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Pesticide Usage in Scotland

A National Statistics Publication for Scotland

Protected Edible Crops 2015

Pesticide Usage in Scotland

Protected Edible Crops 2015 – Summary Report

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Executive summary

This summary report presents information from a survey of pesticide use on edible crops (excluding soft fruit) grown under protection in Scotland during 2015. The crop groups surveyed were tomatoes and vegetables which were permanently covered by glass or polytunnels.

Data were collected from 16 holdings, which collectively represented 16 per cent of the total census area of protected edible crops grown in Scotland (Table 13). Ratio raising was used to estimate national pesticide usage from the sampled data.

Data relating to individual crop types have not been published due to the small cultivation and sample areas and the large range of crops encountered. Protected crop cultivation is a very minor part of Scottish agricultural production but encompasses a wide range of crop types which receive very different pesticide treatment regimes. As the sample of holdings surveyed is randomly selected this may result in different crop types being encountered in different surveys. These factors lead to greater statistical uncertainty associated with the estimates produced, which is reflected in their large relative standard errors (RSE). Therefore, whilst these data give an indication of pesticide use in this sector they are less statistically robust than the estimates from the other reports in this series and should be treated with caution.

The land area used for growing protected edible crops recorded in the June Agricultural Census decreased by 24 per cent from approximately 15 hectares in 2013 to 11 hectares in 2015 (Table 12). However, the estimated crop area grown in Scotland in 2015 was just over 31 hectares, including multi-cropping, representing a 46 per cent increase since the previous survey in 2013 (Table 11, Figure 1). This indicates that more multi-cropping was recorded in 2015 than in the previous survey. However, this may be a consequence of the type of crops encountered in the sample rather than representing an overall increase in the multi-cropped area of all protected crops.

It was estimated that pesticides were applied to almost 40 per cent of the protected edible crop area. Sulphur accounted for 49 per cent of the total pesticide-treated area, biological control agents 21 per cent, insecticides 15 per cent, seed treatments 14 per cent and fungicides, herbicides and molluscicides less than one per cent each (Figure 7).

Overall the estimated quantity of pesticides applied per hectare has declined over the last three surveys. Average application rates declined from just over 16 kg/ha in 2011 to just under 8 kg/ha in 2013 (Figure 4). In 2015 it was estimated that less than 0.1 kg/ha of pesticides were applied. The decline between 2011 and 2013 was primarily driven by the reduction in the usage of soil sterilants which were applied at high dose rates (Figure 3). The reduction in quantity applied between 2013 and 2015 was mainly due to a decrease in the reported use of fungicides. However, this is likely to be the result of differences in sample composition in 2015 rather than representing a real change in pesticide usage patterns in protected edible crops.

Data collected from growers about their Integrated Pest Management (IPM) activities showed that growers were using a variety of IPM methods in relation to risk management, pest monitoring and pest control.

Due to the very small area of protected edible crops grown in Scotland, the limited pesticide input and the issues associated with estimating pesticide use, this report will not be produced in subsequent years unless crop area or pesticide input increases. Data will continue to be collected and submitted to the UK reports.

Introduction

The Scottish Government (SG) is required by legislation[1, 2] to carry out post-approval surveillance of pesticide use. This is conducted by the Pesticide Survey Unit at Science and Advice for Scottish Agriculture (SASA), a division of the Scottish Government's Agriculture, Food and Rural Communities Directorate. As part of this programme a survey of pesticide usage in protected edible crops harvested in 2015 was conducted. This is the eleventh survey of pesticide usage on protected edible crops in Scotland. The survey covered tomatoes and vegetable crops (including vegetables in propagation).

This survey is part of a series of annual reports which are produced to detail pesticide usage in Scotland for arable, vegetable, soft fruit and protected edible crops on a biennial basis and for fodder and forage crops every four years. The Scottish survey data are incorporated with England, Wales and Northern Ireland data to provide estimates of annual UK-wide pesticide use. Information on all aspects of pesticide usage in the United Kingdom as a whole may be obtained from the Pesticide Usage Survey Team at Fera Science Ltd, Sand Hutton, York. Also available at:

https://secure.fera.defra.gov.uk/pusstats/surveys/index.cfm

The Scottish Pesticide Usage reports have been designated as Official Statistics since August 2012 and as National Statistics since October 2014. The Chief Statistician (Roger Halliday) acts as the statistics Head of Profession for the Scottish Government and has overall responsibility for the quality, format, content and timing of all Scottish Government national statistics publications, including the pesticide usage reports. As well as working closely with Scottish Government statisticians, SASA receive survey specific statistical support from Biomathematics and Statistics Scotland (BioSS).

All reports are produced according to a published timetable. For further information in relation to Pesticide Survey Unit publications and their compliance with the code of practice please refer to the pesticide usage survey section of the SASA website. The website also contains other useful documentation such as confidentiality and revision policies, user feedback and detailed background information on survey methodology.

Additional information regarding pesticide use can be supplied by the Pesticide Survey unit. Please email psu@sasa.gsi.gov.uk or visit the survey unit webpage:

http://www.sasa.gov.uk/pesticides/pesticide-usage

Structure of report and how to use these statistics

This report is intended to provide data in a useful format to a wide variety of data users. The general trends section provides commentary of recent changes in survey data and the 2015 pesticide usage section summarises the pesticide usage on all protected edible crops in 2015. Appendix 1 presents all estimated pesticide usage in two formats (areas of formulations and quantity of active ingredients). These different measures are provided to satisfy the needs of different data users. Appendix 2 summarises survey statistics including census and holding information, raising factors and survey response rates. Appendix 3 defines many of the terms used throughout the report. Appendix 4 describes the methods used during sampling, data collection and analysis as well as measures undertaken to avoid bias and reduce uncertainty. Any changes in method from previous survey years are also explained.

It is important to note that the figures presented in this report are produced from surveying a sample of holdings rather than a census of all the holdings in Scotland. Therefore the figures are estimates of the total pesticide use for Scotland and should not be interpreted as exact. To give an idea of the precision of estimates, the report includes relative standard errors. A full explanation of standard errors can be found in Appendix 5. Appendix 6 outlines the results of an additional survey which was conducted for all growers collecting details of their Integrated Pest Management (IPM) activities (i.e. includes non-chemical methods of control).

Data uses

The data are used for a number of purposes including:

- Informing UK and Scottish Government about the post-approval use of pesticides
- Aiding Government officials in their response to Scottish Parliamentary and Ministerial questions regarding the use of pesticides
- To inform and complement research projects conducted by agricultural and academic research institutions
- To inform and prioritise monitoring strategies of environmental quality bodies
- To provide data to the pesticide industry to allow insight into the use patterns of pesticide products
- To provide information to interested or concerned environmental and wildlife groups and members of the public
- To provide an educational resource for teaching and student research projects

Case studies of how the Scottish dataset has been used are provided on the SASA webpage.

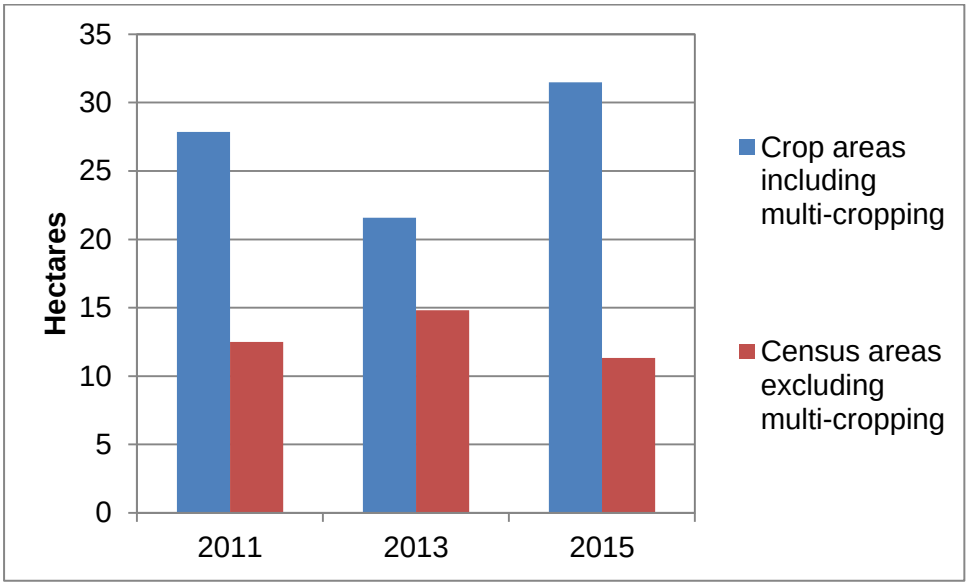
General trends

Some trends relating to crop area and total pesticide use are discussed below. However, it should be noted that the protected edible survey is the smallest in the series of pesticide usage surveys conducted by the Pesticide Survey Unit. The area of protected edible crops grown (excluding soft fruit) in Scotland is very small in comparison to other agricultural and horticultural crop groups. In addition, the large range of crops encountered, which have markedly different pesticide use, as well as the use of multi-cropping, all combine to make this report more complex and the estimates less robust than other reports in this series. Because of these factors, this summary report does not break estimates down into different crops and caution must be applied when looking at trends in the data as it is not possible to assess to what extent trends are influenced by differences in the crop types encountered in the sample. This uncertainty is reflected in the large relative standard errors associated with these estimates (RSE 89 and 86 per cent for area and weight respectively, Table 17).

Crop area

The land area used for growing protected edible crops recorded in the June Agricultural Census decreased by 24 per cent from approximately 15 hectares in 2013 to 11 hectares in 2015 (Table 12). However, the estimated crop area grown in Scotland in 2015 was just over 31 hectares, including multi-cropping, representing a 46 per cent increase since the previous survey in 2013 (Table 11, Figure 1). This indicates that more multi-cropping was recorded in 2015 than in the previous survey. The estimated area which was multi-cropped almost trebled between 2013 and 2015. However, this may be due to the type of crops encountered in the sample rather than solely representing an increase in the multi-cropped area overall. The area of salad crops encountered in 2015 was four times higher than in 2013, which are more routinely multi-cropped than other crop types. There are a large range of crop types grown under protection and the crops encountered vary from survey to survey depending on the sample composition.

