Scottish Government
Riaghaltas na h-Alba

Pesticide Usage in Scotland

A National Statistics Publication for Scotland

Outdoor Vegetable Crops 2021

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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 2021. The crops surveyed included vining peas, broad beans, Brussels sprouts, calabrese, carrots, turnips & swedes and other minor vegetable crops.

In 2021 the census area of outdoor vegetable crops grown in Scotland was approximately 22,100 hectares. This represents an 18 per cent increase in area from the previous survey in 2019 and a 14 per cent increase from 2017. The principal outdoor vegetable crops grown in Scotland were peas and beans accounting for 53 per cent of the cropped area. Leaf brassicas accounted for 17 per cent, carrots 16 per cent, turnips & swedes seven per cent and other vegetable crops six per cent.

Data was collected from a total of 73 holdings, representing 10 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 was ca. 149,200 ha (± 9 per cent Relative Standard Error, RSE) with a combined weight of ca. 53.6 tonnes (± 9 per cent RSE). Overall, pesticides were applied to 89 per cent of the vegetable crop area, a decrease from 96 per cent in 2019. Herbicides were applied to 84 per cent of the crop area, fungicides to 75 per cent, insecticides to 42 per cent, molluscicides to 13 per cent and 28 per cent of seed was treated.

Taking into account changes in crop area, the 2021 total pesticide treated area was 28 per cent lower than that reported in the previous survey in 2019 and 23 per cent lower than in 2017. The weight of pesticides applied to vegetable crops per hectare was 38 per cent lower in 2021 than in 2019 and 28 per cent less when compared to 2017. The application of fungicides, insecticides, herbicides, seed treatments and growth regulators have decreased since 2019 (20, 41,16, 64 and 68 per cent decreases in treated area respectively). The area treated with molluscicides was similar in 2019 and 2021. An increase in the use of physical control agents was recorded in 2021 with area treated 193 per cent higher than in 2019. Overall, pesticide application to vegetable crops was substantially lower in 2021 than in 2019 and 2017. This decline in overall pesticide use in 2021 may have been influenced by a number of factors such as the withdrawal of a number of key active substances from the market reducing pesticide availability, and possibly driving greater use of integrated control strategies. The cold, dry, late spring, and dry summer may also have helped reduce pest and pathogen pressure on crops in 2021, reducing the need for pesticide application.

In terms of area treated, the most used foliar fungicide active substances were boscalid and pyraclostrobin. 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. The herbicide bromoxynil, the nematicide fluopyram and fungicides fluxapyroxad, oxathiapiprolin and benthiavalicarb were recorded for the first time on outdoor vegetable crops in this survey.

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, or visit the Fera pesticide usage survey webpage.

The Scottish Pesticide Usage reports have been designated as Official Statistics since August 2012 and as National Statistics since October 2014. The interim Chief Statistician (Ally McAlpine) 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 SASA privacy policies and SASA revision policies, a pesticide usage report feedback survey and detailed background information on the survey methodology used and uses of the PSU pesticide usage dataset.

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

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 2021. 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.

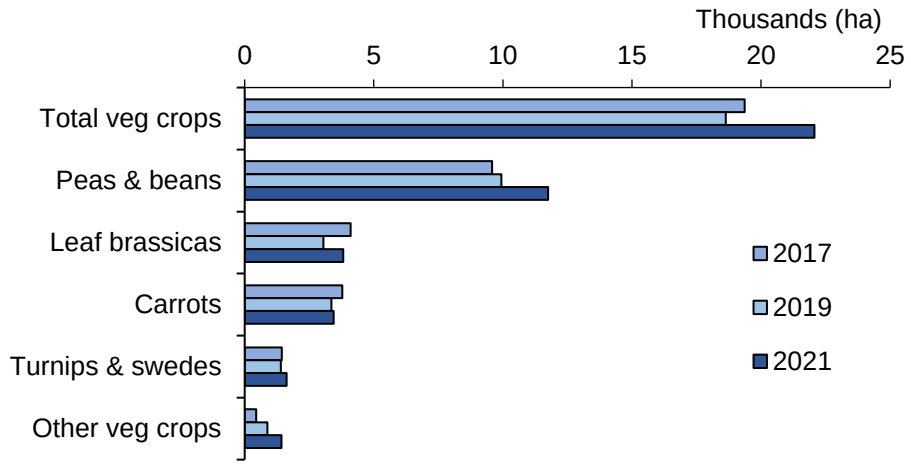
General trends

Crop area

In 2021 the census area of outdoor vegetable crops grown in Scotland was 22,066 hectares (Table 20). This represents an 18 per cent increase in cropped area from 2019[3] and a 14 per cent increase from 2017[4]. Since the last survey, census areas of all vegetable crops have increased (Figure 1). The largest increases were seen for cauliflower (97 per cent), leeks (46 per cent), broad beans (27 per cent) and Brussels sprouts (26 per cent) (Table 20).

