A system-based approach with a statutory cap on the total pesticide use per crop could partially or fully prevent both the stacking and waterbed effect. Under the PlanetProof certification scheme, a cap is already used based on the amount of active ingredients

(i.e. kg used). To be effective for the protection of the environment, the cap should, however, be based on the environmental risk. The more limited scope for the use of plant protection products that this creates could encourage growers to look for alternatives such as preventive measures and non-chemical methods. But these do need to be available. That is why more effort is needed from the government and the sector to stimulate research into alternatives.

## 4.2 Balanced mix of policy instruments

Although the *Healthy Growth, Sustainable Harvest* policy document takes integrated pest management as its starting point, the generic government policy continues to focus strongly on chemical plant protection products; prevention and monitoring receive less policy attention. The national policy is mainly focused on regulation and information and makes little use of price incentives. Integral projects may bring the targets for water quality and agricultural biodiversity closer within reach.

### ***Considerations concerning taxation of chemical plant protection products***

Some European Member States levy a tax on chemical plant protection products. The effect depends on appropriate flanking policies (Lefebvre et al., 2015; Böcker and Finger, 2016). Scientific empirical studies on the effectiveness of taxing chemical crop protection products are scarce. However, economic arguments for introducing price incentives are the efficient use of resources and the promotion of innovation in the longer term. A tax on chemical crop protection products is in line with the ‘polluter pays’ principle. The disadvantage would be that it would need to be high in order to have a substantial effect, which adversely affects the competitive position of growers (Hof et al., 2013). In a number of countries, such tax revenues are returned to the sector by reducing the financial burden of growers or by using those revenues for the development and dissemination of knowledge for the sector. Provided it is designed correctly, a tax may be an effective addition to the available policy instruments. It is recommended that the various arguments for and against such a tax be weighed against the background of future policies on plant protection products.

### ***An integrated approach is promising yet expensive***

Regional or sector-specific projects that link awareness in an integrated way to guidance, intensive monitoring and subsidy possibilities for physical measures that go beyond the statutory requirements appear to be promising approaches to improving water quality. It is precisely the mix of policy instruments that is important here. However, these projects are expensive and generally rely on public funding. National and regional governments could agree on joint funding.

An important policy route for allowing growers to voluntarily take measures beyond statutory requirements is that of the Delta Programme for Agricultural Water Management (DAW), in which projects are co-funded by various government authorities. An important success factor in regional and sector-specific projects is the joint efforts and support of

both the sector and government parties to make an active contribution (Boezeman et al., 2019). In addition, it should be investigated whether access to funding frameworks under the European Rural Development Programme could be simplified. Management and monitoring are needed to stimulate projects with proven effectiveness using public funding. In addition, it is ultimately important that there are consequences – in the form of legislation in the event that the voluntary route has insufficient effect – in order to get those who are staying behind on board, as well.

#### ***Integrated approach needed to stimulate functional agricultural biodiversity***

Paying farmers for non-productive services, such as the creation and management of field margins, under a different interpretation of the CAP, could offer possibilities. Good management is needed to ensure that field margins function optimally. Knowledge sharing among growers is important and the collectives in the Agricultural Nature and Landscape Management (ANLb) offer possibilities for this. However, attention must also be paid to the agricultural area outside the areas designated by the provinces, in order to prevent the loss of biodiversity in those areas (Melman et al., 2014).

#### ***Occupational safety issues require stronger government effort***

Occupational health and safety are seen as a joint responsibility of employers and employees. The characteristics of personnel deployment in the sector, on the one hand, and the knowledge required to safely handle plant protection products, on the other, do not always prove to be a realistic starting point. Support from the business community and the government is therefore considered necessary.

First, the government, in collaboration with the sector, could play an important financial and facilitating role in assembling all the information about working safely with plant protection products, making it available at a single (virtual) location. Data from the Ctgb, the safety data sheets (SDS) and information on possible alternatives to hazardous substances (products with the skull-and-crossbones symbol) could be entered into a free online database. Familiarity with and user-friendliness of this database are crucial. A user and expert panel could check the accessibility, completeness and reliability of the information. The suppliers of information must keep the database up to date. This database can be promoted as a basic source of information and for drawing up Health and Safety Catalogues and RI&Es.

