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Pesticide Usage in Scotland

A National Statistics Publication for Scotland

Outdoor Vegetable Crops 2019

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Executive summary

This report presents information from a survey of pesticide use on outdoor vegetable crops grown for human consumption in Scotland during 2019. The crops surveyed included vining peas, broad beans, Brussels sprouts, calabrese, carrots, turnips & swedes and other minor vegetable crops.

In 2019 the census area of outdoor vegetable crops grown in Scotland was approximately 18,600 hectares. This represents a four per cent decrease in area from the previous survey in 2017 and a 12 per cent increase from 2015. The principal outdoor vegetable crops grown in Scotland were peas and beans making up 53 per cent of the cropped area. Carrots accounted for 18 per cent, leaf brassicas 16 per cent, turnips and swedes eight per cent and other vegetables five per cent.

Data were collected from a total of 86 holdings, representing 12 per cent of the total vegetable area grown in Scotland. Ratio raising was used to produce estimates of national pesticide usage from sampled data. The estimated total area of outdoor vegetable crops treated with a pesticide formulation (area grown multiplied by number of treatments) was 176,200 ha (± 5 per cent Relative Standard Error, RSE) with a combined weight of ca. 72.6 tonnes (± 5 per cent RSE). Overall, pesticides were applied to 96 per cent of the vegetable crop area. Herbicides were applied to 89 per cent of the crop area, insecticides to 75 per cent, fungicides 82 per cent, molluscicides to 12 per cent and 74 per cent of seed was treated.

Taking into account changes in crop area, the 2019 total pesticide treated area was seven per cent higher than that reported in 2017 and 12 per cent lower than in 2015. The weight of pesticides applied to vegetable crops was 15 per cent higher in 2019 than in 2017, though four per cent less when compared to 2015. The application of fungicides, insecticides and sulphur have increased since 2017 (19, 13 and 33 per cent increases in treated area respectively). Minor use of biological control agents and growth regulators were recorded in 2019, but were not recorded in the 2017 survey. The application of seed treatments, herbicides and molluscicides has decreased since 2017 (1, 5 and 14 per cent decreases in treated area respectively). Overall, pesticide application to vegetable crops was higher in 2019 than in 2017. However, lower pesticide use in 2017 was influenced by climatic conditions and lower pest pressure.

In terms of area treated, the most used foliar fungicide active substance was azoxystrobin. Lambda-cyhalothrin and pendimethalin were the most used insecticide and herbicide active substances respectively. Cymoxanil, fludioxonil and metalaxyl-m, were the most used seed treatment active substances.

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. This dataset is the second in this series of surveys of IPM measures on vegetable crops, allowing the adoption of IPM techniques to be monitored.

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 SASA, a division of the Scottish Government's Agriculture and Rural Economy Directorate.

This survey is part of a series of annual reports which are produced to detail pesticide usage in Scotland for arable, vegetable, and soft fruit 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 privacy and revision policies, user feedback and detailed background information on survey methodology and data uses.

Additional information regarding pesticide use can be supplied by the Pesticide Survey unit. Please email psu@sasa.gov.scot 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 on recent changes in survey data and longer-term trends. The pesticide usage section summarises usage on all outdoor vegetable crops in 2019. Appendix 1 presents all estimated pesticide usage in three formats, area and weight of formulations by crop and area and weight of active substances grouped by their mode of action. The area and weight of active substances by crop data, which were previously published in this report, are now published as supplementary data in Excel format. These different measures are provided to satisfy the needs of different data users (see Appendix 3 for examples). 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 indication of the precision of estimates, the report includes relative standard errors. A full explanation of standard errors can be found in Appendix 5.

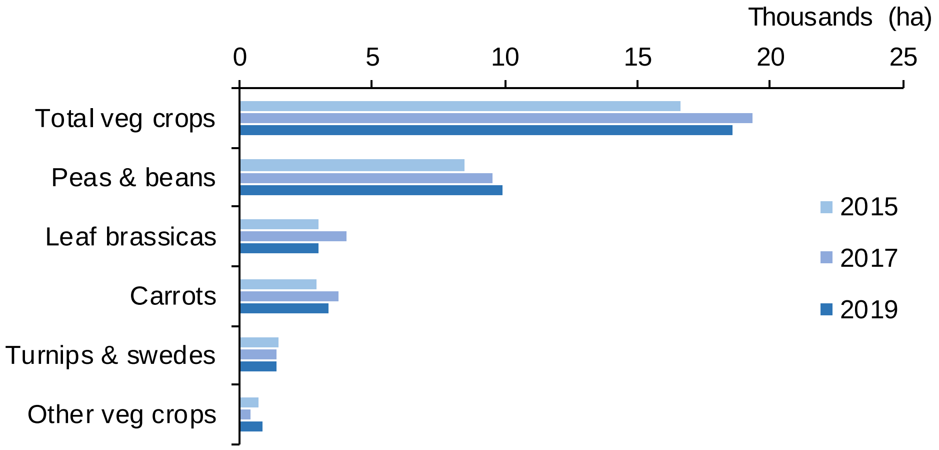
General trends

Crop area

In 2019 the census area of outdoor vegetable crops grown in Scotland was 18,624 hectares (Table 20). This represents a four per cent reduction in cropped area from 2017[(3)] and a 12 per cent increase from 2015[(4)]. Since the last survey, census areas of all vegetable crops have decreased with the exception of vining peas, broad beans, leeks and lettuce (Figure 1). The largest reductions were seen in cabbages (18 per cent), calabrese (17 per cent), carrots and Brussels sprouts (both 11 per cent) (Table 20).

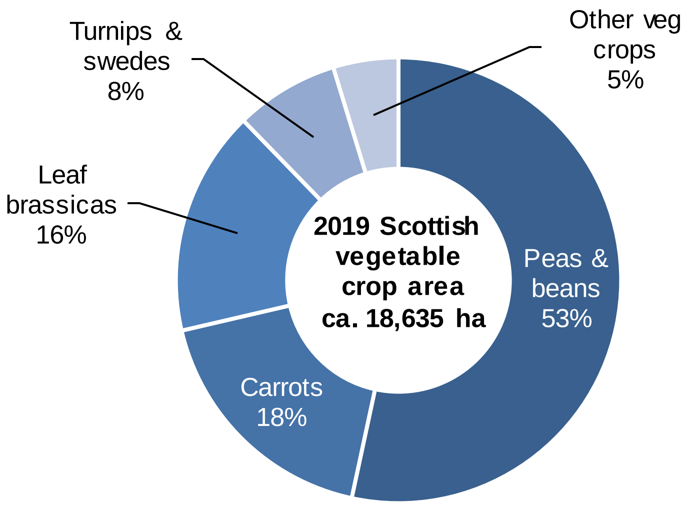
In 2019 peas and beans accounted for 53 per cent of the outdoor vegetable crop area, carrots 18 per cent, leaf brassicas 16 per cent, turnips and swedes eight per cent and other vegetables five per cent (Figure 2).

Figure 1 Area of vegetable crops grown in Scotland 2015-2019



Note: areas do not include multi-cropping

Figure 2 Vegetable crop area 2019 (percentage of total area)



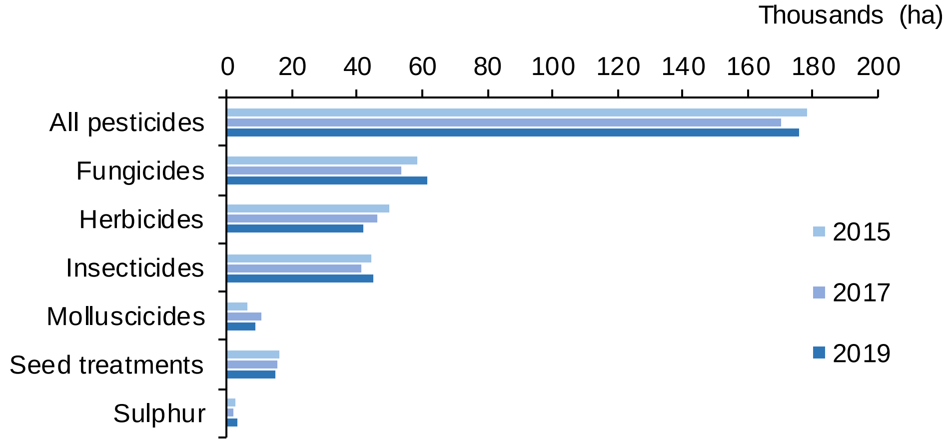
Note: areas include multi-cropping

Pesticide usage

In 2019, 96 per cent of vegetable crops received a pesticide treatment, a slight increase from the 2017 figure of 93 per cent and a decrease from the 2015 figure of 98 per cent. The crops receiving the highest overall treatments proportionally were vining peas, broad beans, Brussels sprouts, calabrese and turnips and swede (96 to 100 per cent, Table 1). Carrots, other brassica crops and other vegetable crops had the lowest proportion of treated crop (87, 84 and 84 per cent treated respectively). The treated area of crops received on average 5.3 sprays compared to 5.4 sprays in 2017 and 5.8 in 2015. The highest average number of spray applications were to Brussels sprouts with 18.5 sprays. The lowest number of sprays, as in 2017, were to vining peas at 2.2 sprays on average (Table 1).

The estimated area of outdoor vegetables treated with a pesticide formulation was 176,200 in 2019 compared with ca. 170,900 hectares in 2017 and ca. 179,000 in 2015 (Table 19, Figure 3). This represents an increase of three per cent since 2017 and a decrease of two per cent since 2015.

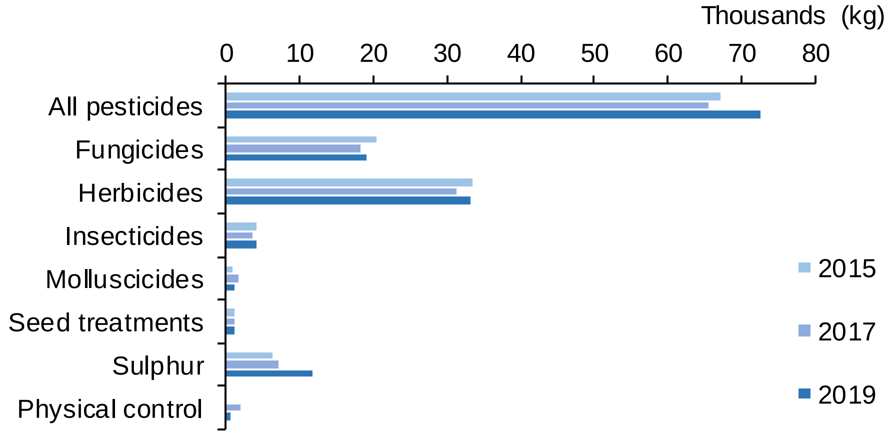
Figure 3 Area of vegetable crops treated with the major pesticide groups in Scotland 2015-2019



Note: growth regulators, biological control, biopesticides and physical control have all been excluded as their use represents <500 hectares

The weight of pesticide applied was ca. 72.6 tonnes in 2019, an increase of 11 per cent from 2017 (ca. 65.6 tonnes) and an increase of 8 per cent from 2015 (ca. 67.3 tonnes) (Figure 4).

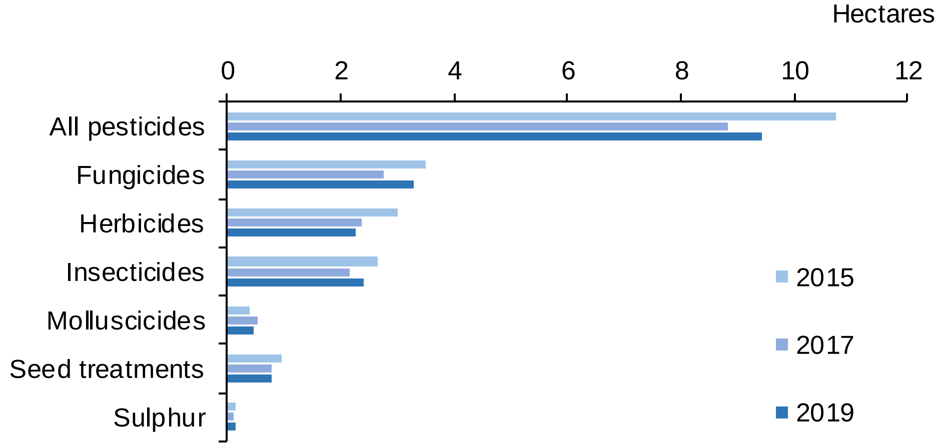
Figure 4 Weight of the major pesticide groups applied to vegetable crops in Scotland 2015-2019



Note: biopesticides and growth regulators have been excluded as their use represents <700 kg. Invertebrate biological control agents are applied by number of organisms rather than weight therefore weight data are not presented

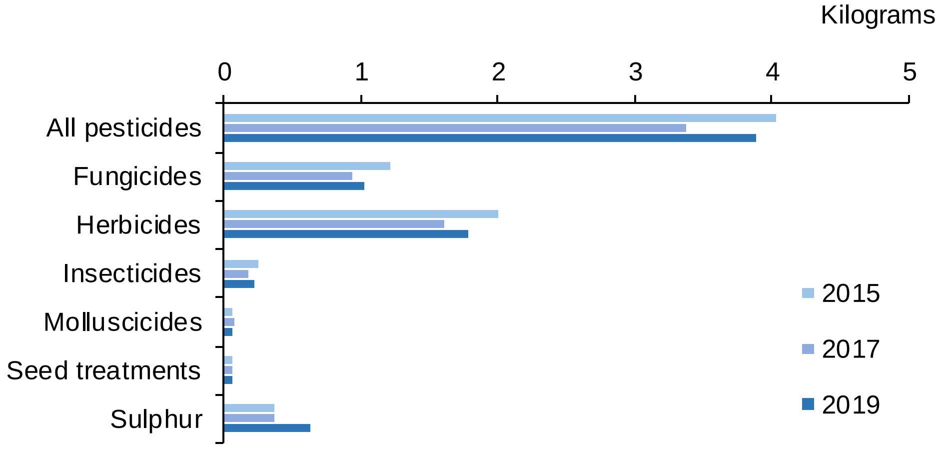
In order to make accurate comparisons between the 2019 data and that reported in previous surveys, it is important to take into account differences in crop areas between years. Therefore, the number of treated hectares per hectare of crop grown and the total weight of pesticide used per hectare of crop grown were calculated. In 2019, for each hectare of crop grown, almost 9.5 pesticide treated hectares were recorded (Figure 5). This represents an increase of seven per cent when compared to 2017 but a reduction of 12 per cent from 2015. The estimated weight of pesticide applied per hectare of crop grown in 2019 was slightly below four kilograms (Figure 6). This represents an increase of 15 per cent from 2017 and a decrease of four per cent from 2015. There was a reduction in overall pesticide use in 2017 influenced by the climatic conditions that year, leading to a lower pest pressure[(3)]. Therefore, although pesticide use in 2019 is greater than reported in 2017, overall it is lower than encountered in 2015.

Figure 5 Number of pesticide treated hectares (formulations) per hectare of crop grown in Scotland 2015-2019



Note: growth regulators, biological control, biopesticides and physical control have been excluded as their use represents <0.1 treated hectares per hectare of crop grown

Figure 6 Weight of pesticides applied per hectare of crop grown in Scotland 2015-2019

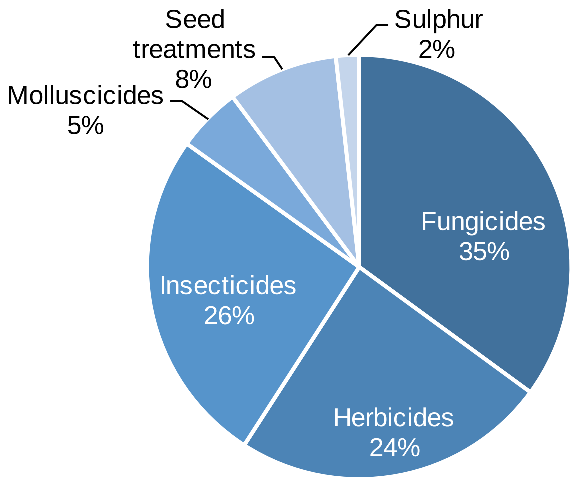


Note: growth regulators, biopesticides and physical control agents have been excluded as their use represents <0.1 kg per hectare of crop grown. Invertebrate biological control agents are applied by number of organisms rather than weight therefore weight data are not presented

As in 2017, fungicides were the most frequently used pesticides, by area treated, on outdoor vegetable crops (Figure 7). They were followed by insecticides and herbicides. Fungicides accounted for 35 per cent of total pesticide treated area and 26 per cent of the total weight of pesticides applied (Figures 7 & 8). When changes in crop area are taken into account, the area treated with fungicides increased by 19 per cent from 2017 to 2019 but has decreased by six per cent between 2015 and 2019 (Figure 5). From 2017 to 2019, there was an increase of nine per cent in the weight of fungicides used per hectare of crop grown, but a decrease of 16 per cent between 2015 and 2019 (Figure 6). The decreased use of fungicides in 2017 compared to 2015 and 2019 may have been influenced by the weather. There was 63 per cent more rainfall recorded in spring 2015 than in spring 2017 and 77 per cent more rainfall in spring 2019 than in spring 2017 in the East of Scotland where the majority of vegetable crops are grown(5). The drier spring may have helped to reduce disease pressure on crops in 2017(3). The principal fungicide mode of action on vegetable crops continues to be inhibition of respiration (this group includes strobilurins and SDHIs, Table 15). The use of fungicides with this mode of action increased by 22 per cent when compared to the previous survey in 2017.

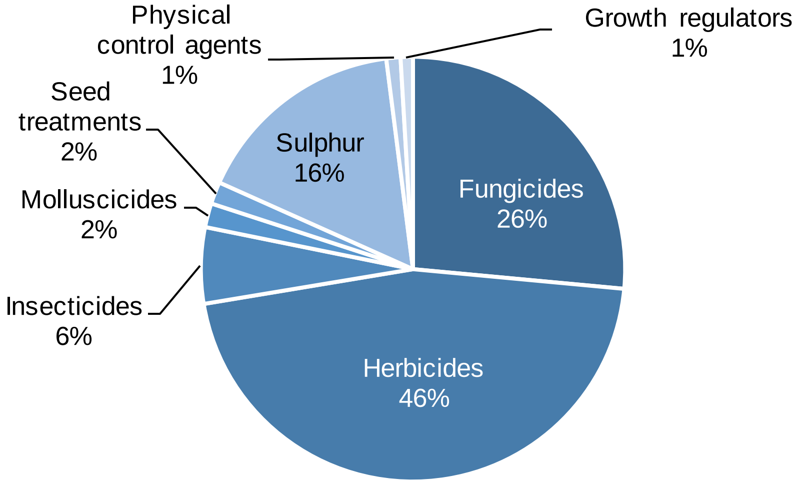
In 2019, herbicides accounted for 24 per cent of the total pesticide treated area and 46 per cent of the total weight of pesticides applied (Figures 7 & 8). When changes in crop area are taken into account, there was a decrease in area treated with herbicide formulations of five per cent from 2017 to 2019 and 24 per cent from 2015 and 2019 (Figure 5). In terms of weight of pesticide applied, when area of crop grown is taken into account, there was an increase of 10 per cent from 2017 to 2019 and a decrease of 11 per cent from 2015 to 2019 (Figure 6). The loss of the active substance linuron, used as a herbicide on carrots (final use June 2018), may have had an impact as the replacement active substance, aclonifen, which was approved in March 2019, is applied at a higher rate, resulting in an increased weight of herbicides applied. Other replacements for linuron used as pre-emergence and early post emergence treatments were pendimethalin, the most used active substance by weight in 2019, with total weight applied increasing 16 per cent since 2017 and diflufenican which was recorded for the first time on vegetable crops in 2019. When corrected for area of crop grown, the glyphosate treated area decreased by 31 per cent and the weight applied decreased by 34 per cent from 2017 to 2019. Glyphosate is applied both as an inter-row herbicide and as a before planting treatment. The wet spring in 2019 followed a particularly dry February, with 45 per cent lower rainfall recorded in the East of Scotland in 2019 compared to 2017[5]. This dry spell may have reduced the weed emergence before planting and resulted in less requirement for before planting treatments (Prof. Fiona Burnett, pers. comm.) There has also been an increase in the use of non-chemical methods for the control of weeds such as mechanical and hand weeding since 2015, which may also have led to the reduction in area treated with herbicides (see Appendix 6).