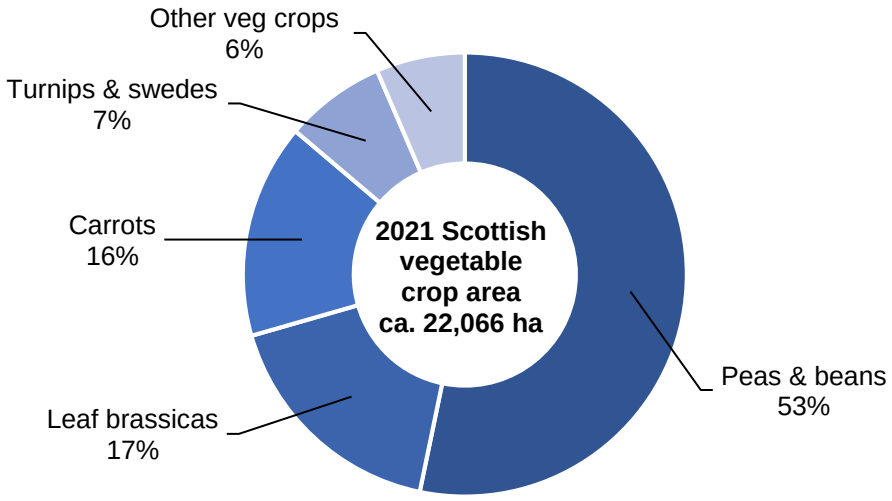
In 2021 peas and beans accounted for 53 per cent of the outdoor vegetable crop area, leaf brassicas 17 per cent, carrots 16 per cent, turnips & swedes seven per cent and other vegetables six per cent (Figure 2).

Figure 1 Area of vegetable crops grown in Scotland 2017-2021



Note: areas do not include multi-cropping.

Figure 2 Vegetable crop area 2021 (percentage of total area)



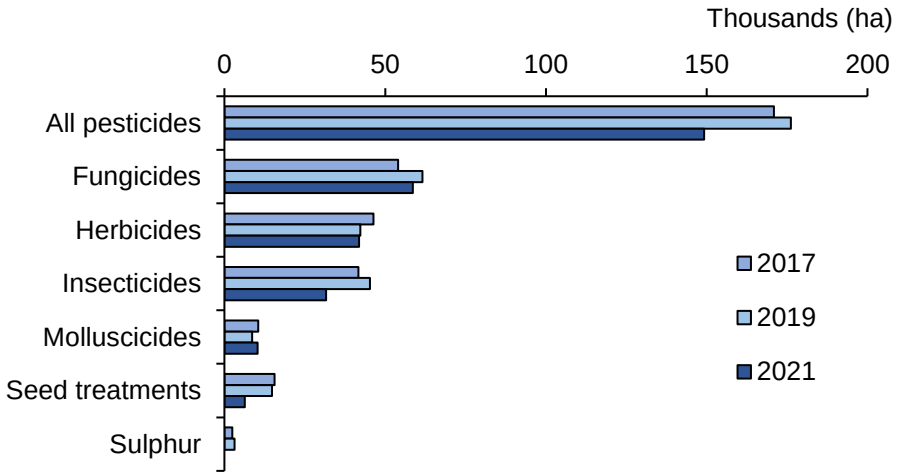
Note: areas do not include multi-cropping.

Pesticide usage

In 2021, 89 per cent of vegetable crops received a pesticide treatment, a decrease from the 2019 figure of 96 per cent and a slight decrease from the 2017 figure of 93 per cent. The crops receiving the highest overall treatments proportionally were Brussels sprouts, calabrese and vining peas (97 to 100 per cent, Table 1). Other vegetable crops, turnips & swedes, carrots and other brassica crops had the lowest proportion of treated crop (88, 77, 73 and 62 per cent treated respectively) (see Appendix 3 – definitions and notes, for the list of crops included in the 'other vegetable' and 'other brassica' crop categories). The treated area of crops received on average 5.2 applications compared to 5.3 in 2019 and 5.4 in 2017. The highest average number of applications were to Brussels sprouts with 17.4s and the lowest number were to vining peas at 2.1 applications (Table 1).

