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Pesticide Usage in Scotland

A National Statistics Publication for Scotland

Outdoor Vegetable Crops 2017

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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 2017. The crops surveyed included vining peas, broad beans, calabrese, carrots, turnips & swedes and other minor vegetable crops.

The census area of outdoor vegetable crops grown in Scotland in 2017 was approximately 19,300 hectares. This represents a 16 per cent increase from the previous survey in 2015 and a 22 per cent increase from 2013. Peas and beans accounted for 50 per cent of the outdoor vegetable crop area, leaf brassicas 21 per cent, carrots 20 per cent, turnips and swedes seven per cent and other vegetables two per cent.

Data were collected from a total of 84 holdings, collectively representing 11 per cent of the total vegetable crop area grown. 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 ca. 170,900 ha (± 10 per cent Relative Standard Error, RSE) with a combined weight of ca. 66 tonnes (± seven per cent RSE). Overall, pesticides were applied to 93 per cent of the vegetable crop area. Herbicides were applied to 90 per cent of the crop area, fungicides and insecticides to 79 per cent, molluscicides to 13 per cent and 70 per cent of the seed was treated.

Taking into account changes in crop area, the 2017 total pesticide treated area was almost a fifth lower (18 per cent) than that reported in 2015 and six per cent lower than 2013. The weight of pesticides applied to vegetable crops in 2017 was 16 per cent lower than in 2015, but very similar to that encountered in 2013. The application of fungicides, herbicides, insecticides and seed treatments in 2017 decreased from the 2015 survey (21, 20, 19 and 18 per cent decreases in treated area respectively). Only the use of molluscicides increased (37 per cent increase in treated area).

In terms of area treated, the most commonly used foliar fungicide active substance was pyraclostrobin. However, when foliar and seed treatment use is combined, metalaxyl-M was the most commonly used fungicide by area. Lambda-cyhalothrin and pendimethalin were the most used insecticide and herbicide active substances respectively. Metalaxyl-M was the most used seed treatment active substance.

Introduction

The Scottish Government (SG) is required by legislation[1][2] to carry out post-approval surveillance of pesticide use. This is conducted by the Pesticide Survey Unit at Science and Advice for Scottish Agriculture (SASA), a division of the Scottish Government's Agriculture 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, soft fruit and protected edible crops on a biennial basis and for fodder and forage crops every four years. The Scottish survey data are incorporated with England, Wales and Northern Ireland data to provide estimates of annual UK-wide pesticide use. Information on all aspects of pesticide usage in the United Kingdom as a whole may be obtained from the Pesticide Usage Survey Team at Fera Science Ltd, Sand Hutton, York. Also available at:

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

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

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

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

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

Structure of report and how to use these statistics

This report is intended to provide data in a useful format to a wide variety of data users. The general trends section provides commentary on recent changes in survey data and longer term trends. The 2017 pesticide usage section summarises usage on all outdoor vegetable crops in 2017. 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

The census area of outdoor vegetable crops grown in 2017 was 19,336 hectares (Table 21). This represents a 16 per cent increase from 2015[(3)] and a 22 per cent increase from 2013[(4)]. Since the last survey, census areas of all vegetable crops have increased with the exception of leeks and turnips & swedes which decreased by 19 and four per cent respectively (Figure 1). The area of cauliflower increased by 51 per cent, cabbages by 36 per cent, Brussels sprouts by 34 per cent and carrots by 30 per cent (Table 21).

In 2017, peas and beans accounted for 50 per cent of the outdoor vegetable crop area, leaf brassicas 21 per cent, carrots 20 per cent, turnips and swedes seven per cent and other vegetables two per cent (Figure 2).

Figure 1 Area of vegetable crops grown in Scotland 2013-2017

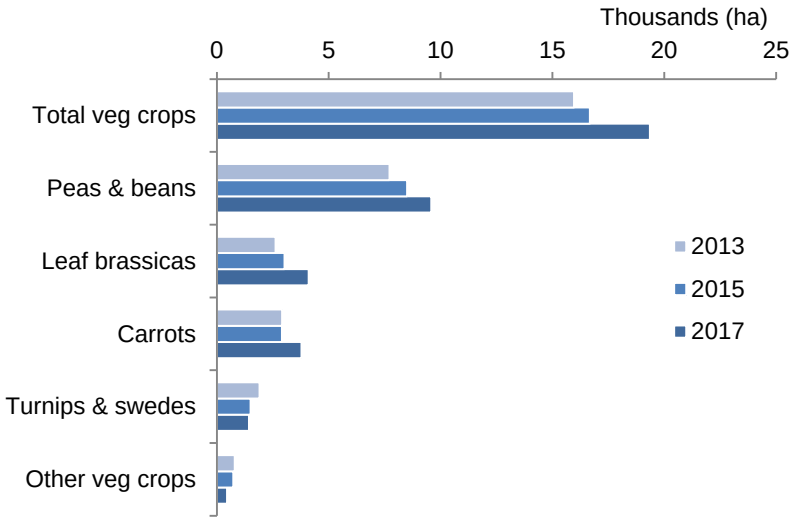
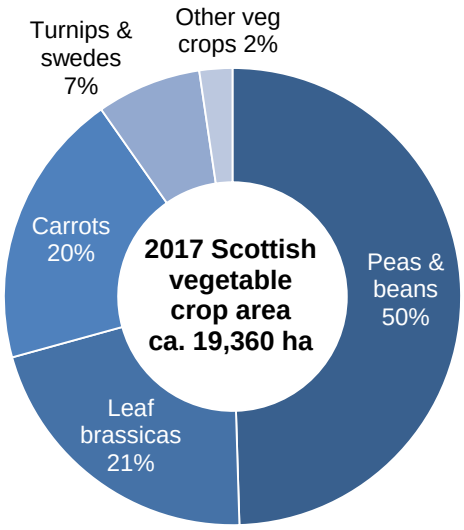


Figure 2 Vegetable crop areas 2017 (percentage of total area)

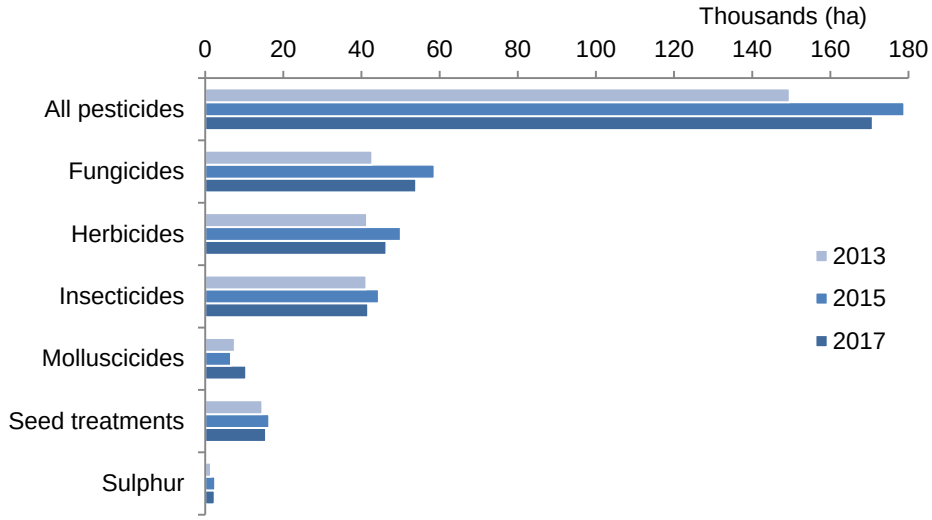


Pesticide usage

As in 2015, the majority of vegetable crops received a pesticide treatment in 2017 (98 & 93 per cent respectively). Vining peas, turnips & swedes, broad beans, calabrese and other brassica crops had the highest overall proportion of crop treated with a pesticide (94 to 100 per cent, Table 1). Cabbage, carrots and other vegetables were estimated to have lower proportions of treated crop (89, 76 and 60 per cent respectively). In relation to the average number of pesticide applications, the treated area of vegetable crops received on average 5.4 sprays, compared with 5.8 sprays in the previous survey. The other brassica category, which includes Brussels sprouts, received the highest number of applications with an average of 12.6 sprays. In contrast, vining peas received 2.3 sprays on average (Table 1).

It is estimated that the area of outdoor vegetable crops treated with a pesticide formulation in 2017 was ca. 170,900 hectares compared with ca.179,000 hectares in 2015 and ca. 149,600 hectares in 2013 (Table 20, Figure 3). This represents a decrease of five per cent since 2015 and an increase of 14 per cent since 2013.

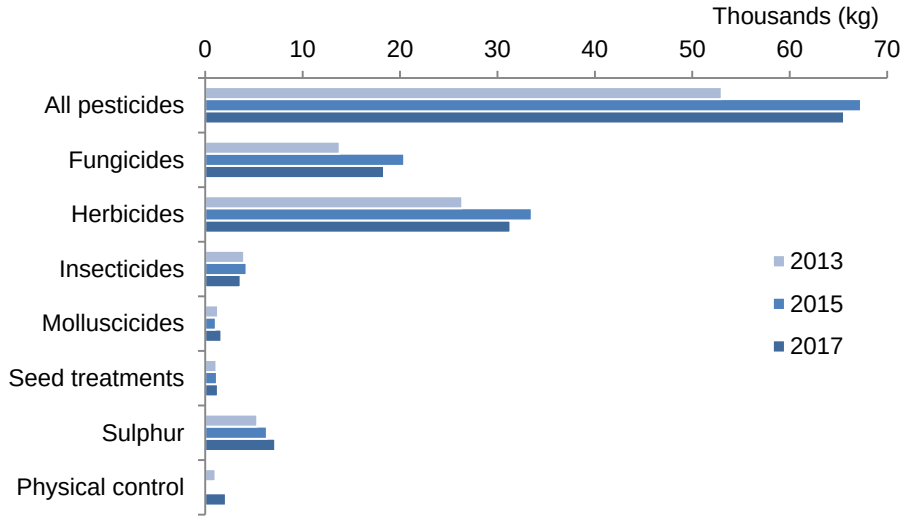
Figure 3 Area of vegetable crops treated with the major pesticide groups in Scotland 2013-2017



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

In terms of weight of pesticide applied, ca. 65.5 tonnes were applied in 2017 which was very similar to 2015 (67 tonnes) and an increase of 24 per cent from 2013 (53 tonnes) (Figure 4).

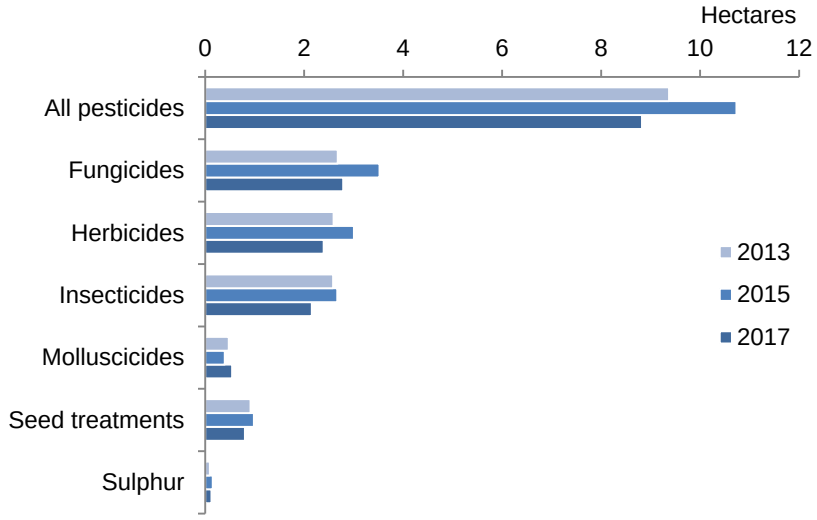
Figure 4 Weight of the major pesticide groups applied to vegetable crops in Scotland 2013-2017



Note: growth regulators and biopesticides have been excluded as their use represents ≤500 kg

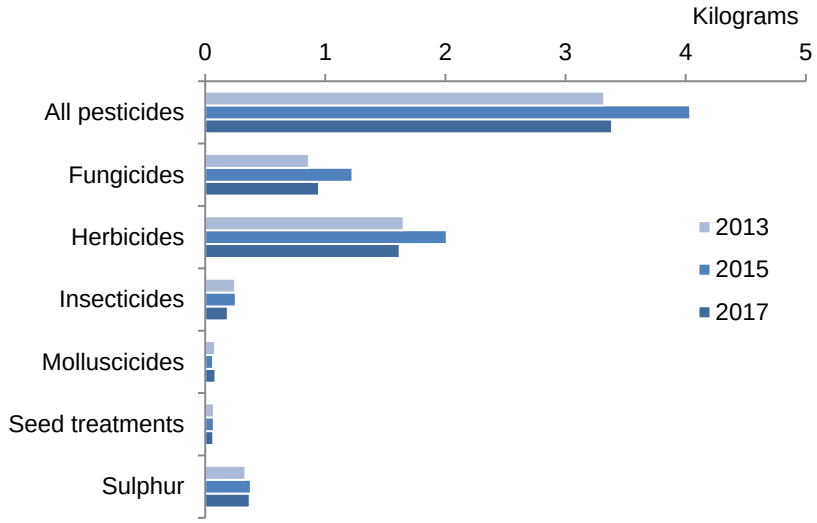
In order to make accurate comparisons between the 2017 data and that reported in previous surveys, it is important to take into account differences in crop areas between years. Therefore, the number of treated hectares per hectare of crop grown and the total weight of pesticide used per hectare of crop grown were calculated. When crop area is taken into account there is a decrease in the area and weight of pesticide applied (Figures 5 & 6). In 2017, for each hectare of crop grown, around nine pesticide treated hectares were recorded (Figure 5). This represents a decrease of 18 per cent from 2015 and six per cent from 2013. The estimated weight of pesticide applied per hectare of crop grown in 2017 was three kilograms (Figure 6). This is similar to the amount applied in 2013 but a decrease of 16 per cent from 2015.