Second, the safe use of plant protection products and compliance with regulation should receive more attention. The inspection and enforcement capacity of the Social Affairs and Employment Inspectorate (ISZW) could be increased. This could lead to a higher level of compliance with occupational health and safety regulations and provide more insight into them. Inspections can also have a learning effect on making the workplace safer, by providing advice on alternatives, the provision of information and specific attention to vulnerable groups.

### ***Prevent voluntariness from turning into non-commitment***

The policy memorandum hinges largely on a voluntary approach. Assessment shows that it is important that, in both public and private initiatives, consequences in the form of coercive measures are implemented to prevent voluntariness from turning into non-commitment. The positive experiences with the ban on using these products on sealed surfaces show that regulation can also play an important role in the transition to a system that is less based on chemical crop protection. Such a transition calls for policies that stop chemical plant protection products from being routinely used and stimulate new methods and techniques through knowledge development, knowledge transfer and – where necessary and possible – financial incentives.

## **4.3 Supply chain governance**

### ***Non-statutory requirements in the lead, the government can play a supportive role***

Non-statutory requirements play an important role in the practice of growers, but these requirements rarely focus on integrated pest management. The likelihood of growers applying integrated pest management measures increases if the additional investments in time and costs are offset by enough revenues. Competition law and the complexity of food flows limit the government's options to promote integrated pest management through the supply chain. However, the government can influence private management by stimulating the provision of information about these chain initiatives, and by bringing parties together or by promoting benchmarking (De Krom and Prins, 2019; WRR, 2014). Although it is up to private parties to decide on the specific substantive requirements of chain management, the government has a role to play in creating a supportive framework. Buyers, in particular, could encourage integrated pest management by offering growers greater security of supply or by offering them a better public image, a higher price or a contribution to the development costs of integrated pest management measures.

Private and public regulations are also interlinked, as the link between statutory requirements and private requirements for residue levels has shown. Conversely, elements from the operationalisation of PlanetProof – *private* regulation – could provide inspiration for changes in government regulation. Examples include a cap on the use of plant protection products and the phasing out of products with a relatively high risk for human health and the environment. In addition, the Plant Protection Products and Biocides Decree offers the possibility of adopting a 'guide to good plant protection practices'. The further specified steps of integrated pest management from private regulation, such as the cap on the use of plant protection products, could be included in this future guide.

## 4.4 Strengthening knowledge development, transfer and deployment

The availability of effective measures and the knowledge and skills to apply them in practice are prerequisites for bringing goals closer within reach. Strengthening the development and dissemination of knowledge is important in order to offer growers more scope for action to make integrated pest management possible in practice.

### ***It is still up to the government to fund research aimed at public interests***

Thijssen et al. (2019) have identified bottlenecks in the field of collective research. This has to do with the financing structure of knowledge development. Because companies with top sector budgets have to co-finance, there is mainly an incentive for research with a direct added value for the participating companies and less for research that benefits society. Improved water quality, for example, is important for society, but its direct added value is zero for an individual company. The Schaaf Committee (2017) and Pardey et al. (2016) concluded that it is difficult to finance agricultural research aimed at public values by using private financing. It therefore remains necessary for the government to continue funding research that serves the public interest, especially for the longer term.

### ***General Declarations of Commitment can alleviate coordination problems in applied research.***

After the disappearance of the collective product boards, coordination problems arose in collectively applied research. These relate to both drawing up and coordinating the knowledge agenda and collecting funds to co-finance research. In response to this, sector organisations in a number of sectors have set up 'collectives'. For these collectives to successfully generate research funds, General Declarations of Commitment under Dutch law by the government can help. However, not every sector is able to start such collectives on its own. Where this is not the case, the government could actively bring parties together and help draw up an agenda for collective research (PBL, 2018). In addition, the government could play a role by making a greater effort than is currently the case to fund applied research aimed at protecting public values, such as improving the quality of the physical environment.