Figure 1 Estimated area of protected edible crops grown in Scotland 2011-2015



Pesticide usage

It is estimated that almost 40 per cent of the 2015 protected edible crop was treated with a pesticide, the same as recorded in 2013 (Table 1). The treated area on average received 1.3 applications of pesticide (excluding seed treatments, Figure 6). Despite a similar proportion of crop being treated the estimated area of pesticide formulations applied decreased by over 80 per cent to just under 20 hectares in 2015, indicating that the treated area received fewer applications in 2015 compared with 2013. Due to the aforementioned issues with the wide range of crops grown under protection and differences in the crops encountered among surveys, the differences in pesticide use detected are likely to have been influenced by sample composition rather than solely reflecting changes in pesticide usage pattern. For example, the use of fungicides and sulphur (which was used for the control of powdery mildew) decreased by 89 per cent in 2015 compared with the previous two surveys (Figure 2). The use of fungicides in 2013 and 2011 were mainly recorded on micro-propagated potatoes which are sprayed with multiple applications of fungicides for the control of blight. In contrast to previous years, no micro-propagated potatoes were encountered during the 2015 survey. The area treated with biological control agents more than doubled from just under two hectares in 2013 to just over four hectares in 2015. This may also be the result of sample composition as biologicals are more likely to be used on salad and vegetable crops than on micro-propagated potatoes.

Overall the estimated quantity of pesticides applied per hectare has declined over the last three surveys. Average application rates declined from just over 16 kg/ha in 2011 to just under 8 kg/ha in 2013 (Figure 4). This then fell to less than 0.1 kg/ha in 2015. The decline between 2011 and 2013 was primarily driven by the reduction in the usage of soil sterilants which were applied at

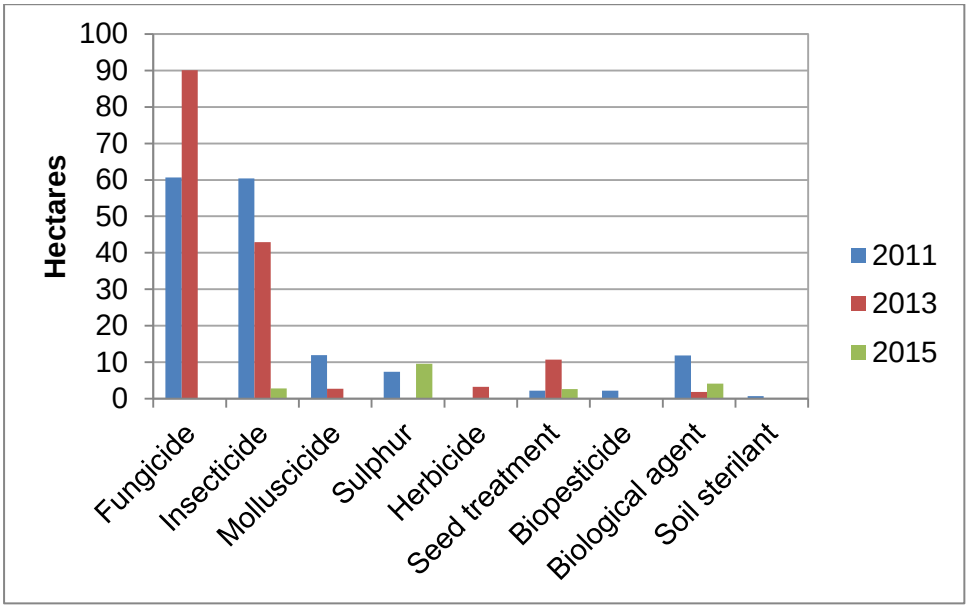
high dose rates (Figure 3). The reduction in quantity applied between 2013 and 2015 was mainly due to a decrease in the usage of most pesticide groups, particularly fungicides. As discussed previously, this is likely to be the result of the sample composition rather than representing a real change in pesticide usage pattern in protected crop cultivation.

Information on the timings of pesticide applications to protected crops is included for the first time in this report (Figure 5). Most applications were recorded in late spring in March and April with the exception of herbicides which were applied in October and disinfectants which were applied during the winter months. The area treated with disinfectants decreased by 74 per cent from ca. 13 hectares in 2013 to ca. three hectares in 2015. Disinfectants are not pesticides and are not applied directly to the crop themselves but are applied to the fabric of the tunnels/glasshouses as washes or to sterilise equipment.

In terms of area treated, sulphur was the most commonly used active substance, followed by the seed treatment metalaxyl-M and the insecticide spinosad (Table 8). Sulphur was also the most commonly used active substance by weight (Table 9). Sulphur was primarily used as a fungicide for the control of powdery mildew.

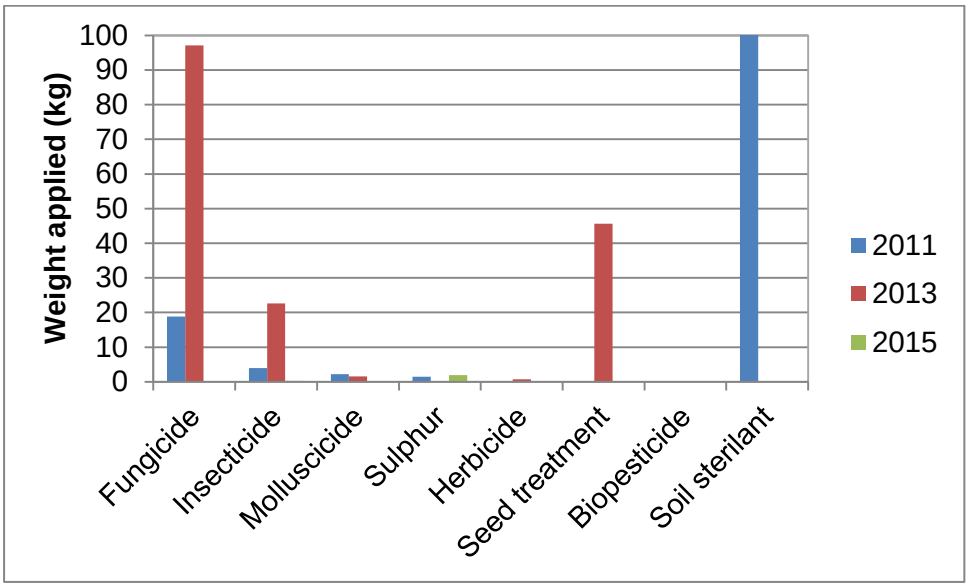
A number of active substances were encountered for the first time on protected edible crops in 2015. These included the fungicide copper sulphate and two biological control agents (parasitic wasps and the nematode *Steinernema carpocapsae*) (Table 10).

Figure 2 Area of protected edible crops treated with the major pesticide groups 2011-2015



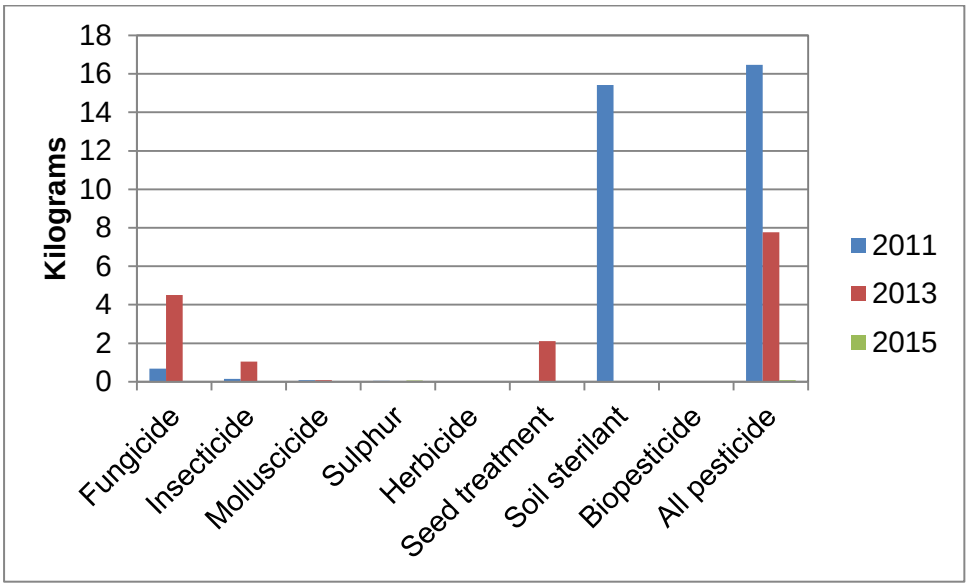
Note: see appendix 3 – definitions for differences between biopesticide and biological control agent.

Figure 3 Weight of the major pesticide groups applied to protected edible crops in Scotland 2011-2015



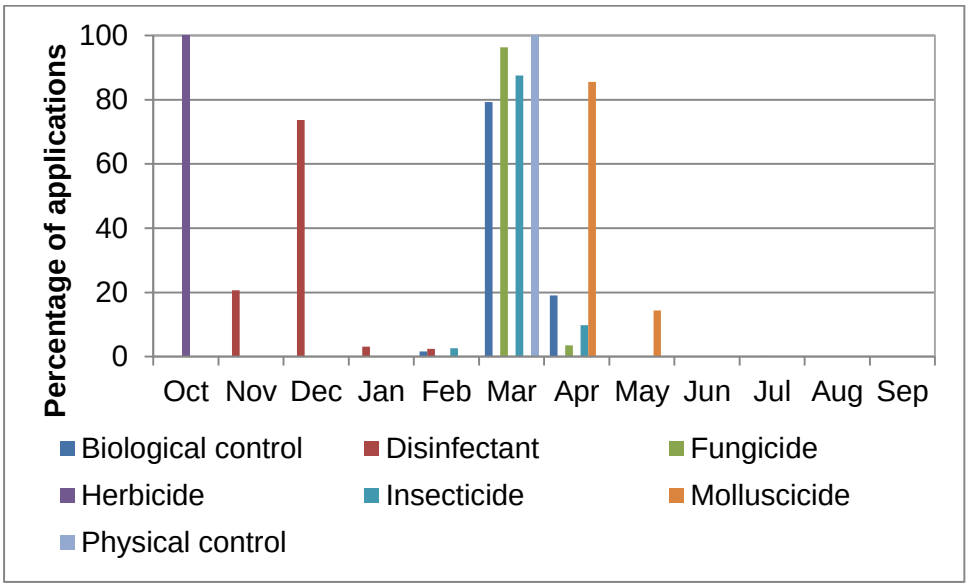
Note: As it is not always possible to collect rates for biological control agents, their quantities are unknown and are therefore not included in the graph above.