Figure 5 Number of pesticide treated hectares (formulations) per hectare of crop grown



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



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

Fungicides were the most frequently used pesticides by area treated on outdoor vegetable crops, followed by herbicides and insecticides (Figure 7). This was the same pattern observed in the previous survey (Figure 3). In 2017, fungicides accounted for almost a third (32 per cent) of the total pesticide treated area and 28 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 decreased by 21 per cent from 2015 to 2017 but has increased by four per cent between 2013 and 2017 (Figure 5). From 2015 to 2017, there was a decrease of 23 per cent in the weight of fungicides used per hectare of crop grown, but an increase of 10 per cent between 2013 and 2017 (Figure 6). The decreased use of fungicides in 2017 compared with 2015 may be influenced by the weather. Scotland experienced a considerably drier spring in 2017 than in 2015 (39 per cent decrease in rainfall[5]) which may have resulted in lower disease pressure. Fungicide use in 2017 was similar to use in 2013 which was also a low disease year[4]. In comparison with the previous survey in 2015, there were decreases in fungicide use across all modes of action, with the exception of those affecting respiration which increased by 10 per cent (this group includes strobilurins and SDHIs, Table 16).

Sulphur accounted for two per cent of the total treated area and 11 per cent of the total weight of pesticides applied (Figures 7 & 8). Foliar use of sulphur has both fungicidal and fertilising properties. When changes in area grown are taken into account there was a 18 per cent decrease in the use of sulphur between 2015 and 2017 and a 34 per cent increase between 2013 and 2017 (Figure 5). The weight of sulphur applied per hectare of crop grown decreased by two per cent from 2015 to 2017 and increased by 11 per cent between 2013 and 2017 (Figure 6). The majority of sulphur use was on calabrese and vining peas which have both seen increases in crop area (Table 21).

In 2017, herbicides accounted for 27 per cent of the total pesticide treated area and 48 per cent of the total weight of pesticides applied (Figures 7 & 8). When changes in crop area are taken into account, there is a decrease in area treated with herbicide formulations of 20 per cent from 2015 to 2017 and eight per cent from 2013 and 2017 (Figure 5). In terms of weight of pesticide applied, when area of crop grown is taken into account, there was a decrease of 19 per cent from 2015 to 2017 and a decrease of two per cent from 2013 to 2017 (Figure 6). It is possible that herbicide use is influenced to some extent by grower utilisation of mechanical weeding technology. In the 2015 survey of integrated pest management (IPM) by vegetable growers, 36 per cent of respodents used mechanical weeding as well as, or instead of, herbicides[3]. The next survey of IPM in vegetable crops is scheduled for the 2019 crop season. Despite the overall decrease in herbicide use there were some increases in individual active substances. For example, the area treated with the herbicide MCPB increased by 72 per cent by area treated and by 104 per cent by weight. There are no clear temporal trends in relation to herbicide modes of action (Table 17).

Figure 7 Use of pesticides on outdoor vegetable crops – 2017 (percentage of total area treated with formulations)

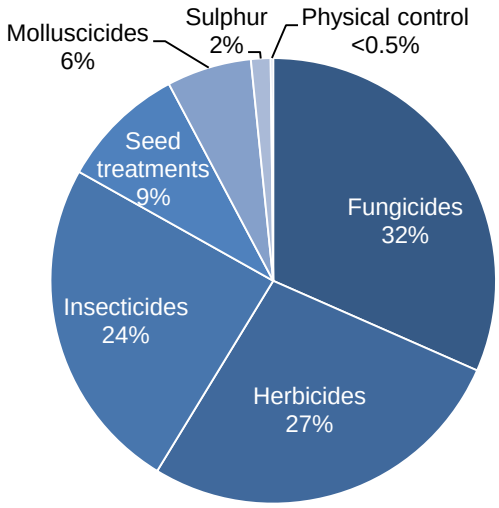
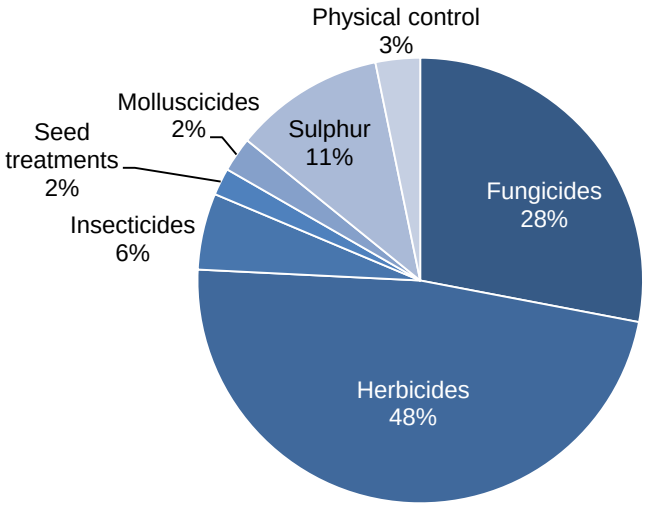


Figure 8 Use of pesticides on outdoor vegetable crops (percentage of total weight of pesticides applied) – 2017



Insecticides accounted for 24 per cent of the total pesticide treated area and six per cent of the total weight of pesticides applied (Figures 7 & 8). When changes in crop area are taken into account, there was a 19 per cent decrease from 2015 to 2017 and a 17 per cent decrease from 2013 to 2017 in the area treated with insecticide formulations (Figure 5). Similarly, in terms of weight applied per hectare of crop grown, there was a decrease of 26 per cent from 2015 to 2017 and a decrease of 25 per cent from 2013 to 2017 (Figure 6). There were also changes in the types of insecticides encountered in the 2017 survey (Table 15). Overall, use of the carbamate insecticide pirimicarb halved in comparison with the previous survey, reflecting its loss of approval on a range of vegetable crops in July 2017, half way through the field season. Pirimicarb is now approved only for peas and beans, leaving fewer options for aphid control. Pyrethroid use per hectare, whilst still the

principal form of insect control employed, also decreased in the 2017 survey. Use of insecticides with other modes of action (thiacloprid, spinosad, pymetrozine and indoxacarb) all increased, suggesting that these alternatives, rather than pyrethroids, replaced the lost pirimicarb authorisations. This is likely to be related to the pyrethroid resistance status of a number of target species.

Over 96 per cent of leaf brassica crops and 43 per cent of other vegetable crops were grown from transplants. The remaining crops were grown directly from seed. Of these, vining peas had the highest proportion of treated seed with 100 per cent treated, followed by broad beans (99 per cent) and turnips & swedes (96 per cent). Seed treatments accounted for nine per cent of the total area treated and two per cent of the total weight applied (Figures 7 & 8). When changes in crop area are taken into account, there was a decrease in area treated with seed treatments of 18 per cent from 2015 to 2017 and a decrease of 12 per cent from 2013 to 2017 (Figure 5). The weight of seed treatment applied per hectare of crop grown decreased by seven per cent from 2015 to 2017 and by eight per cent from 2013 to 2017 (Figure 6).

Molluscicides accounted for six per cent of the total pesticide treated area and two per cent of the total weight of pesticides applied (Figures 7 & 8). When changes in crop areas between years are taken into account, there was an increase in molluscicide applications per unit area of 37 per cent between 2015 and 2017 and an increase of 14 per cent between 2013 and 2017 (Figure 5). The weight of molluscicides applied per hectare of crop grown increased by 32 per cent from 2015 to 2017 and by four per cent from 2013 to 2017 (Figure 6). Molluscicide usage varies greatly from year to year as slug population levels are closely linked to climatic conditions. There were reduced levels of slug activity in 2015 due to the late cold spring[3]. In contrast, the wet summer months in 2017 helped increase the risk of slug damage[6]. The use of the molluscicide ferric phosphate, increased by 158 per cent (area treated) and 132 per cent (weight) (Tables 18 & 19). This increase may have been influenced by the loss of approval of methiocarb in September 2015 and the current industry led stewardship scheme which aims to minimise the environmental impacts of metaldehyde use. Metaldehyde use showed little change between the surveys. Ferric phosphate and metaldehyde are currently the only approved molluscicide active substances.

Pesticides classified as physical control accounted for less than 0.5 per cent of the total pesticide treated area and three per cent of the total weight of pesticides applied (Figures 7 & 8). In 2017 all physical control encountered was garlic-containing granules. This pesticide, which is approved for use against free-living nematodes, was only applied to carrot crops. No physical control was encountered in 2015, but a similar proportion of the carrot crop was treated with garlic in the 2013 survey.

No growth regulators or biopesticides were encountered during the 2017 survey. In the previous survey growth regulators and biopesticides accounted for less than one per cent of the total pesticide treated area each. The fungicides isopyrazam and epoxiconazole and the herbicide clethodim were recorded for the first time on outdoor vegetable crops in 2017 (Table 14).

2017 Pesticide usage

Vining peas

- An estimated 7,808 hectares of vining peas were gown in Scotland in 2017, an increase of 11 per cent since 2015
- 100 per cent of the crop was treated with a pesticide (see Figure 9 for types of pesticides used)
- Pesticide formulations were applied to 31,571 treated hectares with 18,719 kilograms of pesticide applied in total (see summary table below)
- Vining pea crops received on average 2.3 pesticide applications (Table 1). These included 1.4 herbicide applications (applied to 96 per cent of the crop area), 1.1 insecticide applications (applied to 75 per cent of the crop) and one fungicide and one sulphur application (applied to 70 and 18 per cent of the crop respectively)
- Timings of pesticide applications are shown in Figure 10
- The only reasons specified for fungicide and herbicide use were disease control and general weed control. There were no reasons recorded for insecticide or sulphur use
- The most common varieties encountered were Spandimo, Corus and Pizarro, accounting for 21, 17 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	5,597	1,428	70	Azoxystrobin (2,764), Boscalid/pyraclostrobin (2,687)
Herbicides	10,452	10,062	96	Imazamox/pendimethalin (6,114)
Insecticides	6,284	740	75	Pirimicarb (5,516)
Sulphur	1,432	5,727	18	N/A
Seed treatments	7,807	762	100	Cymoxanil/fludioxonil/ metalaxyl-M (7,807)
All pesticides	**31,571**	**18,719**	**100**	

N/A = not applicable

Figure 9 Use of pesticides on vining peas (percentage of total area treated with formulations) – 2017