### ***Encourage knowledge transfer via independent advisors and study groups***

The development of new alternatives and techniques and the development of resistant pest species requires that the grower has continual access to up-to-date knowledge. Advisors and study groups play an important role here. It is important that attention is also paid to the costs and benefits of the various alternatives. The supplier of plant protection products is the most important source of knowledge for growers, who also have an interest in the sale of products (Leendertse et al., 2019). This raises the question of whether advice that is not charged separately provides a balanced picture of all the possibilities of integrated pest management. The costs of the advice are integrated into the price of the product. As a result, there is no level playing field with independent advisors. The government could play a role in creating a more level playing field by

requiring – as is the case in the Dutch mortgage sector – that the costs of advice and products are charged separately. Such a construction could help to avoid any perception of a conflict of interest.

Greater attention must be paid to integrated pest management in the curricula of agricultural training courses. Further training via study groups is promising; projects that show new techniques and good applications to colleagues contribute to reducing emissions. Public co-funding of these projects is therefore an option. In order to reach the front runners as well as those operating in the middle group, knowledge meetings in the context of the spray licence can promote knowledge and skills.

# References

- Alavanja MC and Bonner MRO. (2012). Occupational Pesticide Exposures and Cancer Risk: A Review. *Journal of Toxicology and Environmental Health, Part B: Critical Reviews* 15: 238–263.
- Betekov MA, Kefford BJ, Schäfer RB and Liess M. (2013). Pesticides reduce regional biodiversity of stream invertebrates. *PNAS* 110: 11039–11043.
- Blacquièrè T, Smagghe G, Gestel CAM and Mommaerts V. (2012). Neonicotinoids in bees: A review on concentrations, side-effects and risk assessment. *Ecotoxicology*, DOI: 10.1007/s10646-012-0863-x.
- Blacquièrè T and Van der Steen JJM. (2017). Three years of banning neonicotinoid insecticides based on sub-lethal effects: Can we expect to see effects on bees? *Pest Management Science* 73(7): 1299–1304.
- Böcker T and Finger R. (2016). European pesticide tax schemes in comparison: An analysis of experiences and developments. *Sustainability* 8(4): 378.
- Boezeman D, Liefferink D and Wiering M. (2019). Nieuwe richtingen voor de implementatie van de Kaderrichtlijn Water. Regionale governance verschillen en sturingsvarianten voor de toekomst. Radboud University Nijmegen.
- Boon PE, Van Donkersgoed G, Van der Vossen W, Sam M, Noordam MY and Van der Schee H. (2019). Tussenevaluatie van de nota Gezonde Groei, Duurzame Oogst. Deelproject Voedselveiligheid. RIVM Report 2018-0127, National Institute for Public Health and the Environment (RIVM), Bilthoven.
- Bos MM, Musters CJM and De Snoo GR. (2014). De effectiviteit van akkerranden in het vervullen van maatschappelijke diensten. Een overzicht uit wetenschappelijke literatuur en praktijkervaringen. CML report 188. CML, Leiden.
- Boyd IL. (2018). An inside view on pesticide policy. *Nature Ecology and Evolution* 2: 920-921.
- Bozzini E. (2018). Pesticide Policy and Politics in the European Union. Regulatory Assessment, Implementation and Enforcement. Palgrave Pivot, Bologna.
- Brock TCM, Arts GHP, Hulscher TEM, De Jong FMW, Luttik R, Roex EWM, Smit CE and Van Vliet PJM. (2011). Aquatic effect assessment for plant protection products. Dutch proposal that addresses the requirements of the Plant Protection Regulation and the Water Framework Directive. Alterra Report 2235, Alterra, Wageningen.
- CBS (2018). Landbouw gebruikt 5.7 miljoen kg chemische middelen [Agriculture uses 5.7 million kilograms in chemical substances], News message 27 August 2018, <https://www.cbs.nl/nl-nl/nieuws/2018/30/landbouw-gebruikt-5-7-miljoen-kg-chemische-middelen>.
- Commissie Schaaf (2017). Van excellente instituten naar vitale innovatie ecosystemen.
- Ctgb (2017b). Ctgb-advies inzake voorstellen Commissie voor verdere beperking drie neonicotinoiden en verkenning risico's alternatieve werkzame stoffen. Beschikbaar via [www.ctgb.nl](http://www.ctgb.nl). Ctgb, Wageningen.