The estimated area of outdoor vegetables treated with a pesticide formulation was ca. 149,200 hectares in 2021 compared with ca. 176,200 hectares in 2019 and ca. 170,900 hectares in 2017 (Table 19, Figure 3). This represents a decrease of 15 per cent since 2019 and a decrease of 13 per cent since 2017.

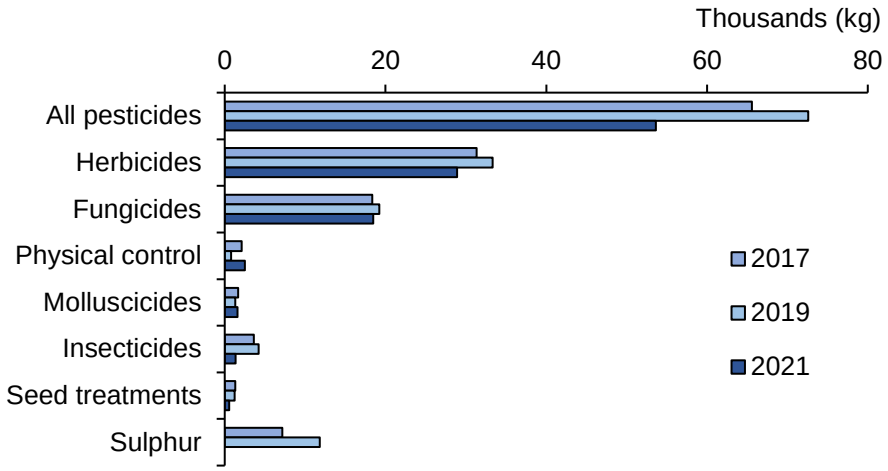
Figure 3 Area of vegetable crops treated with the major pesticide groups in Scotland 2017-2021



Note: physical control agents, biological control agents & growth regulators have been excluded as their use represents < 500 hectares. No sulphur was encountered in 2021.

The weight of pesticide applied was ca. 53.6 tonnes in 2021, a decrease of 26 per cent from 2019 (ca. 72.6 tonnes) and a decrease of 18 per cent from 2017 (ca. 65.6 tonnes) (Figure 4).

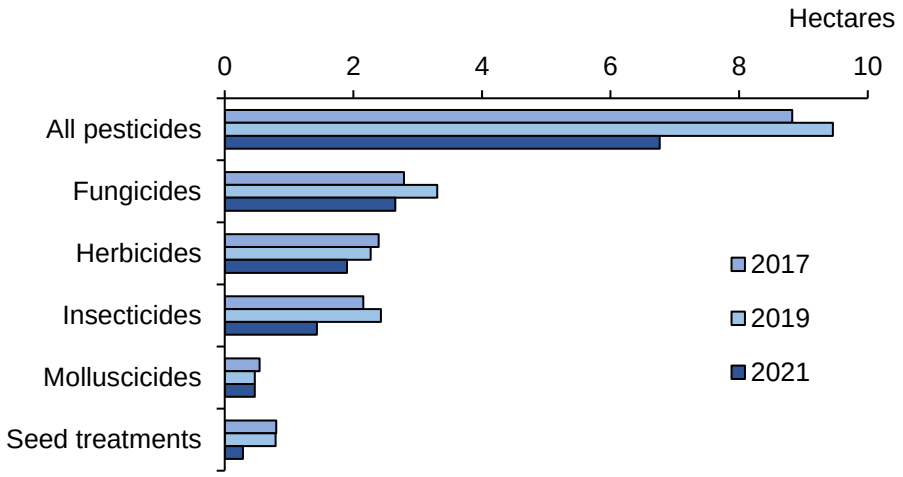
Figure 4 Weight of the major pesticide groups applied to vegetable crops in Scotland 2017-2021



Note: 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 (2019 only). No sulphur was encountered in 2021.