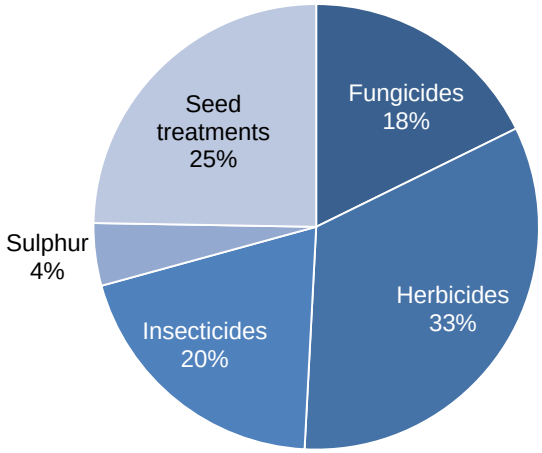
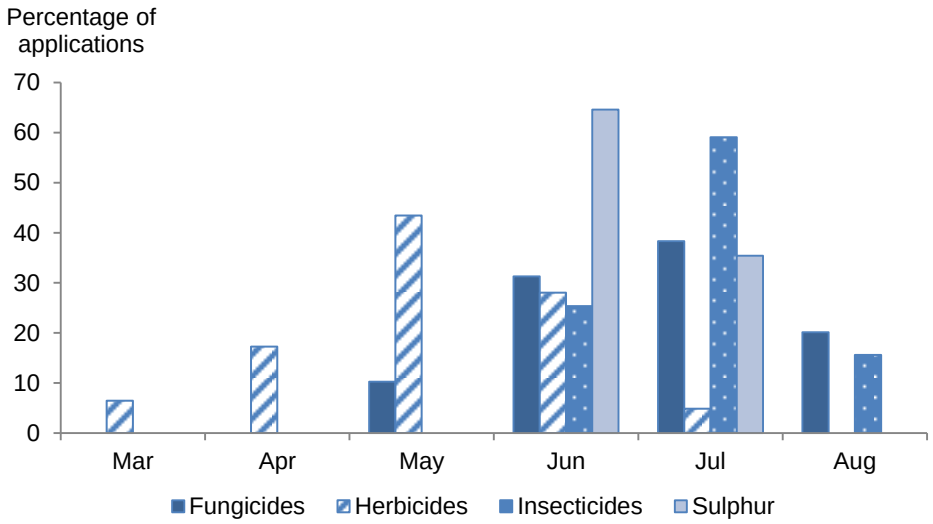


Figure 10 Timing of pesticide applications on vining peas – 2017



Broad beans

- An estimated 1,779 hectares of broad beans was grown in Scotland in 2017, an increase of 21 per cent since 2015. This was comprised of 1,767 hectares recorded in the 'broad bean' census category and 12 hectares recorded in the 'other vegetable' census category
- 99 per cent of the crop was treated with a pesticide (see Figure 11 for types of pesticides used)
- Pesticide formulations were applied to 14,707 treated hectares with 5,440 kilograms of pesticide applied in total (see summary table below)
- The 99 per cent of broad bean crop treated with a pesticide received on average 4.3 pesticide sprays (Table 1). These included 2.7 fungicide applications, 2.1 insecticide applications and 1.4 herbicide applications (applied to 99, 90 and 90 per cent of the crop respectively)
- Timings of pesticide applications are shown in Figure 12
- Reasons for fungicide applications were supplied for 19 per cent of total use; 7 per cent for control of chocolate spot and 12 per cent for general disease control. The only reason specified for herbicides was general weed control (50 per cent use) and for insecticides was aphid control (16 per cent of use)
- The two main varieties encountered were Listra and Talia, accounting for 75 and 17 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	7,323	2,895	99	Tebuconazole (2,007)
Herbicides	2,299	2,164	90	Imazamox/pendimethalin (1,601)
Insecticides	3,318	87	90	Lambda-cyhalothrin (2,171)
Seed treatments	1,767	294	99	Thiram (1,767)
All pesticides	**14,707**	**5,440**	**99**	

Figure 11 Use of pesticides on broad beans (percentage of total area treated with formulations) - 2017

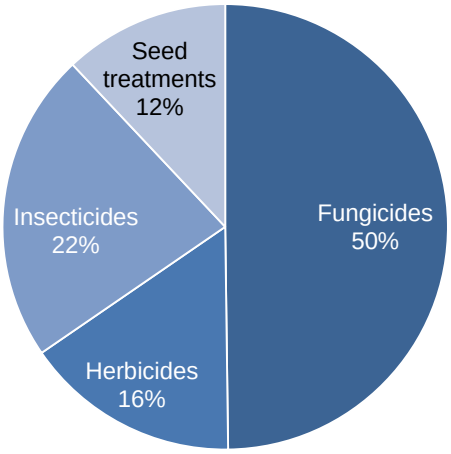
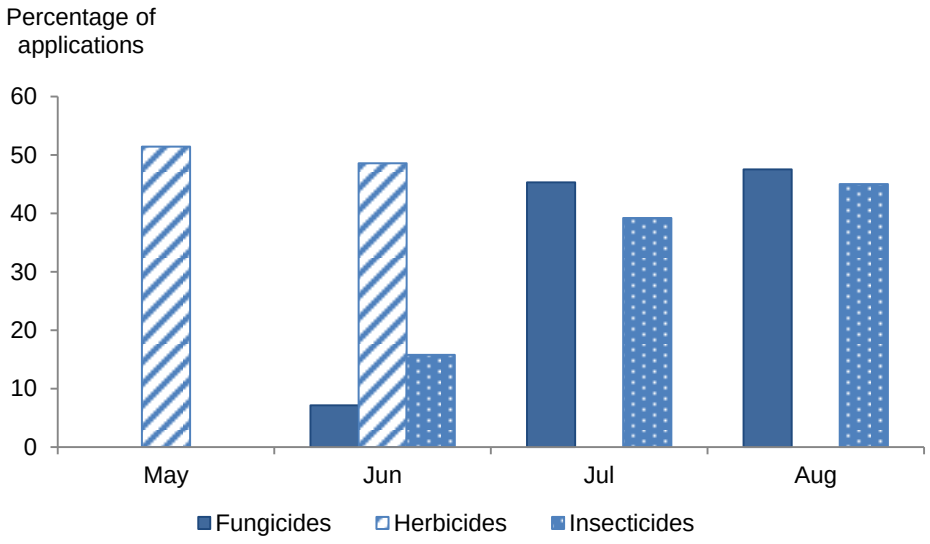


Figure 12 Timing of pesticide applications on broad beans – 2017



Cabbages

- An estimated area of 313 hectares was grown in Scotland in 2017. This represents an increase of 5 per cent since 2015. 278 hectares were recorded in the 'cabbage and savoy' census category and 35 hectares in the 'other vegetable' category
- 96 per cent of the cabbage crop was grown from transplants
- 89 per cent of the crop was treated with a pesticide (see Figure 13 for types of pesticides used)
- Pesticide formulations were applied to 2,314 treated hectares with 1,511 kilograms of pesticide applied in total (see summary table below)
- The 89 per cent of cabbage crop treated with a pesticide received on average 5.9 pesticide applications (Table 1). These included 3.3 fungicide applications, 1.9 herbicide applications and one molluscicide application (applied to 81, 89 and 81 per cent of the crop respectively)
- Timings of pesticide applications are shown in Figure 14
- The only reason specified for herbicide use was general weed control (eight per cent of use). No reasons were recorded for fungicide use
- The most common varieties encountered were Dutchman, Monarchy and Regency which accounted for 32, 28 and 24 per cent of the sample area respectively

Summary of pesticide use on cabbages:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	1,020	415	81	Azoxystrobin (508)
Herbicides	1,040	1,025	89	Metazachlor (278), Clomazone, Glyphosate, Pendimethalin (all 254)
Molluscicides	254	71	81	Metaldehyde (254)
All pesticides	**2,314**	**1,511**	**89**	

Figure 13 Use of pesticides on cabbages (percentage of total area treated with formulations) – 2017

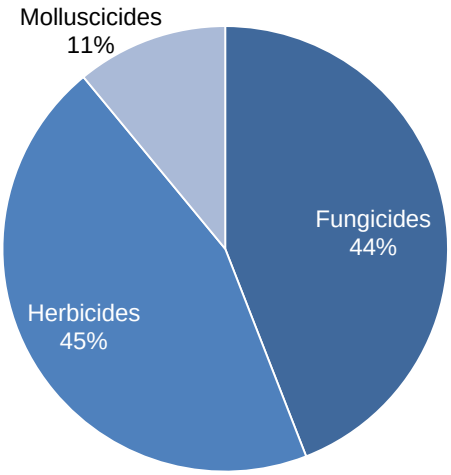
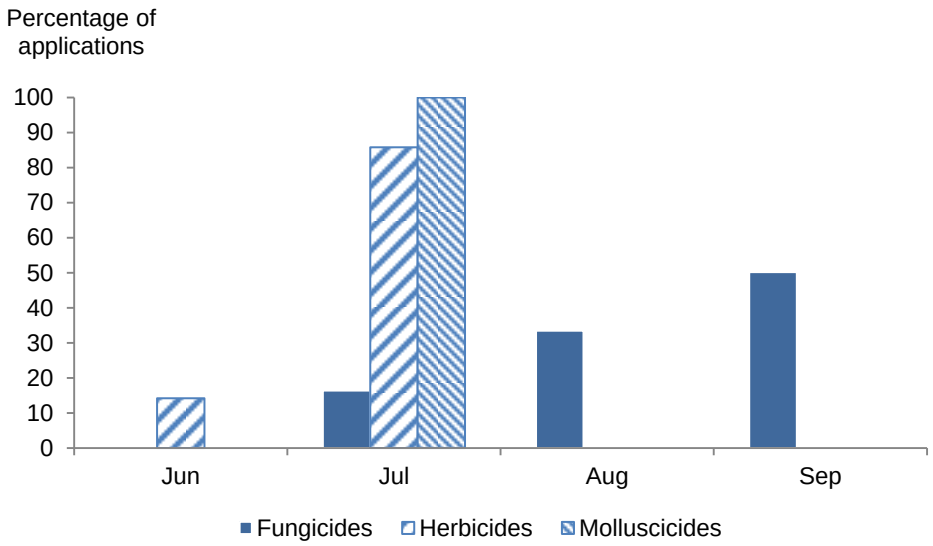


Figure 14 Timing of pesticide applications on cabbages – 2017



Calabrese

- An estimated area of 1,995 hectares of calabrese was grown in Scotland in 2017, an increase of 18 per cent since 2015. This included 1,718 hectares recorded in the 'calabrese' census category with the remainder recorded in the 'other vegetable' category
- Over 99 per cent of the calabrese crop was grown from transplants
- 94 per cent of the crop was treated with a pesticide (see Figure 15 for types of pesticides used)
- Pesticide formulations were applied to 15,481 treated hectares with 7,520 kilograms of pesticide applied in total (see summary table below)
- The 94 per cent of calabrese crop treated with a pesticide received on average six pesticide applications (Table 1). These applications included three molluscicides (applied to 12 per cent of the crop area), 2.6 fungicides, two herbicides,1.7 insecticides (applied to 92 per cent of the crop) and one sulphur application (applied to 41 per cent of the crop)
- The timings of pesticide applications are shown in in Figure 16
- 65 per cent of fungicide use was for downy mildew, 27 per cent for botrytis and eight per cent for head rot. General weed control was the only specified reason for herbicide use (73 per cent of use). Reasons for insecticide applications were supplied for 56 per cent of total use. 19 per cent was for caterpillars, 14 per cent for general pests, 10 per cent for both diamond-back moth and hoverfly and two per cent for pollen beetle. Please note hoverflies are classified as beneficial insects, but may be treated to reduce the presence of hoverfly larvae in the harvested crop
- The most common varieties encountered were Parthenon accounting for 51 per cent of the sample area and Monrello and Titanium both 18 per cent

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	5,526	2,035	92	Copper oxychloride (2,279)
Herbicides	4,151	3,938	92	Metazachlor (1,838)
Insecticides	4,299	95	92	Lambda-cyhalothrin (2,467)
Molluscicides	691	152	12	Metaldehyde (691)
Sulphur	812	1,299	41	N/A
Seed treatments	2	<0.5	<0.5	Iprodione, Metalaxyl-M, Thiram (all 1)
All pesticides	**15,481**	**7,520**	**94**	

N/A = not applicable

Figure 15 Use of pesticides on calabrese (percentage of total area treated with formulations) – 2017