- Daniels L. (2015). De oogst van Bloeiend Bedrijf. Louis Bolk Instituut rapport 2015-002, Louis Bolk Institute, Driebergen.
- De Geus J, Van Gorp H, Van Alebeek FAN, Bos M, Janmaat L, Molendijk LPG, Van Rijn P, Schaap BF, Visser A, Vlaswinkel MET, Van der Wal E, Willemse J and Zanen M. (2011). Eindrapportage FAB2 2008-2011: functionele agrobiodiversiteit. ZLTO Projecten, 's Hertogenbosch.
- De Krom M and Prins A. (2019). Verduurzaming van landbouw via de keten. De kracht en beperkingen van private sturing in de aardappel- en de zuivelketen. PBL Netherlands Environmental Assessment Agency, The Hague.
- De Weert J, Roex E, Klein J and Janssen G. (2014). Opzet Landelijk Meetnet Gewasbeschermingsmiddelen land- en tuinbouw. Deltares report 1207762-008, Deltares, Utrecht.
- EC (2009). EU Regulation (EG) No. 1107/2009 of the European Parliament and of the Council of 21 October 2009 concerning the placing of plant protection products on the market and repealing Council Directives 79/117/EEC and 91/414/EEC. Official Journal, L 309.1, 24.11.2009. European Commission, Brussels.
- EC (2018). Study supporting the REFIT Evaluation of the EU legislation on plant protection products and pesticides residues (Regulation (EC) No. 1107/2009 and Regulation (EC) No. 396/2005). European Commission, Brussels.
- EFSA (2013). EFSA Guidance Document on the risk assessment of plant protection products on bees (*Apis mellifera*, *Bombus* spp. and solitary bees). EFSA Journal 11(7): 3295.
- EFSA PPR Panel (2010). Scientific Opinion on the development of specific protection goal options for environmental risk assessment of pesticides, in particular in relation to the revision of the Guidance Documents on Aquatic and Terrestrial Ecotoxicology. EFSA Journal 8(10): 1821.
- EFSA PPR Panel (2013a). Guidance on tiered risk assessment for plant protection products for aquatic organisms in edge-of-field surface waters. EFSA Journal 11(7): 3290
- EFSA PPR Panel (2013b). Scientific Opinion on the identification of pesticides to be included in cumulative assessment groups on the basis of their toxicological profile. EFSA Journal 11(7): 3293.
- EFSA PPR Panel (2014). Scientific Opinion addressing the state of the science on risk assessment of plant protection products for non-target terrestrial plants. EFSA Journal 12(7): 3800.
- EFSA PPR Panel (2015). Scientific Opinion addressing the state of the science on risk assessment of plant protection products for non-target arthropods. EFSA Journal 13(2): 3996.
- EFSA PPR Panel (2017). Scientific Opinion addressing the state of the science on risk assessment of plant protection products for in-soil organisms. EFSA Journal 15(2): 4690.
- EPRS (2018). Regulation (EC) 1107/2009 on the Placing of Plant Protection Products on the Market. European Implementation Assessment, EPRS Ex-post Evaluatoin Unit PE 615.668. EPRS, Brussels.
- EPRS (2019). Farming without plant protection products, EPRS Scientific Foresight Unit PE 634.416. EPRS, Brussels.