Figure 4 Weight of pesticide (kg) applied per hectare of crop grown



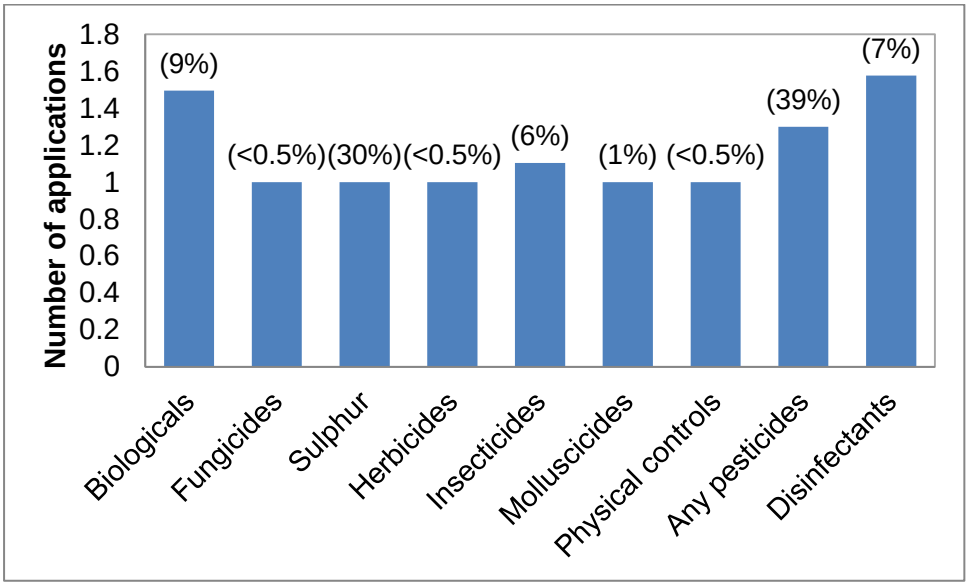
Note: Biological control agents are applied by number of organisms rather than weight therefore data are not included in the graph above.

Figure 5 Timing of pesticide applications to protected edible crops Oct 2014 - Sep 2015



Note: Biological control includes both biopesticides and biological control agents

Figure 6 Average number of applications made to protected edible crops excluding seed treatments (% of crop treated)



Note: Biological control includes both biopesticides and biological control agents
The average number of applications is calculated only on the areas using each pesticide group and therefore the minimum number of applications is always going to be one.

Integrated Pest Management

For the first time in this series of surveys, additional data collection was conducted in relation to grower adoption of Integrated Pest Management (IPM) measures (see Appendix 6 for full details). The term 'pest' is used to denote diseases, weeds and pests. Unlike the other statistics in this report, the figures relating to IPM are not raised (i.e. are not national estimates) but represent only the responses of those surveyed.

In total IPM data was collected from 15 holdings, representing 87 per cent of the sampled crop area and 15 per cent of the total crop area. Of these growers, 13 per cent had completed an IPM plan for their crops (Figure 10). Growers were asked about their IPM activities in relation to three categories; risk management, pest monitoring and pest control. Despite the low level of IPM plan completion the growers surveyed adopted a range of IPM activities during their crop production.

A number of risk management measures were adopted by the growers surveyed (Table 18). Two thirds of growers used crop rotation to manage the risk of pest damage. A similar proportion (60 per cent) of growers tested their soils in order to tailor inputs to improve crop performance. Almost three quarters of growers managed their seed bed production to reduce risk and a similar number amended cultivation methods at sowing. Almost two thirds of the growers surveyed also considered risk management when selecting seeds and/or varieties and almost half of respondents sowed catch or cover crops as part of their crop production cycle. Finally, 60 per cent of the growers sampled adopted techniques to protect or enhance populations of beneficial insects.

A number of pest monitoring activities were recorded (Table 19). Sixty seven per cent of growers regularly monitored crop growth stages and 73 per cent monitored and identified pests on their crops. In addition, some growers (13 per cent) used specialist diagnostic testing for pests that are more problematic to identify or monitor.

The majority of growers (80 per cent) used non-chemical control in partnership or instead of chemical control (Table 20). A range of control methods were adopted, including use of biological control and physical/mechanical control measures (Figure 18). Forty per cent of growers stated that they targeted their pesticide applications using monitoring data. In addition, 27 per cent of growers stated that they followed anti-resistance strategies. Finally the majority of growers (80 per cent) stated that they monitored the success of their crop protection measures.

2015 Pesticide usage

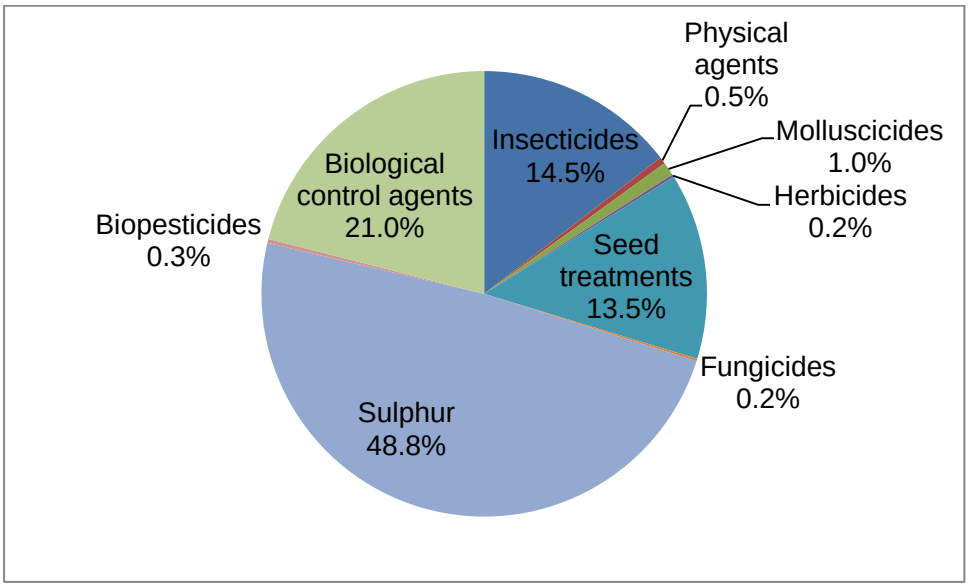
Protected edible crops

- An estimated 31 hectares (including multi-cropping) of protected edible crops were grown under permanent protection in Scotland, an increase of 46 per cent since 2013
- 39 per cent of the crop area was treated with a pesticide
- Pesticides were applied to 20 treated hectares (exc. disinfectants)
- 2.5 kg of pesticides were applied (excludes disinfectants and biological control agents)
- Where reasons were given, 66 per cent of biologicals were for the control of two-spotted spider mite and 34 per cent for aphids. Powdery mildew was the principal reason specified for fungicide use and caterpillars was the only reason specified for the control of insecticides
- Crops encountered included tomatoes, herbs, brassicas, various salad crops, vegetables in propagation and a wide range of minor vegetables
- Summary of pesticide use on protected edible crops:

Pesticide group	Formulation area treated (ha)	Weight applied (kg)	% of crop area treated	Most used formulations (ha)
Insecticides	2.84	0.30	5.9	Spinosad (1.39)
Molluscicides	0.19	0.09	0.6	Ferric phosphate (0.16)
Biological control agents	4.11	NA	8.4	*Phytoseiulus persimilis* (1.36)
Biopesticides	0.06	<0.005	0.2	*Bacillus thuringiensis* var. *kurstaki* (0.06)
Fungicides	0.03	0.02	0.1	Copper sulphate (0.03)
Sulphur	9.53	1.91	30.3	Sulphur (9.53)
Herbicides	0.04	0.04	0.1	Glyphosate (0.04)
Seed treatments	2.64	0.03	5.6	Metalaxyl-M (1.76)
Physical agents	0.10	0.10	0.3	Carbonic acid diamide/urea (0.1)
Disinfectants/ surface cleaners	3.37	20.73	6.8	Acetic acid/hydrogen peroxide/peracetic acid and Sodium hypochlorite (both 1.23)

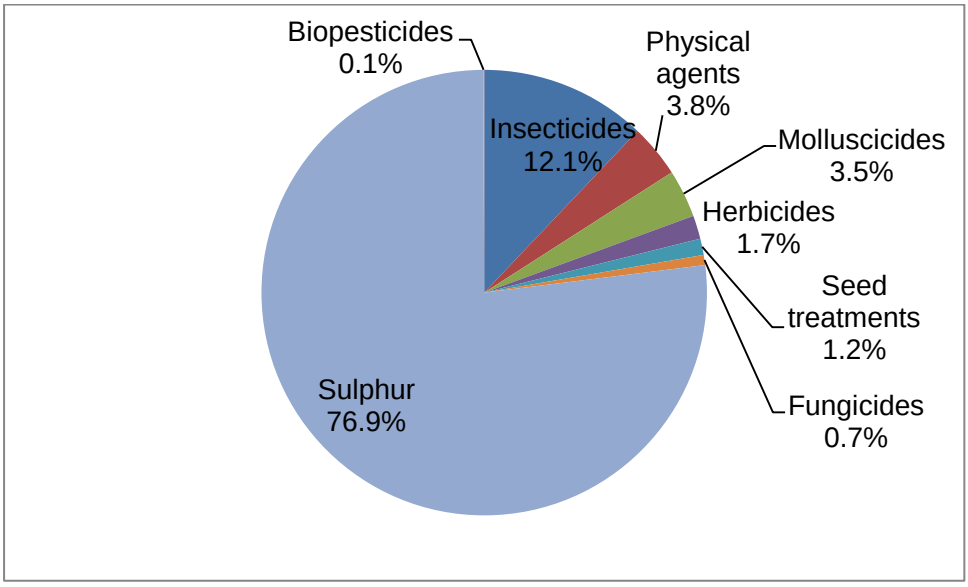
.