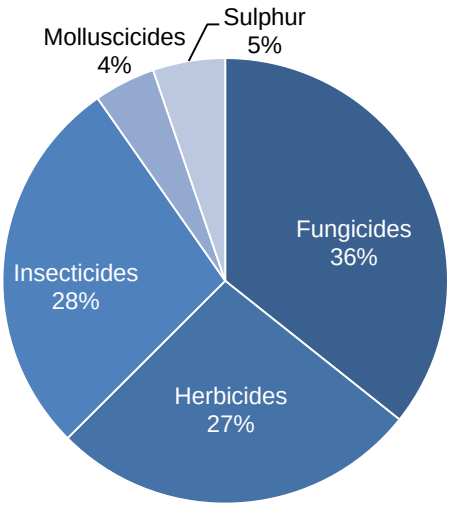
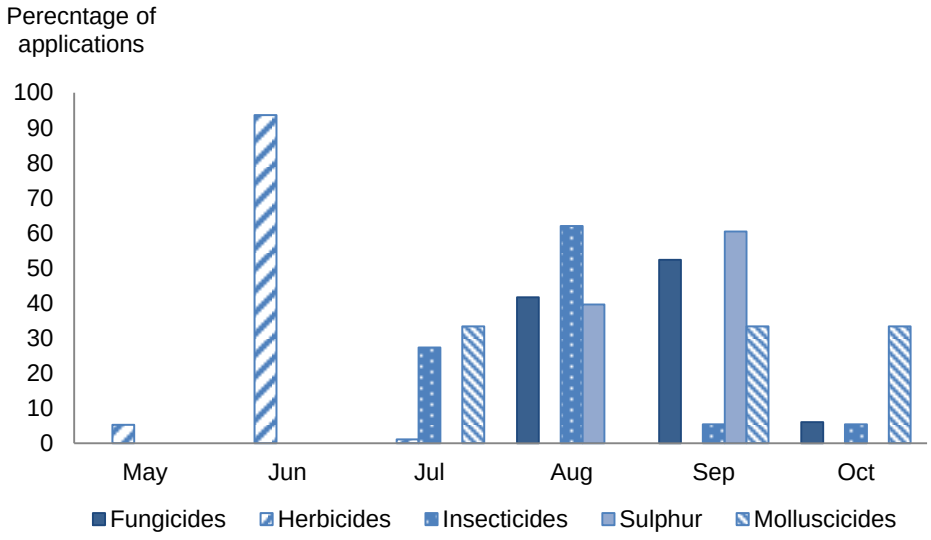


Figure 16 Timing of pesticide applications on calabrese – 2017



Other brassica crops

- Other brassica crops encountered in the 2017 survey were sprouting broccoli, Brussels sprouts, cauliflower and kale (in previous reports Brussels sprouts were reported separately but this was not possible in 2017 due to reduced area of crop encountered in the sample)
- The total estimated area of other brassica crops was 1,796 hectares
- 99 per cent of other brassica crops were grown from transplants
- 97 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 39,650 treated hectares with 9,266 kilograms of pesticide applied in total (see summary table below)
- The 97 per cent of other brassica crops treated with a pesticide received on average 12.6 pesticide applications (Table 1). These included 6.3 molluscicide, 5.7 fungicide, 4.3 insecticide and 2.6 herbicide applications (applied to 76, 88, 97 & 88 per cent of the crop respectively)
- The timings of pesticide applications are shown in Figure 18
- General disease control and general pest control were the only specified reasons reported for fungicide and insecticide application respectively (84 and 83 per cent of use respectively). Reasons for herbicide applications were supplied for 79 per cent of total use. Thirty nine per cent for annual broad-leaf weeds, 26 per cent for annual meadow grass and 13 per cent for general weed control

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	11,656	3,686	88	Prothioconazole (2,757)
Herbicides	5,310	3,375	88	Metazachlor (1,822)
Insecticides	13,839	775	97	Lambda-cyhalothrin (3,850)
Molluscicides	8,654	1,280	76	Ferric phosphate (4,837)
Sulphur	185	148	5	N/A
Seed treatments	6	<0.5	<0.5	Iprodione, Metalaxyl-M, Thiram (all 2)
All pesticides	**39,650**	**9,266**	**97**	

N/A = not applicable

Figure 17 Use of pesticides on other brassica crops (percentage of total area treated with formulations) – 2017

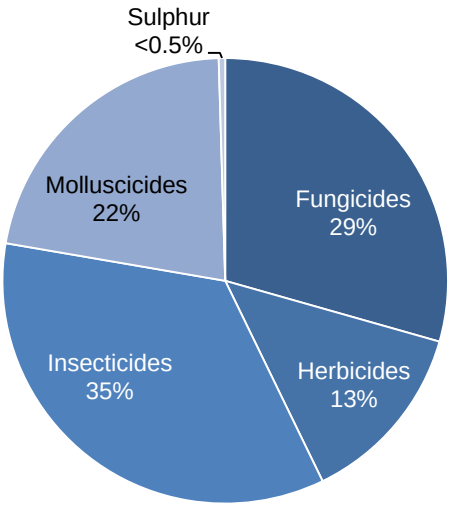
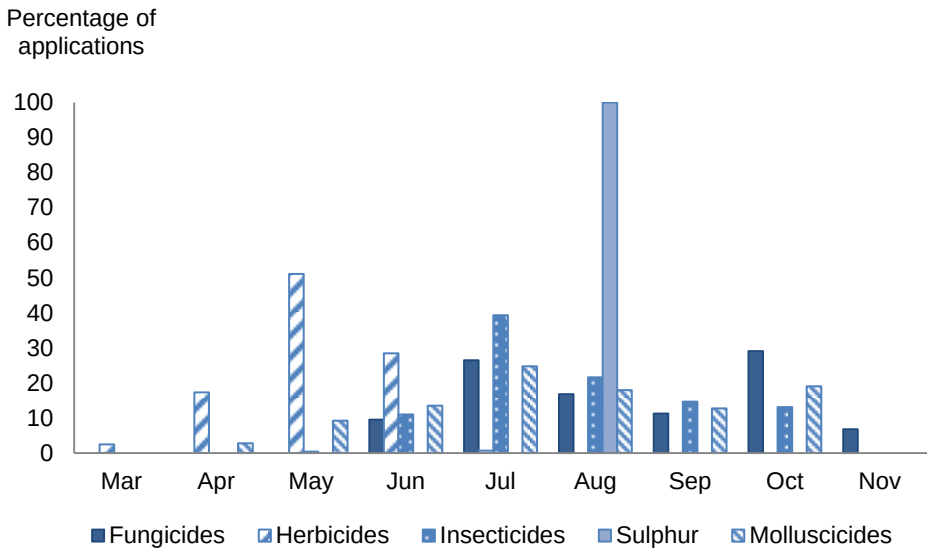


Figure 18 Timing of pesticide applications on other brassica crops – 2017



Carrots

- An estimated 3,785 hectares of carrots was grown in Scotland in 2017, an increase of 30 per cent since 2015. This consists of 3,752 hectares recorded in the 'carrots' census category and 32 hectares in the 'other vegetable' category
- 76 per cent of the crop was treated with a pesticide (see Figure 19 for types of pesticides used)
- Pesticide formulations were applied to 51,781 treated hectares with 19,381 kilograms of pesticide applied in total (see summary table below)
- The 76 per cent of carrot crop treated with a pesticide received on average 10.1 applications (Table 1). These included 6.4 fungicide applications, 3.6 insecticide applications and 3.1 herbicide applications (applied to 76 percent of the crop)
- The timing of pesticide applications is shown in Figure 20
- Reasons for fungicide applications were supplied for 27 per cent of total use; 11 per cent for *Sclerotinia*, eight per cent for disease control/prevention, four per cent for both cavity spot and crown rot and less than one per cent for *Alternaria.* Reasons for insecticide/ nematicide applications were supplied for 40 per cent of total use; 27 per cent for carrot fly, nine per cent for aphids and three per cent for nematodes
- 56 per cent of herbicide use was for general weed control; 10 per cent for fumitory, eight per cent for annual broad-leaved weeds, six per cent for annual meadow grass and annual grass weeds, five per cent for mayweed and control of volunteers with others accounting for the final four per cent (others included groundsel, bindweed and fools parsley)
- The most common variety encountered was Nairobi, accounting for 71 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	18,731	6,625	76	Isopyrazam (4,109)
Herbicides	18,237	8,684	76	Linuron (5,966)
Insecticides	10,349	1,841	76	Lambda-cyhalothrin (7,417)
Seed treatments	4,149	113	63	Cymoxanil/fludioxonil/ metalaxyl-M (2,394)
Physical control	314	2,117	8	Garlic (314)
All pesticides	**51,781**	**19,381**	**76**	

Figure 19 Use of pesticides on carrots (percentage of total area treated with formulations) – 2017

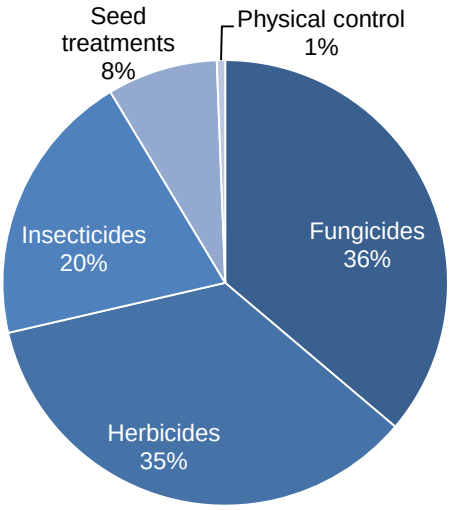
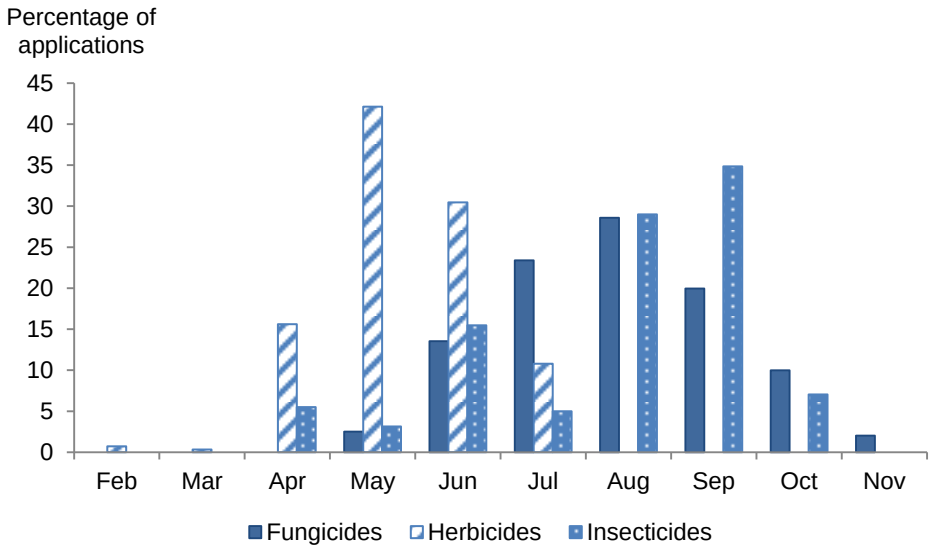


Figure 20 Timing of pesticide applications on carrots – 2017



Note: Physical control was all applied in April

Turnips and swedes

- The total estimated area of turnips and swedes grown in 2017 was 1,434 hectares, representing a five per cent decrease from 2015. 1,413 hectares were recorded in the 'turnips & swedes' census category and 21 hectares were recorded in the 'other vegetable' census category
- 99 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 12,694 treated hectares with 2,481 kilograms of pesticide applied in total (see summary table below)
- The turnip and swede crop received on average 4.1 pesticide applications (Table 1). These included two herbicide and insecticide applications (applied to 99 and 83 per cent of the crop area respectively) as well as 1.7 fungicide applications and 1.3 molluscicide applications (applied 85 and 36 per cent of the crop respectively)
- The timing of pesticide applications is shown in Figure 22
- General disease control and general pests were the only specified reasons for the use of fungicides and insecticides (88 and 99 per cent of use respectively). Reasons for herbicide applications were supplied for 97 per cent of total use; 69 per cent for general weed control, 14 per cent for annual broad-leaved weeds and 13 per cent for annual meadow grass
- The most common variety encountered was Magres, accounting for 73 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	3,060	752	85	Azoxystrobin (1,547)
Herbicides	3,954	1,477	99	Clomazone (1,403)
Insecticides	3,141	98	83	Deltamethrin (1,261), Lambda-cyhalothrin (1,016)
Molluscicides	838	143	36	Metaldehyde (679)
Seed treatments	1,701	12	96	Thiram (1,340)
All pesticides	**12,694**	**2,481**	**99**	