- EZ (2013). Nota Gezonde Groei, Duurzame Oogst [policy document 'Healthy Growth, Sustainable Harvest']. Ministry of Economic Affairs, The Hague.
- Goulson D, Nicholls E, Botías C and Rotheray EL. (2015). Bee declines driven by combined stress from parasites, pesticides, and lack of flowers. *Science* 347(6229): 1255957.
- Hallmann CA, Sorg M, Jongejans E, Siepel H, Hofland N, Schwan H, et al. (2017). More than 75 percent decline over 27 years in total flying insect biomass in protected areas. *PLoS ONE* 12(10): e0185809.
- Hallmann CA, Zeegers T, Van Klink R, Vermeulen R, Van Wielink P, Spijkers H and Jongejans E. (2018). Analysis of insect monitoring data from De Kaaistoep and Drenthe. Reports Animal Ecology and Physiology 2018-2, Radboud University, Nijmegen.
- Hees E, Leendertse P and Hoftijser E. (2016). Supermarkt aan zet voor duurzame gewasbescherming. CLM Onderzoek en Advies.
- Hof B, Koopmans C, Rougoor W and Van der Voort J. (2013). Effecten en vormgeving van een heffing op gewasbeschermingsmiddelen. SEO Economisch Onderzoek, Amsterdam.
- Hoogendoorn M, Van Vliet J, Veenenbos M, Rougoor C, Lommen J and Leendertse P. (2018). Schoon Water voor Brabant – tussenrapportage 2017. CLM, Culemborg.
- Hoogendoorn M, Leendertse P and Hoftijser E. (2019). Update van de risicolijst van bestrijdingsmiddelen. CLM-publicatie 967, CLM, Culemborg.
- Karp SD, et al. (2018), Crop pests and predators exhibit inconsistent responses to surrounding landscape composition. *PNAS* August 14, 2018 115 (33) E7863–E7870.
- Koutros S, Freeman LEB, Lubin JH, Heltshe SL, Andreotti G, Barry KH, DellaValle CT, Hoppin JA, Sandler DP, Lynch CF, Blair A and Alavanja MC. (2013). Risk of total and aggressive prostate cancer and pesticide use in the Agricultural Health Study. *American Journal of Epidemiology* 177(1): 59–74.
- Kruijne R, Van der Linden AMA, Deneer JW, Groenwold JG and Wipfler EL. (2011). Dutch environmental risk indicator for plant protection products, NMI 3. Alterra report 2250.1, Alterra, Wageningen.
- Lamichhane JR, Akbas B, Andreasen CB, Arendse W, Bluemel S, Dachbrodt-Saaydeh S and Malet JC. (2018). A call for stakeholders to boost integrated pest management in Europe: A vision based on the three-year European research area network project. *International Journal of Pest Management* 64(4): 352–358.
- Lechenet M, Dessaint F, Py G, Makowski D and Munier-Jolain N. (2017). Reducing pesticide use while preserving crop productivity and profitability on arable farms. *Nature Plants* (3): 17008.
- Leendertse PC, Lageschaar L, Hoftijser E, Rougoor CW, Boeke SJ and Van Beek J. (2019). Tussenevaluatie Gezonde Groei, Duurzame Oogst (GGDO): Geïntegreerde gewasbescherming. CLM-publicatie 968, CLM, Culemborg.
- Lefebvre M, Langrell SRH and Gomez-Y-Paloma S. (2015). Incentives and policies for integrated pest management in Europe: A review. *Agronomy for Sustainable Development* (35): 27–45.
- LNV (2004). Duurzame gewasbescherming. Beleid voor gewasbescherming tot 2010. Ministry of Agriculture, Nature and Food Quality, The Hague.