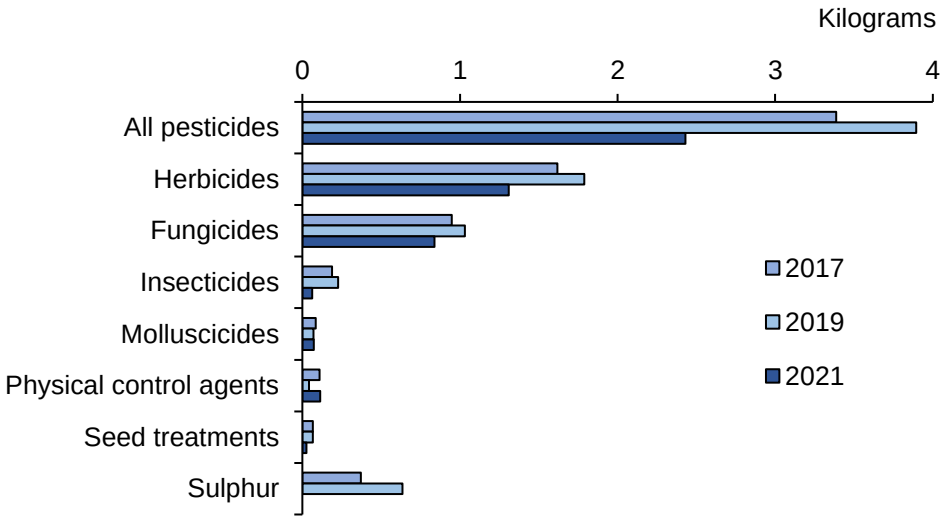
In order to make accurate comparisons between the 2021 data and that reported in previous surveys, it is important to take into account differences in crop areas between years. Therefore, the number of treated hectares per hectare of crop grown and the total weight of pesticide used per hectare of crop grown were calculated. In 2021, for each hectare of crop grown, almost 6.8 pesticide treated hectares were recorded (Figure 5). This represents a decrease of 28 per cent when compared to 2019 and a reduction of 23 per cent from 2017. The estimated weight of pesticide applied per hectare of crop grown in 2021 was slightly below two and a half kilograms (Figure 6). This represents a decrease of 38 per cent from 2019 and a decrease of 28 per cent from 2017. This decline in overall pesticide use in 2021 may have been influenced by a number of factors such as the continuing withdrawal of active substances from the market reducing pesticide availability, and possibly driving greater use of integrated control and unfavourable climatic conditions for pests and pathogens. In 2021, there was a cold, dry, late spring on the East of Scotland where the vast majority of vegetable crops are grown (ca. 1.1 and 1.8 degrees cooler than in spring 2019 and 2017 respectively). April 2021 received 56 and 14 per cent less rainfall than in 2019 and 2017 respectively. There was also 44 and 41 per cent less rainfall in summer 2021 than in summer 2019 and 2017 respectively[5]. This cold, dry, late spring, and dry summer may have helped reduce disease and weed pressure on crops in 2021.

Figure 5 Number of pesticide treated hectares (formulations) per hectare of crop grown in Scotland 2017-2021



Note: growth regulators, physical control & sulphur 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 2017-2021



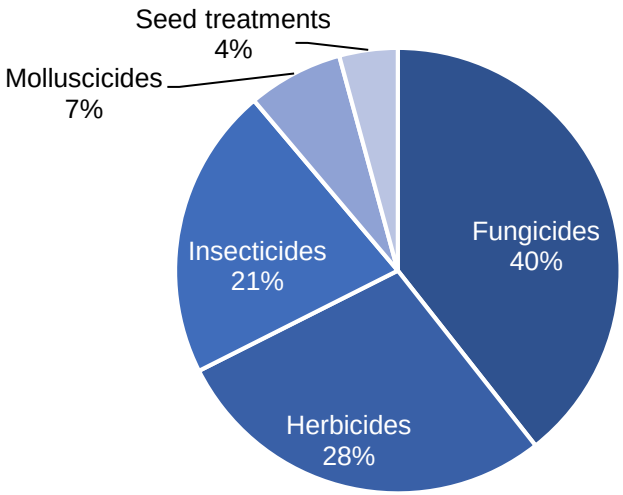
Note: growth regulators have been excluded as their use represents < 0.1 kg per hectare of crop grown.