Figure 21 Use of pesticides on turnips and swedes (percentage of total area treated with formulations) – 2017

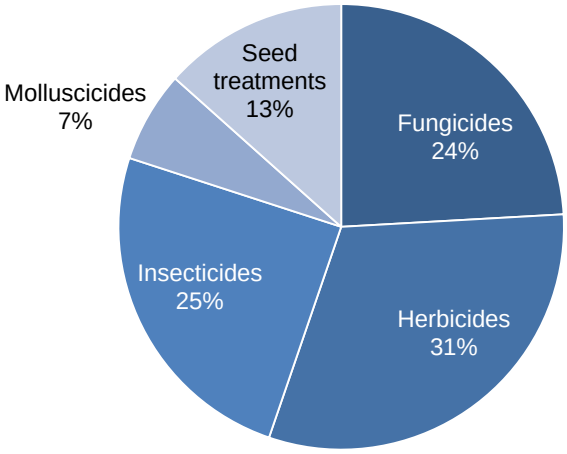
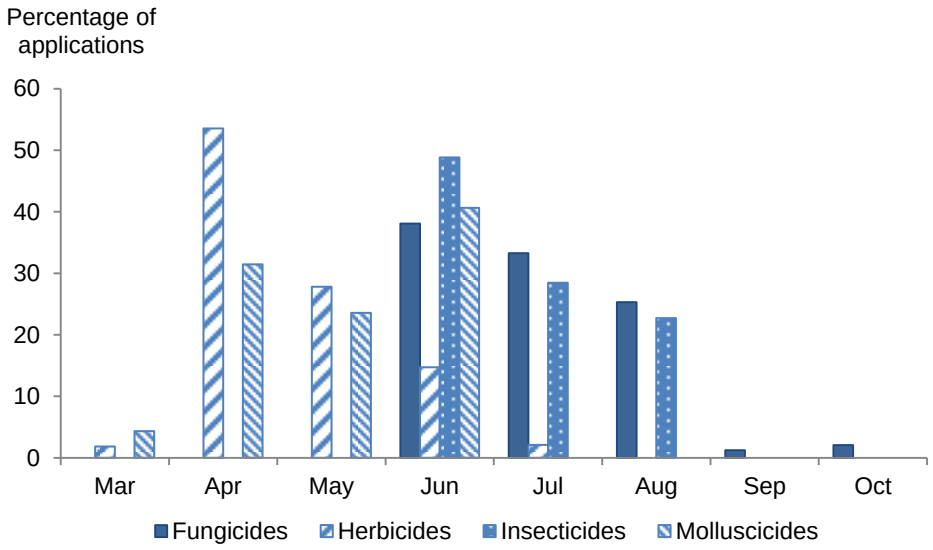


Figure 22 Timing of pesticide applications on turnips and swedes – 2017



Other vegetable crops

- Other vegetable crops encountered in the 2017 survey were beetroot, leeks, lettuce, parsnips, podded peas, pumpkin, rhubarb, sweetcorn and squash
- The total estimated area of other vegetable crops was 451 hectares. This includes 23 hectares of multi-cropping
- 43 per cent of other vegetable crops were grown from transplants
- 60 per cent of other vegetable crops were treated with a pesticide (see Figure 23 for types of pesticides used)
- Pesticide formulations were applied to 2,665 treated hectares with 1,146 kilograms of pesticide applied in total (see summary table below)
- The 60 per cent of the other vegetable crop treated with a pesticide received on average 5.9 pesticide applications (Table 1). These included 3.2 fungicide applications (applied to 57 per cent of the crop area), 2.9 insecticides, 2.4 herbicides and one molluscicide application (applied to 37, 60 & 16 per cent respectively)
- The timing of pesticide applications is shown in Figure 24
- Reasons for herbicide applications were supplied for 45 per cent of total use; 16 per cent for general weed control and 14 per cent for both annual broad-leaved weeds and annual meadow grass. General disease control and general pests were the only specified reasons for fungicide and insecticide use (61 and 56 per cent of use respectively)

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	1,064	519	57	Prothioconazole (205)
Herbicides	914	615	60	Metamitron (167)
Insecticides	494	4	37	Deltamethrin (262)
Molluscicides	74	8	16	Metaldehyde (74)
Seed treatments	120	1	22	Thiram (117)
All pesticides	**2,665**	**1,146**	**60**	

Figure 23 Use of pesticides on other vegetable crops (percentage of total area treated with formulations) – 2017

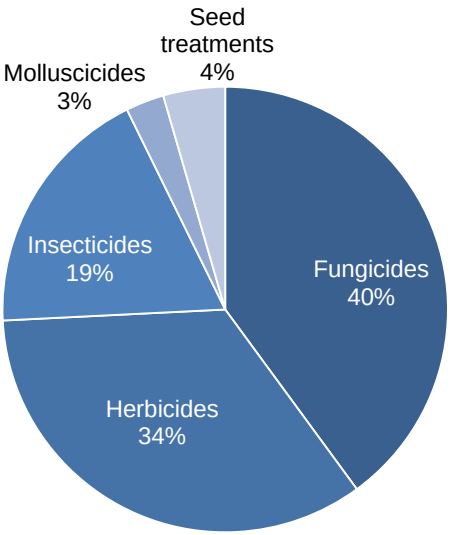
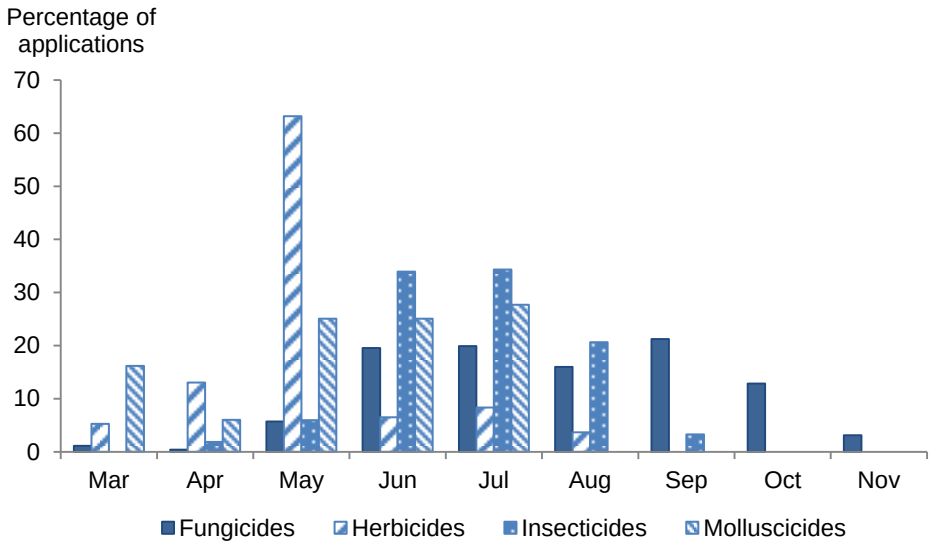


Figure 24 Timing of pesticide applications on other vegetable crops – 2017



Appendix 1 – Estimated application tables

Table 1 Percentage of each crop treated with pesticides and mean number of spray applications - 2017

Crop	Fungicides		Herbicides		Insecticides		Molluscicide		Sulphur		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	%	%
Vining peas	70	1.0	96	1.4	75	1.1	0	0.0	18	1.0	0	0.0	98	2.3	100	100
Broad beans	99	2.7	90	1.4	90	2.1	0	0.0	0	0.0	0	0.0	99	4.3	99	99
Cabbage	81	3.3	89	1.9	0	0.0	81	1.0	0	0.0	0	0.0	89	5.9	0	89
Calabrese	92	2.6	92	2.0	92	1.7	12	3.0	41	1.0	0	0.0	94	6.0	<0.5	94
Other brassicas	88	5.7	88	2.6	97	4.3	76	6.3	5	2.0	0	0.0	97	12.6	<0.5	97
Carrots	76	6.4	76	3.1	76	3.6	0	0.0	0	0.0	8	1.0	76	10.1	63	76
Turnips & swedes	85	1.7	99	2.0	83	2.0	36	1.3	0	0.0	0	0.0	99	4.1	96	99
Other vegetable crops	57	3.2	60	2.4	37	2.9	16	1.0	0	0.0	0	0.0	60	5.9	26	60
All vegetable crops	**79**	**3.0**	**90**	**1.9**	**79**	**2.2**	**13**	**4.2**	**12**	**1.0**	**2**	**1.0**	**92**	**5.4**	**70**	**93**

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 - 2017

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

Seed treatment	Broad beans		Vining peas		Total 2017	Total 2017	2015	2015
	ha	%	ha	%	**ha**	**kg**	ha	kg
Cymoxanil/fludioxonil/metalaxyl-M	0	0	7,807	100	**7,807**	**917**	7,790	838
Thiram	1,767	99	0	0	**1,767**	**250**	1,469	217
All seed treatments	**1,767**	**99**	**7,807**	**100**	**9,574**	**1,167**	**9,259**	**1,055**
No seed treatment	12	1	0	0	**12**	**N/A**	7	N/A
Area grown	1,779		7,807		**9,586**		8,504	

N/A = not applicable

Table 3 Peas and beans insecticide formulations - 2017

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

Insecticides	Broad beans		Vining peas		Total 2017	Total 2017	2015[(1)]	2015[(1)]
	ha	%	ha	%	**ha**	**kg**	ha	kg
Deltamethrin	524	29	0	0	**524**	**4**	0	0
Lambda-cyhalothrin	2,171	61	767	10	**2,938**	**22**	2,937	18
Pirimicarb	623	35	5,516	71	**6,139**	**801**	8,765	1,052
All insecticides	**3,318**	**90**	**6,284**	**75**	**9,601**	**827**	**12,464**	**1,082**
Area grown	1,779		7,807		**9,586**		8,504	

(1) For full list of formulations recorded in 2015 please refer to the 2015 report[(3)]

Table 4 Peas and beans fungicide and sulphur formulations - 2017

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

Fungicides	Broad beans		Vining peas		Total 2017	Total 2017	2015	2015
	ha	%	ha	%	**ha**	**kg**	ha	kg
Azoxystrobin	1,271	58	2,764	35	**4,034**	**873**	4,578	791
Boscalid/pyraclostrobin	1,601	90	2,687	34	**4,288**	**1,173**	4,602	1,228
Chlorothalonil/metalaxyl-M	1,252	70	0	0	**1,252**	**1,204**	2,176	1,930
Cyprodinil/fludioxonil	1,193	61	146	2	**1,339**	**753**	1,956	1,093
Tebuconazole	2,007	70	0	0	**2,007**	**320**	3,399	476
All fungicides	**7,323**	**99**	**5,597**	**70**	**12,920**	**4,324**	**16,711**	**5,518**
Sulphur	**0**	**0**	**1,432**	**18**	**1,432**	**5,727**	**1,069**	**4,277**
Area grown	1,779		7,807		**9,586**		8,504	

Table 5 Peas and beans herbicide formulations - 2017

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

Herbicides	Broad beans		Vining peas		Total 2017	Total 2017	2015	2015
	ha	%	ha	%	**ha**	**kg**	ha	kg
Bentazone	292	16	1,300	17	**1,593**	**1,111**	2,389	1,650
Clomazone/linuron	0	0	859	11	**859**	**507**	729	430
Glyphosate	406	23	795	10	**1,202**	**997**	1,702	1,418
Imazamox/pendimethalin	1,601	90	6,114	78	**7,715**	**7,187**	7,768	7,069
MCPB	0	0	1,384	18	**1,384**	**2,425**	0	0
All herbicides	**2,299**	**90**	**10,452**	**96**	**12,751**	**12,226**	**12,589**	**11,757**
Area grown	1,779		7,807		**9,586**		8,504	

Table 6 Leaf brassica seed treatment formulations - 2017

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

Seed treatments	Cabbages		Calabrese		Other brassicas[1]		Total 2017	Total 2017	2015	2015
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Iprodione	0	0	1	<0.5	2	<0.5	**3**	**<0.5**	79	<0.5
Metalaxyl-M	0	0	1	<0.5	2	<0.5	**3**	**<0.5**	79	<0.5
Thiram	0	0	1	<0.5	2	<0.5	**3**	**<0.5**	79	<0.5
All seed treatments	**0**	**0**	**2**	**<0.5**	**6**	**<0.5**	**8**	**<0.5**	**236**	**<0.5**
No seed treatment	12	4	0	0	12	<1	**23**	**N/A**	13	N/A
Crop grown from transplant	301	96	1,995	>99	1,782	>99	**4,078**	**N/A**	2,934	N/A
Area grown	313		1,995		1,796		**4,104**		3,025	