- Melman TCP, Sierdsema H, Buij R, Roerink G, Ten Holt H, Martens S, Meeuwssen HAM and Schotman AGM. (2014). Uitwerking kerngebieden weidevogels. Alterra report 2564, Alterra, Wageningen.
- Mnif W, Hassine AIH, Bouaziz A, Bartegi A, Thomas O and Roig BT. (2011). Effect of Endocrine Disruptor Pesticides: A Review. *International Journal of Environmental Research and Public Health* 8(6): 2265–2303.
- Montforts MHMM, Bodar CWM, Smit CE, Wezenbeek JM and Rietveld AG. (2019). Bestrijdingsmiddelen en omwonenden. Samenvattend rapport over blootstelling en mogelijke gezondheidseffecten. RIVM Report 2019-0052, National Institute for Public Health and the Environment (RIVM), Bilthoven.
- NVWA (2017). Update landbouwkundige impactanalyse n.a.v. door COM voorgestelde beperking van het gebruik van drie neonicotinoïden (clothiadin, imidacloprid en thiamethoxam). Netherlands Food and Consumer Product Safety Authority, Utrecht.
- Palumbi SR. (2001). Humans as the world's greatest evolutionary force. *Science* 293: 1786–1790.
- Pardey PG, Chan-Kang C, Dehmer SP and Beddow JM. (2016). Agricultural R&D is on the move. *Nature News* 537(7620): 301.
- PBL (2012). Evaluatie van de nota duurzame gewasbescherming. PBL Netherlands Environmental Assessment Agency, The Hague.
- PBL (2018). Naar een wenkend perspectief voor de Nederlandse landbouw. Voorwaarden voor verandering. PBL Netherlands Environmental Assessment Agency, The Hague.
- PBL (2019). Geïntegreerde gewasbescherming nader beschouwd. Tussenevaluatie van de nota Gezonde Groei, Duurzame Oogst. PBL Netherlands Environmental Assessment Agency, The Hague.
- Priyadarshi A, Khuder SA, Schaub EA and Priyadarshi SS. (2001). Environmental risk factors and Parkinson's disease: A metaanalysis. *Environmental Research* 86(2): 122–127.
- Prokopy RJ. (2003). Two decades of bottom-up, ecologically based pest management in a small commercial apple orchard in Massachusetts. *Agriculture, Ecosystems and Environment* 94: 299–309.
- Rougoor C, Broos J and Gooijer Y. (2018). Erfemissie? Natuurlijk niet! CLM-report 959, CLM, Culemborg.
- Seufert V, Ramankutty N and Foley JA. (2012). Comparing the yields of organic and conventional agriculture. *Nature* 485(7397): 229.
- SMK (2018). Toelichting beoordeling risico gewasbeschermingsmiddelen voor 'On the way to PlanetProof'. Stichting Milieukeur, The Hague.
- Spaan S, Van Duuren-Stuurman B, Van de Brug F, Voogd E and Gerritsen-Ebben R. (2019). Evaluatie nota Gezonde Groei, Duurzame Oogst (GGDO), Deelproject Arbeidsveiligheid en Productverantwoordelijkheid. TNO Netherlands Organisation for Applied Scientific Research, Zeist.
- Spoorenberg P, Verstand D and Beerling E. (2019). Tussenevaluatie van de nota Gezonde Groei, Duurzame Oogst – Deelrapport Knelpuntenanalyse en ontwikkeling. WPR, Wageningen.
- Stokkers R. (2019). Tussenevaluatie van de nota Gezonde Groei, Duurzame Oogst – Deelrapport Naleving. WEcR, Wageningen.

- Tamis WLM and Van 't Zelfde M. (2017). Uitwerking referentieperiode Tweede nota Duurzame Gewasbescherming. CML, Leiden.
- Tamis WLM and Van 't Zelfde M. (2019). Gewasbeschermingsmiddelen in het oppervlaktewater in Nederland: Metingen. Bijdrage aan het deelrapport milieu van de Tussenevaluatie van Gezonde Groei, Duurzame Oogst, Tweede nota duurzame gewasbescherming periode 2013 tot 2023. CML, Leiden.
- Thijssen M, Verwoerd L, Westerhof R and Brinks H. (2018). Eindrapportage GGDO: Handelingsperspectieven. ORG-ID bv., Leiden.
- Tiktak A, Adriaanse PI, Boesten JJTI, Van Griethuysen C, Ter Horst MMS, Linders JBHJ, Van der Linden AMA and Van de Zande JC. (2012). Scenarios for exposure of aquatic organisms to plant protection products in the Netherlands. Part 1: Field crops and downward spraying. RIVM report 607407002/2012, National Institute for Public Health and the Environment (RIVM), Bilthoven.
- Topping CJ, Craig PS, De Jong F, Klein M, Laskowski R, Manachini B, Pieper S, Smith R, Sousa JP, Streissl F, Swarowsky K, Tiktak A and Van der Linden AMA. (2015). Towards a landscape scale management of pesticides: ERA using changes in modelled occupancy and abundance to assess long-term population impacts of pesticides. *Science of the Total Environment* 537: 159–169.
- Url B. (2018). Don't attack science agencies for political gain. *Nature* 553: 381.
- Van Alebeek F. (2015) Duurzaamheidseffecten van akkerranden. Wetenschappelijke en praktische onderbouwing van duurzaamheidsaspecten van akkerranden. Een Helpdeskvraag t.b.v. Stichting Veldleeuwewik. Wageningen University and Research, Wageningen (<http://edepot.wur.nl/363477>).
- Van Eerd MM, Spruijt J, Van der Wal E, Van Zeijts H and Tiktak A. (2014). Costs and effectiveness of on-farm measures to reduce aquatic risks from pesticides in the Netherlands. *Pest Management Science* (70)12: 1840–1849.
- Van de Zande JC, Holterman HJ and Huijsmans JFM. (2012). Spray drift for the assessment of exposure of aquatic organisms to plant protection products in the Netherlands. Part 1: Field crops and downward spraying. WPR report 419, WPR, Wageningen.
- Van Lienen F and Schuerhoff M. (2015). Duurzaam gebruik van natuurlijk kapitaal voor Schoon Water in Brabant. Van succesvol project naar verankering in de bedrijfspraktijk. PBL Netherlands Environmental Assessment Agency, The Hague.
- Verschoor A, Zwartkruis J, Hoogsteen M, Van der Knaap Y, Scheepmaker J, De Jong F, Leendertse P, Boeke S, Tamis W and Vijftigschild R. (2019). Tussenevaluatie van de 2e nota duurzame gewasbescherming: Deelproject Milieu. National Institute for Public Health and the Environment (RIVM), Bilthoven.
- Verstand D, Spoorenberg P, Van Kuik F, Raaphorst M and Beerling E. (2019). Tussenevaluatie van de nota Gezonde Groei, Duurzame Oogst – Deelrapport Economisch perspectief. WPR, Wageningen.
- Vugteveen P and Van Hinsberg A. (2017). Achteruitgang insecten. PBL Netherlands Environmental Assessment Agency, The Hague.
- Waterfield G and Zilberman D. (2012). Pest Management in Food Systems: An Economic Perspective. *Annual Review Environmental Resources* 2012.37:223–245.