Figure 7 Use of pesticides on outdoor vegetable crops (percentage of total area treated with formulations) – 2019



Note: growth regulators, biological control, biopesticides and physical control have been excluded as their use represents <0.5 % treated area

Figure 8 **Use of pesticides on outdoor vegetable crops (percentage of total weight of pesticides applied) – 2019**



Note: invertebrate biological control agents are applied by number of organisms rather than weight therefore weight data are not presented

Insecticides accounted for 26 per cent of the total pesticide treated area and six per cent of the total weight of pesticides applied (Figures 7 & 8). There was a 13 per cent increase from 2017 to 2019 and a nine per cent decrease from 2015 to 2019 in the area treated with insecticide formulations when changes in crop area are taken into account (Figure 5). Similarly, in terms of weight applied per hectare of crop grown, there was an increase of 20 per cent from 2017 to 2019 and a decrease of 11 per cent from 2015 to 2019 (Figure 6). Pyrethroids remain the principal form of insect control employed, in terms of area treated (Table 14). However, this was the only chemical group to see a decrease in use from 2017. Use of insecticides with other modes of action (spinosad, pymetrozine, indoxacarb, spirotetramat and flonicamid) all increased. This is likely to be related to the pyrethroid resistance status of a number of target species. One noted increase is in the active substance spinosad, which is one of the few options remaining for the treatment of cabbage root fly after the application of chlorpyriphos was restricted to use in propagation areas. The control of diamondback moths was one of the reasons provided for the use of insecticides. Diamondback moths are also thought to be resistant to pyrethroid insecticides with spinosad being an alternative for their control[(6)].

All the leaf brassica crops, 26 per cent of other vegetables and three per cent of turnips and swedes were grown from transplants. The rest of the crops were grown directly from seed. Of these crops, vining peas had the highest proportion of treated seed with 100 per cent treated, followed by 82 per cent of carrots and 75 per cent of turnips and swedes. Seed treatments accounted for eight per cent of the total area treated and two per cent of the total weight applied (Figure 7 & 8). When changes in crop area are taken into account, there was a decrease in area treated with seed treatments of one per cent from 2017 to 2019 and a decrease of 19 per cent from 2015 to 2019 (Figure

5). The weight of seed treatment applied per hectare of crop grown decreased by two per cent from 2017 to 2019 and by nine per cent from 2015 to 2019 (Figure 6).

Molluscicides accounted for five per cent of the total pesticide treated area and two per cent of weight (Figures 7 & 8). When changes in crop area are taken into account, there was a decrease in area treated of 14 per cent between 2017 and 2019 and an increase of 18 per cent between 2015 and 2019 (Figure 5). Similarly, the weight of molluscicides applied per hectare of crop grown was lower in 2019 compared to 2017 (17 per cent less) and higher in 2019 than 2015 (ten per cent). Slug numbers are closely linked to weather conditions and fluctuate accordingly. There were reduced levels of slug activity in 2015 due to the late cold spring, whereas the wet summer in 2017 increased the risk of slug damage(3).

Sulphur applications accounted for two per cent of the total pesticide area treated and 16 per cent of total weight applied (Figures 7 & 8). Sulphur has dual use as both a fertiliser and a fungicidal treatment and is permissible in some organic systems. When area grown is accounted for, there was a 33 per cent increase in the use of sulphur between 2017 and 2019 and a nine per cent increase between 2015 and 2019 (Figure 5). The weight of sulphur applied per hectare of crop grown also increased by 71 per cent from 2017 to 2019 and by 67 per cent between 2015 and 2019 (Figure 6). Most of the sulphur use was on vining peas and other vegetable crops which have both seen increases in crop area (Table 20).

Pesticides classified as physical control represented less than 0.5 per cent of the total pesticide treated area and one per cent of the total weight of pesticides applied (Figure 7 & 8). In 2019, as in 2017, all physical control encountered was garlic based. This pesticide type was only applied to carrots as a control for free living nematodes. No physical control was encountered in 2015.

Growth regulators and biological control agents were encountered in this survey, but their use represents less than 0.5 per cent of the treated area. This is the first time the use of biological control agents have been encountered in this series of vegetable reports since the 2013 survey(7). All biological control recorded in 2019 was *Phasmarhabditis hermaphrodita* applied to Brussels sprouts as a treatment for slugs. No biopesticides were recorded in this survey. Growth regulators were previously encountered in the 2015 survey.

As well as changes in overall trends in application of pesticide groups since the previous survey, there has been variation in the use of individual active substances. The herbicides diflufenican, aclonifen and the insecticides flonicamid, cyantraniliprole and chlorantraniliprole were recorded for the first time on outdoor vegetable crops in this survey (Table 13). In terms of area treated, the most used active substance was the fungicide azoxystrobin, which has increased by 70 per cent since 2017 (Table 17). Other notable changes in fungicide active substance use include difenconazole which increased by 141 per cent in area treated. The herbicides prosulfocarb and bentazone have increased by 128 and 121 per cent respectively by quantity of active substance applied (Table 18).

There was a continued increase in the molluscicide ferric phosphate, repeating the trend seen in the previous two reports. The use of ferric phosphate increased by 11 per cent (area treated) and nine per cent (weight applied) (Tables 17 & 18). Whereas the use of metaldehyde decreased by 43 per cent (area treated) and 45 per cent (weight applied). We also recorded the use of *Phasmarhabditis hermaphrodita* to control slugs as an alternative to metaldehyde. All products containing metaldehyde formed part of an enhanced stewardship plan from 2017 reducing its usage(8). In December 2018 it was announced that the authorisation of metaldehyde containing products had been refused and that their use would be phased out. However, following a legal challenge, this decision was quashed in July 2019 and metaldehyde is currently still on the market. The reduction in use of metaldehyde and the continuing increase of ferric phosphate, may have been in preparation for the change in legislation. It should be noted that, unlike metaldehyde, there are no watercourse restrictions when using ferric phosphate.

Integrated pest management

Information about the uptake of IPM measures by Scottish growers was collected alongside the 2019 outdoor vegetable crops pesticide usage survey. This 2019 IPM survey represents the second in the series of surveys of IPM measures on vegetable crops, allowing the adoption of IPM techniques to be monitored.

This is a summary of the data; please refer to Appendix 6 for the full dataset. Growers were asked a series of questions about the IPM activities that they implemented for outdoor vegetable crop production. Unlike the other statistics in this report, the figures relating to IPM are not raised to produce national estimates but represent only the responses of those surveyed.

In total, IPM data was collected from 27 growers and grower groups, collectively representing 63 holdings and eight per cent of Scotland's 2019 outdoor vegetable crop area. Of these growers, 67 per cent had an IPM plan (33 per cent completed their own IPM plan and 33 per cent had a plan completed by their agronomist) (Figure 26). This represents a significant increase in the use of IPM plans from the 2015 survey where 36 per cent of growers completed an IPM plan. Since 2015, there has been a focus on the promotion of IPM and the introduction of mandatory completion of IPM plans within some key QA schemes to help growers make the best possible and most sustainable use of all available methods of pest control. Growers were asked about their IPM activities is relation to three categories; risk management, pest monitoring and pest control.

In both 2019 and 2015, all growers sampled reported that they implemented at least one measure associated with an IPM risk management approach (Table 32). Although not statistically significant, there were increases in uptake in some risk management activities from 2015 including soil testing (88 per cent of respondents in 2015 to 96 per cent in 2019), management of seed bed agronomy (76 per cent in 2015 to 81 per cent in 2019), use of catch or cover cropping (36 per cent in 2015 to 44 per cent in 2019) and adoption of techniques to protect or enhance populations of beneficial organisms (72 per cent in 2015 to 81 per cent in 2019).

In terms of the uptake of pest monitoring activities, there was very little change seen between 2015 and 2019 and no statistically significant differences. In both years, the majority of growers sampled (96 per cent) reported they implemented at least one pest monitoring measure (Table 33). There were some changes, however, in the methods of monitoring and identifying pests with an increase in self-inspection of crops (28 per cent in 2015 to 67 per cent in 2019), use of risk warnings, technical bulletins and press articles in 2019 (48, 44 and 22 per cent of growers respectively, Figure 34).

Ninety six per cent of the growers sampled in 2019 adopted at least one IPM pest control activity, a small decrease from 100 per cent in 2015. There were no statistically significant differences in pest control activities from 2015 to 2019. (Table 34). There was an increase in the use of non-chemical control (from 76 per cent of respondents in 2015 to 81 per cent in 2019). There were small decreases in the use of targeted pesticide applications to reduce pesticide use (76 per cent in 2015 to 70 per cent in 2019) and anti-resistance strategies (80 per cent in 2015 to 74 per cent in 2019). This may have been influenced by the increase in the proportion of organic growers from 12 per cent of respondents in 2015 to 19 per cent in 2019. Finally, there was a small decrease in the proportion of respondents who stated that they regularly monitored the success of their crop protection measures (100 per cent in 2015 to 93 per cent in 2019).

2019 Pesticide usage

Vining peas

- An estimated 8,142 hectares of vining peas were grown in Scotland in 2019, an increase of four per cent since 2017
- 100 per cent of the crop was treated with a pesticide (see Figure 9 for types of pesticides used)
- Pesticide formulations were applied to 34,818 treated hectares with 27,875 kilograms of pesticide applied in total (see summary table below)
- Vining pea crops received on average 2.2 pesticide applications (Table 1). These included 1.4 herbicide applications (applied to 96 per cent of the crop area), 1.2 insecticide applications (applied to 60 per cent of the crop) and one fungicide and one sulphur application (applied to 74 and 24 per cent of the crop respectively)
- Timings of pesticide applications are shown in Figure 10
- The only reasons specified for herbicide and insecticide use were general weed control (18 per cent) and aphids (11 per cent). There were no reasons recorded for fungicide or sulphur use
- The most common varieties encountered were Corus, Naches and Romance, accounting for 26, 12 and 10 per cent of the sample area respectively

Summary of pesticide use on vining peas:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	6,050	5,569	74	Boscalid/ pyraclostrobin (3,583)
Herbicides	12,976	12,842	96	Imazamox/ pendimethalin (7,490)
Insecticides	5,712	739	60	Pirimicarb (4,846)
Sulphur	1,938	7,751	24	N/A
Seed treatments	8,142	973	100	Cymoxanil/fludioxonil/ metalaxyl-M (7,364)
All pesticides	**34,818**	**27,875**	**100**	

Figure 9 Use of pesticides on vining peas (percentage of total area treated with formulations) – 2019

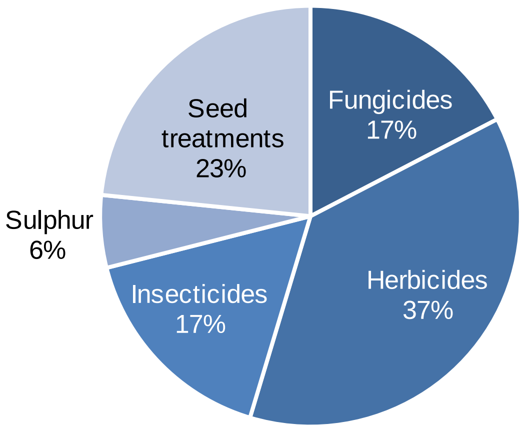
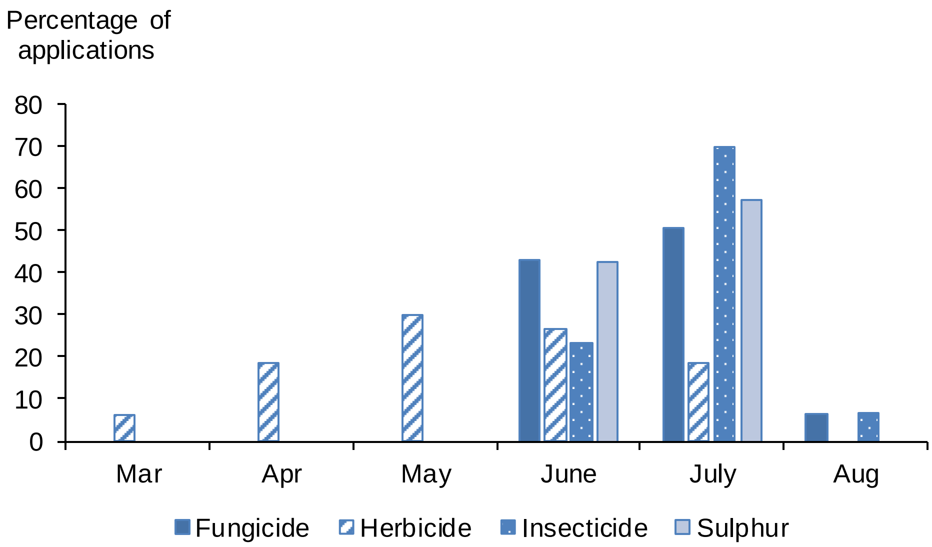


Figure 10 Timing of pesticide applications on vining peas – 2019



Broad beans

- An estimated 1,804 hectares of broad beans was grown in Scotland in 2019, an increase of one per cent since 2017
- 100 per cent of the crop was treated with a pesticide (see Figure 11 for types of pesticides used)
- Pesticide formulations were applied to 17,229 treated hectares with 6,499 kilograms of pesticide applied in total (see summary table below)
- The broad bean crop received on average 5.1 pesticide sprays (Table 1). These included 3.3 fungicide applications, 3.3 insecticide applications and 1.1 herbicide applications (applied to 100 per cent of the crop)
- Timings of pesticide applications are shown in Figure 12
- No reasons were supplied for pesticide use
- The two varieties encountered were Listra and Talia, accounting for 79 and 21 per cent of the sampled area respectively

Summary of pesticide use on broad beans:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	8,042	3,894	100	Boscalid/ pyraclostrobin, (1,800) Cyprodinil/fludioxonil (1,800)
Herbicides	1,988	2,164	100	Imazamox/ pendimethalin (1,800)
Insecticides	5,928	283	100	Lambda-cyhalothrin (3,600)
Seed treatments	1,272	157	70	Thiram (1,272)
All pesticides	**17,229**	**6,499**	**100**	

Figure 11 Use of pesticides on broad beans (percentage of total area treated with formulations) - 2019

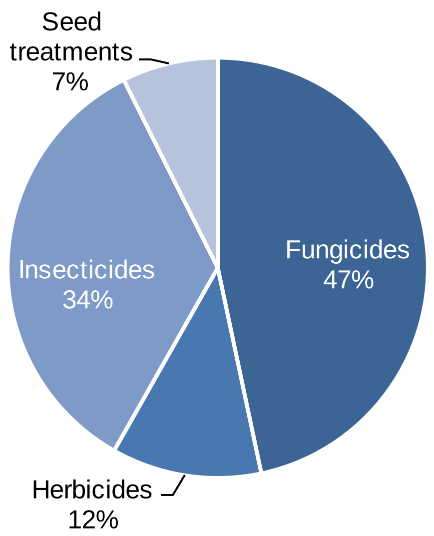
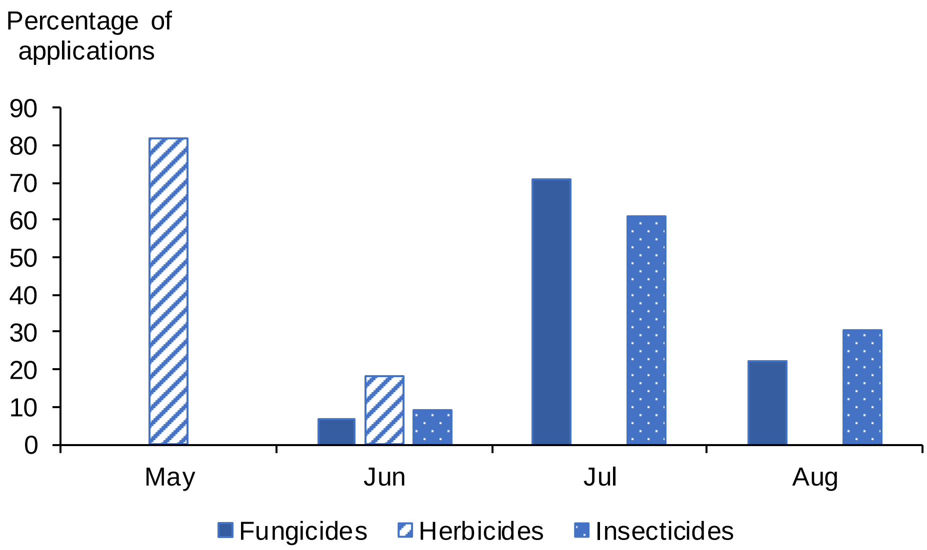


Figure 12 Timing of pesticide applications on broad beans – 2019



Brussels sprouts

- An estimated area of 932 hectares was grown in Scotland in 2019. This represents an increase of 13 per cent since 2017. In 2019, 930 hectares were recorded in the Brussels sprouts census category and two hectares in the 'other vegetable' category
- All the Brussels sprouts crop was grown from transplants
- 100 per cent of the crop was treated with a pesticide (see Figure 13 for types of pesticides used)
- Pesticide formulations were applied to 31,255 treated hectares with 5,896 kilograms of pesticide applied in total (see summary table below)
- The 100 per cent of Brussels sprouts crop treated with a pesticide received on average 18.5 pesticide applications (Table 1). These included 8.1 insecticide applications, 7.5 molluscicide applications and 7.3 fungicide applications (applied to 100 per cent of the crop) and 2.8 herbicide applications (applied to 69 per cent of the crop)
- Timings of pesticide applications are shown in Figure 14
- The only reason specified for fungicide use was disease control (five per cent of use). Reasons for insecticide applications were supplied for three per cent of total use. Two per cent for aphids and one per cent for caterpillars. General weed control was the only specified reason for herbicide use (four per cent of use). No reasons were recorded for the use of biological control agents, however, *Phasmarhabditis hermaphrodita* is typically used for slug control
- The most common variety encountered was Petrus which accounted for 59 per cent of the sample area

Summary of pesticide use on Brussels sprouts:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	8,656	2,161	100	Prothioconazole (2,367)
Herbicides	2,420	1,796	69	Clomazone (644), Metazachlor (644) Pendimethalin (644)
Insecticides	13,131	905	100	Indoxacarb (2,655), Lambda-cyhalothrin (2,553)
Biological control agents	63	N/A	7	*Phasmarhabditis hermaphrodita* (63)
Molluscicides	6,985	1,034	100	Ferric phosphate (4,269)
All pesticides	**31,255**	**5,896**	**100**	