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

Table 7 Leaf brassica insecticide and molluscicide formulations - 2017

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

Insecticides	**Cabbages**		**Calabrese**		**Other brassicas[1]**		**Total 2017**	**Total 2017**	**2015[2]**	**2015[2]**
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Deltamethrin	0	0	0	0	2,136	60	**2,136**	**16**	1,589	12
Indoxacarb	0	0	1,335	67	2,508	82	**3,843**	**98**	2,331	60
Lambda-cyhalothrin	0	0	2,467	90	3,850	82	**6,317**	**34**	5,518	33
Pymetrozine	0	0	0	0	1,982	52	**1,982**	**396**	692	138
Spinosad	0	0	36	2	0	0	**36**	**3**	0	0
Spirotetramat	0	0	0	0	2,084	64	**2,084**	**156**	1,265	95
Thiacloprid	0	0	461	12	1,278	61	**1,739**	**167**	1,087	104
All insecticides	**0**	**0**	**4,299**	**92**	**13,839**	**97**	**18,137**	**871**	**14,560**	840
Molluscicides										
Ferric phosphate	0	0	0	0	4,837	58	**4,837**	**738**	1,936	332
Metaldehyde	254	81	691	12	3,817	76	**4,762**	**765**	3,403	501
All molluscicides	**254**	**81**	**691**	**12**	**8,654**	**76**	**9,599**	**1,504**	**5,742**	**893**
Area grown	313		1,995		1,796		**4,104**		3,025	

(1) Other brassicas include broccoli, Brussels sprouts, cauliflower and kale
(2) For full list of formulations recorded in 2015 please refer to the 2015 report[3]

Table 8 Leaf brassica fungicide and sulphur formulations - 2017

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

Fungicides	Cabbages		Calabrese		Other brassicas[1]		Total 2017	Total 2017	2015	2015
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Azoxystrobin	508	81	1,809	91	776	28	**3,093**	**742**	1,559	390
Azoxystrobin/difenoconazole	0	0	0	0	927	52	**927**	**301**	714	232
Boscalid/pyraclostrobin	341	55	1,207	61	1,159	57	**2,708**	**861**	1,221	385
Chlorothalonil/metalaxyl-M	0	0	0	0	799	44	**799**	**429**	21	17
Copper oxychloride	0	0	2,279	61	698	30	**2,976**	**1,466**	5,258	1,980
Difenoconazole	0	0	0	0	927	52	**927**	**70**	464	35
Fluopicolide/propamocarb hydrochloride	0	0	230	12	59	3	**290**	**318**	376	414
Iprodione	0	0	0	0	1,588	44	**1,588**	**715**	822	389
Mancozeb/metalaxyl-M	171	55	0	0	0	0	**171**	**174**	0	0
Prothioconazole	0	0	0	0	2,757	58	**2,757**	**529**	1,356	260
Tebuconazole/trifloxystrobin	0	0	0	0	1,967	58	**1,967**	**531**	1,985	562
All fungicides	**1,020**	81	**5,526**	92	**11,656**	88	**18,202**	**6,136**	**13,776**	4,664
Sulphur	**0**	**0**	**812**	**41**	**185**	**5**	**997**	**1,448**	**1,276**	**1,215**
Area grown	313		1,995		1,796		**4,104**		3,025	

(1) Other brassicas include broccoli, Brussels sprouts, cauliflower and kale

Table 9 Leaf brassica herbicide formulations - 2017

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

Herbicides	Cabbages		Calabrese		Other brassicas[1]		Total 2017	Total 2017	2015[2]	2015[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Clomazone	254	81	1	<0.5	1,044	58	**1,300**	**93**	1,035	62
Cycloxydim	0	0	0	0	799	44	**799**	**160**	0	0
Dimethenamid-P/pendimethalin	0	0	0	0	111	6	**111**	**205**	0	0
Glyphosate	254	81	1,822	80	365	20	**2,441**	**2,828**	2,497	2,446
Metazachlor	278	89	1,838	92	1,822	88	**3,937**	**2,906**	2,504	1,832
Pendimethalin	254	81	490	25	1,170	65	**1,914**	**2,146**	1,526	1,791
All herbicides	**1,040**	**89**	**4,151**	**92**	**5,310**	**88**	**10,501**	**8,338**	**7,938**	**6,170**
Area grown	313		1,995		1,796		**4,104**		3,025	

(1) Other brassicas include broccoli, Brussels sprouts, cauliflower and kale
(2) For full list of formulations recorded in 2015 please refer to the 2015 report[3]

Table 10 Vegetables (excluding legumes and leaf brassicas) seed treatment formulations – 2017

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 2017	Total 2017	2015[2]	2015[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Cymoxanil/fludioxonil/metalaxyl-M	2,394	63	0	0	0	0	**2,394**	**7**	2,745	6
Tefluthrin	1,755	46	0	0	3	1	**1,758**	**106**	1,474	72
Thiamethoxam	0	0	361	25	0	0	**361**	**10**	724	66
Thiram	0	0	1,340	93	117	26	**1,457**	**3**	1,356	4
All seed treatments	**4,149**	63	**1,701**	96	**120**	26	**5,970**	**126**	**6,878**	148
Crops grown from transplant	0	0	0	0	195	43	**195**	**N/A**	141	N/A
No seed treatment	902	24	35	2	67	15	**1,004**	**N/A**	252	N/A
No information seed treatment[3]	489	13	20	1	0	0	**509**	**N/A**	0	N/A
Area grown	3,785		1,434		451		**5,669**			

(1) In 2017 other vegetable crops included beetroot, leeks, lettuce, parsnips, podded peas, pumpkin, rhubarb, sweetcorn and squash
(2) For full list of formulations recorded in 2015 please refer to the 2015 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 11 Vegetables (excluding legumes & leaf brassicas) insecticide, molluscicide and physical control formulations

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

Insecticides/nematicides	Carrots		Turnips & swedes		Other vegetable crops[1]		Total 2017	Total 2017	2015[2]	2015[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Deltamethrin	696	18	1,261	62	262	35	**2,219**	**9**	3,498	24
Indoxacarb	0	0	0	0	55	12	**55**	**1**	0	0
Lambda-cyhalothrin	7,417	76	1,016	21	177	23	**8,609**	**94**	10,166	115
Oxamyl	862	23	0	0	0	0	**862**	**1,600**	1,001	1,764
Pirimicarb	409	11	36	3	0	0	**446**	**65**	2,148	344
Pymetrozine	0	0	300	21	0	0	**300**	**45**	295	44
Spirotetramat	0	0	264	18	0	0	**264**	**12**	0	0
Thiacloprid	965	22	264	18	0	0	**1,228**	**118**	240	23
All insecticides/nematicides	**10,349**	**76**	**3,141**	**83**	**494**	**37**	**13,984**	**1,943**	**17,445**	**2,317**
Molluscicides										
Ferric phosphate	0	0	159	11	0	0	**159**	**33**	0	0
Metaldehyde	0	0	679	36	74	16	**753**	**118**	847	188
All molluscicides	**0**	**0**	**838**	**36**	**74**	**16**	**912**	**150**	**847**	**188**
Physical control										
Garlic	314	8	0	0	0	0	**314**	**2,117**	0	0
Area grown	3,785		1,434		451		**5,669**		5,142	

(1) In 2017 other vegetable crops included beetroot, leeks, lettuce, parsnips, podded peas, pumpkin, rhubarb, sweetcorn and squash
(2) For full list of formulations recorded in 2015 please refer to the 2015 report[3]

Table 12 Vegetables (excluding legumes and leaf brassicas) fungicide formulations - 2017

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

Fungicides	Carrots		Turnips & swedes		Other vegetable crops[1]		Total 2017	Total 2017	2015[2]	2015[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Azoxystrobin	0	0	1,547	85	162	25	**1,709**	**427**	3,851	874
Azoxystrobin/difenoconazole	469	12	0	0	137	15	**606**	**197**	2,083	608
Boscalid/pyraclostrobin	2,810	74	525	24	131	29	**3,465**	**1,147**	3,705	1,253
Cyprodinil/fludioxonil	2,024	53	0	0	47	11	**2,072**	**1,025**	2,271	1,134
Dimethomorph/mancozeb	0	0	0	0	137	15	**137**	**203**	233	346
Epoxiconazole/pyraclostrobin	0	0	0	0	83	19	**83**	**5**	0	0
Fenpropimorph	2,682	47	0	0	0	0	**2,682**	**2,012**	3,140	1,984
Fluopicolide/propamocarb hydrochloride	0	0	0	0	13	3	**13**	**15**	0	0
Isopyrazam	4,109	62	0	0	0	0	**4,109**	**508**	0	0
Mancozeb/metalaxyl-M	0	0	0	0	72	13	**72**	**93**	60	77
Mandipropamid	0	0	0	0	77	15	**77**	**11**	81	12
Metalaxyl-M	2,136	56	0	0	0	0	**2,136**	**1,135**	2,245	1,183
Prothioconazole	3,604	52	988	30	205	15	**4,798**	**915**	6,017	1,154
Tebuconazole/trifloxystrobin	897	20	0	0	0	0	**897**	**202**	1,149	265
All fungicides	**18,731**	**76**	**3,060**	**85**	**1,064**	**57**	**22,856**	**7,896**	**28,215**	**10,248**
Area grown	3,785		1,434		451		**5,669**		5,142	

(1) In 2017 other vegetable crops included beetroot, leeks, lettuce, parsnips, podded peas, pumpkin, rhubarb, sweetcorn and squash
(2) For full list of formulations recorded in 2015 please refer to the 2015 report[3]

Table 13 Vegetables (excluding legumes and leaf brassicas) herbicide formulations - 2017

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

Herbicides	Carrots		Turnips & swedes		Other vegetable crops[1]		Total 2017	Total 2017	2015[2]	2015[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Clethodim	540	14	0	0	0	0	**540**	**95**	0	0
Clomazone	2,713	72	1,403	98	0	0	**4,116**	**252**	4,039	290
Clopyralid	0	0	550	20	0	0	**550**	**57**	512	85
Cycloxydim	0	0	324	23	0	0	**324**	**73**	132	33
Dimethenamid-P/metazachlor	0	0	1,057	74	0	0	**1,057**	**630**	0	0
Dimethenamid-P/pendimethalin	0	0	0	0	68	15	**68**	**59**	125	82
Diquat	35	1	0	0	17	4	**52**	**14**	403	78
Ethofumesate	0	0	0	0	83	19	**83**	**17**	21	21
Fluazifop-P-butyl	59	2	0	0	0	0	**59**	**15**	0	0
Glyphosate	570	13	264	18	35	8	**869**	**894**	66	35
Linuron	5,966	63	0	0	135	15	**6,101**	**1,577**	8,771	2,404
Metamitron	0	0	0	0	167	19	**167**	**161**	330	692
Metazachlor	0	0	56	4	0	0	**56**	**38**	1,352	995
Metribuzin	3,101	42	0	0	0	0	**3,101**	**471**	2,623	423
Pendimethalin	3,609	76	0	0	116	26	**3,725**	**4,965**	3,718	5,113

Cont…

Table 13 Vegetables (excluding legumes and leaf brassicas) herbicide formulations continued

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

Herbicides	Carrots		Turnips & swedes		Other vegetable crops[1]		Total 2017	Total 2017	2015[2]	2015[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Phenmedipham	0	0	0	0	83	19	**83**	**13**	0	0
Propaquizafop	1,221	32	0	0	0	0	**1,221**	**171**	1,134	169
Propyzamide	0	0	0	0	74	16	**74**	**104**	81	61
Prosulfocarb	422	11	0	0	67	7	**489**	**752**	2,511	4,367
S-metolachlor	0	0	300	21	66	12	**366**	**416**	378	508
All herbicides	**18,237**	**76**	**3,954**	**99**	**914**	**60**	**23,105**	**10,775**	**28,745**	**15,586**
Area grown	3,785		1,434		451		**5,669**		5,142	

1) In 2017 other vegetable crops included beetroot, leeks, lettuce, parsnips, podded peas, pumpkin, rhubarb, sweetcorn and squash
2) For full list of formulations recorded in 2015 please refer to the 2015 report[3]

Table 14 Compounds encountered in the vegetable survey for the first time in 2017