Ziółkowska E and Topping CJ. (2019). A modelling approach to evaluate the effectiveness of different mitigation strategies to reduce the negative effects of agricultural practices on biodiversity in the Netherlands: Final report within the framework of the project: 'Developing and application of a methodology to assess impacts of pesticides on key ecosystem services', Kraków: Jagiellonian University.

# Abbreviations

AA-EQS	Annual Average – Environmental Quality Standard
ALMaSS	Animal, Landscape and Man Simulation System
ANLb	Agricultural Nature and Landscape management
ARFD	Acute Reference Dose
CAG	Cumulative Assessment Group
CAP	Common Agricultural Policy
Cas	CRISPR associated system
CBS	Statistics Netherlands
CEMP	Coordinator Effective Package of Plant Protection Products
CLM	CLM Research and Advice
CML	Centre of Environmental Science Leiden University
CMR	Carcinogenic, mutagenic, reprotoxic
CRISPR	Clustered Regularly Interspaced Short Palindromic Repeats
Ctgb	Board for the Authorisation of Plant Protection Products and Biocides
DAW	Delta plan Agricultural Water Management
DRT	Drift Reducing Technology
DSS	Decision Support System
EC	European Commission
EFSA	European Food Safety Authority
EU	European Union
EZK	Dutch Ministry of Economic Affairs and Climate Policy
IenW	Dutch Ministry of Infrastructure and Water Management
IPM	Integrated Pest Management
ISZW	Dutch Inspectorate of Social Affairs and Employment
LM-GBM	Dutch Monitoring Network Crop Protection Products
LNV	Dutch Ministry of Agriculture, Nature and Food Quality
MAC-EQS	Maximum Admissible Concentration – Environmental Quality Standard
MRL	Maximum Residue Level
NMI	Dutch Pesticide Risk Indicator
NVWA	Netherlands Food and Consumer Product Safety Authority
ORG-ID	ORG-ID organisation & policy development
PBL	PBL Netherlands Environmental Assessment Agency
PDG	Platform Sustainable Crop Protection
PPR	Panel on Plant Protection Products and their Residues
RI&E	Risk Inventory & Evaluation
RIVM	National Institute for Public Health and the Environment
ScoPAFF	Standing Committee on Plants, Animals, Food and Feed
SDS	Safety Data Sheets

SMK	Eco-label Foundation
SZW	Dutch Ministry of Social Affairs and Employment
TNO	Netherlands Organisation for Applied Scientific Research
UvW	Union of Water Boards
VU	VU Amsterdam
VWS	Dutch Ministry of Health, Welfare and Sport
WEcR	Wageningen Economic Research
WEnR	Wageningen Environmental Research
WFD	Water Framework Directive
WUR	Wageningen University & Research
WPR	Wageningen Plant Research

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