As in 2019 & 2017, fungicides were the most frequently used pesticides by area treated, on outdoor vegetable crops (Figure 7). They were followed by herbicides and insecticides. Fungicides accounted for 40 per cent of total pesticide treated area and 35 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 20 per cent from 2019 to 2021 and decreased five per cent between 2017 and 2021 (Figure 5). From 2019 to 2021, there was a decrease of 19 per cent in the weight of fungicides used per hectare of crop grown, and a decrease of 12 per cent between 2017 and 2021 (Figure 6). The decreased use of fungicides in 2021 compared to the previous two surveys may have been influenced by a number of factors such as the weather and loss of active substances from the market. The cold, dry, spring and dry summer may have helped to reduce disease pressure on crops in 2021[5] and thus the need to apply fungicide sprays. In addition, since the previous survey, the fungicides fenpropimorph and chlorothalonil applied to 2,953 ha and 1,061 ha respectively in 2019 have been withdrawn from the market and were not available during the 2021 season. 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 11 per cent in terms of treated area when compared to the previous survey in 2019.

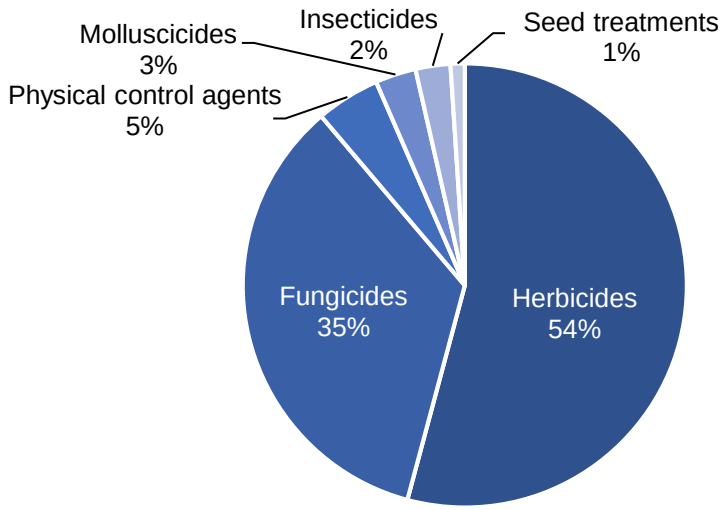
In 2021, herbicides accounted for 28 per cent of the total pesticide treated area and 54 per cent of the total weight of pesticides applied (Figures 7 & 8). When changes in crop area are taken into account, there was a decrease in area treated with herbicide formulations of 16 per cent from 2019 to 2021 and 21 per cent from 2017 and 2021 (Figure 5). In terms of weight of pesticide applied, when area of crop grown is taken into account, there was a decrease of 27 per cent from 2019 to 2021 and 19 per cent from 2017 to 2021 (Figure 6). The continuation of the bentazone stewardship campaign designed to promote responsible product use and sustainable on-farm water stewardship may have influenced the decline in the use of this active substance[6]. The area treated with bentazone, primarily applied to peas and beans, decreased by 26 per cent in 2021 compared with 2017 despite an increase in the area of crop grown (Table 17). When corrected for area of crop grown, the glyphosate treated area decreased by 25 per cent and the weight applied decreased by 19 per cent from 2019 to 2021. Glyphosate is applied both as an inter-row herbicide and as a before planting treatment to create stale seed beds. The cold, dry spring in 2021 reduced weed emergence before planting and resulted in less requirement for before planting treatments.

Figure 7 Use of pesticides on outdoor vegetable crops (percentage of total area treated with formulations) – 2021



Note: growth regulators and physical control have been excluded as their use represents < 0.5 per cent treated area.

Figure 8 Use of pesticides on outdoor vegetable crops (percentage of total weight of pesticides applied) – 2021



Note: growth regulators have been excluded as their use represents < 0.5 per cent quantity applied.

Insecticides accounted for 21 per cent of the total pesticide treated area and two per cent of the total weight of pesticides applied (Figures 7 & 8). There was a 41 per cent decrease from 2019 to 2021 and a 34 per cent decrease from 2017 to 2021 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 a decrease of 73 per cent from 2019 to 2021 and 67 per cent from 2017 to 2021 (Figure 6). Pyrethroids remain the principal form of insect control employed, in terms of area treated (Table 14). Several key insecticide active substances from other chemical groups have been withdrawn since the previous survey including oxamyl, pymetrozine and thiacloprid. With few chemical alternatives, growers are increasingly reliant on the use of pyrethroids. Several insect pests have known resistance to pyrethroids and growers are increasingly taking a more integrated approach to control pests. In addition, the cold, dry, late spring may have helped reduce pest pressure in 2021 and thus the need to apply insecticides.