Figure 7 Proportion of pesticide groups used on protected edible crops (percentage of total area treated with formulations)



Note: chart excludes disinfectants

Figure 8 Proportion of pesticide groups used on protected edible crops (percentage of total weight applied)



Note: chart excludes disinfectants and biological control agents. Biological control agents are applied by number of organisms rather than weight therefore data are not presented

Appendix 1 – Estimated pesticide application tables

Table 1 Percentage of protected edible crops treated with pesticides

	2015	2013
Fungicides	< 0.5	33
Sulphur	30	0
Biologicals (1)	9	4
Insecticides	6	31
Seed treatments	6	10
Molluscicides	1	12
Physical control agents	< 0.5	0
Herbicides	< 0.5	7
Any pesticides(2)	**39**	**39**
Disinfectants/surface cleaners	7	45

(1) Biologicals includes biopesticides and biological control agents
(2) Note: any pesticides includes biological control agents and seed treatments but excludes disinfectants

Table 2 Insecticide/acaricide, biological, molluscicide, physical control and disinfectant formulations

Area (ha) and percentage of crop treated

Insecticides/acaricides	**Protected Edible Crops 2015**		**2013[3]**
	(ha)	(%)	(ha)
Abamectin	0.18	0.3	0
Acetamiprid	0.64	2.0	0
Pirimicarb	0.64	2.0	0
Spinosad	1.39	4.1	0
All Insecticides/acaricides	**2.84**	**5.9**	**42.91**
Molluscicides			
Ferric phosphate	0.16	0.5	0
Metaldehyde	0.03	0.1	2.68
All molluscicides	**0.19**	**0.6**	**2.68**
Physical controls			
Carbonic acid diamide/urea	0.10	0.3	0
Biopesticides			
Bacillus thuringiensis var. *kurstaki*	0.06	0.2	0
All biopesticides	**0.06**	**0.2**	**0**
Biological control agents			
Aphidoletes aphidimyza	0.13	0.4	0
Macrolophus pygmaeus	1.23	3.9	1.55
Parasitic wasps (unknown species)	1.23	3.9	0
Phytoseiulus persimilis	1.36	4.3	0.31
Steinernema carpocapsae	0.16	0.2	0
All Biological control agents	**4.11**	**8.4**	**1.86**
All Biologicals[1]	**4.17**	**8.6**	**1.86**
Disinfectants/surface cleaners			
Acetic acid/hydrogen peroxide/peracetic acid	1.23	3.9	10.62
Ammonium hydrogen difluoride	0.69	2.2	0.48
Sodium hypochlorite	1.23	3.9	0.50
Unspecified disinfectant	0.21	0.7	<0.05
All disinfectants	**3.37**	**6.8**	**12.86**
Area grown[2]	31.49		21.58

(1) All biologicals includes biopesticides and biological control agents
(2) Area grown includes multi-cropping
(3) For full list of formulations recorded in 2013 please refer to the 2013 report[5]

Table 3 Fungicide and herbicide formulations

Area (ha) and percentage of crop treated

Fungicides	**Protected Edible Crops 2015**		**2013[2]**
	(ha)	(%)	(ha)
Copper sulphate	0.03	0.1	0
All fungicides	**0.03**	**0.1**	**90.1**
Sulphur	**9.53**	**30.3**	**0**
Herbicides			
Glyphosate	0.04	0.1	0
All herbicides	**0.04**	**0.1**	**3.23**
Area grown[1]	31.49		21.58

(1) Area grown includes multi-cropping
(2) For full list of formulations recorded in 2013 please refer to the 2013 report[5]

Table 4 Seed treatment formulations

Area (ha) and percentage of crop treated

Seed treatments	**Protected edible crops 2015**		**2013[2]**
	(ha)	(%)	(ha)
Metalaxyl-M	1.76	5.6	2.13
Thiram	0.88	2.8	2.13
All seed treatments	**2.64**	**5.6**	**10.67**
Area grown[1]	31.49		21.58

(1) Area grown includes multi-cropping
(2) For full list of formulations recorded in 2013 please refer to the 2013 report[5]
Note: many of the crops are grown from modules, blocks or other planted material grown from seed by plant propagators from outside Scotland. Seed treatments were not collected from these plant propagators

Table 5 Quantities (kg) of insecticides/acaricides, molluscicides, physical control and disinfectant active substances

Insecticides/acaricides	Protected Edible Crops 2015	2013[2]
	(kg)	(kg)
Carbamates		
Pirimicarb	0.09	0.28
All carbamates	**0.09**	**0.28**
Neonicotinoids		
Acetamiprid	0.03	0
All neonicotinoids	**0.03**	**0.50**
Others		
Abamectin	<0.005	0
Spinosad	0.18	0
All others	**0.18**	**1.38**
All insecticides/acaricides	**0.30**	**22.65**
Molluscicides		
Ferric phosphate	0.08	0
Metaldehyde	<0.005	1.57
All molluscicides	**0.09**	**1.57**
Physical control		
Carbonic acid diamide/urea	0.10	0
Biopesticides		
Bacillus thuringiensis var. *kurstaki*	<0.005	0
Disinfectant/surface cleaners		
Acetic acid	1.38	16.73
Ammonium hydrogen difluoride	8.31	7.26
Hydrogen peroxide	2.76	47.57
Peracetic acid	0.69	10.66
Sodium hypochlorite	7.59	4.44
All disinfectants	**20.73**	**123.48**
Area grown[1]	31.49	21.58

(1) Area grown includes multi-cropping
(2) For full list of active substances recorded in 2013 please refer to the 2013 report[5]
Note: Biological control agents are applied by number of organisms rather than weight therefore data are not presented

Table 6 Quantities (kg) of fungicide and herbicide active substances

Fungicides	**Protected Edible Crops 2015**	**2013[2]**
	(kg)	(kg)
Copper sulphate	0.02	0
All fungicides	**0.02**	**97.08**
Sulphur	1.91	0
Herbicides		
Glyphosate	0.04	0
All herbicides	**0.04**	**0.68**
Area grown[1]	31.49	21.58

(1) Area grown includes multi-cropping
(2) For full list of active substances recorded in 2013 please refer to the 2013 report[5]

Table 7 Quantities (kg) of seed treatment active substances

Seed treatments	**Protected Edible Crops 2015**	**2013[2]**
	(kg)	(kg)
Metalaxyl-M	<0.005	0.02
Thiram	0.03	0.25
All seed treatments	**0.03**	**45.68**
Area grown[1]	31.49	21.58

(1) Area grown includes multi-cropping
(2) For full list of active substances recorded in 2013 please refer to the 2013 report[5]
Note: many of the crops are grown from modules, blocks or other planted material grown from seed by plant propagators from outwith Scotland. Seed treatments were not collected from these plant propagators

Table 8 Principal active substances by area treated

Area (ha) treated with the 10 most used active substances on protected edible crops (excluding disinfectants)

	Active substance	Type	2015	2013	% change
1	Sulphur	S	9.53	0	
2	Metalaxyl-M	ST	1.76	2.13	-17
3	Spinosad	I	1.39	0	
4	*Phytoseiulus persimilis*	BC	1.36	0.31	339
5	*Macrolophus pygmaeus*	BC	1.23	1.55	-20
6	Parasitic wasps	BC	1.23	0	
7	Thiram	ST	0.88	2.13	-58
8	Pirimicarb	I	0.64	2.11	-70
9	Acetamiprid	I	0.64	0	
10	Abamectin	I	0.18	0	

Pesticide type = BC: biological control agent, I: insecticide, S: sulphur, ST: seed treatment

Table 9 Principal active substances by weight

Quantity (kg) of the 10 most used active substances on protected edible crops (excluding disinfectants)

	Active substance	Type	2015	2013	% change
1	Sulphur	S	1.91	0	
2	Spinosad	I	0.18	0	
3	Carbonic acid diamide/urea	P	0.10	0	
4	Pirimicarb	I	0.09	0.28	-68
5	Ferric phosphate	M	0.08	0	
6	Glyphosate	H	0.04	0	
7	Acetamiprid	I	0.03	0	
8	Thiram	ST	0.03	0.25	-89
9	Copper sulphate	F	0.02	0	
10	Metaldehyde	M	<0.005	1.57	

Pesticide type = F: fungicide, H: herbicide, I: insecticide, M: molluscicide, P: Physical control agent, S: Sulphur, ST: seed treatment

Note: As disinfectants are not pesticides they have been excluded from the above tables.

Table 10 Pesticides encountered on protected edible crops for the first time in 2015

Active substance	Type	Area treated (ha)	Amount used (kg)
Copper sulphate	F	0.03	0.02
Parasitic wasps	BC	1.23	NA
Steinernema carpocapsae	BC	0.16	NA

Pesticide type = BC: biological control agent, F: fungicide
NA = biological control agents are applied by number of organisms rather than weight therefore data are not presented

Table 11 Protected edible crops summary of total pesticide use and comparison with previous years

Pesticide usage 2011 - 2015, total pesticide treated area (ha) of formulations, active substances and quantities used (kg)

	2011			2013			2015		
	Formulations (ha)	**a.s. (ha)**	**Kg**	**Formulations (ha)**	**a.s. (ha)**	**Kg**	**Formulations (ha)**	**a.s. (ha)**	**Kg**
Insecticides	60.37	60.37	3.92	42.91	45.02	22.65	2.84	2.84	0.30
Molluscicides	11.98	11.98	2.20	2.68	2.68	1.57	0.19	0.19	0.09
Fungicides	60.70	70.33	18.86	90.10	117.33	97.08	0.03	0.03	0.02
Sulphur	7.38	7.38	1.48	0.00	0.00	0.00	9.53	9.53	1.91
Herbicides	0.12	0.12	0.10	3.23	3.23	0.68	0.04	0.04	0.04
Soil sterilants	0.74	0.74	429.40	0.00	0.00	0.00	0.00	0.00	0.00
Biopesticides	2.21	2.21	0.03	0.00	0.00	0.00	0.06	0.06	0.002
Biological control agents	11.82	11.82	NA	1.86	1.86	NA	4.11	4.11	NA
Seed treatments	2.17	28.29	0.05	10.67	10.67	45.68	2.64	2.64	0.03
Physical control agents	0.66	0.66	2.60	0.00	0.00	0.00	0.10	0.10	0.10
All pesticides	**158.15**	**193.91**	**458.64**	**151.45**	**180.79**	**167.66**	**19.53**	**19.53**	**2.48**
Disinfectants	5.16	9.06	388.91	12.86	34.88	123.48	3.37	5.84	20.73
Area grown (ha)[(1)]	27.85			21.58			31.49		

(1) Area grown includes multi-cropping. NA = not applicable.

Note: There have been minor differences in crop range, crop areas and methods used for estimating pesticide use between surveys. Please see Appendix 4 - survey methodology for changes in method between years and the general trends section for discussion on sample composition and its impact on pesticide estimates.

Appendix 2 – Survey statistics

Census and sample information

Table 12 Estimated crop area

Census area (ha) of permanently protected crops grown in Scotland

	2015	2013	% change
Tomatoes	2.54	3.25	-22
Vegetables	8.80	11.58	-24
All protected edible	**11.34**	**14.83**	**-24**

Note: Data taken from the 2015 and 2013 June Agricultural Census. All areas exclude multi-cropping.

Table 13 Sample & census areas (ha) of protected edible crops in Scotland

Crop	Census areas	Sampled areas	% Census area sampled
Tomatoes	2.54	0.92	36
Vegetables	8.80	0.90	10
All edible crops	**11.34**	**1.82**	**16**

Note: Data taken from the 2015 June Agricultural Census. All areas exclude multi-cropping.