Active substance	Type[1]	Area (ha)	Weight (kg)
Isopyrazam	F	4,109	508
Clethodim	H	540	95
Epoxiconazole	F	83	1

(1) Pesticide type = F: Fungicide and H: Herbicide

Table 15 Mode of action/chemical group of insecticide & nematicide active substances - 2017

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) inhibitors	Oxamyl	Carbamate	1A	862	1,600
	Pirimicarb	Carbamate	1A	6,585	866
All AChE inhibitors				**7,447**	**2,465**
Sodium channel modulators	Deltamethrin	Pyrethroid	3A	4,879	29
	Lambda-cyhalothrin	Pyrethroid	3A	17,865	150
All sodium channel modulators				**22,744**	**178**
Nicotinic acetylcholine receptor (nAChR) competitive modulators	Thiacloprid	Neonicotinoid	4A	2,968	285
Nicotinic acetylcholine receptor (nAChR) allosteric modulators	Spinosad	Spinosyns	5	36	3
Chordotonal organ TRPV channel modulators	Pymetrozine	Pyridine azomethine derivative	9B	2,282	441
Voltage-dependent sodium channel blockers	Indoxacarb	Oxadiazine	22A	3,898	99
Inhibitors of acetyl CoA carboxylase	Spirotetramat	Tetramic acid	23	2,347	168
All other modes of action				**11,531**	**997**
All insecticides				**41,722**	**3,641**
Area grown[(1)]				19,359	

(1) includes multi-cropping

Note: Active substances have been grouped by their mode of action. Full details on mode of action classification can be found on the Insecticide Resistance Action Committee (IRAC) webpage[(7)]

Table 16 Mode of action/chemical group of fungicide active substances - 2017

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	3,411	1,067
All amino acids & protein synthesis					**3,411**	**1,067**
Cell wall biosynthesis	Dimethomorph	Carboxylic acid amide	Morpholine	40	137	21
	Mandipropamid	Carboxylic acid amide	Mandelic acid amide	40	77	11
All cell wall biosynthesis					**214**	**32**
Cytoskeleton and motor proteins	Fluopicolide	Benzamide	pyridinylmethyl-benzamide	43	303	30
All cytoskeleton and motor proteins					**303**	**30**
Lipid synthesis and membrane integrity	Propamocarb hydrochloride	Carbamate	Carbamate	28	303	303
All lipid synthesis & membrane integrity					**303**	**303**
Multi-site contact activity	Copper oxychloride	Inorganic	Inorganic	M01	2,976	1,466
	Mancozeb	Dithiocarbamate	Dithiocarbamate	M03	379	434
	Chlorothalonil	Chloronitrile	Chloronitrile	M05	2,050	1,520
All multi-site contact activity					**5,406**	**3,420**
Nucleic acid synthesis	Metalaxyl-M	Phenylamide	Acylalanines	4	4,429	1,264
All nucleic acid synthesis					**4,429**	**1,264**

Cont…

Table 16 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	10,461	2,543
	Isopyrazam	SDHI	pyrazole-4-carboxamides	7	4,109	508
	Azoxystrobin	Qo inhibitor	Strobilurin	11	10,368	2,348
	Pyraclostrobin	Qo inhibitor	Strobilurin	11	10,545	642
	Trifloxystrobin	Qo inhibitor	Strobilurin	11	2,864	244
All respiration					**38,347**	**6,285**
Signal transduction	Iprodione	Dicarboximide	Dicarboximide	2	1,588	715
	Fludioxonil	Phenylpyrroles	Phenylpyrroles	12	3,411	711
All signal transduction					**4,999**	**1,426**
Sterol biosynthesis in membranes	Difenoconazole	Demethylation inhibitor	Triazole	3	2,459	261
	Epoxiconazole	Demethylation inhibitor	Triazole	3	83	1
	Prothioconazole	Demethylation inhibitor	Triazolinthione	3	7,554	1,444
	Tebuconazole	Demethylation inhibitor	Triazole	3	4,870	809
	Fenpropimorph	Morpholine	Morpholine	5	2,682	2,012
All sterol biosynthesis in membranes					**17,650**	**4,528**
All fungicides					**75,061**	**18,356**
Multi-site contact activity	Sulphur	Inorganic	Inorganic	M02	2,429	7,174
Area grown[(1)]					19,359	

(1) Includes multi-cropping. Note: Active substances have been grouped by their mode of action. Full details on mode of action classification can be found on the Fungicide Resistance Action Committee (FRAC) webpage[(8)]

Table 17 Mode of action/chemical group of herbicide active substances - 2017

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

Mode of Action	Active substance	Chemical Group	HRAC Group	Total Vegetables	Total Vegetables
				ha	kg
Inhibition of acetyl CoA carboxylase	Clethodim	Cyclohexanedione	A	540	95
	Cycloxydim	Cyclohexanedione	A	1,123	232
	Fluazifop-P-butyl	Aryloxyphenoxy-propionate 'FOPs'	A	59	15
	Propaquizafop	Aryloxyphenoxy-propionate 'FOPs'	A	1,221	171
All Inhibition of acetyl CoA carboxylase				**2,943**	**514**
Inhibition of acetolactate synthase ALS	Imazamox	Imidazolinone	B	7,715	450
All inhibition of acetolactate synthase ALS				**7,715**	**450**
Inhibition of photosynthesis at photosystem II	Metamitron	Triazinone	C1	167	161
	Metribuzin	Triazinone	C1	3,101	471
	Phenmedipham	Phenyl-carbamate	C1	83	13
	Linuron	Urea	C2	6,960	2,007
	Bentazone	Benzothiadiazinone	C3	1,593	1,111
All inhibition of photosynthesis at photosystem II				**11,904**	**3,763**
Photosystem-I-electron diversion	Diquat	Bipyridylium	D	52	14
All photosystem-I-electron diversion				**52**	**14**
Bleaching: DOXP inhibitors	Clomazone	Isoxazolidinone	F4	6,275	423
All bleaching: DOXP inhibitors				**6,275**	**423**
Inhibition of EPSP synthase	Glyphosate	Glycine	G	4,511	4,719
All inhibition of EPSP synthase				**4,511**	**4,719**

Cont…

Table 17 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	Total Vegetables	Total Vegetables
				ha	kg
Microtubule assembly inhibition	Pendimethalin	Dinitroaniline	K1	13,533	13,991
	Propyzamide	Benzamide	K1	74	104
All microtubule assembly inhibition				**13,608**	**14,095**
Inhibition of VLCFAs	Dimethenamid-P	Chloroacetamide	K3	1,236	436
	Metazachlor	Chloroacetamide	K3	5,050	3,259
	S-metolachlor	Chloroacetamide	K3	366	416
All Inhibition of VLCFAs				**6,652**	**4,112**
Inhibition of lipid synthesis	Ethofumesate	Benzofuran	N	83	17
	Prosulfocarb	Thiocarbamate	N	489	752
All inhibition of lipid synthesis				**573**	**768**
Action like indole acetic acid	Clopyralid	Pyridine carboxylic acid	O	550	57
	MCPB	Pyridine carboxylic acid	O	1,384	2,425
All action like indole acetic acid				**1,934**	**2,483**
All herbicides				**56,166**	**31,340**
Area grown[(1)]				19,359	

(1) includes multi-cropping

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

Table 18 Principal active substances by area treated

Area treated (ha) of the 20 most used active substances on all vegetable crops surveyed

	Active substance	Type[(1)]	2017	2015	% change
1	Lambda-cyhalothrin	I	17,865	18,622	-4
2	Metalaxyl-M	F/S	14,633	15,433	-5
3	Fludioxonil	F/S	13,612	14,762	-8
4	Pendimethalin	H	13,533	13,138	3
5	Pyraclostrobin	F	10,545	9,528	11
6	Boscalid	F	10,461	9,528	10
7	Azoxystrobin	F	10,368	12,786	-19
8	Cymoxanil	S	10,201	10,535	-3
9	Imazamox	H	7,715	7,768	-1
10	Prothioconazole	F	7,554	7,373	2
11	Linuron	H	6,960	9,500	-27
12	Pirimicarb	I	6,585	12,990	-49
13	Clomazone	H	6,275	5,804	8
14	Metaldehyde	M	5,516	4,250	30
15	Metazachlor	H	5,050	3,856	31
16	Ferric Phosphate	M	4,996	1,936	158
17	Deltamethrin	I	4,879	5,086	-4
18	Tebuconazole	F	4,870	8,694	-44
19	Glyphosate	H	4,511	4,265	6
20	Isopyrazam	F	4,109	0	

Table 19 Principal active substances by weight

Weight (kg) of the 20 most used active substances on all vegetable crops surveyed

	Active substance	Type[(1)]	2017	2015	% change
1	Pendimethalin	H	13,991	13,574	3
2	Sulphur	SU	7,174	6,335	13
3	Glyphosate	H	4,719	3,900	21
4	Metazachlor	H	3,259	2,826	15
5	Boscalid	F	2,543	2,291	11
6	MCPB	H	2,425	1,190	104
7	Azoxystrobin	F	2,348	2,571	-9
8	Garlic	P	2,117	0	
9	Fenpropimorph	F	2,012	1,984	1
10	Linuron	H	2,007	2,769	-28
11	Metalaxyl-M	F/S	1,762	1,778	-1
12	Oxamyl	I/N	1,600	1,764	-9
13	Chlorothalonil	F	1,520	1,812	-16
14	Copper oxychloride	F	1,466	2,047	-28
15	Prothioconazole	F	1,444	1,414	2
16	Bentazone	H	1,111	1,661	-33
17	Cyprodinil	F	1,067	1,336	-20
18	Metaldehyde	M	883	689	28
19	Pirimicarb	I	866	1,793	-52
20	Fludioxonil	F/S	854	1,020	-16

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

Table 20 Total vegetable crop, comparison with previous years

Pesticide usage in 2013, 2015 and 2017, area treated with formulations and active substances (a.s.) and the weight (kg) applied

	2013			2015			2017		
	Formulations	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**
	ha	**ha**	**kg**	**ha**	**ha**	**kg**	**ha**	**ha**	**kg**
Insecticides	41,273	41,273	3,992	44,468	44,468	4,240	41,722	41,722	3,641
Molluscicides	7,589	7,589	1,313	6,589	6,589	1,081	10,512	10,512	1,654
Biological agents[1]	154	154	N/A	0	0	0	0	0	0
Biopesticides	0	0	0	82	82	2	0	0	0
Fungicides	42,753	58,228	13,796	58,702	81,890	20,429	53,977	75,061	18,356
Sulphur	1,495	1,495	5,341	2,556	2,556	6,335	2,429	2,429	7,174
Herbicides	41,424	48,880	26,379	50,079	58,701	33,513	46,357	56,166	31,340
Growth regulators	0	0	0	104	104	500	0	0	0
Physical control	312	312	1,048	0	0	0	314	314	2,117
Seed treatments[1]	14,622	33,141	1,153	16,373	37,444	1,203	15,552	36,464	1,293
All pesticides	**149,623**	**191,073**	**53,022**	**178,953**	**231,834**	**67,303**	**170,863**	**222,668**	**65,575**
Area grown	15,968[2]			16,672[3]			19,359[4]		

(1) No weights can be calculated for biological control agents and biological seed treatments
(2) Includes 66 hectares of multi-cropping
(3) No multi-cropping was encountered in 2015
(4) Includes 23 hectares of multi-cropping

Appendix 2 – Survey statistics

Census and sample information

Table 21 Census crop areas 2017

Census area (ha) of vegetable crops grown in Scotland

	Scotland 2017	Scotland 2015	% change
Vining Peas	7,808	7,029	11
Broad beans	1,767	1,469	20
Brussels Sprouts	1,040	776	34
Cabbages	278	204	36
Calabrese	1,794	1,513	19
Carrots	3,752	2,877	30
Cauliflower	330	218	51
Leeks	68	84	-19
Lettuce	93	87	8
Rhubarb	75	71	5
Turnips & Swedes	1,413	1,479	-4
All vegetable Crops[(1)]	**19,336**	**16,672**	**16**

(1) Includes other vegetable crops
Note: Data taken from the 2017 and 2015 June Agricultural Census

Table 22 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	1	1	2	1	1	0	1	0	**11**
10-19.9	0	0	1	1	6	4	0	1	2	**15**
20-29.9	0	0	1	1	3	1	1	1	1	**9**
30-39.9	0	0	1	0	4	2	0	0	1	**8**
>40	0	0	1	0	4	2	1	1	1	**10**
All sizes	**4**	**1**	**5**	**4**	**18**	**10**	**2**	**4**	**5**	**53**