Eighty-six per cent of leaf brassica crops and nine per cent of other vegetables were grown from transplants. The rest of the crops were grown directly from seed. Of these crops, other vegetables had the highest proportion of treated seed (78 per cent) followed by carrots (45 per cent) then vining peas (23 per cent). Seed treatments accounted for four per cent of the total area treated and one 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 64 per cent from both 2019 to 2021 and 2017 to 2021 (Figure 5). The weight of seed treatment applied per hectare of crop grown decreased by 62 per cent from 2019 to 2021 and by 63 per cent from 2017 to 2021 (Figure 6). This large decrease in the use of seed treatments is the result of the withdrawal of a number of key products. Wakil XL containing cymoxanil, fludioxonil and metalaxyl-M was withdrawn in June 2021. This was a primary seed treatment of vining peas, broad beans, carrots and parsnips applied to 10,329 ha in 2019 compared with only 5,574 ha in 2021. The use of seed treatments on vining peas decreased from 100 per cent treatment in 2019 to only 23 per cent in 2021 (Table 2). The 2021 season was also the final season for the use of Force ST containing tefluthrin prior to its withdrawal for use on vegetable crops in December 2021. Tefluthrin applied to carrot seed was applied to 1,357 ha in 2019 compared with only 732 ha in 2021. In addition, thiram which had been applied to 3,100 ha in 2019 (applied to peas, beans and turnips and swede) was unavailable during 2021 following its withdrawal in January 2020.

Molluscicides accounted for seven per cent of the total pesticide treated area and three per cent of weight (Figures 7 & 8). When changes in crop area are taken into account, there was no change between 2019 and 2021 and a decrease of 14 per cent between 2017 and 2021 (Figure 5). Similarly, the weight of molluscicides applied per hectare of crop grown was very similar in 2021 compared to 2019 and decreased 16 per cent compared to 2017. Slug numbers are closely linked to weather conditions and fluctuate accordingly. There were increased levels of slug activity in 2017 due to the wet summer, whereas in 2019 and 2021 the cold, late spring decreased the risk of slug damage[5].

Sulphur has dual use as both a fertiliser and a fungicidal treatment and is permissible in some organic systems. In 2021, there was no use of sulphur encountered in the survey. In 2019, an estimated 3,110 ha was treated with

sulphur. The reduction in use in 2021 may have been influenced by supply issues and price increases.

Pesticides classified as physical control represented less than 0.5 per cent of the total pesticide treated area and five per cent of the total weight of pesticides applied (Figure 7 & 8). In 2021, as in 2019, all physical control encountered was garlic based. This pesticide type was only applied to carrots (13 per cent of crop grown, Table 10) likely as a control for free living nematodes. When changes in crop area are taken into account, there was an increase in area treated with physical control by 194 per cent from 2019 to 2021 (weight applied increased by 168 per cent).

Growth regulators accounted for less than 0.5 per cent of the treated area and weight applied in 2021. Maleic hydrazide was the only growth regulator encountered in the 2021 survey and has seen a 62 per cent decrease in use from 2019 to 2021.

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 herbicide bromoxynil, the insecticide/nematicide fluopyram and fungicides fluxapyroxad, oxathiapiprolin and benthiavalicarb were recorded for the first time on outdoor vegetable crops in this survey (Table 13). It should be noted that fluopyram is classed as a broad-spectrum fungicide but also has nematicide activity and was only used as a nematicide on vegetable crops in 2021. This may be as an alternative to the nematicide oxamyl which was withdrawn in December 2020. In terms of area treated, the most used active substances were the fungicides boscalid and pyraclostrobin, which both increased by 50 per cent since 2019 (Table 17). Other notable changes include an increase (1,382 per cent) in the area treated with the fungicides fluopicolide and propamocarb hydrochloride. The use of the insecticide cyantraniliprole increased by 817 per cent in terms of both area treated and weight applied, while the area treated with the herbicide clopyralid increased by 257 percent and 366 per cent by weight applied (Table 18).

There was a continued increase in use of the molluscicide ferric phosphate, repeating the trend seen in the previous two reports. Use of ferric phosphate increased by 28 per cent (area treated) and 32 per cent (weight applied) (Tables 17 & 18). The use of metaldehyde in 2021 was similar to 2019, with an increase of two per cent of area treated and a decrease of two per cent of weight applied. This was the final season growers could use metaldehyde prior to its withdrawal in March 2022[7].