Table 14 Distribution of sample

Number of holdings sampled in each region

Highlands & Islands	Caithness & Orkney	Moray Firth	Aberdeen	Angus	East Fife	Lothian	Central Lowlands	Tweed Valley	Southern Uplands	Solway	Scotland
5	0	1	3	0	0	1	5	0	1	0	**16**

Raising factors

Table 15 Raising factors

	Scotland
Tomatoes	2.7694
Vegetables	9.7679

Note: Raising factors are calculated by comparing the sampled crop area to the census crop area. Please see Appendix 4 - survey methodology for a full explanation.

Response rates

The table below summarises the number of holdings which were contacted during the survey.

Table 16 Response rate

	2015	% total
Target sample (no. of holdings)	16	100
Total achieved	**16**	**100**
Total number of refusals/non-contact	5	
Total number of farms approached	**21**	

Financial burden to growers

In order to minimise the burden on farmers the survey uses non-visit methods of collection, such as email, post or telephone call, where possible.

To determine the total burden the 2015 Protected Edible Crop survey placed on those providing the information, the surveyors recorded the time that 15 respondents spent providing the data during the survey. This sample represents 94 per cent of growers surveyed. The median time taken to provide the information was 10 minutes.

The following formula was used to estimate the total cost of participating:

Burden (£) = No. surveyed x median time taken (hours) x typical hourly rate* (* using median "Full Time Gross" pay for Scotland of £13.45) [3]

The total financial burden to all growers resulting from participation in the 2015 Scottish Protected Edible Survey was calculated to be £34.

Appendix 3 - Definitions and notes

1) '**Pesticide**' is used throughout this report to include commercial formulations containing active substances (a.s.) used as herbicides, fungicides, insecticides, molluscicides, biological control agents, biopesticides, soil sterilants and seed treatments. A pesticide product consists of one or more active substances co-formulated with other materials.

2) An **active substance** (or active ingredient) is any substance or micro-organism which has a general or specific action against harmful organisms; or on plants, parts of plants or plant products.

3) In this report the term '**formulation**(s)' is used to describe the pesticide active substance or mixture of active substances in a product(s). It does not refer to any of the solvents, pH modifiers or adjuvants also contained within a product that contribute to its efficacy.

4) **Biological control** is use of a micro-organism, such as a bacteria or virus, or, macro-organisms, such as insect predators or nematodes that are used to control insect pests, weeds and diseases. In this report biologicals which do not require to be authorised are referred to as biological control agents. These are generally macro-organisms such as parasites or predators. Biologicals which do require to be authorised like other pesticides are referred to as **biopesticides**. Biopesticides are pesticides that are derived from natural materials and include micro-organisms (bacteria, fungus, virus or protozoa) to control pest populations or compounds such as semio-chemicals that cause behavioural changes in the target pest. In previous surveys biopesticides were included in the biological control agent category.

5) A **fungicide** is a pesticide used to control fungal diseases in plants.

6) A **herbicide** is a pesticide used to control unwanted vegetation (weed killer).

7) An **insecticide** is a pesticide used to control unwanted insects. An **acaricide** is a pesticide used to control mites. As some products are approved for use against both insects and mites, insecticide and acaricide use have been combined in this report.

8) A **molluscicide** is a pesticide used to control unwanted slugs and snails.

9) A **soil sterilant** is a pesticide used to control unwanted diseases or insects in soil.

10) A **seed treatment** is a pesticide applied to seed before planting to protect that plant against diseases and pests from the earliest stage of development. The pesticide can be either a fungicide or an insecticide.

11) A **physical control agent** is a substance, preparation or organism designed or used for destroying or controlling pests if their principal mode of action does not involve chemical or biological action.

12) **Disinfectants**, although not a pesticide, are also included in this report. Disinfectants are not applied directly to the crop; however they are used in the protected area as glasshouse washes and for the sterilisation of equipment, trays and pots etc.

13) This report only includes protected edible crops (excluding soft fruit). Protected means that the crops were permanently covered by glass or polytunnel. Crops grown under temporary structures such as French or Spanish tunnels are excluded from this survey.

14) **Basic area** is the planted area of crop which was treated with a given pesticide or pesticide group, irrespective of the number of times it was applied to that area. Basic areas are not presented anywhere in the report, but their values are used to calculate the percentage of crop treated with a given pesticide or pesticide group.

15) **Area treated** is the basic area of a crop treated with a given pesticide multiplied by the number of treatments that area received. These terms are synonymous with “spray area” and “spray hectare” which have appeared in previous reports. For example, if a field of five hectares gets sprayed with the same fungicide twice, the basic area is five hectares, and the treated area is ten hectares.

16) Farmers/growers can apply pesticides to crops by a number of different methods. Multiple pesticides can be applied to a crop in a single tank mix. For example a crop could be sprayed with two different fungicides and an insecticide at the same time.

17) In this report each pesticide is reported in two formats. The area of each pesticide is reported as a formulation i.e. mixture of active substances in a product (Tables 2 to 4). Quantities of active ingredient are reported in Tables 5 to 7. It should be noted that separate active substance tables have not been included in this report as all pesticide formulations encountered only contained one active substance (excluding disinfectants). The different formats are provided to satisfy the needs of all data users and allow them to assess pesticide use trends. Both quantity and area of pesticide applications are important indicators of changes in use over time. Different pesticides are applied at different dose rates and only by comparing both area and quantity can trends in use be elucidated.

18) It should be noted that some herbicides may not have been applied directly to the crop itself but either as land preparation treatments prior to sowing/planting the crop, or to the ground beneath crops grown on table tops, or the pathways between crops.

19) The areas of crop grown include successional sowings during the same season; therefore the areas of crops grown can be larger than the total area of glasshouses and polytunnels. This is referred to throughout the report as **multi-cropping**.

20) The **June Agricultural Census** is conducted annually by the Scottish Government's Rural and Environmental Science Analytical Services (RESAS). The June Agricultural Census collects data on land use, crop areas, livestock and the number of people working on agricultural holdings. For this report the June Agricultural Census was used to draw a sample of growers growing the relevant crops to participate in the survey.

21) Throughout this report the term '**census area**' refers to the total area for a particular crop or group of crops recorded within the June Agricultural Census. These are the areas which the sampled areas are raised to. Please see Appendix 4 - survey methodology for details. The June Agricultural Census Form is divided up into different categories which relates to a particular crop or group of crops. These are referred to as '**census categories**' throughout this report.

22) Where quoted in the text or within figures, reasons for application are the growers' stated reasons for use of that particular pesticide on that crop and may not always seem appropriate.

23) Protected edible crops include all tomatoes and vegetable crops including vegetables in propagation. **Vegetables in propagation** are vegetable plants (seedlings) for sale to other growers.

24) Due to rounding, there may be slight differences in totals both within and between tables.

25) Data from the 2011[(4)] and 2013[(5)] surveys are provided for comparison purposes in some of the tables, although it should be noted that there may be minor differences in the range of crops surveyed, together with changes in areas of each of the crops grown. Changes from previous surveys are described in Appendix 4 - survey methodology.

26) **Integrated pest management** The sustainable use directive[(6)] defines IPM as follows; "'integrated pest management' means careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimise risks to human health and the environment. 'Integrated pest management' emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms."

27) The average **number of applications** (figure 6) is calculated only on the areas using each pesticide group and therefore the minimum number of applications is always one. Several pesticides may be applied as a tank mix as part of the same spray event; therefore the average number of pesticide sprays reported is less than the sum of sprays of each chemical group.

Appendix 4 - Survey methodology

Sampling and data collection

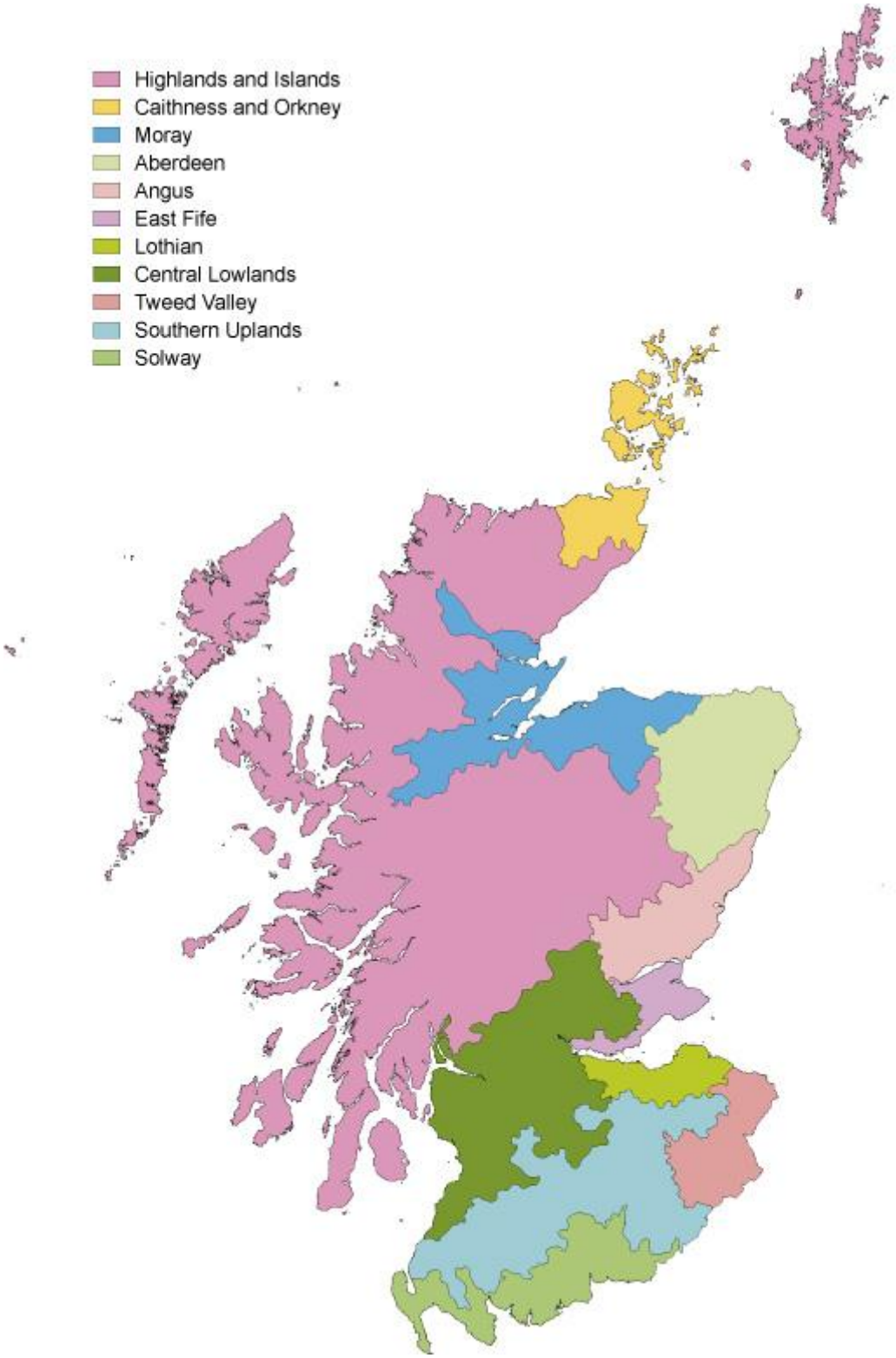
Using the June 2015 Agricultural Census[7] a sample was drawn from growers of protected edible crops, these being any edible crop grown within a glasshouse or permanent polytunnel. Crops grown under temporary structures such as French or Spanish tunnels were excluded. For 2015 this involved selecting from growers who recorded crop areas in the 'Tomatoes' or 'Vegetables' categories within the glasshouses and walk-in plastic structures' section of the Agricultural Census Form. For the purpose of sampling, the country was divided into 11 land-use regions as shown in Figure 9. The sample was stratified by region and according to holding size, and sampling within holding size groups was based on area rather than numbers of holdings, so that smaller holdings were not over-represented in the sample.