Figure 13 Use of pesticides on Brussels sprouts (percentage of total area treated with formulations) - 2019

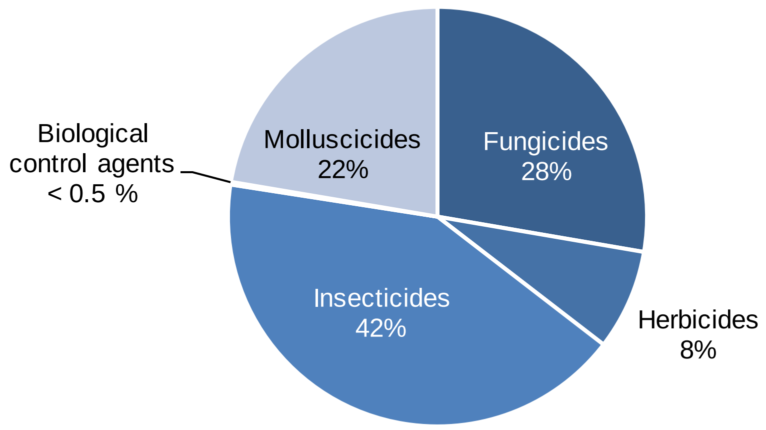
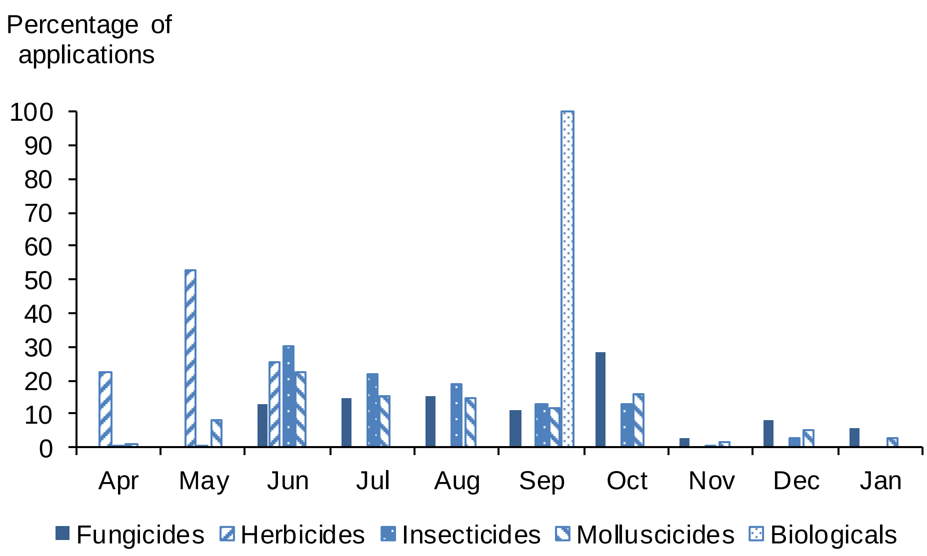


Figure 14 Timing of pesticide applications on Brussels sprouts – 2019



Calabrese

- An estimated area of 1,489 hectares of calabrese were grown in Scotland in 2017, a decrease of 25 per cent since 2017. This included 1,487 hectares recorded in the 'calabrese' census category with the remainder recorded in the 'other vegetable' category
- All the calabrese crop was grown from transplants
- 97 per cent of the crop was treated with a pesticide (see Figure 15 for types of pesticides used)
- Pesticide formulations were applied to 9,934 treated hectares with 4,893 kilograms of pesticide applied in total (see summary table below)
- The 97 per cent of calabrese crop treated with a pesticide received on average 5.3 pesticide applications (Table 1). These applications included 3.0 fungicides and 1.9 herbicides, (applied to 92 per cent of the crop) and 1.3 insecticides (applied to 84 per cent of the crop)
- The timings of pesticide applications are shown in Figure 16
- Nine per cent of fungicide use was for downy mildew, four per cent for mildew and five per cent for disease control. Forty per cent of recorded fungicide use was copper oxychloride, applied as a trace element but which also has fungicidal properties. General weed control was the only specified reason for herbicide use (58 per cent of use). Reasons for insecticide applications were supplied for 63 per cent of total use. Of these 36 per cent was for diamondback moth, 18 per cent was for caterpillars and nine per cent for general pests
- The most common variety encountered was Parthenon, accounting for 79 per cent of the sample area

Summary of pesticide use on calabrese:

Pesticide group	**Formulation area treated**	**Weight of pesticides applied**	**Percentage of crop treated**	**Most used formulations**
	ha	**kg**	**%**	**ha**
Fungicides	4,301	1,402	92	Copper oxychloride (2,751)
Herbicides	3,312	3,179	92	Metazachlor (1,369)
Insecticides	1,980	54	84	Indoxacarb (1,454)
Molluscicides	120	25	8	Ferric phosphate (120)
Sulphur	221	233	9	N/A
All pesticides	**9,934**	**4,893**	**97**	

Figure 15 Use of pesticides on calabrese (percentage of total area treated with formulations) - 2019

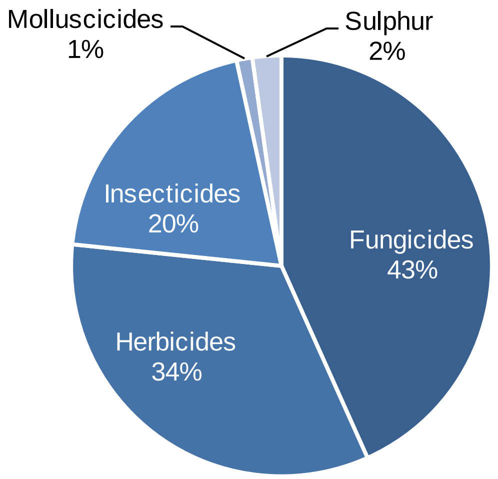
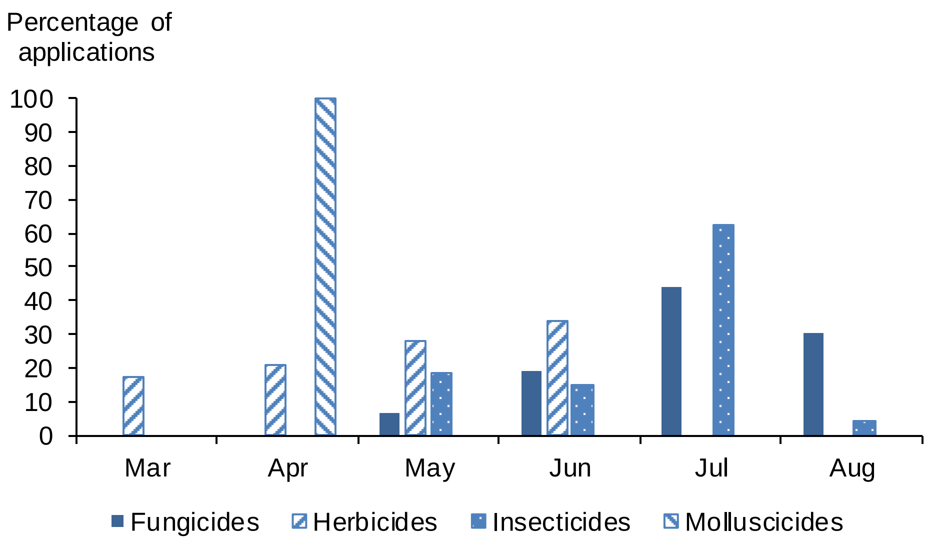


Figure 16 Timing of pesticide applications on calabrese – 2019



Other brassica crops

- Other brassica crops encountered in the 2019 survey were red, savoy and winter cabbage and cauliflower. In the other vegetable census category, broccoli, curly kale, kohlrabi and black kale were recorded (in previous publications cabbages were reported separately but this was not possible in 2019 due to reduced area of crop encountered in the sample)
- The total estimated area of other brassica crops was 626 hectares
- 100 per cent of other brassica crops were grown from transplants
- 84 per cent of the other brassica crop was treated with a pesticide (see Figure 17 for types of pesticides used)
- Pesticide formulations were applied to 3,581 treated hectares with 719 kilograms of pesticide applied in total (see summary table below)
- The 84 per cent of other brassica crops treated with a pesticide received on average 4.0 pesticide applications (Table 1). These included 2.0 each of fungicide, insecticide and herbicide and 1.3 molluscicide applications (applied to 78, 73, 13 & 82 per cent of the crop respectively)
- The timings of pesticide applications are shown in Figure 18
- Aphids and caterpillars were the only specified reasons reported for insecticide application (one per cent each). Reasons were supplied for 10 per cent of total herbicide use; with general weed control at four per cent, annual meadow grass three per cent, volunteer rape two per cent and crop destruction one per cent. No reasons for fungicide applications were supplied

Summary of pesticide use on other brassicas:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	963	269	78	Azoxystrobin (656)
Herbicides	301	288	13	Pendimethalin (76)
Insecticides	1,656	69	73	Indoxacarb (610)
Molluscicides	662	93	82	Ferric phosphate (662)
All pesticides	**3,581**	**719**	**84**	

Figure 17 Use of pesticides on other brassica crops (percentage of total area treated with formulations) – 2019

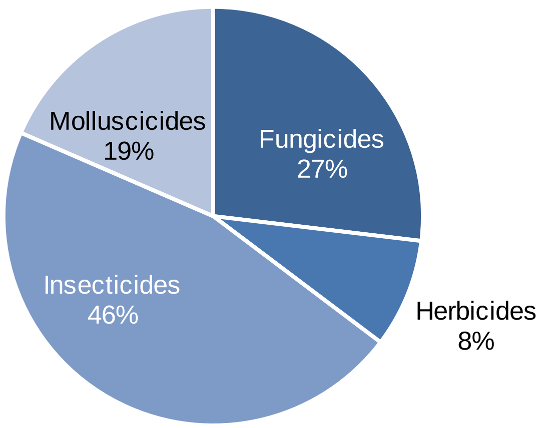
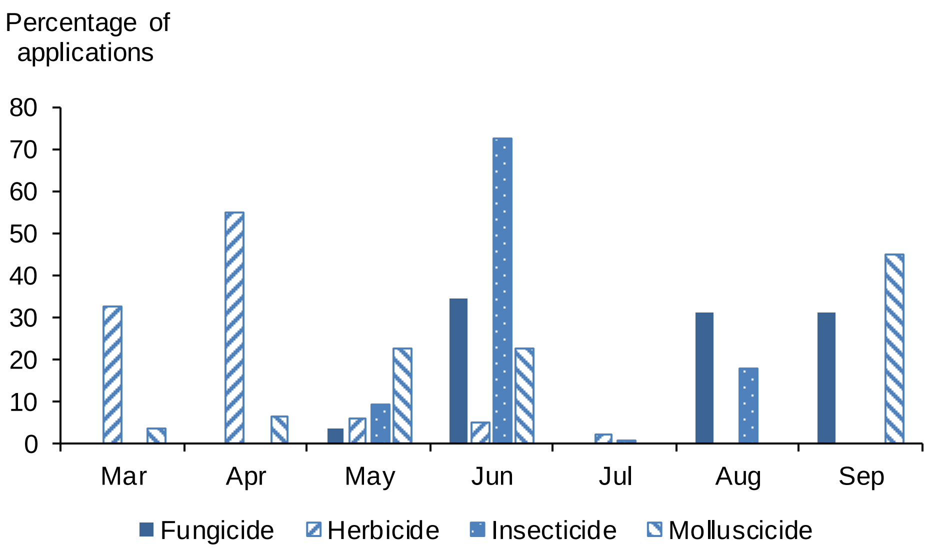


Figure 18 Timing of pesticide applications on other brassica crops – 2019



Carrots

- An estimated 3,353 hectares of carrots was grown in Scotland in 2019, a decrease of 11 per cent since 2017. This consists of 3,325 hectares recorded in the 'carrots' census category and 29 hectares in the 'other vegetable' category
- 87 per cent of the crop was treated with a pesticide (see Figure 19 for types of pesticides used)
- Pesticide formulations were applied to 56,300 treated hectares with 20,851 kilograms of pesticide applied in total (see summary table below)
- The 87 per cent of carrot crop treated with a pesticide received on average 9.6 applications (Table 1). These included 6.8 fungicide applications, 3.6 insecticide applications and 2.7 herbicide applications (applied to 84, 84, and 85 per cent of the crop)
- The timing of pesticide applications is shown in Figure 20
- Reasons for fungicide applications were supplied for 34 per cent of total use; 16 per cent for disease control/prevention, 10 per cent for *Sclerotinia*, six per cent for crown rot, two per cent for cavity spot and one per cent for *Alternaria.* Reasons for insecticide/nematicide applications were supplied for 54 per cent of total use; 40 per cent for carrot fly, 13 per cent for aphids and one per cent for nematodes. All physical control was garlic-based and the only reason supplied for use was carrot fly control (34 per cent of use)
- 29 per cent of herbicide use was for general weed control; three per cent for broad-leaved weeds, one per cent for wild oats and one per cent for inter-row weed control. Other reasons accounting for the final one per cent included fumitory, volunteer cereals, annual meadow grass and cover crop control
- The most common variety encountered was Nairobi, accounting for 81 per cent of the sample area surveyed

Summary of pesticide use on carrots:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	26,500	7,967	84	Prothioconazole (4,678)
Herbicides	15,387	9,028	85	Metribuzin (3,619)
Insecticides	10,150	1,413	84	Lambda-cyhalothrin (7,726)
Sulphur	383	1,570	4	N/A
Seed treatments	3,754	91	82	Cymoxanil/fludioxonil/ metalaxyl-M (2,397)
Physical control	125	782	3	Garlic (125)
All pesticides	**56,300**	**20,851**	**87**	

Figure 19 Use of pesticides on carrots (percentage of total area treated with formulations) – 2019

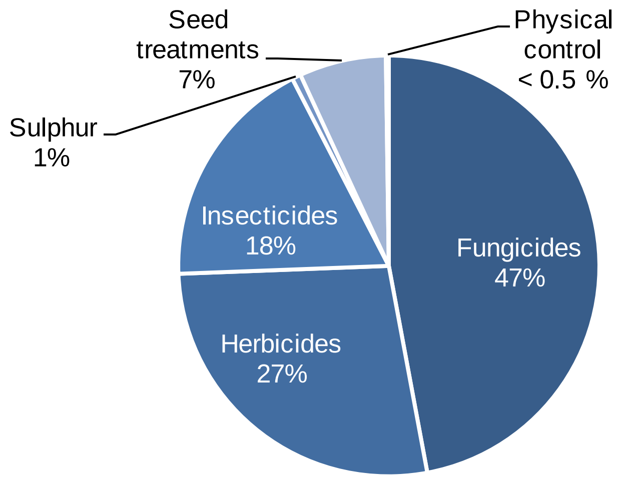
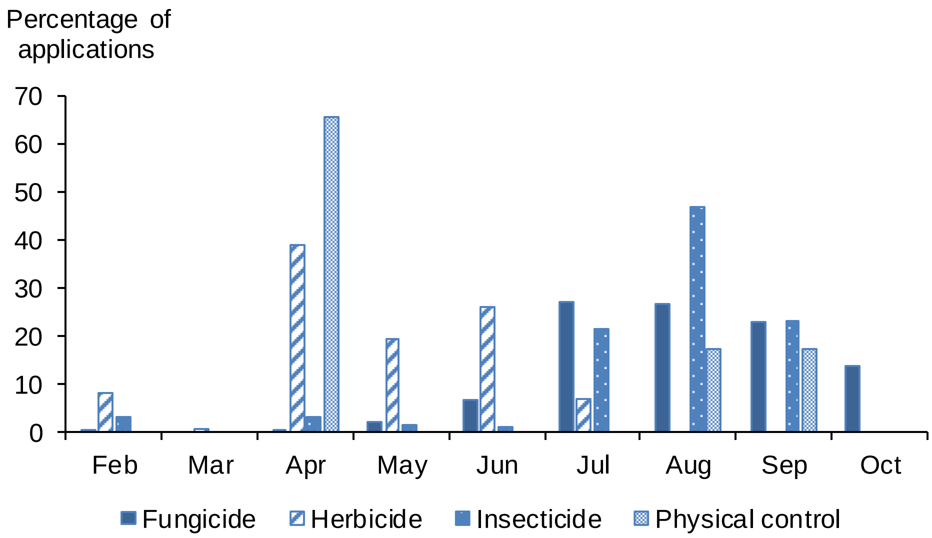


Figure 20 Timing of pesticide applications on carrots – 2019



Note: there were small amounts of (<1%) herbicide applications in November which are not shown on this figure.