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

Table 23 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	2	0	0	1	0	**3**
10-19.9	7	1	1	2	1	**12**
20-29.9	4	1	0	1	2	**8**
30-39.9	1	0	0	2	1	**4**
>40	2	0	0	1	1	**4**
All sizes	**16**	**2**	**1**	**7**	**5**	**31**

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

Table 24 Sampled areas (vegetables excluding peas)

Areas (ha) of vegetable crops grown in sample

Size[1] (ha)	Scotland[2]
0.1-9.9	63
10-19.9	208
20-29.9	206
30-39.9	248
>40	415
All sizes	**1,140**

Table 25 Census areas (vegetables excluding peas)

Areas (ha) of vegetable crops grown in Scotland

Size[1] (ha)	Scotland[2]
0.1-9.9	1,718
10-19.9	3,704
20-29.9	2,373
30-39.9	1,315
>40	2,419
All sizes	**11,529**

Table 26 Sampled areas (peas)

Areas (ha) of peas grown in sample

Size[3] (ha)	Scotland[2]
0.1-9.9	25
10-19.9	261
20-29.9	242
30-39.9	160
>40	226
All sizes	**913**

Table 27 Census areas (peas)

Areas (ha) of peas grown in Scotland

Size[3] (ha)	Scotland[2]
0.1-9.9	888
10-19.9	2,889
20-29.9	1,548
30-39.9	835
>40	1,649
All sizes	**7,808**

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(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 28 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	5.09	2.49	20.56	12.29	71.91	36.46	N/A	34.82	N/A
10-19.9	N/A	N/A	31.51	12.86	14.68	11.99	N/A	26.88	13.72
20-29.9	N/A	N/A	15.19	4.94	8.71	24.64	14.89	9.09	6.91
30-39.9	N/A	N/A	18.42	N/A	2.82	4.58	N/A	N/A	1.96
>40	N/A	N/A	14.23	N/A	4.28	5.84	10.92	4.93	5.59

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

Table 29 Raising factors (peas)

Size [1] (ha)	Angus	East Fife	Lothian	Central Lowlands	Tweed Valley
0.1-9.9	43.82	N/A	N/A	10.80	N/A
10-19.9	9.74	21.25	7.78	15.27	11.59
20-29.9	7.49	4.18	7.49	4.90	5.41
30-39.9	12.49	1.00	N/A	2.06	7.95
>40	6.82	N/A	N/A	2.79	13.62

(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 30 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	0.82	N/A	N/A	N/A	5.02	1.50
Brussels sprouts	N/A	N/A	N/A	N/A	N/A	1.92	1.46	N/A	N/A	1.37
Cabbages	2.28	N/A	N/A	N/A	N/A	0.65	N/A	N/A	N/A	3.37
Calabrese	N/A	N/A	N/A	N/A	1.87	0.64	N/A	N/A	0.43	1.07
Carrots	0.44	0.44	0.89	4.57	1.53	2.39	0.30	0.62	0.27	1.01
Cauliflower	N/A	N/A	N/A	N/A	0.14	N/A	N/A	N/A	N/A	7.70
Leeks	N/A	N/A	N/A	N/A	N/A	N/A	0.57	N/A	N/A	1.66
Lettuce	N/A	N/A	N/A	N/A	N/A	0.64	N/A	N/A	N/A	1.86
Other Vegetables	6.37	0.90	N/A	N/A	0.42	0.53	N/A	N/A	0.18	1.78
Rhubarb	N/A	N/A	N/A	N/A	N/A	N/A	N/A	0.23	N/A	1.24
Turnips & Swedes	0.97	1.32	N/A	0.25	0.75	N/A	0.32	1.43	1.55	1.13
Vining peas	N/A	N/A	N/A	N/A	1.00	1.10	1.47	1.00	1.03	1.00

N/A = not applicable

Response rates

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

Table 31 Response rate

	2017	% total
Target sample vegetables	60	100
Target sample vining peas	30	100
Total achieved vegetables	**53**	**88**
Total achieved vining peas	**31**	**103**
Total number of refusals/non-contact	41	
Total number of farms approached	**125**	

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, where possible.

To determine the total burden that the 2017 outdoor vegetable crop survey placed on those providing the information, the surveyors recorded the time that 39 respondents spent providing the data during the surveys. This sample represents 46 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 £13.98)[10]

The total financial burden to all growers resulting from participation in the 2017 outdoor vegetable crop survey was calculated to be £196.

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) **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.

14) **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.

15) 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.

16) 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.

17) 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.

18) The **June Agricultural Census**[11] 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.

19) 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.

20) 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**.

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

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

23) Data from the 2015[(3)] and 2013[(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 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.

24) When leaf brassicas are referred to in the text, this includes, cabbage, calabrese and other brassicas. Other brassicas includes broccoli, Brussels sprouts, cauliflower and kale. Crops encountered in the 'other vegetable' category in the 2017 survey were beetroot, parsnips, podded peas, pumpkin, sweetcorn and squash. For reporting purposes, the data for leeks, lettuce and rhubarb have also been presented under the 'other vegetable' category.

25) 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.

Appendix 4 – Survey methodology

Sampling and data collection

Using the June 2017 Agricultural Census[11], 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.

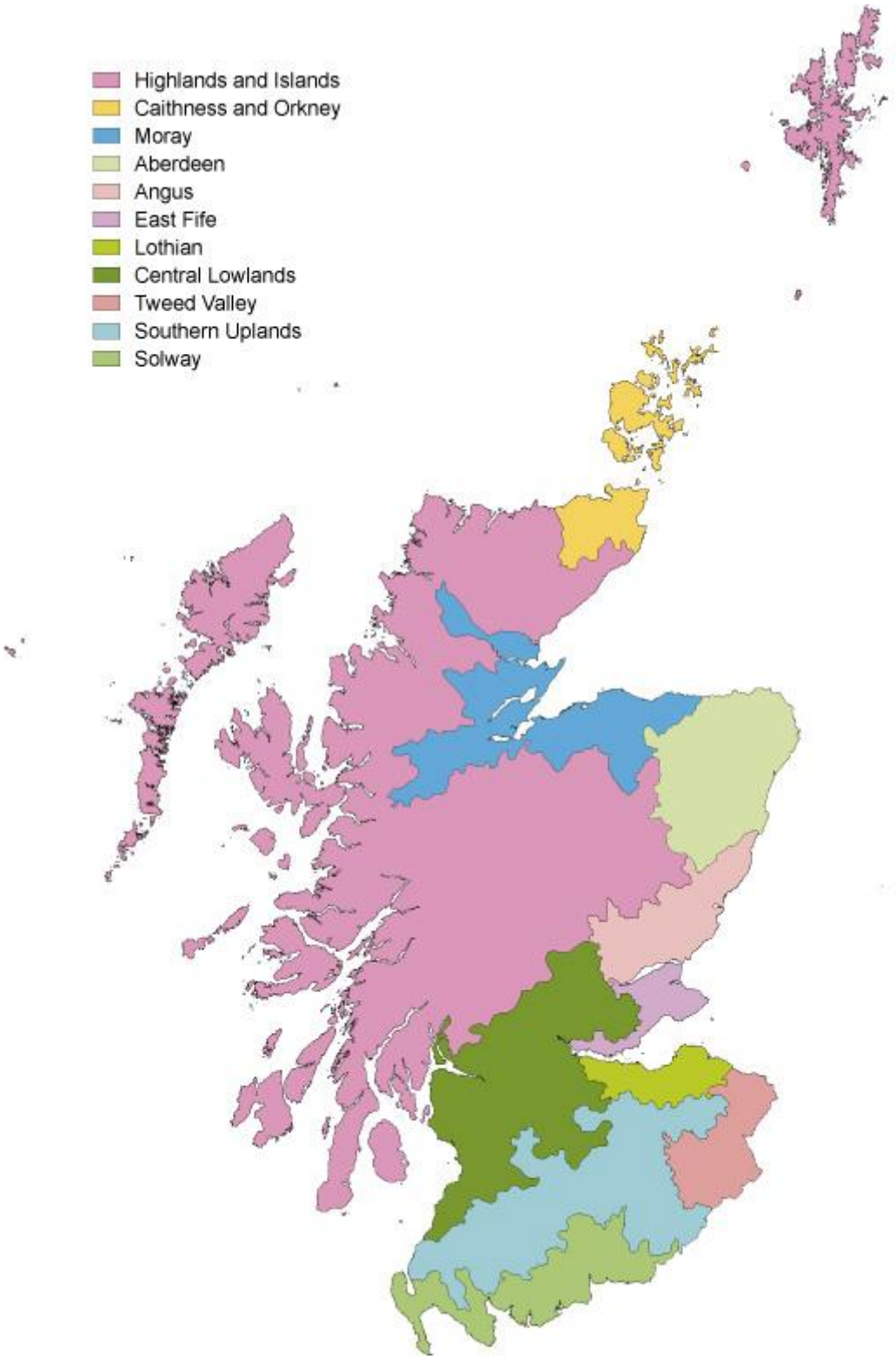
The survey covered pesticide applications to vegetable crops where all or the majority of the growing season was in 2017. As well as recording treatments applied directly to the crop, data was also collected on land preparation treatments prior to sowing or planting the crop.

Following an introductory letter and phone call, data were collected during a phone interview or by email. Where necessary, information was also collected from agronomists and contractors. In total, information was collected from 53 holdings growing vegetable crops and 31 holdings growing only peas (Tables 22 & 23). These 84 holdings represent 11 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 28 & 29). 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 30) 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[12]



Changes from previous years

There are a number of changes which should be noted when comparing the 2017 data with the previous survey.

The areas and weights treated with individual active substances are no longer included at crop level in this report. These data are now published separately as supplementary tables in Excel format to allow continued user access to the full dataset. In this report, the areas treated and weights of pesticide formulations (mixture of active substances in a product) by crop are presented in Tables 2-13 and summary active substance data are presented in Tables 15 to 20. The aim of this change is to focus on the key metrics at crop level and reduce the size of the published report. This approach is consistent with the output from the other UK pesticide survey teams.

For the first time, Brussels sprouts have been included in the 'other brassica' category. This is due to too few crops being encountered in the holdings sampled in 2017 to adequately represent usage. This must be taken into account when comparing other brassica data between surveys.

The previous report contained information about grower adoption of Integrated Pest Management (IPM). IPM data was not collected during the 2017 survey. It is anticipated that IPM data will be collected and published every 4 years. This allows IPM uptake to be monitored over time but reduces the burden on, growers and surveyors.

It should also be noted that the total number of refusals to participate in this voluntary survey increased from 18 per cent in 2015 to 33 per cent in 2017. This has resulted in a 2017 sample size 12 per cent lower than target. This trend in decreased participation has been noted in our surveys in all crop sectors and it is possible that reduced sample size has influenced the estimates made in this report (please refer to appendix 5).

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 9001:2008. All survey related processes are documented in Standard Operating Procedures (SOPs) and our output is audited against these SOPs by internal auditors annually and by external auditors every three years.

Main sources of bias

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 32). 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 32) 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 32) was ten per cent for area and seven per cent for weight, compared with seven and eight per cent respectively in 2015. For constituent crop groups, the RSE varied from three to 29 per cent for area and four to 56 per cent for weight, varying with sample size and uniformity of pesticide regime encountered. For Brussels sprouts, cauliflower, leeks, lettuce, other vegetables and rhubarb, a standard error could not be calculated due to too few active ingredients being recorded; therefore pesticide estimates for these crops should be treated with caution. These standard errors, particularly at individual crop level are higher than in previous surveys. This may have been influenced by the reduced sample size which is a result of an increase in farmer non-participation rates. Higher standard errors mean that there is more uncertainty associated with estimates of pesticide use.

Table 32 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]	9	10
Brussel sprouts[2]	NC	NC
Cabbages[1]	3	1
Calabrese[1]	3	7
Carrots[1]	16	22
Cauliflower[2]	NC	NC
Leeks[2]	NC	NC
Lettuce[2]	NC	NC
Other vegetables[2]	NC	NC
Rhubarb[2]	NC	NC
Turnips & swedes[1]	29	56
Vining peas	5	8
All vegetable crops	**10**	**7**

(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 Brussel sprouts, 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

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