The survey period covered pesticide applications to crops during the 12 month period from October 2014 to September 2015. Following an introductory letter and telephone call, data were collected by either personal interview during a visit to the holding or via a telephone interview. In total, information was collected from 16 holdings (Table 14 & 16). These 16 holdings collectively grew 16 per cent of the census crop area.

Raising factors

National pesticide use was estimated by ratio raising. This is a standard statistical technique for producing estimates from a sample. It is the same methodology used by the other UK survey teams and has been used for all historical datasets produced by the Pesticide Survey Unit, allowing comparability over time. The sample data were multiplied by raising factors (Table 15). These factors were calculated by comparing the sampled tomato and vegetable cropped areas to the areas recorded in the Agricultural Census. Due to a combination of small sample size, the wide range of crops encountered and there being little regional variation in pesticide use within protected edible crops, raising factors were calculated at a national rather than a regional level and without taking into account holding size.

Figure 9 Land use regions of Scotland[8]



Changes from previous years

There are a number of changes which should be noted when comparing the 2015 data with the previous survey.

The term active substance is now used instead of active ingredient which appeared in previous reports. This change makes the Scottish reports consistent with the UK pesticide usage reports.

The biological data has been split for the first time into both biological control agents and biopesticides. Biopesticides require to be authorised like other pesticides, whereas biological control agents do not (see section 3 definitions and notes for details). As it is not always possible to collect rates for biological control agents, their quantities are unknown and are therefore not included in weight tables. Rates are available for biopesticides and quantity data are provided.

Another change to note is that sulphur was previously reported as a fungicide. It is now reported in a category on its own to acknowledge that as well as being used as a fungicide, it has other functions in some crops. In order to allow comparison with previous surveys, fungicide data from the 2013 and 2011 surveys included in this report have been recalculated to exclude sulphur.

The 2015 report also presents a number of new reports of pesticide use pattern to help improve data quality for users. Information relating to pesticide application timings can be found in figure 5. Data relating to the average number of applications can be found in figure 6. There is also a new section reporting integrated pest management techniques used by growers i.e. for the first time the reports include information about non chemical methods growers use to control pests, weeds and diseases (see appendix 6).

Data quality assurance

The data undergo several validation processes as follows; (i) checking for any obvious errors upon data receipt (ii) checking and identifying inconsistencies with use and pesticide approval conditions once entered into the database (iii) 100 per cent checking of data held in the database against the raw data. Where inconsistencies are found these are checked against the records and with the grower if necessary. Additional quality assurance is provided by sending reports for review to members of the Working Party on Pesticide Usage Surveys and other agricultural experts. In addition, the Scottish pesticide survey unit is accredited to ISO 9001:2008. All survey related processes are documented in Standard Operating Procedures (SOPs) and our output is audited against these SOPs by internal auditors annually and by external auditors every three years.

Main sources of bias

A stratified random sample, grouped by farm size and region, is used to select holdings used in this survey. Sampling within size groups is based on area rather than numbers of holdings, so that smaller size groups are not over-represented in the sample. The pesticide survey may be subject to measurement bias as it is reliant on farmers/growers recording data accurately. As this survey is not compulsory it may also be subject to non-response bias, as growers on certain farm/holding types may be more likely to respond to the survey than others. Reserve lists of holdings are held for each stratum to allow non-responding holdings to be replaced with similar holdings.

Experience indicates that stratified random sampling, including reserves, coupled with personal interview technique, delivers the highest quality sample data and minimises non-response bias.

Appendix 5 – Standard errors

The figures presented in this report are produced from surveying a sample of holdings rather than a census of all the holdings in Scotland. Therefore the figures are estimates of the total pesticide use for Scotland and should not be interpreted as exact. To give an indication of the precision of estimates the report includes standard errors. Standard errors are produced using the raising factors. An overall variance is calculated by summing the variance estimates for individual strata (region and size group) multiplied by the square of their raising factors. These variance estimates include a finite population correction. The overall standard error is calculated from the overall variance by taking its square root. This method of standard estimation was implemented as it is both relatively straightforward and has advantages over ratio estimator methods when within-strata sample sizes are small.

Standard errors are expressed as percentage relative standard errors (Table 17) for both total pesticide use by area treated and for weight applied. Larger relative standard errors mean that the estimates are less precise. A relative standard error of 0 per cent would be achieved by a census. A relative standard error of 100 per cent indicates that the error in the survey is of the same order as the measurement. Relative standard errors may be reduced with larger sample sizes. However, larger relative standard errors can also result from greater variability in pesticides among holdings. This is common in the protected edible report as, unlike other surveys, holdings grow a large variety of different crops which receive very different pesticide treatments. For this reason, the standard errors for protected edible crops are much higher than for the other pesticide usage reports (89 and 86 per cent for area and weight respectively) and as such data users should exercise caution when drawing conclusions from the data.

Table 17 Relative standard errors

Estimated standard errors for the area treated (ha) with pesticide and for weight of active ingredient (kg) applied

	Area SE (%)	Weight SE (%)
All protected edible crops	89	86

Appendix 6 – Integrated pest management

It is a requirement of the EU Sustainable use of Pesticides Directive (2009/128/EC)[6] that member states should promote low pesticide input pest management, in particular Integrated Pest Management (IPM).

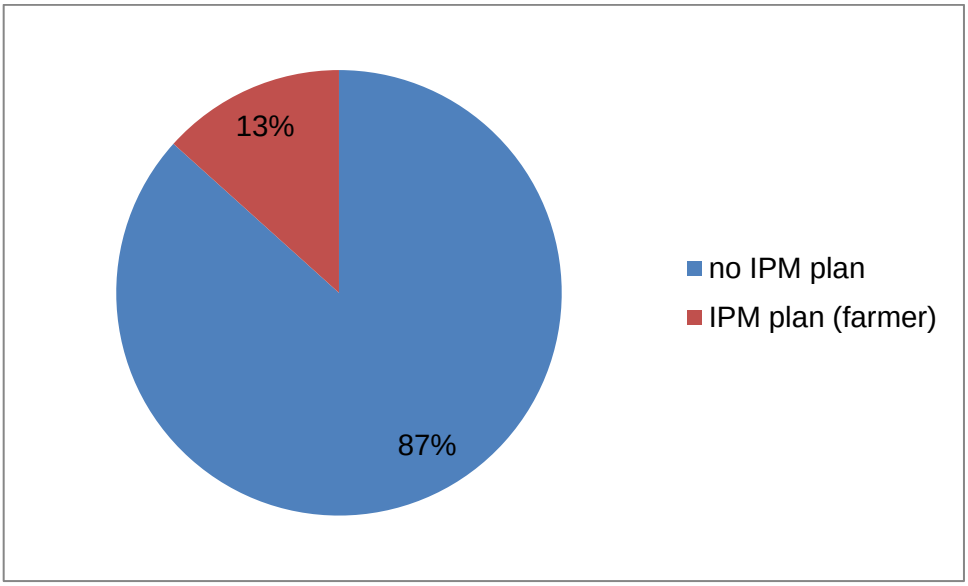
The Directive defines IPM as follows "'integrated pest management' means careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and reduce or minimise risks to human health and the environment. 'Integrated pest management' emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms."

Therefore, for the first time in this series of surveys, additional data collection was conducted in relation to grower adoption of Integrated Pest Management (IPM) measures. The term 'pest' is used to denote diseases, weeds and pests. This data collection was designed to inform the Scottish Government about the current adoption of IPM in the main crop sectors and will be collected for all subsequent surveys to allow analysis of changes in uptake over time.

All growers were asked a series of questions about the IPM activities that they were implementing for their protected edible crop production. Unlike the other statistics in this report, the figures reported in this section are not raised (i.e. are not national estimates) but represent only the responses of those surveyed.

In total IPM data was collected from 15 holdings, representing 87 per cent of the sampled crop area and 15 per cent of the total crop area. Of these growers, 13 per cent had completed an IPM plan for their crops (Figure 10).

Figure 10 Proportion of respondents with an IPM Plan



Growers were asked about their IPM activities in relation to three categories; risk management, pest monitoring and pest control. Information was collected about all activities growers conducted in relation to each category.

Risk management

IPM programs aim to prevent or reduce the risk of pests becoming a threat by minimising the risk of damage occurring that will require subsequent control. Table 18 presents an overview of the risk management measures adopted by the growers surveyed.

Two thirds of growers used crop rotation to manage the risk of pest damage. Rotation is a basic principle of farming breaking the link between pathogen and host and reducing pest population build-up. It can also improve soil fertility and structure consequently increasing the vigour of subsequent crops.

A similar proportion (60 per cent) of growers tested their soils in order to tailor inputs to improve crop performance. Almost half of growers tested soil nutrient levels with lower proportions testing for disease, pH and insect pests (Figure 11). By pre-emptively testing for nutritional and pest status farmers' can make informed decisions about inputs required and crop choice for that field.

Almost three quarters of growers managed their seed bed agronomy to reduce risk. All increased organic matter to improve soil quality while a smaller proportion implemented other measures such as using a stale seed bed, considering pest management when planning irrigation, adoption of no till systems and use of seaweed to control pests (Figure 12).

Almost two thirds of growers amended cultivation methods at sowing. Just over half chose to use pest free growing media such as peat, coir and hydroponic systems. Other growers varied sowing rates and dates to mitigate for potential pest damage (Figure 13).