2021 Pesticide usage

Vining peas

- An estimated 9,458 hectares of vining peas were gown in Scotland in 2021, an increase of 16 per cent since 2019
- 97 per cent of the crop was treated with a pesticide (see Figure 9 for types of pesticides used)
- Pesticide formulations were applied to 22,535 treated hectares with 13,738 kilograms of pesticide applied in total (see summary table below)
- Vining pea crops received on average 2.1 pesticide applications (Table 1). These applications included 1.3 herbicides (applied to 94 per cent of the crop area) and one fungicide (applied to 74 per cent of the crop area)
- Timing of pesticide applications are shown in Figure 10
- The only reasons specified for herbicide and fungicide use were general weed (10 per cent) and disease control (18 per cent). There were no reasons recorded for insecticide use
- The most common varieties encountered were Kimberley and Corus accounting for 29 and 25 per cent of the sample respectively, and Romance and Spandimo both accounting for seven per cent of the sample area

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	6,975	1,796	74	Boscalid/pyraclostrobin (6,975)
Herbicides	12,522	11,538	94	Imazamox/pendimethalin (8,893)
Insecticides	822	115	9	Pirimicarb (822)
Seed treatments	2,217	288	23	Cymoxanil/fludioxonil/ metalaxyl-M (2,217)
All pesticides	**22,535**	**13,738**	**97**	

Figure 9 Use of pesticides on vining peas (percentage of total area treated with formulations) – 2021

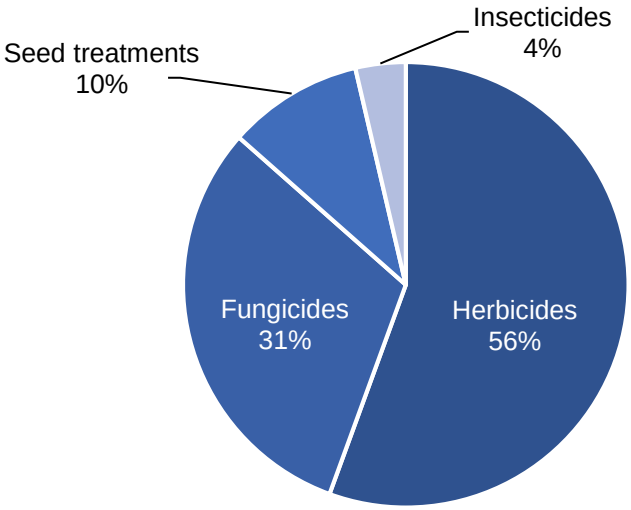
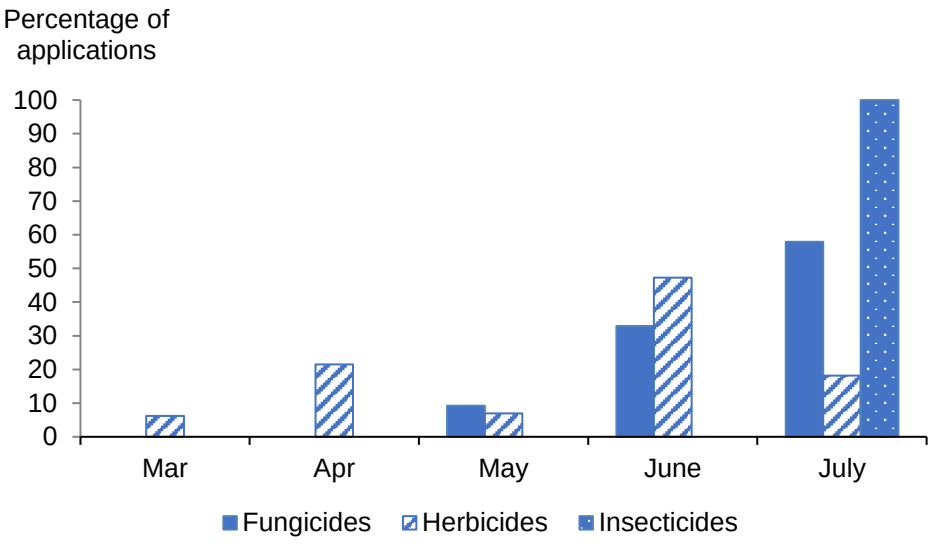