Turnips and swedes

- The total estimated area of turnips and swedes grown in 2019 was 1,405 hectares, representing a two per cent decrease from 2017. 1,359 hectares were recorded in the 'turnips & swedes' census category and 46 hectares were recorded in the 'other vegetable' census category
- Three per cent of turnips and swedes were grown from transplants
- 96 per cent of the turnip and swede crop was treated with a pesticide (see Figure 21 for types of pesticides used)
- Pesticide formulations were applied to 13,081 treated hectares with 2,504 kilograms of pesticide applied in total (see summary table below)
- The turnip and swede crop received on average 5.6 pesticide applications (Table 1). These included 3.1 insecticide and 2.3 fungicide applications (each applied to 86 per cent of the crop area) as well as 1.5 herbicide and 1.2 molluscicide applications (applied to 94 and 46 per cent of the crop respectively)
- The timing of pesticide applications is shown in Figure 22
- General disease control was the only specified reason for the use of fungicides (six per cent). Reasons for herbicide applications were supplied for 29 per cent of total use; 27 per cent for general weed control and two per cent was for stale seed bed preparation. Caterpillars and diamondback moth were the only reasons given for insecticide use (two and four per cent respectively)
- The most common variety encountered was Magres, accounting for 77 per cent of the sample area surveyed

Summary of pesticide use on turnips and swedes:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	3,334	848	86	Azoxystrobin (1,381)
Herbicides	3,404	1,353	94	Clomazone (1,307)
Insecticides	4,492	142	86	Deltamethrin (2,329)
Molluscicides	800	161	46	Ferric phosphate (484)
Seed treatments	1,051	1	75	Thiram (1,051)
All pesticides	**13,081**	**2,504**	**96**	

Figure 21 Use of pesticides on turnips and swedes (percentage of total area treated with formulations) – 2019

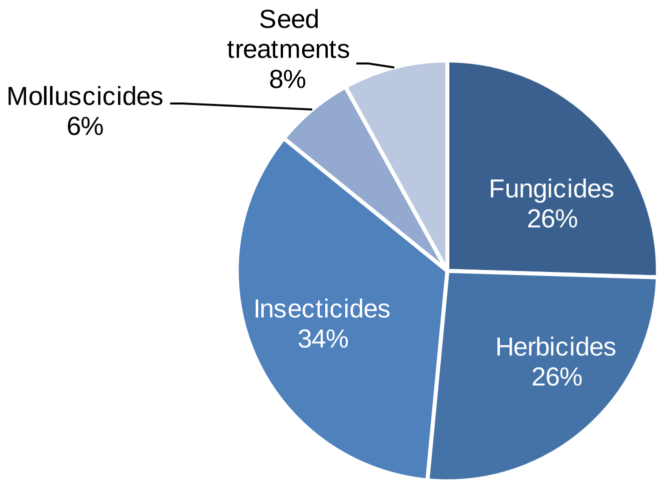
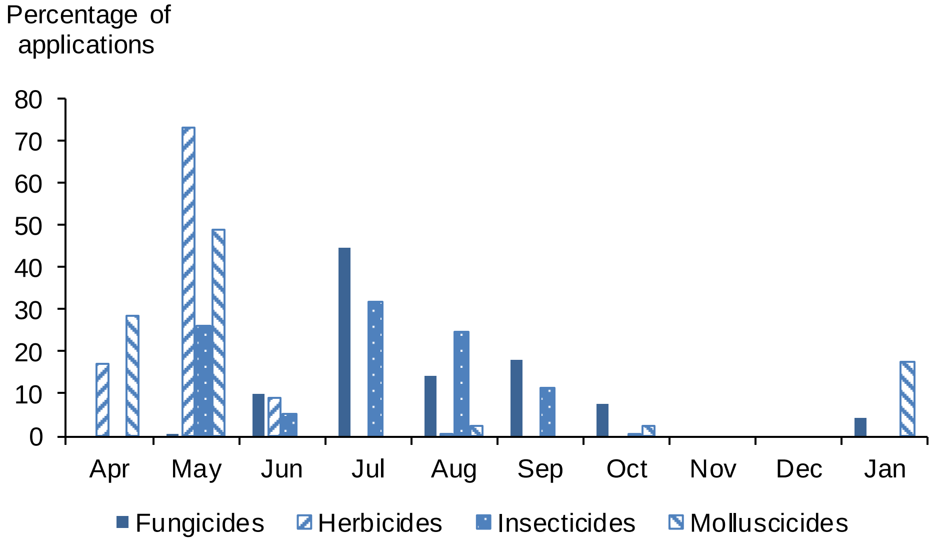


Figure 22 Timing of pesticide applications on turnips and swedes – 2019



Other vegetable crops

- Other vegetable crops encountered in the 2019 survey were beetroot, celeriac, chard, garlic, leeks, lettuce, onions, parsnips, podded peas, rhubarb and spinach
- The total estimated area of other vegetable crops was 883 hectares. This includes 10 hectares of multi-cropping
- 26 per cent of other vegetable crops were grown from transplants
- 84 per cent of other vegetable crops were treated with a pesticide (see Figure 23 for types of pesticides used)
- Pesticide formulations were applied to 10,002 treated hectares with 7,241 kilograms of pesticide applied in total (see summary table below)
- The 84 per cent of the other vegetable crop treated with a pesticide received on average 6.8 pesticide applications (Table 1). These included 3.9 fungicide applications (applied to 84 per cent of the crop area), 3.2 insecticides, 2.1 herbicides and 1.0 molluscicide application (applied to 76, 84 & 12 per cent respectively)
- The timing of pesticide applications is shown in Figure 24
- The only reason supplied for herbicide applications was general weed control (13 per cent). General disease control (five per cent), downy mildew and mildew (less than one per cent each) were the only specified reasons for fungicide use. Reasons for insecticide applications were supplied for nine per cent of use; six per cent for caterpillars and three per cent for aphids

Summary of pesticide use on other vegetable crops:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	3,752	1,003	84	Azoxystrobin/ difenoconazole (1,205)
Herbicides	2,519	2,669	84	Pendimethalin (959)
Insecticides	2,204	603	76	Lambda-cyhalothrin (1,704)
Growth regulators	284	682	32	Maleic hydrazide (284)
Molluscicides	108	12	12	Metaldehyde (97)
Seed treatments	568	< 0.5	64	Cymoxanil/fludioxonil/ metalaxyl-M (568)
Sulphur	568	2,272	64	N/A
All pesticides	**10,002**	**7,241**	**84**	

Figure 23 Use of pesticides on other vegetable crops (percentage of total area treated with formulations) – 2019

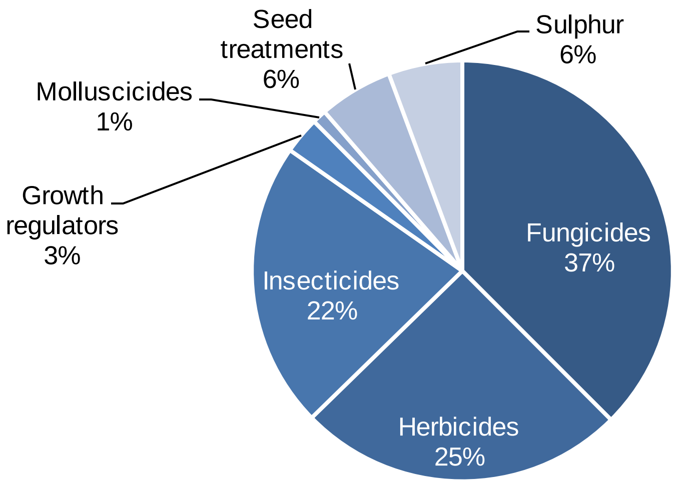
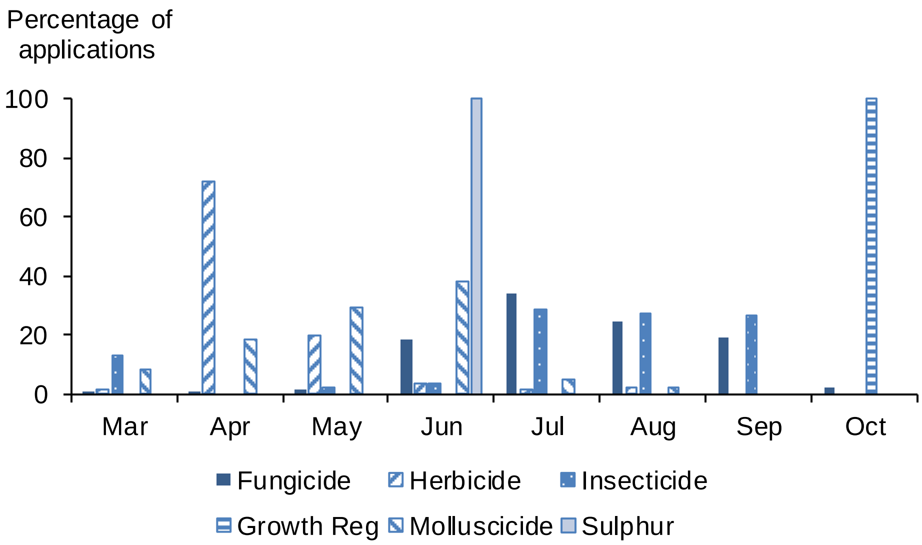


Figure 24 Timing of pesticide applications on other vegetable crops – 2019



Note: there were small amounts (<1%) of fungicide applications on other vegetable crops in March 2019 which are not shown on this figure.

Appendix 1 – Estimated application tables

Table 1 Percentage of each crop treated with pesticides and mean number of spray applications - 2019

Crop	Fungicides		Herbicides		Insecticides/ nematicides		Molluscicides		Sulphur		Biological control agents		Physical control		Any pesticide exc. STs		Seed treatments	Any pesticide inc. STs
	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	%
Vining peas	74	1.0	96	1.4	60	1.2	0	0.0	24	1.0	0	0.0	0	0.0	100	2.2	100	100
Broad beans	100	3.3	100	1.1	100	3.3	0	0.0	0	0.0	0	0.0	0	0.0	100	5.1	70	100
Brussels sprouts	100	7.3	69	2.8	100	8.1	100	7.5	0	0.0	7	1.0	0	0.0	100	18.5	0	100
Calabrese	92	3.0	92	1.9	84	1.3	8	1.0	9	1.7	0	0.0	0	0.0	97	5.3	0	97
Other brassicas	78	2.0	13	2.0	73	2.0	82	1.3	0	0.0	0	0.0	0	0.0	84	4.0	0	84
Carrots	84	6.8	85	2.7	84	3.6	0	0.0	4	3.0	0	0.0	3	1.2	87	9.6	82	87
Turnips & swedes	86	2.3	94	1.5	86	3.1	46	1.2	0	0.0	0	0.0	0	0.0	96	5.6	75	96
Other vegetable crops	84	3.9	84	2.1	76	3.2	12	1.0	64	1.0	0	0.0	0	0.0	84	6.8	64	84
All vegetable crops	**82**	**3.2**	**89**	**1.7**	**75**	**2.7**	**12**	**3.8**	**15**	**1.1**	**<0.5**	**1.0**	**1**	**1.2**	**96**	**5.3**	**74**	**96**

Note: STs = seed treatments
The average number of spray applications is calculated only on the areas receiving each pesticide group and therefore the minimum number of applications is always one (see appendix 3 – definitions and notes for details)

Table 2 Peas and beans seed treatment formulations - 2019

Area (ha), weight (kg) and percentage of crop treated

Seed treatment	Broad beans		Vining peas		Total 2019	Total 2019	2017	2017
	ha	%	ha	%	**ha**	**kg**	ha	kg
Cymoxanil/fludioxonil/metalaxyl-M	0	0	7,364	90	**7,364**	**870**	7,807	917
Thiram	1,272	70	778	10	**2,049**	**261**	1,767	250
All seed treatments	**1,272**	**70**	**8,142**	**100**	**9,414**	**1,130**	**9,574**	**1,167**
No seed treatment	528	29	0	0	**528**	**N/A**	12	N/A
Area grown	1,804		8,142		**9,946**			

N/A = not applicable

Table 3 Peas and beans insecticide formulations - 2019

Area (ha), weight (kg) and percentage of crop treated

Insecticides	Broad beans		Vining peas		Total 2019	Total 2019	2017	2017
	ha	%	ha	%	**ha**	**kg**	ha	kg
Deltamethrin	528	29	0	0	**528**	**4**	524	4
Flonicamid	0	0	866	11	**866**	**61**	0	0
Lambda-cyhalothrin	3,600	100	0	0	**3,600**	**27**	2,938	22
Pirimicarb	1,800	100	4,846	60	**6,646**	**930**	6,139	801
All insecticides	**5,928**	**100**	**5,712**	**60**	**11,640**	**1,022**	**9,601**	**827**
Area grown	1,804		8,142		**9,946**		9,586	

Table 4 Peas and beans fungicide and sulphur formulations - 2019

Area (ha), weight (kg) and percentage of crop treated

Fungicides	Broad beans		Vining peas		Total 2019	Total 2019	2017	2017
	ha	%	ha	%	**ha**	**kg**	ha	kg
Azoxystrobin	1,057	29	2,467	30	**3,524**	**683**	4,034	873
Boscalid/pyraclostrobin	1,800	100	3,583	44	**5,383**	**1,624**	4,288	1,173
Chlorothalonil/metalaxyl-M	1,057	29	0	0	**1,057**	**1,136**	1,252	1,204
Cyprodinil/fludioxonil	3,071	100	0	0	**3,071**	**1,863**	1,339	753
Tebuconazole	1,057	29	0	0	**1,057**	**264**	2,007	320
All fungicides	**8,042**	**100**	**6,050**	**74**	**14,092**	**5,569**	**12,920**	**4,324**
Sulphur	**0**	**0**	**1,938**	**24**	**1,938**	**7,751**	**1,432**	**5,727**
Area grown	1,804		8,142		**9,946**		9,586	

Table 5 Peas and beans herbicide formulations - 2019

Area (ha), weight (kg) and percentage of crop treated

Herbicides	Broad beans		Vining peas		Total 2019	Total 2019	2017[1]	2017[1]
	ha	%	ha	%	**ha**	**kg**	ha	kg
Bentazone	0	0	2,612	32	**2,612**	**2,457**	1,593	1,111
Glyphosate	188	10	936	11	**1,123**	**886**	1,202	997
Imazamox/pendimethalin	1,800	100	7,490	92	**9,290**	**8,828**	7,715	7,187
MCPB	0	0	1,938	24	**1,938**	**2,836**	1,384	2,425
All herbicides	**1,988**	**100**	**12,976**	**96**	**14,963**	**15,006**	**12,751**	**12,226**
Area grown	1,804		8,142		**9,946**		9,586	

(1) For full list of formulations recorded in 2017 please refer to the 2017 report[3]

Table 6 Leaf brassica insecticide, biological control and molluscicide formulations - 2019

Area (ha), weight (kg) and percentage of crop treated

Insecticides	Brussels sprouts		Calabrese		Other brassicas(1)		Total 2019	Total 2019	2017	2017
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Acetamiprid	755	81	0	0	0	0	**755**	**38**	0	0
Alpha-cypermethrin	22	2	0	0	0	0	**22**	**<0.5**	0	0
Deltamethrin	547	47	0	0	301	24	**847**	**6**	2,136	16
Indoxacarb	2,655	100	1,454	74	610	73	**4,719**	**120**	3,843	98
Lambda-cyhalothrin	2,553	91	384	26	149	24	**3,086**	**17**	6,317	34
Pymetrozine	2,080	91	0	0	0	0	**2,080**	**379**	1,982	396
Spinosad	1,284	93	71	5	149	24	**1,504**	**144**	36	3
Spirotetramat	1,469	88	0	0	298	24	**1,767**	**132**	2,084	156
Thiacloprid	1,767	98	71	5	149	24	**1,987**	**191**	1,739	167
All insecticides	**13,131**	**100**	**1,980**	**84**	**1,656**	**73**	**16,767**	**1,028**	**18,137**	**871**
Biological control agents										
Phasmarhabditis hermaphrodita	63	7	0	0	0	0	**63**	**N/A**	0	N/A
All biological control agents	**63**	**7**	**0**	**0**	**0**	**0**	**63**	**N/A**	**0**	**N/A**
Molluscicides										
Ferric phosphate	4,269	100	120	8	662	82	**5,051**	**745**	4,837	738
Metaldehyde	2,716	91	0	0	0	0	**2,716**	**407**	4,762	765
All molluscicides	**6,985**	**100**	**120**	**8**	**662**	**82**	**7,767**	**1,153**	**9,599**	**1,504**
Area grown	932		1,489		626		**3,048**		4,104	

(1) Other brassicas include cabbage, cauliflower, broccoli, kale and kohlrabi
N/A = not applicable

Table 7 Leaf brassica fungicide and sulphur formulations - 2019

Area (ha), weight (kg) and percentage of crop treated

Fungicides	Brussels sprouts		Calabrese		Other brassicas(1)		Total 2019	Total 2019	2017(2)	2017(2)
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Azoxystrobin	808	87	1,213	81	656	55	**2,677**	**669**	3,093	742
Azoxystrobin/difenoconazole	1,719	98	0	0	149	24	**1,868**	**607**	927	301
Boscalid/pyraclostrobin	1,420	100	88	6	153	25	**1,662**	**555**	2,708	861
Chlorothalonil/metalaxyl-M	5	1	0	0	0	0	**5**	**3**	799	429
Copper oxychloride	0	0	2,751	76	0	0	**2,751**	**1,032**	2,976	1,466
Difenoconazole	831	89	0	0	0	0	**831**	**62**	927	70
Fluopicolide/propamocarb hydrochloride	0	0	0	0	5	1	**5**	**5**	290	318
Mandipropamid	0	0	249	17	0	0	**249**	**37**	0	0
Prothioconazole	2,367	100	0	0	0	0	**2,367**	**454**	2,757	529
Tebuconazole/trifloxystrobin	1,507	100	0	0	0	0	**1,507**	**407**	1,967	531
All fungicides	**8,656**	**100**	**4,301**	**92**	**963**	**78**	**13,920**	**3,832**	**18,202**	**6,136**
Sulphur	**0**	**0**	**221**	**9**	**0**	**0**	**221**	**233**	**997**	**1,448**
Area grown	932		1,489		626		**3,048**		4,104	

(1) Other brassicas include cabbage, cauliflower, broccoli, kale and kohlrabi
(2) For full list of formulations recorded in 2017 please refer to the 2017 report(3)

Table 8 Leaf brassica herbicide formulations - 2019

Area (ha), weight (kg) and percentage of crop treated

Herbicides	Brussels sprouts		Calabrese		Other brassicas[1]		Total 2019	Total 2019	2017[2]	2017[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Clomazone	644	69	292	20	71	11	**1,007**	**73**	1,300	93
Dimethenamid-P/pendimethalin	0	0	459	31	0	0	**459**	**694**	111	205
Glyphosate	487	44	746	50	73	12	**1,306**	**1,625**	2,441	2,828
Metazachlor	644	69	1,369	92	71	11	**2,084**	**1,557**	3,937	2,906
Pendimethalin	644	69	447	30	76	12	**1,168**	**1,306**	1,914	2,146
Pyridate	0	0	0	0	9	1	**9**	**8**	0	0
All herbicides	**2,420**	**69**	**3,312**	**92**	**301**	**13**	**6,033**	**5,263**	**10,501**	**8,338**
Area grown	932		1,489		626		**3,048**		4,104	

(1) Other brassicas include cabbage, cauliflower, broccoli, kale and kohlrabi
(2) For full list of formulations recorded in 2017 please refer to the 2017 report[3]

Table 9 Vegetables (excluding legumes and leaf brassicas) seed treatment formulations - 2019

Area (ha), weight (kg), percentage of crop treated and percentage of crop grown from transplants

Seed treatments	Carrots		Turnips & swedes		Other vegetable crops[1]		Total 2019	Total 2019	2017[2]	2017[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Cymoxanil/fludioxonil/metalaxyl-M	2,397	71	0	0	568	64	**2,965**	**8**	2,394	7
Tefluthrin	1,357	40	0	0	0	0	**1,357**	**83**	1,758	106
Thiram	0	0	1,051	75	0	0	**1,051**	**1**	1,457	3
All seed treatments	**3,754**	**82**	**1,051**	**75**	**568**	**64**	**5,374**	**92**	**5,970**	**126**
Crops grown from transplant	0	0	43	3	230	26	**273**	**N/A**	195	N/A
No seed treatment	452	13	310	22	12	1	**775**	**N/A**	1,004	N/A
No information seed treatment[3]	149	4	0	0	0	0	**149**	**N/A**	509	N/A
Area grown	3,353		1,405		883		**5,641**		5,669	

(1) In 2019 other vegetable crops included beetroot, celeriac, chard, garlic, leeks, lettuce, onions, parsnips, podded peas, rhubarb and spinach
(2) For full list of formulations recorded in 2017 please refer to the 2017 report[3]
(3) No information seed treatment refers to occasions where the grower was unable to confirm whether the seed had received a treatment
N/A = not applicable

Table 10 Vegetables (excluding legumes & leaf brassicas) insecticide, molluscicide and physical control formulations - 2019

Area (ha), weight (kg) and percentage of crop treated

Insecticides/nematicides	Carrots		Turnips & swedes		Other vegetable crops(1)		Total 2019	Total 2019	2017(2)	2017(2)
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Chlorantraniliprole	0	0	0	0	39	4	**39**	**1**	0	0
Cyantraniliprole	0	0	137	10	0	0	**137**	**10**	0	0
Deltamethrin	578	17	2,329	68	25	3	**2,932**	**9**	2,219	9
Indoxacarb	0	0	0	0	70	7	**70**	**2**	55	1
Lambda-cyhalothrin	7,726	72	825	22	1,704	64	**10,255**	**124**	8,609	94
Oxamyl	789	24	0	0	284	32	**1,073**	**1,819**	862	1,600
Pymetrozine	0	0	235	17	0	0	**235**	**35**	300	45
Spinosad	0	0	395	24	17	2	**413**	**40**	0	0
Spirotetramat	715	19	295	21	64	7	**1,074**	**59**	264	12
Thiacloprid	342	6	276	20	0	0	**618**	**59**	1,228	118
All insecticides/nematicides	**10,150**	**84**	**4,492**	**86**	**2,204**	**76**	**16,845**	**2,159**	**13,984**	**1,943**
Molluscicides										
Ferric phosphate	0	0	484	33	10	1	**495**	**96**	159	33
Metaldehyde	0	0	315	22	97	11	**413**	**77**	753	118
All molluscicides	**0**	**0**	**800**	**46**	**108**	**12**	**907**	**173**	**912**	**150**
Physical control										
Garlic	125	3	0	0	0	0	**125**	**782**	314	2,117
Area grown	3,353		1,405		883		**5,641**		5,669	