Almost two thirds of the growers surveyed also considered risk management when selecting seeds and/or varieties. A third selected pest resistant varieties to reduce damage. Some growers (13 per cent) also confirmed that they chose to adopt varietal diversification (using a range of different varieties) to increase overall resistance to pests and environmental stresses. The same percentage used certified seed which has been tested to ensure it meets quality standards. A fifth of growers used seed treatments to protect seedlings at crop emergence. A fifth also reported other activities such as avoiding growing crops which had been affected by insect and disease damage in the past and choosing to grow heritage varieties (Figure 14).

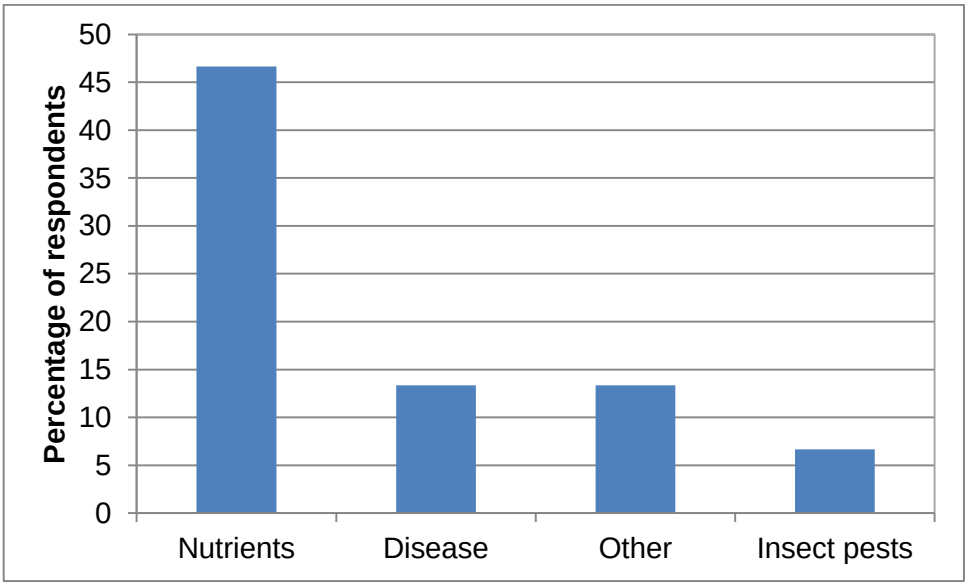
Almost half of respondents sowed catch or cover crops as part of their crop production cycle. These crops were cultivated to improve soil quality, suppress weeds and provide habitats for beneficial insects (Figure 15).

Finally, 60 per cent of the growers sampled adopted techniques to protect or enhance populations of beneficial insects (Table 18). A third planted wild flower strips, 20 per cent planted pollen sources and 13 per cent maintained uncultivated strips. Other strategies included creation of ponds and placing bee hives, hedging and trees beside polytunnels. In addition a small number of respondents used push-pull strategies to manage pests by using attractive trap crops and repellent treatments on the main crop (Figure 16)

Table 18 Summary of responses to risk management questions

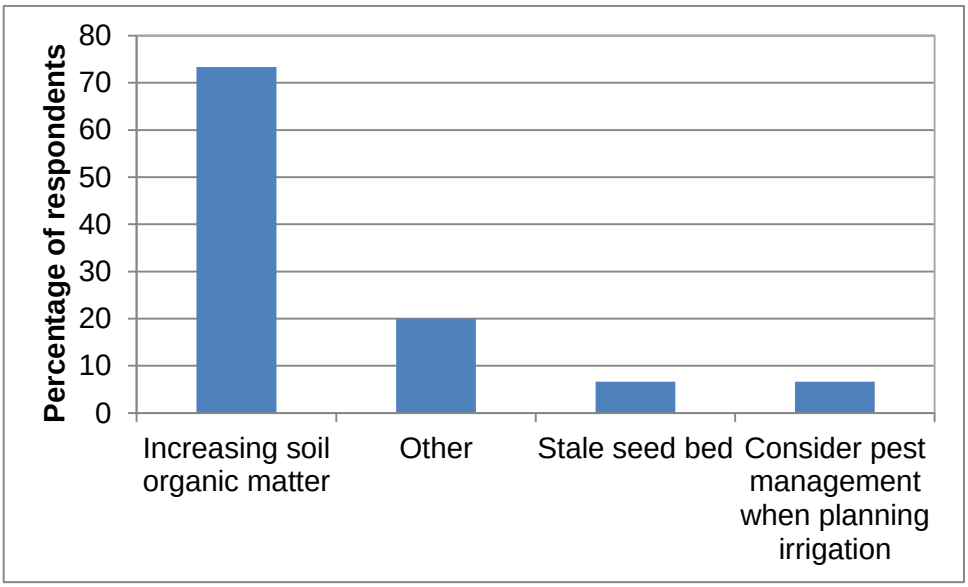
Risk management activity	Percentage yes response
Crop rotation	67
Soil testing	60
Cultivation of seed bed	73
Cultivations at sowing	67
Varietal or seed choice	60
Catch and cover cropping	47
Protection or enhancement of beneficial organism populations	60

Figure 11 Focus of soil testing (percentage of respondents)



Note: other was testing for pH

Figure 12 Seed bed cultivations adopted to reduce pest risk (percentage of respondents)



Note: the other category includes no tillage systems and the use of seaweed to control pests

Figure 13 Sowing cultivations adopted to reduce pest risk (percentage of respondents)

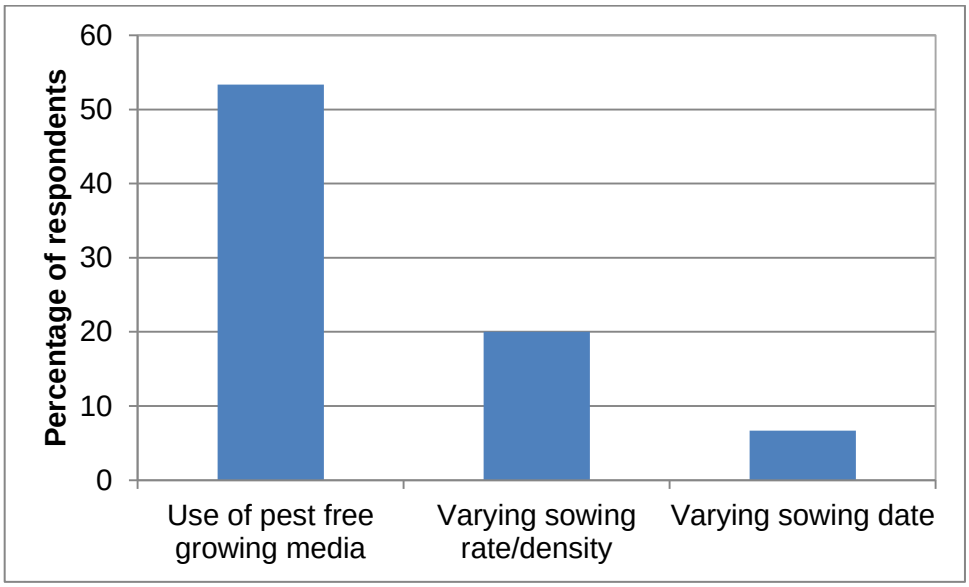
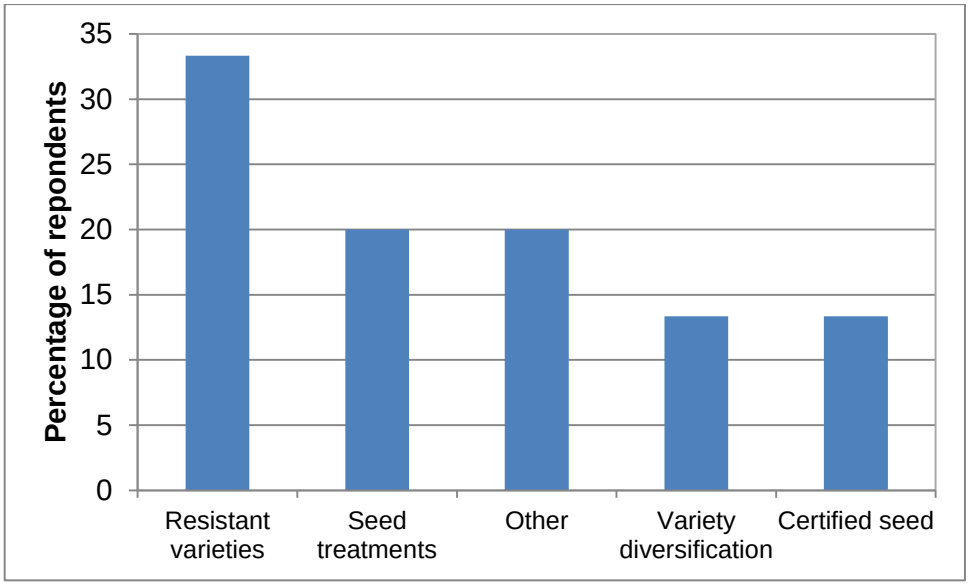


Figure 14 Variety and seed choice to reduce pest risk (percentage of respondents)



Note: the other category included avoiding growing certain crops and growing hardy or heritage varieties.