(1) In 2019 other vegetable crops included beetroot, celeriac, chard, garlic, leeks, lettuce, onions, parsnips, podded peas, rhubarb and spinach
(2) For full list of formulations recorded in 2017 please refer to the 2017 report[3]

Table 11 Vegetables (excluding legumes and leaf brassicas) fungicide and sulphur formulations - 2019

Area (ha), weight (kg) and percentage of crop treated

Fungicides	Carrots		Turnips & swedes		Other vegetable crops(1)		Total 2019	Total 2019	2017(2)	2017(2)
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Azoxystrobin	4,128	77	1,381	83	783	80	**6,292**	**1,096**	1,709	427
Azoxystrobin/difenoconazole	2,014	45	0	0	1,205	72	**3,219**	**898**	606	197
Boscalid/pyraclostrobin	2,859	70	893	37	176	14	**3,928**	**1,298**	3,465	1,147
Cyprodinil/fludioxonil	2,403	72	0	0	9	1	**2,412**	**1,205**	2,072	1,025
Dimethomorph/mancozeb	0	0	0	0	84	5	**84**	**125**	137	203
Fenpropimorph	2,953	48	0	0	0	0	**2,953**	**1,724**	2,682	2,012
Fluopicolide/propamocarb hydrochloride	0	0	0	0	12	1	**12**	**14**	13	15
Isopyrazam	4,223	71	0	0	568	64	**4,791**	**598**	4,109	508
Mancozeb	256	4	0	0	0	0	**256**	**353**	0	0
Mancozeb/metalaxyl-M	0	0	0	0	30	3	**30**	**39**	72	93
Mandipropamid	0	0	0	0	68	6	**68**	**10**	77	11
Metalaxyl-M	1,673	50	0	0	0	0	**1,673**	**940**	2,136	1,135
Prothioconazole	4,678	75	1,050	37	775	72	**6,503**	**1,241**	4,798	915
Tebuconazole	355	11	0	0	0	0	**355**	**71**	0	0
Tebuconazole/trifloxystrobin	959	15	11	1	42	5	**1,012**	**206**	897	202
All fungicides	**26,500**	**84**	**3,334**	**86**	**3,752**	**84**	**33,587**	**9,817**	**22,856**	**7,896**
Sulphur	**383**	**4**	**0**	**0**	**568**	**64**	**951**	**3,842**	**0**	**0**
Area grown	3,353		1,405		883		**5,641**		5,669	

(1) In 2019 other vegetable crops included beetroot, celeriac, chard, garlic, leeks, lettuce, onions, parsnips, podded peas, rhubarb and spinach
(2) For full list of formulations recorded in 2017 please refer to the 2017 report(3)

Table 12 Vegetables (excluding legumes and leaf brassicas) herbicide and growth regulator formulations - 2019

Area (ha), weight (kg) and percentage of crop treated

Herbicides	Carrots		Turnips & swedes		Other vegetable crops[1]		Total 2019	Total 2019	2017[2]	2017[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Aclonifen	1,357	40	0	0	0	0	**1,357**	**1,247**	0	0
Clethodim	872	26	0	0	353	40	**1,225**	**204**	540	95
Clomazone	2,908	83	1,307	93	0	0	**4,215**	**253**	4,116	252
Clopyralid	0	0	314	16	0	0	**314**	**54**	550	57
Diflufenican	1,422	42	0	0	0	0	**1,422**	**78**	0	0
Dimethenamid-P/metazachlor	0	0	147	10	0	0	**147**	**116**	1,057	630
Dimethenamid-P/pendimethalin	0	0	0	0	69	8	**69**	**74**	68	59
Diquat	48	1	0	0	284	32	**332**	**128**	52	14
Glyphosate	336	9	180	13	69	8	**585**	**494**	869	894
Metamitron	0	0	0	0	568	64	**568**	**795**	167	161
Metazachlor	0	0	1,179	84	0	0	**1,179**	**590**	56	38
Metribuzin	3,619	54	0	0	0	0	**3,619**	**503**	3,101	471
Pendimethalin	3,157	83	0	0	959	77	**4,116**	**6,167**	3,725	4,965
Propaquizafop	337	10	0	0	0	0	**337**	**39**	1,221	171
Propyzamide	0	0	0	0	108	12	**108**	**151**	74	104

Cont…

Table 12 Vegetables (excluding legumes and leaf brassicas) herbicide and growth regulator formulations continued

Area (ha), weight (kg) and percentage of crop treated

Herbicides	Carrots		Turnips & swedes		Other vegetable crops(1)		Total 2019	Total 2019	2017(2)	2017(2)
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Prosulfocarb	1,332	25	0	0	0	0	**1,332**	**1,715**	489	752
S-metolachlor	0	0	276	20	109	7	**385**	**444**	366	416
All herbicides	**15,387**	**85**	**3,404**	**94**	**2,519**	**84**	**21,309**	**13,050**	**23,105**	**10,775**
Growth regulators										
Maleic hydrazide	0	0	0	0	284	32	**284**	**682**	0	0
All growth regulators	**0**	**0**	**0**	**0**	**284**	**32**	**284**	**682**	**0**	**0**
Area grown	3,353		1,405		883		**5,641**		5,669	

(1) In 2019 other vegetable crops included beetroot, celeriac, chard, garlic, leeks, lettuce, onions, parsnips, podded peas, rhubarb and spinach
(2) For full list of formulations recorded in 2017 please refer to the 2017 report(3)

Table 13 Compounds encountered in the vegetable survey for the first time in 2019

Active substance	Type(1)	Area (ha)	Weight (kg)
Diflufenican	H	1,422	78
Aclonifen	H	1,357	1,247
Flonicamid	I	866	61
Cyantraniliprole	I	137	10
Chlorantraniliprole	I	39	1

(1) Pesticide type = H: Herbicide and I: Insecticide

Table 14 Mode of action/chemical group of insecticide/nematicide active substances - 2019

Area (ha) and weight (kg) of active substances for all crops

Mode of Action	Active Substance	Chemical Group	IRAC Group	Total Vegetables	Total Vegetables
				ha	kg
Acetylcholinesterase (AChE) inhibitor	Oxamyl	Carbamate	1A	1,073	1,819
	Pirimicarb	Carbamate	1A	6,646	930
All acetylcholinesterase (AChE) inhibitors				**7,719**	**2,749**
Sodium channel modulators	Alpha-Cypermethrin	Pyrethroid	3A	22	0
	Deltamethrin	Pyrethroid	3A	4,308	20
	Lambda-Cyhalothrin	Pyrethroid	3A	16,941	168
All sodium channel modulators				**21,270**	**188**
Nicotinic acetylcholine receptor (nAChR) competitive modulators	Acetamiprid	Neonicotinoid	4A	755	38
	Thiacloprid	Neonicotinoid	4A	2,605	250
All nAChR competitive modulators				**3,360**	**288**
Ryanodine receptor modulators	Chlorantraniliprole	Diamide	28	39	1
	Cyantraniliprole	Diamide	28	137	10
All ryanodine receptor modulators				**176**	**11**

Cont…

Table 14 Mode of action/chemical group of insecticide/nematicide active substances continued

Area (ha) and weight (kg) of active substances for all crops

Mode of Action	Active Substance	Chemical Group	IRAC Group	Total Vegetables	Total Vegetables
				ha	kg
Nicotinic acetylcholine receptor (nAChR) allosteric modulators	Spinosad	Spinosyns	5	1,917	184
Chordontonal organ TRPV channel modulators	Pymetrozine	Pyridine azomethine derivative	9B	2,315	415
Voltage-dependent sodium channel blocker	Indoxacarb	Oxadiazines	22A	4,790	122
Inhibitors of acetyl COA carboxylase	Spirotetramat	Tetramic acid	23	2,840	192
Chordontonal organ modulators - undefined target site	Flonicamid	Flonicamid	29	866	61
All other modes of action				**12,727**	**973**
All insecticides				**45,253**	**4,210**
Area grown(1)				18,634	

(1) includes multi-cropping

Note: Active substances have been grouped by their mode of action. Full details on mode of action classification can be fou nd on the Insecticide Resistance Action Committee (IRAC) webpage[9]

Table 15 Mode of action/chemical group of fungicide active substances - 2019

Area (ha) and weight (kg) of active substances for all crops

Mode of Action	Active Substance	Group Name	Chemical Group	FRAC Group	Total Vegetables	Total Vegetables
					ha	kg
Amino acids & protein synthesis	Cyprodinil	Anilino - pyrimidine	Anilino - pyrimidine	9	5,483	1,838
All amino acids & protein synthesis					**5,483**	**1,838**
Cell wall biosynthesis	Dimethomorph	Carboxylic acid amide	Morpholine	40	84	13
	Mandipropamid	Carboxylic acid amide	Mandelic acid amide	40	317	48
All cell wall biosynthesis					**401**	**60**
Cytoskeleton and motor proteins	Fluopicolide	Benzamide	Pyridinylmethyl-benzamide	43	17	2
All cytoskeleton and motor proteins					**17**	**2**
Lipid synthesis and membrane integrity	Propamocarb hydrochloride	Carbamate	Carbamate	28	17	17
All lipid synthesis and membrane integrity					**17**	**17**
Multi-site contact activity	Copper oxychloride	Inorganic	Inorganic	M01	2,751	1,032
	Mancozeb	Dithio-carbamate	Dithio-carbamate	M03	370	503
	Chlorothalonil	Chloronitrile	Chloronitrile	M05	1,062	1,059
All multi-site contact activity					**4,183**	**2,594**
Nucleic Acid Synthesis	Metalaxyl-M	Phenylamide	Acylalanines	4	2,765	1,022
All Nucleic Acid Synthesis					**2,765**	**1,022**

Cont...

Table 15 Mode of action/chemical group of fungicide active substances continued

Area (ha) and weight (kg) of active substances for all crops

Mode of Action	Active Substance	Group Name	Chemical Group	FRAC Group	Total Vegetables	Total Vegetables
					ha	kg
Respiration	Boscalid	SDHI	Pyridine- carboxamides	7	10,973	2,779
	Isopyrazam	SDHI	Pyrazole-4-carboxamides	7	4,791	598
	Azoxystrobin	Qo inhibitor	Strobilurin	11	17,579	3,374
	Pyraclostrobin	Qo inhibitor	Strobilurin	11	10,973	697
	Trifloxystrobin	Qo inhibitor	Strobilurin	11	2,519	204
All respiration					**46,834**	**7,653**
Signal transduction	Fludioxonil	Phenylpyrroles	Phenylpyrroles	12	5,483	1,230
All signal transduction					**5,483**	**1,230**
Sterol biosynthesis in membranes	Difenoconazole	Demethylation inhibitor	Triazole	3	5,917	641
	Prothioconazole	Demethylation inhibitor	Triazolinthione	3	8,870	1,695
	Tebuconazole	Demethylation inhibitor	Triazole	3	3,930	743
	Fenpropimorph	Amine	Morpholine	5	2,953	1,724
All sterol biosynthesis in membranes					**21,670**	**4,803**
All fungicides					**86,853**	**19,218**
Sulphur					**3,110**	**11,826**
Area grown(1)					18,634	

(1) Includes multi-cropping.
Note: Active substances have been grouped by their mode of action. Full details on mode of action classification can be fou nd on the Fungicide Resistance Action Committee (FRAC) webpage(10)

Table 16 Mode of action/chemical group of herbicide active substances - 2019

Area (ha) and weight (kg) of active substances for all crops

Mode of Action	Active Substance	Chemical Group	HRAC Group	Legacy HRAC Code*	Total Vegetables	Total Vegetables
					ha	kg
Inhibition of acetyl CoA carboxylase	Clethodim	Cyclohexanedione	1	A	1,225	204
	Propaquizafop	Aryloxyphenoxy-propionate 'FOPs'	1	A	337	39
All Inhibition of acetyl CoA carboxylase					**1,562**	**243**
Inhibition of acetolactate synthase ALS	Imazamox	Imidazolinone	2	B	9,290	553
All Inhibition of acetolactate synthase ALS					**9,290**	**553**
Microtubule assembly inhibition	Pendimethalin	Dinitroaniline	3	K1	15,101	16,162
	Propyzamide	Benzamide	3	K1	108	151
All microtubule assembly inhibition					**15,209**	**16,313**
Auxin mimics	Clopyralid	Pyridine carboxylic acid	4	O	314	54
	MCPB	Phenoxy-carboxylates	4	O	1,938	2,836
All auxin mimics					**2,252**	**2,890**
Inhibition of photosynthesis at photosystem II-serine 264 binders	Metamitron	Triazinone	5	C1	568	795
	Metribuzin	Triazinone	5	C1	3,619	503
All inhibition of photosynthesis at photosystem II-serine 264 binders					**4,187**	**1,298**

Cont…

Table 16 Mode of action/chemical group of herbicide active substances continued

Area (ha) and weight (kg) of active substances for all crops

Mode of Action	Active Substance	Chemical Group	HRAC Group	Legacy HRAC Code*	Total Vegetables	Total Vegetables
					ha	kg
Inhibition of photosynthesis at photosystem II-histidine 215 binders	Bentazone	Benzothiadiazinone	6	C3	2,612	2,457
	Pyridate	Phenyl-pyridazine	6	C3	9	8
All inhibition of photosynthesis at photosystem II-histidine 215 binders					**2,621**	**2,464**
Inhibition of EPSP synthase	Glyphosate	Glycine	9	G	3,015	3,004
All inhibition of EPSP synthase					**3,015**	**3,004**
Inhibition of phytoene desaturase	Diflufenican	Phenyl ethers	12	F1	1,422	78
All inhibition of phytoene desaturase					**1,422**	**78**
Inhibition of DOXP synthase	Clomazone	Isoxazolidinone	13	F4	5,223	327
All inhibition of DOXP synthase					**5,223**	**327**
Inhibition of VLCFA synthesis	Dimethenamid-P	Chloroacetamide	15	K3	675	410
	Metazachlor	Chloroacetamide	15	K3	3,411	2,204
	S-metolachlor	Chloroacetamide	15	K3	385	444
	Prosulfocarb	Thiocarbamate	15	K3	1,332	1,715
All inhibition of VLCFA synthesis					**5,801**	**4,774**

Cont…

Table 16 Mode of action/chemical group of herbicide active substances continued

Area (ha) and weight (kg) of active substances for all crops

Mode of Action	Active Substance	Chemical Group	HRAC Group	Legacy HRAC Code*	Total Vegetables	Total Vegetables
					ha	kg
Photosystem-I-electron diversion	Diquat	Bipyridylium	22	D	332	128
All photosystem-I-electron diversion					**332**	**128**
Inhibition of solanesyl diphosphhate synthase	Aclonifen	Diphenyl ether	32	S	1,357	1,247
All inhibition of solanesyl diphosphhate synthase					**1,357**	**1,247**
All herbicides					**52,270**	**33,319**
Area grown(1)					18,634	

(1) includes multi-cropping

Note: Active substances have been grouped by their mode of action. Full details on mode of action classification and HRAC MOA 2020 Revision Description* can be found on the Herbicide Resistance Action Committee (HRAC) webpage(11)

Table 17 Principal active substances by area treated

Area treated (ha) of the 20 most used active substances on all vegetable crops surveyed in 2019 and percentage change

	Active substance	Type[(1)]	2019 (ha)	2017 (ha)	% change
1	Azoxystrobin	F	17,579	10,368	70
2	Lambda-Cyhalothrin	I	16,941	17,865	-5
3	Fludioxonil	F/S	15,812	13,612	16
4	Pendimethalin	H	15,101	13,533	12
5	Metalaxyl-M	F/S	13,094	14,633	-11
6	Boscalid	F	10,973	10,461	5
7	Pyraclostrobin	F	10,973	10,545	4
8	Cymoxanil	S	10,329	10,201	1
9	Imazamox	H	9,290	7,715	20
10	Prothioconazole	F	8,870	7,554	17
11	Pirimicarb	I	6,646	6,585	1
12	Difenoconazole	F	5,917	2,459	141
13	Ferric phosphate	M	5,546	4,996	11
14	Cyprodinil	F	5,483	3,411	61
15	Clomazone	H	5,223	6,275	-17
16	Isopyrazam	F	4,791	4,109	17
17	Indoxacarb	I	4,790	3,898	23
18	Deltamethrin	I	4,308	4,879	-12
19	Tebuconazole	F	3,930	4,870	-19
20	Metribuzin	H	3,619	3,101	17

Table 18 Principal active substances by weight

Weight (kg) of the 20 most used active substances on all vegetable crops surveyed in 2019 and percentage change

	Active substance	Type[(1)]	2019 (kg)	2017 (kg)	% change
1	Pendimethalin	H	16,162	13,991	16
2	Sulphur	SU	11,826	7,174	65
3	Azoxystrobin	F	3,374	2,348	44
4	Glyphosate	H	3,004	4,719	-36
5	MCPB	H	2,836	2,425	17
6	Boscalid	F	2,779	2,543	9
7	Bentazone	H	2,457	1,111	121
8	Metazachlor	H	2,204	3,259	-32
9	Cyprodinil	F	1,838	1,067	72
10	Oxamyl	I/N	1,819	1,600	14
11	Fenpropimorph	F	1,724	2,012	-14
12	Prosulfocarb	H	1,715	752	128
13	Prothioconazole	F	1,695	1,444	17
14	Metalaxyl-M	F/S	1,494	1,762	-15
15	Fludioxonil	F/S	1,365	854	60
16	Aclonifen	H	1,247	0	
17	Chlorothalonil	F	1,059	1,520	-30
18	Copper oxychloride	F	1,032	1,466	-30
19	Pirimicarb	I	930	866	7
20	Ferric phosphate	M	841	771	9

(1) Pesticide type = F: Fungicide, H: Herbicide, I: Insecticide, M: Molluscicide, N: Nematicide, S: Seed treatment, SU: Sulphur

Table 19 Total vegetable crop, comparison with previous years

Pesticide usage in 2015, 2017 and 2019, area treated with formulations and active substances (a.s.) and the weight (kg) applied

	2015			2017			2019		
	Formulations	a.s.	Weight	Formulations	a.s.	Weight	Formulations	a.s.	Weight
	ha	ha	kg	ha	ha	kg	ha	ha	kg
Insecticides	44,468	44,468	4,240	41,722	41,722	3,641	45,253	45,253	4,210
Molluscicides	6,589	6,589	1,081	10,512	10,512	1,654	8,674	8,674	1,326
Biological agents(1)	0	0	0	0	0	0	63	63	N/A
Biopesticides	82	82	2	0	0	0	0	0	0
Fungicides	58,702	81,890	20,429	53,977	75,061	18,356	61,599	86,853	19,218
Sulphur	2,556	2,556	6,335	2,429	2,429	7,174	3,110	3,110	11,826
Herbicides	50,079	58,701	33,513	46,357	56,166	31,340	42,306	52,270	33,319
Growth regulators	104	104	500	0	0	0	284	284	682
Physical control	0	0	0	314	314	2,117	125	125	782
Seed treatments(1)	16,373	37,444	1,203	15,552	36,464	1,293	14,787	35,446	1,222
All pesticides	**178,953**	**231,834**	**67,303**	**170,863**	**222,668**	**65,575**	**176,200**	**232,078**	**72,584**
Area grown	16,672(2)			19,359(3)			18,634(4)		

(1) No weights can be calculated for biological control agents and biological seed treatments
(2) No multi-cropping was encountered in 2015
(3) Includes 23 hectares of multi-cropping
(4) Includes 10 hectares of multi-cropping

Appendix 2 – Survey statistics

Census and sample information

Table 20 Census crop areas 2019

Census area (ha) of vegetable crops grown in Scotland

	Scotland 2019	Scotland 2017	% change
Vining peas	8,142	7,808	4
Broad beans	1,800	1,767	2
Brussels sprouts	930	1,040	-11
Cabbages	228	278	-18
Calabrese	1,487	1,794	-17
Carrots	3,325	3,752	-11
Cauliflower	298	330	-10
Leeks	69	68	1
Lettuce	97	93	4
Rhubarb	72	75	-3
Turnips & swedes	1,359	1,413	-4
All vegetable crops(1)	**18,624**	**19,336**	**-4**

(1) Includes other vegetable crops
Note: Data taken from the 2019 and 2017 June Agricultural Census
All areas exclude multi-cropping

Table 21 Distribution of vegetable sample (excluding holdings growing only peas)

Number of holdings surveyed in each region and size group

Size(1) (ha)	Highlands & Islands	Caithness & Orkney	Moray Firth	Aberdeen	Angus	East Fife	Lothian	Central Lowlands	Tweed Valley	Scotland
0.1-9.9	4	0	1	1	1	2	0	1	1	11
10-19.9	0	0	1	0	6	3	3	1	2	16
20-29.9	0	0	3	2	2	2	2	0	0	11
30-39.9	0	0	0	0	2	2	1	0	0	5
>40	0	0	1	0	4	4	3	1	1	14
All sizes	**4**	**0**	**6**	**3**	**15**	**13**	**9**	**3**	**4**	**57**

(1) Refers to area of vegetable crops (excluding vining peas) grown on holding

Table 22 Distribution of pea sample

Number of holdings surveyed in each region and size group

Size(1) (ha)	Angus	East Fife	Lothian	Central Lowlands	Tweed Valley	Scotland
0.1-9.9	3	0	0	0	0	3
10-19.9	5	1	1	2	1	10
20-29.9	4	0	0	1	1	6
30-39.9	2	0	0	0	2	4
>40	3	1	0	1	1	6
All sizes	**17**	**2**	**1**	**4**	**5**	**29**

(1) Refers to area of vining peas grown on holding

Table 23 Sampled areas (vegetables excluding peas)

Areas (ha) of vegetable crops grown in sample

Size(1) (ha)	Scotland(2)
0.1-9.9	52
10-19.9	182
20-29.9	189
30-39.9	153
>40	793
All sizes	**1,369**

Table 24 Census areas (vegetables excluding peas)

Areas (ha) of vegetable crops grown in Scotland

Size(3) (ha)	Scotland(2)
0.1-9.9	1,968
10-19.9	3,037
20-29.9	1,760
30-39.9	1,448
>40	2,269
All sizes	**10,482**

Table 25 Sampled areas (peas)

Areas (ha) of peas grown in sample

Size(1) (ha)	Scotland(2)
0.1-9.9	23
10-19.9	167
20-29.9	154
30-39.9	138
>40	331
All sizes	**813**

Table 26 Census areas (peas)

Areas (ha) of peas grown in Scotland

Size(3) (ha)	Scotland(2)
0.1-9.9	828
10-19.9	3,084
20-29.9	1,825
30-39.9	1,009
>40	1,396
All sizes	**8,142**

(1) Size refers to area of vegetable crops (excluding peas) grown on holding
(2) Regional data have not been provided in order to prevent disclosure of information relating to fewer than five holdings.
(3) Size refers to area of peas grown on holding

Table 27 Raising factors (vegetable crops excluding peas)

Size[1] (ha)	Highlands & Islands	Caithness & Orkney	Moray Firth	Aberdeen	Angus	East Fife	Lothian	Central Lowlands	Tweed Valley
0.1-9.9	7.49	N/A	34.00	44.39	96.75	20.98	N/A	44.52	19.35
10-19.9	N/A	N/A	26.17	N/A	15.33	16.80	7.94	41.92	9.20
20-29.9	N/A	N/A	4.31	3.82	13.69	10.73	10.32	N/A	N/A
30-39.9	N/A	N/A	N/A	N/A	11.95	5.55	2.77	N/A	N/A
>40	N/A	N/A	4.17	N/A	2.30	3.18	2.73	5.81	1.65

(1) Size refers to area of vegetable crops (excluding peas) grown on holding
N/A = not applicable

Table 28 Raising factors (peas)

Size[1] (ha)	Angus	East Fife	Lothian	Central Lowlands	Tweed Valley
0.1-9.9	28.31	N/A	N/A	N/A	N/A
10-19.9	19.76	11.25	14.00	20.98	21.57
20-29.9	8.36	N/A	N/A	12.09	15.77
30-39.9	4.41	N/A	N/A	N/A	5.28
>40	4.47	0.98	N/A	2.76	5.95

(1) Size refers to area of peas grown on holding
N/A = not applicable
Note: raising factors are calculated by comparing the sampled crop area to the census crop area. Please see Appendix 4 for a full explanation

Table 29 First and second adjustment factors

	Highlands & Islands	Caithness & Orkney	Moray Firth	Aberdeen	Angus	East Fife	Lothian	Central Lowlands	Tweed Valley	ADJ2
Broad beans	N/A	N/A	N/A	N/A	0.90	N/A	N/A	N/A	N/A	2.15
Brussels sprouts	N/A	N/A	N/A	N/A	N/A	0.37	0.76	N/A	0.63	1.15
Cabbages	N/A	N/A	N/A	N/A	N/A	0.74	0.64	N/A	N/A	1.03
Calabrese	N/A	N/A	N/A	N/A	0.39	0.72	N/A	N/A	N/A	1.07
Carrots	N/A	N/A	1.10	4.32	1.92	0.81	0.45	0.55	2.74	1.02
Cauliflower	N/A	N/A	N/A	N/A	N/A	7.15	N/A	N/A	N/A	1.14
Leeks	N/A	N/A	N/A	N/A	N/A	N/A	1.17	N/A	2.34	1.09
Lettuce	N/A	N/A	N/A	N/A	N/A	1.02	N/A	N/A	N/A	1.57
Other Vegetables	1.49	N/A	0.52	N/A	N/A	3.70	N/A	N/A	N/A	2.42
Rhubarb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.20	N/A	1.22
Turnips & swedes	0.77	N/A	N/A	0.57	1.39	1.49	1.50	N/A	0.97	1.26
Vining peas	N/A	N/A	N/A	N/A	1.00	2.14	2.44	1.20	1.02	1.00

N/A = not applicable

Response rates

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

Table 30 Response rate

	2019	% total
Target sample vegetables	60	100
Target sample vining peas	30	100
Total achieved vegetables	**57**	**95**
Total achieved vining peas	**29**	**97**
Total number of refusals/non-contact	38	
Total number of farms approached	**124**	

Financial burden to farmers

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

To determine the total burden that the 2019 outdoor vegetable crop survey placed on those providing the information, the surveyors recorded the time that 40 respondents spent providing the data during the surveys. This sample represents 47 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" hourly pay for Scotland of £13.37)[(12)]

The total financial burden to all growers resulting from participation in the 2019 outdoor vegetable crop survey was calculated to be £192.

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, nematicides, biological control agents, biopesticides, growth regulators, seed treatments and physical control. 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 (before 2015) 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) A **growth regulator** is a pesticide used to regulate the growth of the plant, for example to prevent the crop from growing too tall.

8) An **insecticide** is a pesticide used to control unwanted insects. A **nematicide** is a pesticide used to control unwanted nematodes.

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

10) 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.

11) 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 a fungicide, an insecticide or a biological control agent. Information about pesticides applied as seed treatments was only collected for field sown crops, not for transplanted crops. Pesticides applied to transplants

in nurseries before going to the grower are recorded in the Protected Edible Crops survey.

12) In the pesticide tables, some pesticide treatments may be reported as '**unspecified**'. This description was used for occasions where the use of a particular treatment was reported by the grower, but they were unable to provide details of the product used. For these treatments, we are able to provide an area treated but no weight of pesticide used since the exact pesticide is unknown.

13) Some seed treatments were recorded as '**no information seed treatment**'. This description was used for occasions where the grower was unable to confirm whether the seed had received a treatment.

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 10 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 data are reported in two formats. For each pesticide formulation (mixture of active substances in a product) the area treated and weight applied is reported. Areas and weights for individual active substances are not included in this report but are published in Excel format as supplementary tables. These different formats are provided to satisfy the needs of all data users and allow them to assess pesticide use trends. Some users may be interested in use of pesticide products which contain a number of active substances, thus formulation data would be required. Other users are interested in particular active substances which may be formulated on their own or in combination with other active substances. In addition, both weight 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 weight 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 control weeds at the field margins or inter-row areas

19) The **June Agricultural Census**[13] 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 farmers growing the relevant crops to participate in the survey.

20) 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.

21) 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 crop recorded in the June Agricultural Census. This is referred to throughout the report as **multi-cropping**.

22) Where quoted in the text, reasons for application are the grower's stated reasons for use of that particular pesticide on that crop and may not always seem appropriate. It should be noted that growers do not always provide reasons; therefore, those presented only reflect those specified and may not reflect overall use.

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

24) Data from the 2017[3] and 2015[4] 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. When comparisons are made between surveys it is important to consider changes in the area of crop grown. In order to take this into account, comparisons have been made on a per hectare grown basis, i.e. the number of hectares that have been sprayed (treated hectares) has been divided by the area of crop grown for each survey, and the weight (kilograms) applied has also been divided by the area of crop grown. This is to enable like for like comparisons between surveys, so that changes in pesticide use patterns are not masked by changes in crop area.

25) When leaf brassicas are referred to in the text, this includes, Brussels sprouts, calabrese and other brassicas. Other brassicas include, cabbage, cauliflower, broccoli, kale and kohlrabi. Crops encountered in the 'other vegetable' category in the 2019 survey were beetroot, celeriac, chard, garlic, onions, parsnips, podded peas and spinach. For reporting purposes, the data for leeks, lettuce and rhubarb have also been presented under the 'other vegetable' category.

26) The **average number of applications** indicated in the text for each crop is based on the occurrence of a pesticide group on at least ten per cent of the area grown. The average number of applications is calculated only on the areas receiving 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 pesticide group.

27) **Integrated pest management** The sustainable use directive[14] defines IPM as; "'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."

Appendix 4 – Survey methodology

Sampling and data collection

Using the June 2019 Agricultural Census[13], a sample was drawn representing vegetable cultivation in Scotland. The first sample was selected from holdings growing any vegetable crops excluding vining peas, and the second from holdings known to have grown vining peas. Two samples were taken to achieve a better representation of all vegetable crops, as most vining pea crops are grown on farms growing arable crops rather than vegetable crops.

The country was divided into 11 land-use regions (Figure 25). Each sample was stratified by these land-use regions and according to holding size. The holding size groups were based on the total area of either vegetable or vining peas crops grown. The sampling fractions used within both regions and size groups were based on the areas of relevant crops grown rather than number of holdings, so that smaller holdings would not dominate the sample.

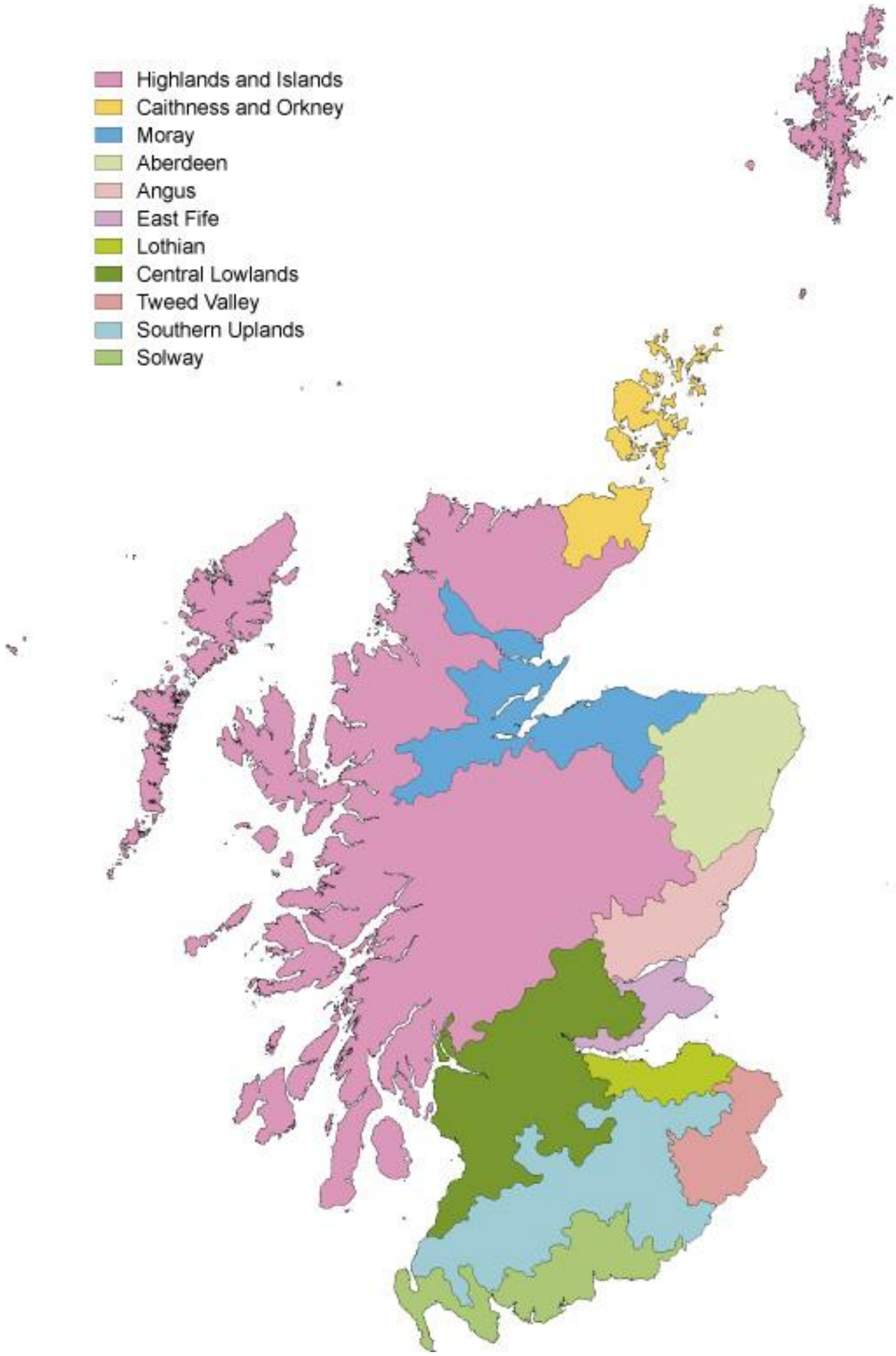
The survey covered pesticide applications to vegetable crops where all or the majority of the growing season was in 2019. As well as recording treatments applied directly to the crop, data was also collected on land preparation treatments prior to sowing or planting the crop.

Following an introductory letter and phone call, data was collected during a phone interview or by email. Where necessary, information was also collected from agronomists and contractors. In total, information was collected from 57 holdings growing vegetable crops and 29 holdings growing only peas (Tables 21 & 22). These 86 holdings represent 12 per cent of the total crop area grown.

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 (Tables 27 and 28). These factors were calculated by comparing the sampled area to the areas recorded in the Agricultural Census within each region and size group. An adjustment (Table 29) was made for each crop within each region by applying the raising factors to the sample area of each crop grown and comparing this with the census area. This adjustment modifies the estimate to take into account differences in composition of crops encountered in the sample and those present in the population. A second adjustment was necessary for some crops which were present in the population but were not encountered in the sample in some strata.

Figure 25 Land use regions of Scotland(15)



Changes from previous years

There are a number of changes which should be noted when comparing the 2019 data with the previous survey.

For the first time, cabbages have been included in the ‘other brassicas’ category. This is due to too few crops being encountered in the holdings sampled in 2019 to adequately represent usage. This must be taken into account when comparing other brassica data between surveys.

This report presents information about grower adoption of Integrated Pest Management (IPM). IPM data was not collected during the 2017 survey. The data presented represents the second in the series of surveys of IPM measures on vegetable crops, first collected alongside the 2015 vegetable crops survey, allowing the adoption of IPM techniques to be monitored.

All farmers who participate in our surveys are now eligible to collect two BASIS and/or NRoSO CPD points. This may have contributed to increased participation levels in our survey in 2019.

Data quality assurance

The dataset undergoes 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 9001:2015. 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

The use of a random stratified sample is an appropriate survey methodology. 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 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 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 idea of the precision of estimates, the report includes relative standard errors (RSE) (Table 31). 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 31) 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 pesticide use among holdings.

The RSE for estimates of total pesticide use on vegetable crops (Table 31) was five per cent for both area and weight, compared with ten per cent for area and seven per cent for weight in 2017. For constituent crop groups, the RSE varied from four to 29 per cent for area and three to 40 per cent for weight, varying with sample size and uniformity of pesticide regime encountered. Standard errors could not be calculated (NC) for cauliflower, leeks, lettuce, other vegetables and rhubarb because there were too few active substances recorded. Therefore, estimates for these crops should be treated with caution. However, the standard errors that could be calculated are lower than the past two vegetable reports. This may be due to increased grower participation leading to an improved sample size. Higher standard errors mean that there is more uncertainty associated with estimates of pesticide use.