Figure 15 Catch and cover cropping (percentage of respondents)

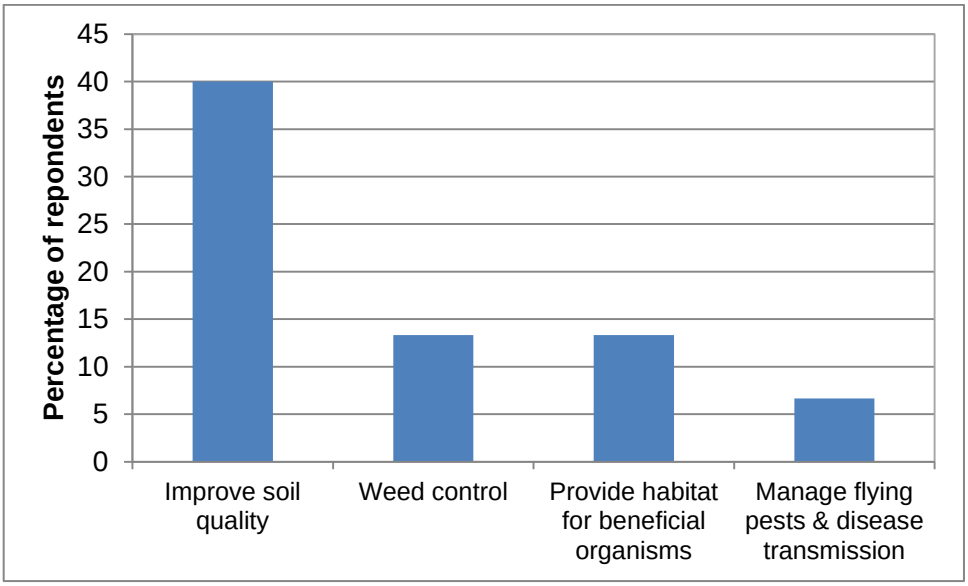
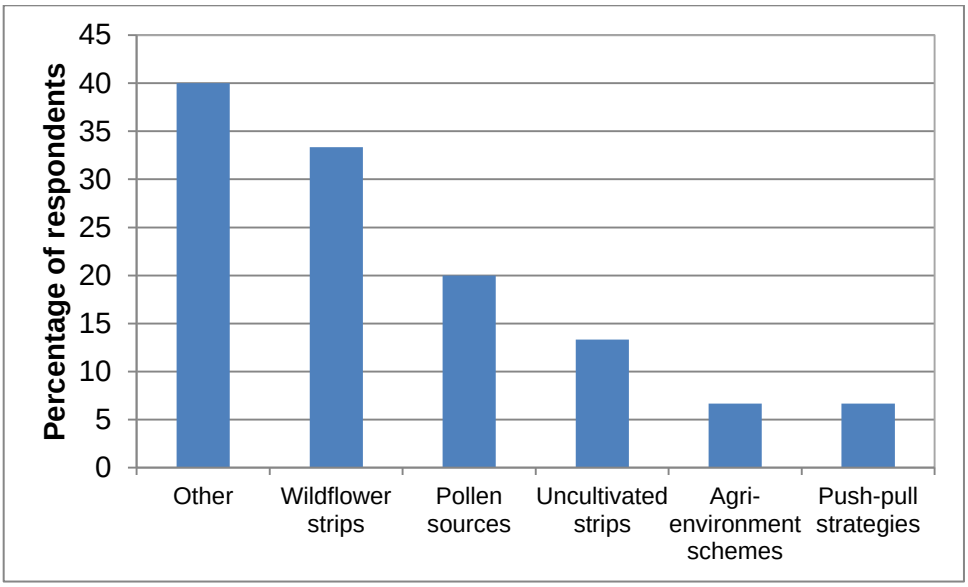


Figure 16 Protection or enhancement of beneficial organism populations (percentage of respondents)



Note: the other category included the use of ponds, bee hives and planting of hedges and trees beside poly tunnels.

Pest monitoring

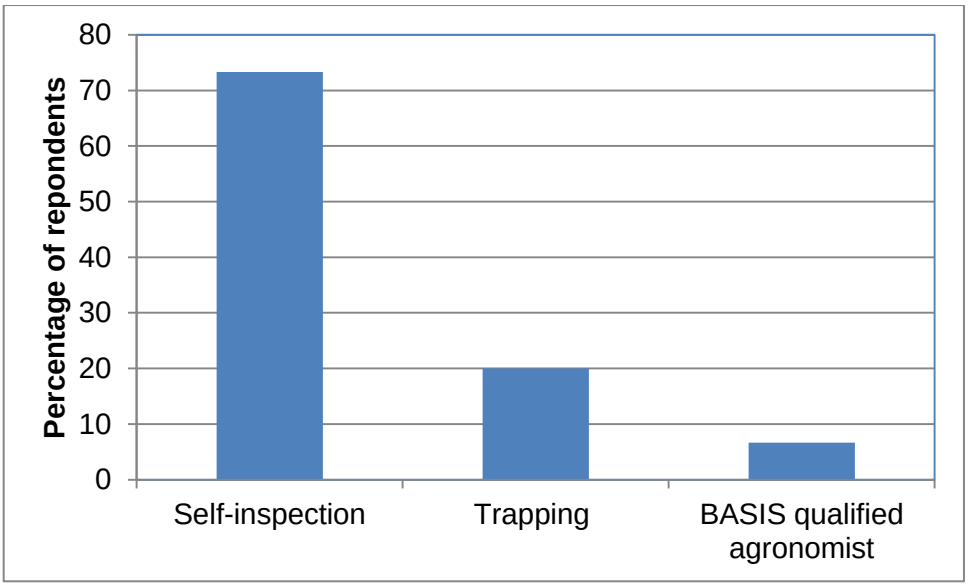
In IPM pests are monitored to determine whether control is economically justified and to be able to effectively target control options. IPM programs aim to monitor and identify pests, so that appropriate control decisions can be made in conjunction with action thresholds. Table 19 presents an overview of the pest monitoring measures adopted by the growers surveyed.

Sixty seven per cent of growers regularly monitored crop growth stages and 73 per cent monitored and identified pests on their crops. Pest monitoring was by conducted primarily by self-inspection (73 per cent) but also by trapping (20 per cent) and by use of agronomists (Figure 17). In addition, some growers (13 per cent) used specialist diagnostic testing for pests that are more problematic to identify or monitor.

Table 19 Summary of responses to pest monitoring questions

Pest monitoring activity	Percentage yes response
Setting action thresholds for crops	13
Monitor and identify pests	73
Use of specialist diagnostics	13
Regular monitoring of crop growth stage	67

Figure 17 Methods of monitoring and identifying pests (Percentage of respondents)



Pest control

If monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM programs evaluate the best control method in relation to effectiveness and risk. Control programmes incorporate non-chemical methods alongside, or instead of, chemical control. Use of chemical pest control should be as targeted as possible and the risk of resistance development should be minimised. The effectiveness of the control programme should be reviewed regularly to gauge success and improve their regime as necessary. Table 20 presents an overview of the pest control measures adopted by the growers surveyed.

The majority of growers (80 per cent) used non-chemical control in partnership or instead of chemical control. A range of control methods were adopted, including use of biological control and physical/mechanical control measures (Figure 18).

Forty per cent of growers stated that they targeted their pesticide applications using monitoring data (Table 20). It should be noted that only 40 per cent of the sample used any pesticides excluding the use of biologicals or disinfectants. In addition, pesticide use was minimised using a range of techniques such as spot treatments (40 per cent) and weed wiping (7 per cent). Thirteen per cent of respondents also stated that they reduced the dosage or frequency of applications where possible.

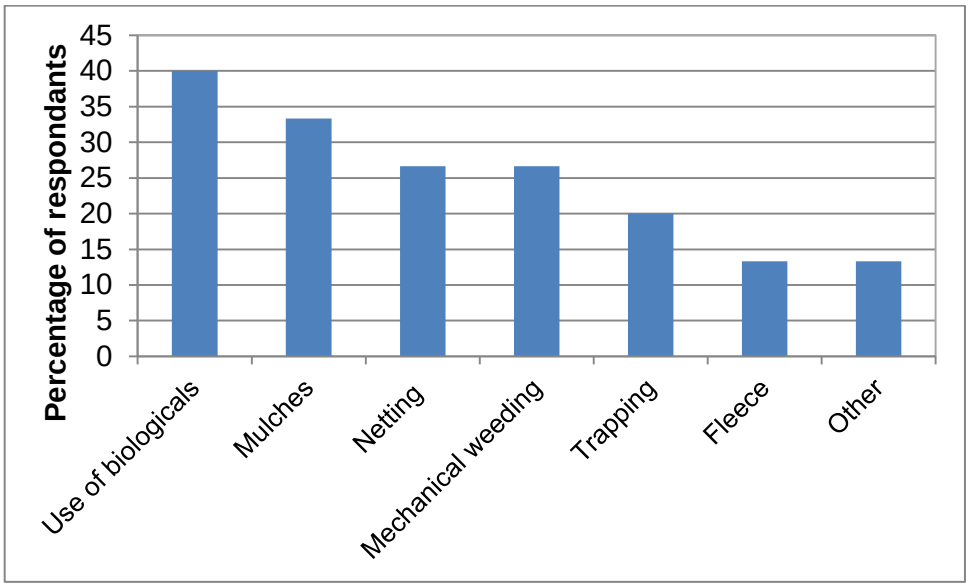
In addition, 27 per cent of growers stated that they followed anti-resistance strategies. These included 20 per cent minimising the number of applications and seven per cent using pesticides with multiple modes of action.

The majority of growers (80 per cent) stated that they monitored the success of their crop protection measures. Almost three quarters self-inspected control measure success and seven per cent conducted a seasonal review of pest control practice and investigated causes of poor efficacy (Figure 19).

Table 20 Summary of responses to pest control questions

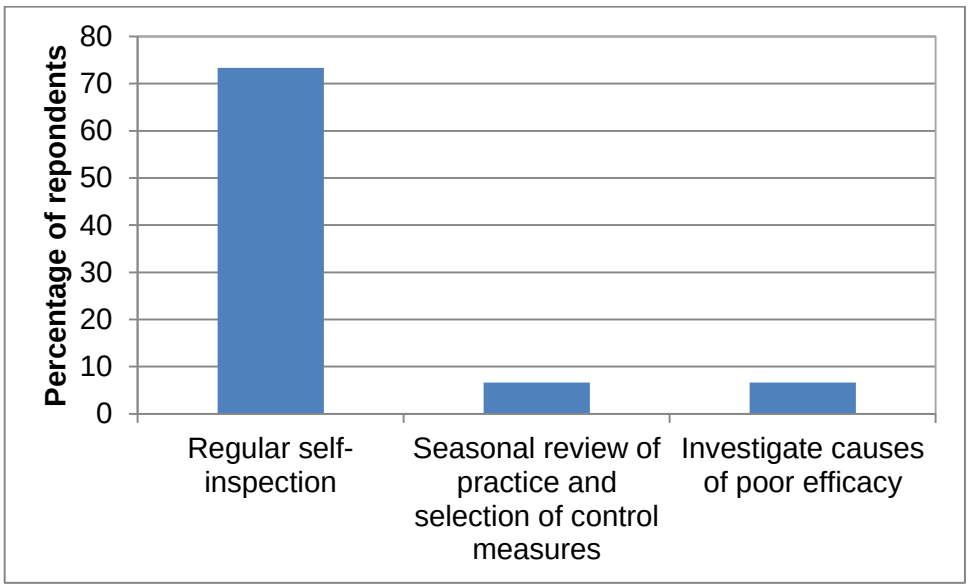
Pest control activity	Percentage yes response
Non-chemical control used in partnership or instead of chemical control	80
Targeted pesticide application (using monitoring data)	40
Follow anti-resistance strategies	27
Monitor success of crop protection measures	80

Figure 18 Types of non-chemical control used (percentage of respondents)



Note biologicals include the use of biological control agents and biopesticides. Other includes removing pests such as slugs by hand.

Figure 19 Methods for monitoring success of crop protection measures (percentage of respondents)



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