Table 31 Relative standard errors

Relative standard errors (RSE) for the area treated (ha) with pesticide and for weight of active substance (kg) applied

	Area SE (%)	Weight SE (%)
Broad beans(1)	4	3
Brussel sprouts(1)	13	13
Cabbages(1)	10	4
Calabrese(1)	9	10
Carrots(1)	8	11
Cauliflower(2)	NC	NC
Leeks(2)	NC	NC
Lettuce(2)	NC	NC
Other vegetables(2)	NC	NC
Rhubarb(2)	NC	NC
Turnips & swedes	29	40
Vining peas	4	4
All vegetable crops	**5**	**5**

(1) For these crops standard errors could not be calculated for all strata due to insufficient data in the sample, as these strata have not been used in the aggregate totals for the region the overall RSE values should be treated with caution

(2) Standard errors could not be calculated (NC) for cauliflower, leeks, lettuce, other vegetables and rhubarb because there were too few active substances recorded. Therefore, estimates for these crops should be treated with caution

Appendix 6 – Integrated pest management

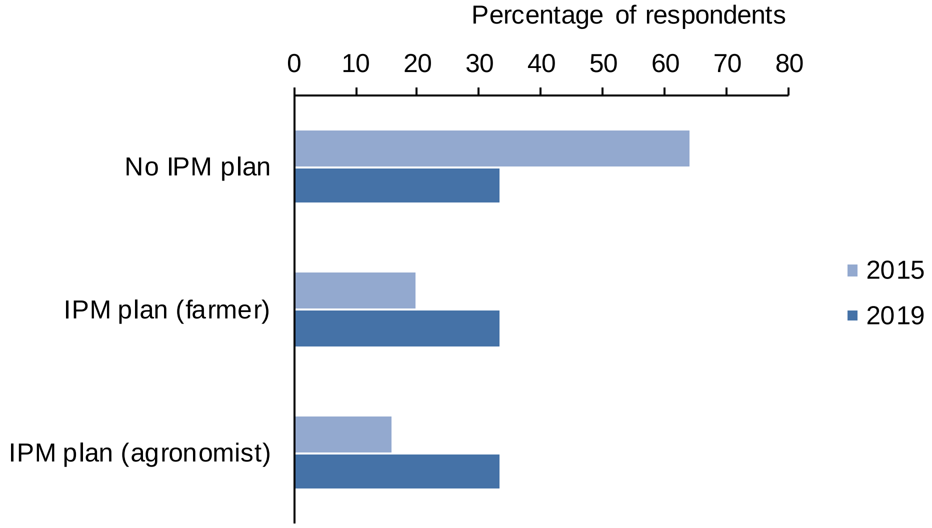
It is a requirement of the EU Sustainable use of Pesticides Directive (2009/128/EC)[14] that member states should promote low pesticide input pest management, in particular Integrated Pest Management (IPM).
The Directive defines IPM as follows "'integrated pest management' means careful consideration 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."

Information about the uptake of IPM measures by Scottish growers was collected alongside the 2019 outdoor vegetable crops pesticide usage survey. IPM data have previously been collected and published for all crop groups in our cycle of pesticide usage surveys (vegetable crops 2015[4], protected edible crops 2015[16], arable crops 2016[17], soft fruit crops 2016[18] and fodder crops 2017[19]). Following collection of this baseline data, our intention is to monitor IPM uptake in each crop sector every four years. This 2019 IPM survey represents the second in the series of surveys of IPM measures on vegetable crops, allowing the adoption of IPM techniques to be monitored. These datasets will be used as an indicator of the success of Scottish Government funded IPM research, knowledge transfer and promotion activities.

Unlike the other statistics in this report, the figures reported in this section are not raised to produce national estimates, but represent only the responses of those surveyed. The IPM sample, whilst smaller than that sampled for the pesticide usage survey, provides a good representation of Scottish regions and farm size groups. When comparing between 2015 and 2019, any noticeable differences are recorded in the text. If no comparison is made then the responses recorded are similar between 2015 and 2019.

In total IPM data was collected from 27 growers and grower groups representing 63 holdings and collectively growing 1,477 ha of crops. This sample represented eight per cent of Scotland's 2019 outdoor vegetable crop area. Of these growers, 67 per cent had an IPM plan (33 per cent completed their own IPM plan and 33 per cent had a plan completed by their agronomist) and 33 per cent did not have an IPM plan (Figure 26). This represents a significant increase ($P<0.05$) in the use of IPM plans from the 2015 survey where 36 per cent of growers had an IPM plan. Using an IPM plan helps growers to make the best possible, and most sustainable, use of all available methods for pest control. Since the 2015 survey, the requirement to complete an IPM plan has been added to some farm assurance schemes; for example, farmers certified with Red Tractor are required to complete the NFU/VI IPM plan[20]. Farmers certified with Scottish Quality Crops (SQC) must complete an IPM plan, a biodiversity plan and a soil testing plan[21].

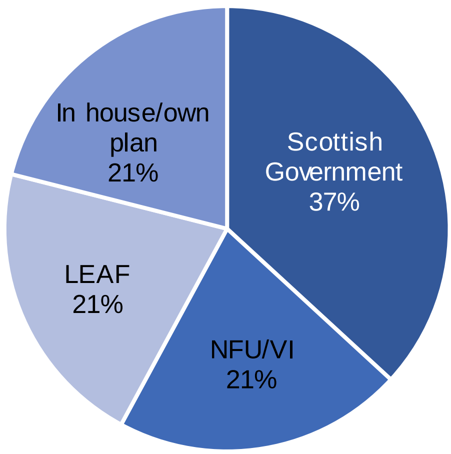
Figure 26 IPM: Percentage of respondents with an IPM plan 2015-2019



Note: The increase in respondents with an IPM plan is statistically significant (P<0.05)

Although more plans were completed in 2019, there was no change in the proportions of plans completed by growers and by agronomists, with around 50 per cent of IPM plans completed by growers and 50 per cent completed by agronomists in both years. Of those growers who had an IPM plan in 2019, either completed themselves or by their agronomist, 37 per cent used the Scottish Government IPM plan, 21 per cent used the NFU/VI plan, 21 per cent used the LEAF plan and 21 per cent used their own plan (Figure 27).

Figure 27 IPM: Type of IPM plan - 2019



Farmers were asked about their IPM activities in relation to three categories; risk management, pest monitoring and pest control. Information was collected about all activities each grower conducted in relation to these categories and the responses are reported in the following sections. The term ‘pest’ is used throughout to denote diseases, weeds and invertebrate pests.

Risk management

IPM programmes aim to prevent, or reduce, the risk of pests becoming a threat by minimising the likelihood of damage occurring that will require subsequent control. Table 32 presents an overview of the risk management measures adopted by those growers surveyed. In both 2019 and 2015, all growers sampled reported that they implemented at least one measure associated with an IPM risk management approach. There were no statistically significant differences in the responses to summary risk management questions between 2015 and 2019.

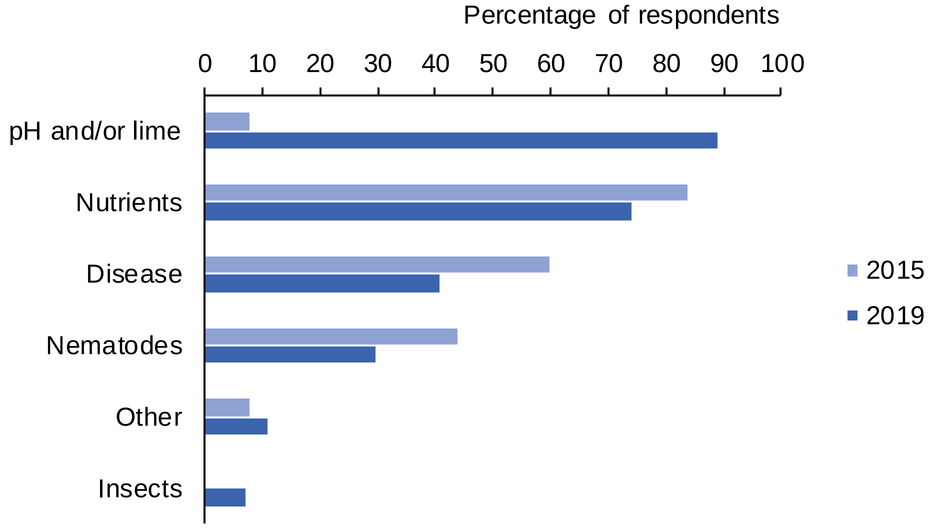
Table 32 IPM: Summary of responses to risk management questions 2015-2019

Risk management activity	Percentage positive response	
	2019	2015
Crop rotation	96	96
Soil testing	96	88
Cultivation of seed bed	81	76
Cultivations at sowing	56	52
Varietal or seed choice	89	88
Catch and cover cropping	44	36
Protection or enhancement of beneficial organism populations	81	72
Any risk management activity	**100**	**100**

Ninety six per cent of growers in both 2019 and 2015 used crop rotation to reduce the risk of pest damage. Rotation breaks the link between pathogen and host, reducing pest population build-up. It can also improve soil fertility and structure, and consequently crop vigour.

The majority of growers (96 per cent) tested their soil in order to tailor inputs to improve crop performance, this was an increase from 88 per cent in 2015 (Table 32). Soil testing allows growers to make informed decisions about the inputs required and optimal crop choice for their land. Most testing encountered in 2019 was for pH or lime (89 per cent). This was the biggest change observed from 2015, however, growers were not asked directly about testing soil for pH or insects in 2015, therefore these responses are underestimated in 2015 (Figure 28). There were some decreases from 2015 in the proportions of growers testing for nutrients (84 per cent to 74 per cent), soil borne disease such as clubroot (60 per cent to 41 per cent) and nematodes (44 per cent to 30 per cent). In 2019, lower proportions of growers tested for insects (seven per cent), conducted soil health tests (seven per cent), organic matter assessments and electrical conductivity tests (four per cent each).

Figure 28 IPM: Soil testing 2015-2019

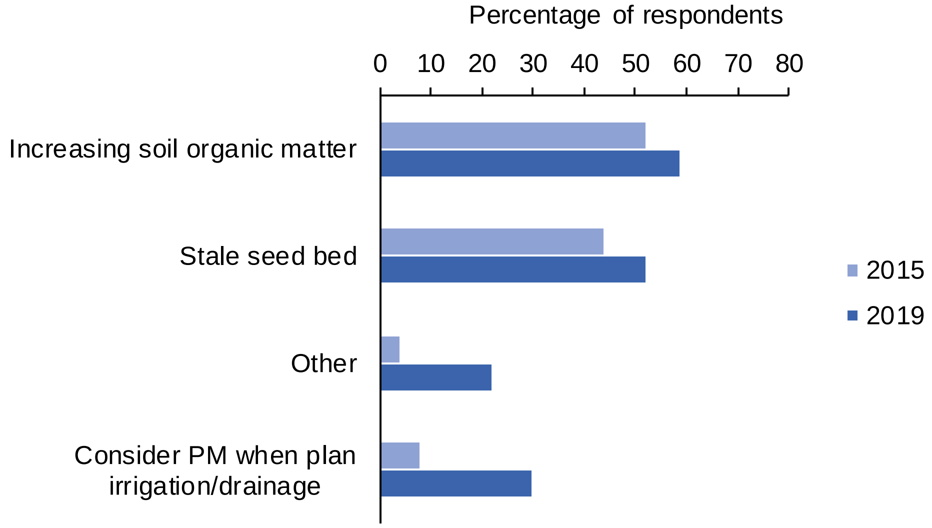


Note: In 2015 growers were not directly asked about testing for insects, pH or lime. However, pH testing was recorded under other in 2015. Therefore the 2015 data are underestimated
'Other' in 2019 included soil health tests, organic matter assessments and electrical conductivity tests.
'Other' in 2015 included texture and electrical conductivity tests.

The majority of growers in 2019 (81 per cent) and in 2015 (76 per cent) reported that they managed their seed bed agronomy to improve crop performance and reduce pest risk (Table 32). In 2019, 59 per cent of growers increased soil organic matter and 52 per cent used a stale seedbed for weed management (Figure 29). A similar pattern was observed in 2015. Stale seed beds allow weeds to germinate before sowing the next crop; these are treated with a herbicide, depleting the seed bank, and resulting in lower weed pressure, and potentially pesticide use in the succeeding crop. Thirty per cent of growers considered pest management when planning irrigation and drainage, an increase from eight per cent in 2015. Other methods employed by growers in 2019 included 19 per cent using non-inversion techniques such as min till and direct drilling and seven per cent using rotational ploughing. These techniques can preserve organic matter in the soil. In 2015, other techniques included deep ploughing used by four per cent of respondents.

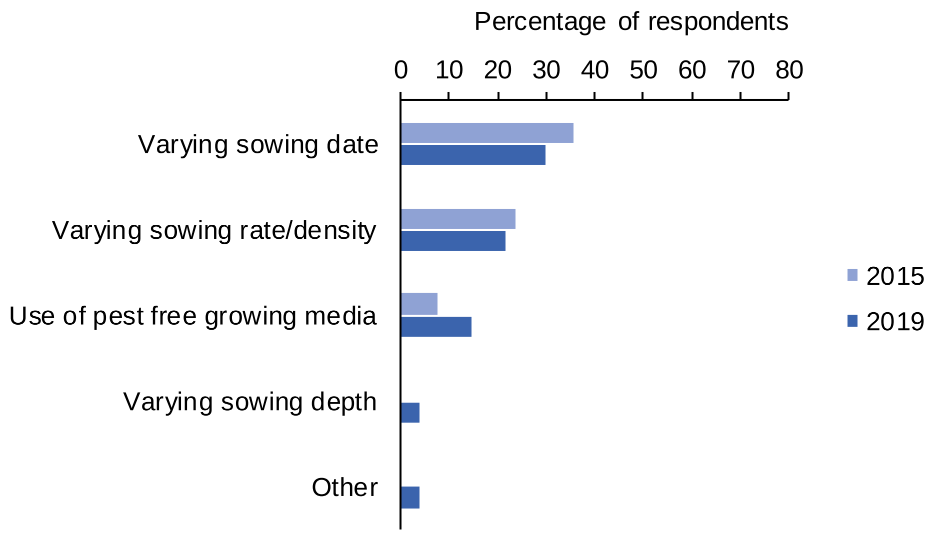
In 2019, 56 per cent of growers amended cultivation methods at sowing with the aim of increasing crop success, a similar proportion to 2015 (Table 32). Thirty per cent varied the date of sowing, 22 per cent varied the sowing rate or density, 15 per cent used pest free growing media such as pre-treated modules (an increase from eight per cent in 2015). Four per cent varied the sowing depth and four per cent used different spatial cultivation arrangements to allow for more effective weeding (Figure 30).

Figure 29 IPM: Seed bed cultivations 2015-2019



Note: 'Other' in 2019 included min till, direct drilling, rotational ploughing, considering pest management when planning crop nutrition
'Other' in 2015 included deep ploughing

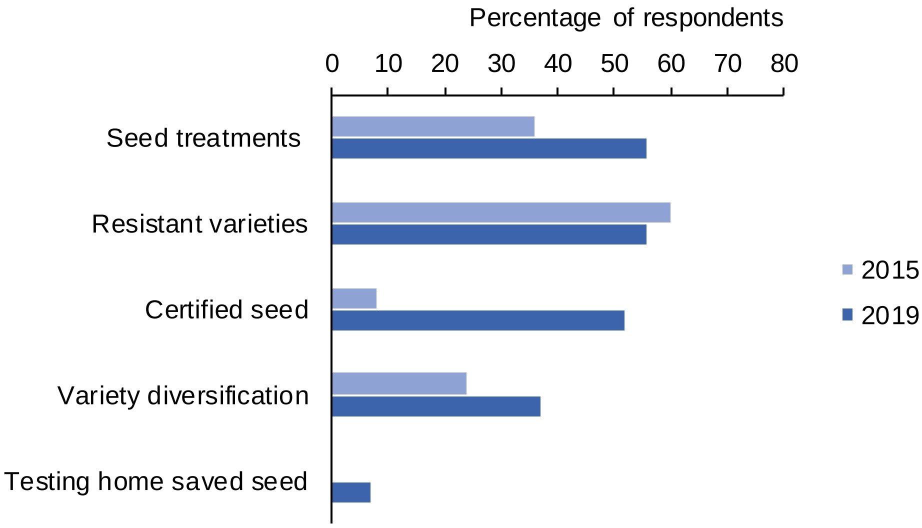
Figure 30 IPM: Cultivations at sowing 2015-2019



Note: 'Other' in 2019 included using different spatial arrangements to facilitate more effective weeding

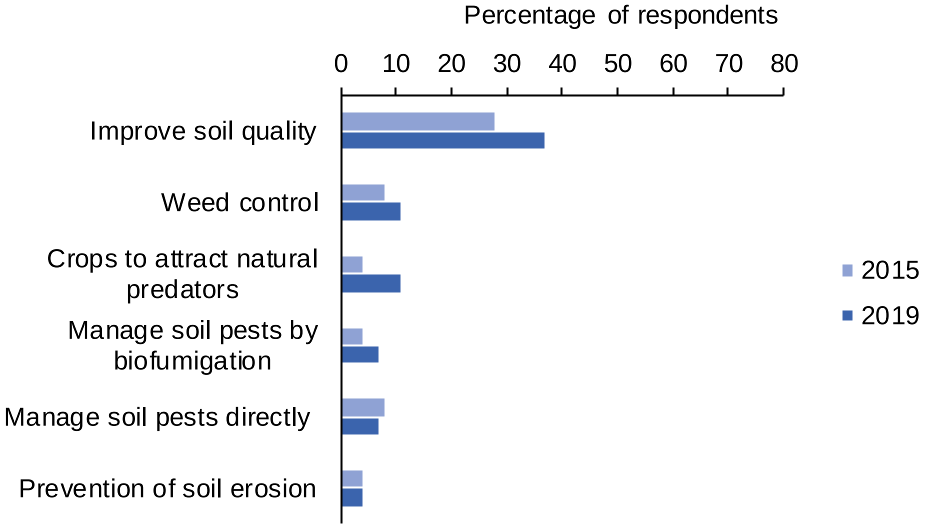
The majority of growers in 2019 and 2015 considered risk management when selecting seeds and/or varieties (Table 32). In 2019 there were increases in the proportions of growers using seed treatments, certified seed and variety diversification when compared to 2015 (Figure 31). Fifty six per cent of growers used seed treatments, both pesticide seed treatments to protect seedlings at crop emergence and growth promotors to improve crop establishment. Fifty six per cent selected pest resistant varieties to reduce damage and the need for pesticide input, 52 per cent used certified seed and seven per cent tested home saved seed. Thirty seven per cent of growers used diversification of varieties to increase overall crop resilience to pests and environmental stresses.

Figure 31 IPM: Variety and seed choice 2015-2019



Forty four per cent of growers sowed catch or cover crops in 2019, a small increase from 36 per cent in 2015 (Table 32). In 2019 there were increases in the proportions of growers using cover crops to improve soil quality, for weed control, to attract natural predators and to manage soil pests by biofumigation (Figure 32). Thirty seven per cent of growers used cover and catch crops such as clover and phacelia to improve soil quality. Eleven per cent were used to suppress weeds, 11 per cent used crops such as marigold and borage to attract natural predators, seven per cent used crops such as mustard or radish with bio-fumigation properties and seven per cent used crops to manage soil pests directly. Four per cent of cover crops were used to prevent soil erosion.

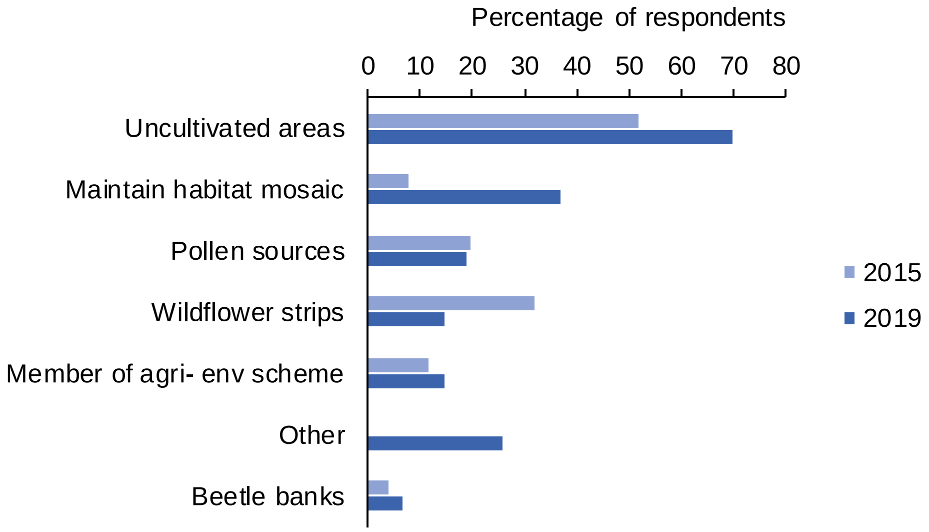
Figure 32 IPM: Catch and cover cropping 2015-2019



Finally, 81 per cent of growers stated that they adopted techniques to protect or enhance populations of beneficial organisms, an increase from 72 per cent in 2015 (Table 32). In 2019 there were increases in the use of uncultivated areas and habitat mosaics and a decrease in the use of wildflower strips (Figure 33). Seventy per cent left uncultivated areas, including leaving margins, headlands, endrigs and other areas wild and using buffer strips to increase biodiversity. Thirty seven per cent maintained a habitat mosaic including planting and maintaining hedgerows, tree planting and pond creation. Nineteen per cent planted pollen sources and 15 per cent planted wildflower strips. Fifteen per cent took part in an agri-environment scheme, with the main scheme reported as the Scottish Government agri-environment climate scheme (AECS). A number of additional actions to support beneficial organism populations were also reported. These additional measures included establishing beetle banks, planting wild bird seed and leaving wood piles (each seven per cent). Other minor categories included selecting pesticides to reduce their effects on beneficial organisms, planting species rich grassland and margin mixtures (each four per cent).

In 2019, 11 per cent of respondents reported that as they were using rented ground and therefore were unable to either use catch or cover crops or implement features for beneficial organisms in the areas where they were growing vegetable crops.

Figure 33 IPM: Protection and enhancement of beneficial organism populations 2015-2019



Note: 'Other' in 2019 included planting wild bird seed, leaving wood piles selecting pesticides to reduce their effects on beneficial organisms, planting species rich grassland and margin mixtures

Pest monitoring

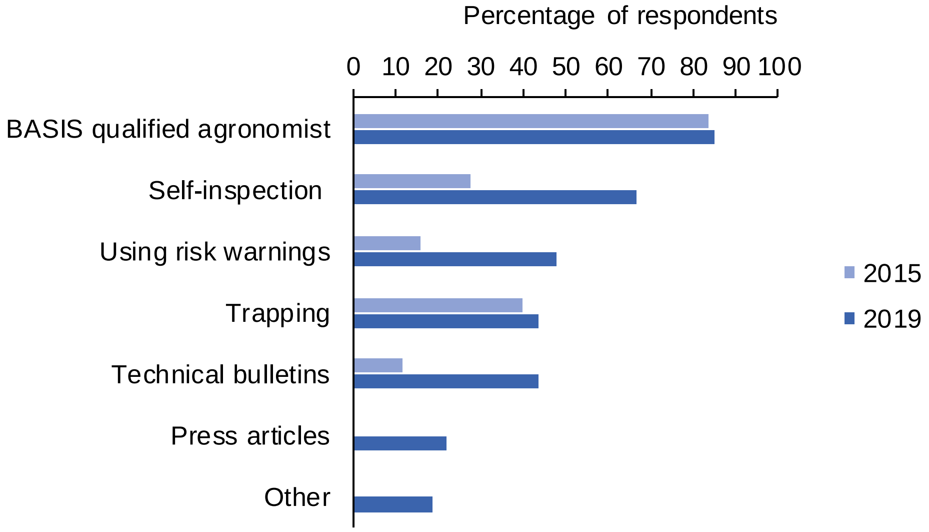
In IPM, pests are monitored both to determine whether control is economically justified and to effectively target control options. IPM programmes aim to monitor and identify pests, so that appropriate control decisions can be made in conjunction with action thresholds. Table 33 presents an overview of the pest monitoring measures adopted by the growers surveyed in 2015 and 2019. The responses show little change between 2015 and 2019. There were no statistically significant differences in the responses to summary pest monitoring questions between 2015 and 2019. In both years, the majority of growers sampled (96 per cent) reported they implemented at least one pest monitoring measure.

Table 33 IPM: Summary of responses to pest monitoring questions 2015-2019

Pest monitoring activity	**Percentage positive response**	
	2019	**2015**
Monitor and identify pests	96	96
Regular monitoring of crop growth stage	96	96
Setting action thresholds for crops	89	88
Use of specialist diagnostics	59	60
Any pest monitoring activity	**96**	**96**

Ninety six per cent of growers reported that they regularly monitored and identified pests and 96 per cent regularly monitored crop growth stages (Table 33). Most growers (89 per cent) also used action thresholds when monitoring pest populations. Pest monitoring information was primarily gained by seeking advice from a BASIS qualified agronomist (85 per cent) (Figure 34). There was an increase in the proportion of growers using self-inspection of crops to collect information from 28 per cent in 2015 to 67 per cent in 2019. In 2019 there were increases in the use of risk warnings, technical bulletins and press articles (48, 44 and 22 per cent of growers respectively). Trapping was used by 44 per cent of growers, a similar proportion to 2015. Other methods of pest monitoring reported in 2019 included using weather data to estimate risk (19 per cent) and local information from other farmers and growers (four per cent).

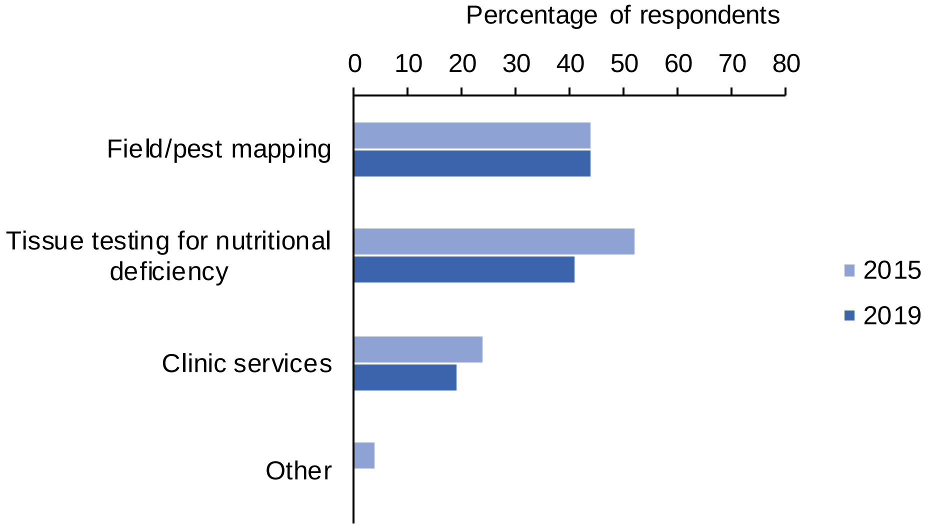
Figure 34 IPM: Monitoring and identifying pests 2015-2019



Note: 'Other' in 2019 included weather data and local information from other farmers and growers

Fifty nine per cent of respondents also used specialist diagnostics when dealing with pests that were more problematic to identify or monitor (Table 33). Forty four per cent of growers used field or pest mapping (predominately field mapping) to aid crop monitoring (Figure 35). Forty one per cent used tissue testing for nutritional deficiencies, a decrease from 52 per cent in 2015. Nineteen per cent of growers used clinic services to identify unknown pests, compared to 24 per cent in 2015. In 2015, testing for chlorophyll levels was used by four per cent of respondents.

Figure 35 IPM: Use of specialist diagnostics 2015-2019



Note: 'Other' in 2015 included testing for chlorophyll levels

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 34 presents an overview of the pest control measures adopted by the growers surveyed. Of the holdings sampled in 2019, 19 per cent were organic, an increase from 12 per cent in 2015. In 2019 there was an additional four per cent which was not organic but did not use pesticides this season. This may have an impact on the responses to questions on use of pest control, in particular relating to targeting pesticide use, anti-resistance strategies and monitoring the success of crop protection measures. Where holdings were registered as organic or not using pesticides, they would also not have implemented such crop protection measures. Therefore, changes in these responses between the years may have been influenced by an increase in the proportion of holdings not using pesticides in 2019.

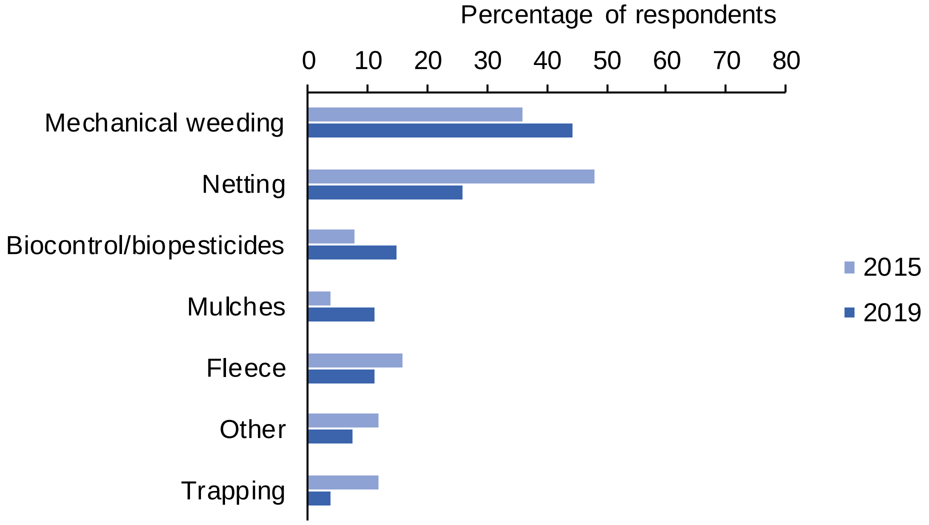
Ninety six per cent of the growers sampled in 2019 adopted at least one IPM pest control activity, a small decrease from 100 per cent in 2015. There were no statistically significant differences in the responses to summary pest control questions between 2015 and 2019.

Table 34 Summary of responses to pest control questions 2015-2019

Pest control activity	Percentage positive response	
	2019	2015
Non-chemical control used in partnership or instead of chemical control	81	76
Targeted pesticide application	70	76
Follow anti-resistance strategies	74	80
Monitor success of crop protection measures	93	100
Any pest control activity	**96**	**100**

Eighty one per cent of growers reported that they used non-chemical control in partnership or instead of chemical control, a small increase from 76 per cent in 2015 (Table 34, Figure 36). The most common non-chemical method employed in 2019 was mechanical weeding used by 44 per cent of respondents, an increase from 36 per cent in 2015. A range of physical control methods which prevent pest access to the crop were also used. Netting was used by 26 per cent of growers in 2019, a decrease from 48 per cent in 2015. Mulches such as plastic and fleece were each used by 11 per cent of growers. The use of biocontrol and biopesticides increased from eight per cent in 2015 to 15 per cent in 2019. Trapping was used by four per cent of growers, a decrease from 12 per cent in 2015. Other methods of non-chemical control used in 2019 were using plant elicitors to encourage natural defences and garlic to protect crops from carrot fly, each used by four per cent of growers. Other non-chemical methods used in 2015 included using garlic to protect swede from flea beetle and using salt water and vinegar to control slugs (each used by four per cent of growers).

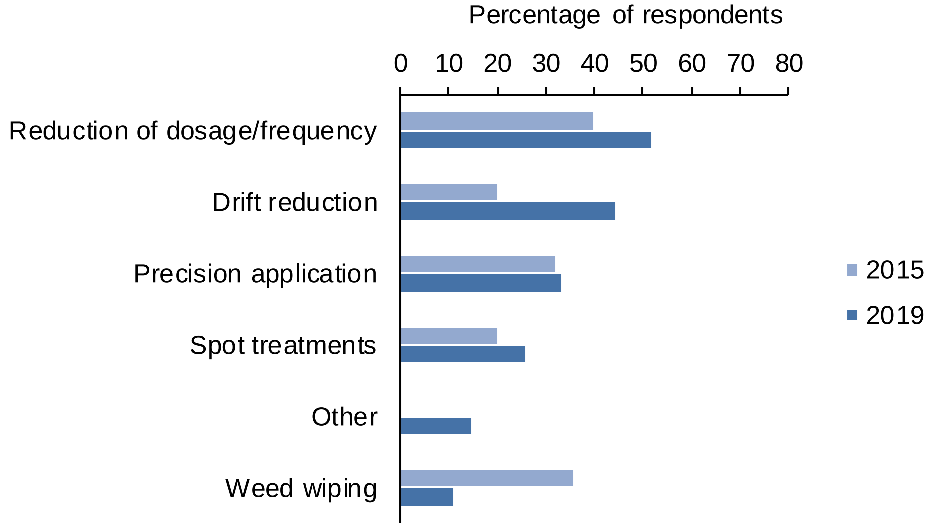
Figure 36 IPM: Non-chemical control 2015-2019



Note: 'Other' in 2019 included using plant elicitors to encourage natural defences and garlic to protect carrot crops from carrot fly.
'Other' in 2015 included using garlic to protect swede from flea beetle and salt water and vinegar for slugs

Seventy per cent of growers in 2019 stated that they targeted their pesticide applications to reduce pesticide use, a decrease from 76 per cent in 2015 (Table 34). The most common method used by 52 per cent of growers in 2019, was reducing their dosage or frequency of pesticide applications, an increase from 40 per cent in 2015 (Figure 37). Forty four per cent of growers decreased pesticide application by using drift reduction apparatus, an increase from 20 per cent in 2015. Precision applications such as inter-row herbicide treatments as seen on carrots were used by 33 per cent of growers, similar to the proportion recorded in 2015. Spot treatments (applying only to the affected area) were used by 26 per cent of growers in 2019, compared to 20 per cent in 2015. The use of weed wiping (direct herbicide application to weeds taller than the host crop), has decreased from 36 per cent in 2015 to 11 per cent in 2019. Other methods used for targeting pesticide application in 2019 included the calibration and maintenance of sprayers used by 15 per cent of growers and technical updates on product efficacy used by four per cent.

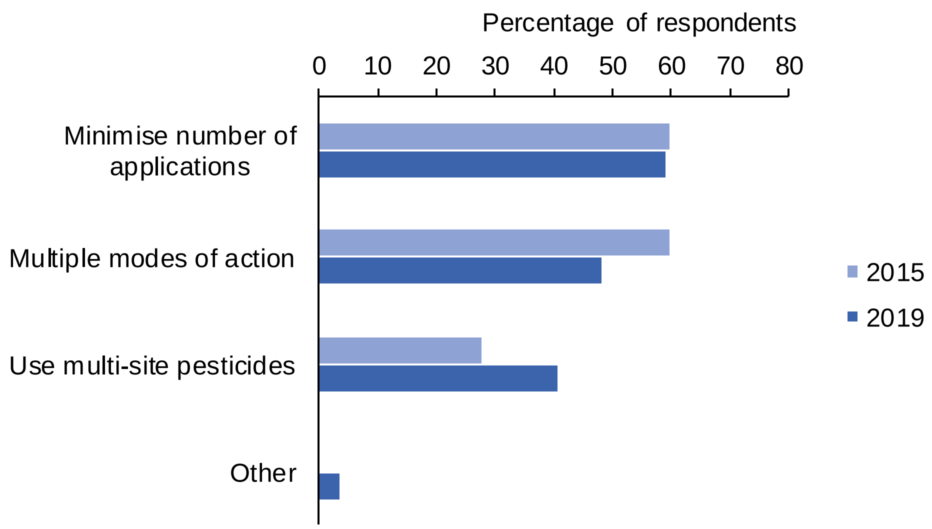
Figure 37 IPM: Targeted pesticide application 2015-2019



Note: 'Other' in 2019 included regular calibration and maintenance of sprayers and technical updates on product efficacy.

In addition, 74 per cent of growers in 2019 stated that they followed anti-resistance strategies, a small decrease from 80 per cent in 2015 (Table 34, Figure 38). Anti-resistance strategies are used to minimise the risk of development of pest resistance. In 2019, 59 per cent of growers, similar to 2015, minimised the number of pesticide applications used. Forty eight per cent of growers in 2019, a decrease from 60 per cent in 2015, used a range of pesticides with multiple modes of action. Forty one per cent of growers used pesticides with multi-site modes of action, an increase from 28 per cent in 2015. Other growers in 2019 (four per cent) stated that their agronomist selected the best anti-resistance option.

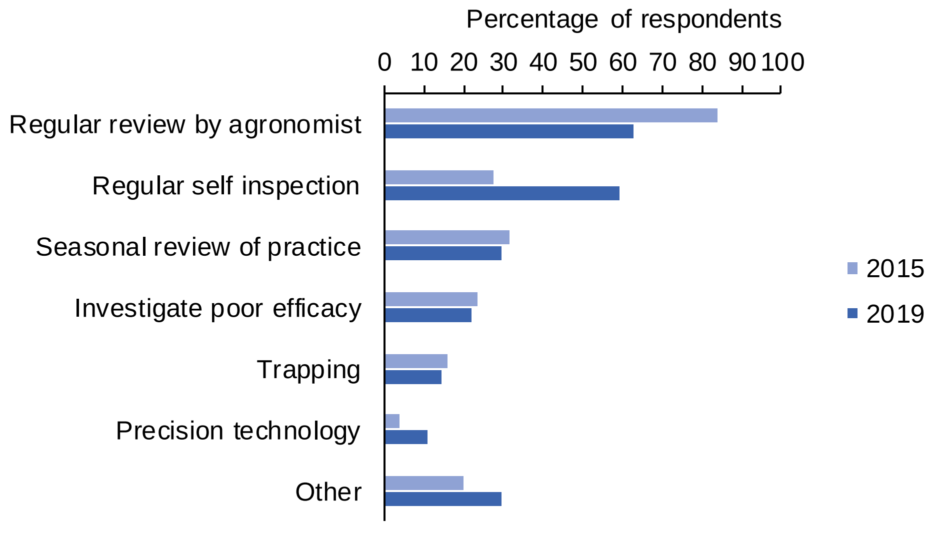
Figure 38 IPM: Types of anti-resistance strategies 2015-2019



Note: 'Other' in 2019 includes agronomist selects the best anti-resistance option

An important aspect of IPM is monitoring the success of risk management and crop protection practices to continually improve regimes. Ninety three per cent of growers in 2019 stated that they monitored the success of their crop protection measures, a decrease from 100 per cent in 2015 (Table 34, Figure 39). Between 2015 and 2019, there has been a decrease in the proportion of growers having a regular review with their agronomist and an increase in the proportion using regular self inspection to monitor their crop protection success. In 2019, 63 per cent of growers had a regular review with their agronomist to monitor crop protection success, a decrease from 84 per cent in 2015 and 59 per cent of growers conducted regular self inspections of their crops, an increase from 28 per cent in 2015. There was a similar increase in the use of self inspection to monitor and identify pests from 2015 to 2019 (Figure 34). However the majority of respondents in both years sought advice from a BASIS qualified agronomist for pest monitoring and identification. Seasonal review of practice, investigating causes of poor efficacy and trapping were used by similar proportions of growers in 2019 and 2015 (30, 22 and 15 per cent respectively in 2019). Eleven per cent of growers in 2019 used precision technology such as yield mapping, an increase from four per cent in 2015. Other methods recorded for monitoring success in 2019 included monitoring crop yields (19 per cent of respondents), trialling different methods of control, feedback from the customer and monitoring residue levels within the crops (each four per cent). Other methods recorded in 2015 included feedback from processors and packers.

Figure 39 IPM: Monitoring success of crop protection measures 2015-2019



Note: 'Other' in 2019 included monitoring yields, trialling different methods of control, feedback from customer and monitor residue levels.
'Other' in 2015 included feedback from processors and packers

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