Figure 10 Timing of pesticide applications on vining peas – 2021



Brussels sprouts

- An estimated area of 1,173 hectares was grown in Scotland in 2021. This represents an increase of 26 per cent since 2019
- 94 per cent of Brussels sprouts crop was grown from transplants
- 100 per cent of the crop was treated with a pesticide (see Figure 11 for types of pesticides used)
- Pesticide formulations were applied to 34,743 treated hectares with 7,165 kilograms of pesticide applied in total (see summary table below)
- The Brussels sprouts crop received on average 17.4 pesticide applications (Table 1). These applications included 6.9 molluscicides, 6.8 fungicides, 5.6 insecticides and 3.1 herbicides (each applied to 100 per cent of the crop area)
- Timing of pesticide applications are shown in Figure 12
- The only reason specified for fungicide use was disease control (27 per cent of use). Aphids were the only reason specified for insecticide applications (11 per cent of total use). Reasons for herbicide applications were supplied for 15 per cent of total use, 13 per cent for general weed control and two per cent for couch grass
- The most common varieties encountered were Petrus, Gladius and Doric, accounting for 25, 16 and 13 per cent of the sample area respectively

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	10,688	2,635	100	Prothioconazole (2,905)
Herbicides	4,866	2,915	100	Clomazone (1,172), metazachlor (1,172), pendimethalin (1,172)
Insecticides	10,988	402	100	Lambda-cyhalothrin (3,305)
Molluscicides	8,201	1,213	100	Ferric phosphate (5,097)
All pesticides	**34,743**	**7,165**	**100**	

Figure 11 Use of pesticides on Brussels sprouts (percentage of total area treated with formulations) - 2021

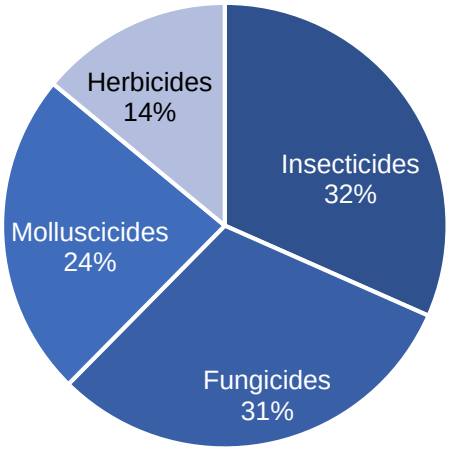
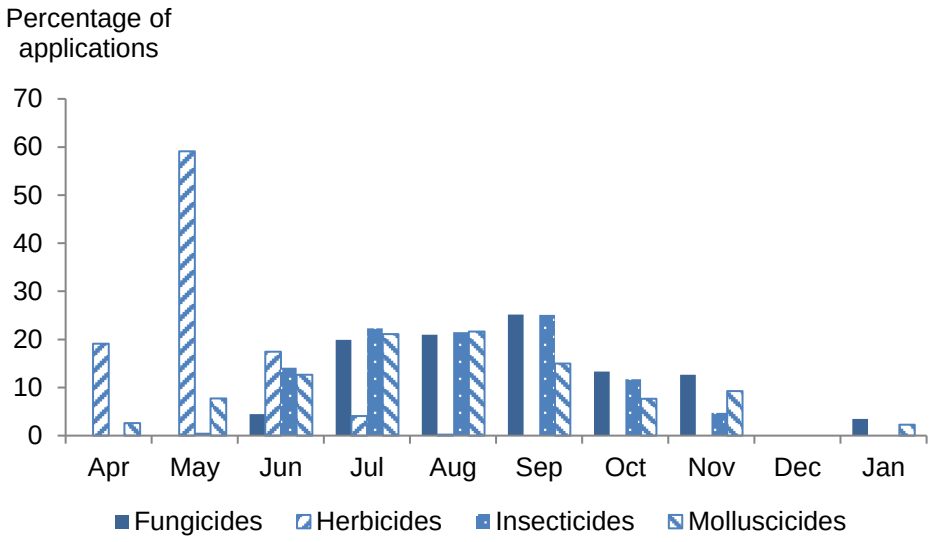


Figure 12 Timing of pesticide applications on Brussels sprouts – 2021



Calabrese

- An estimated area of 1,786 hectares of calabrese were grown in Scotland in 2021, an increase of 20 per cent since 2019. This included 1,779 hectares recorded in the 'calabrese' census category with the remainder recorded in the 'other vegetable' category
- All the calabrese 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 7,635 treated hectares with 3,163 kilograms of pesticide applied in total (see summary table below)
- The calabrese crop received on average 3.9 pesticide applications (Table 1). These applications included 3.1 fungicides, 1.7 insecticides and 1.7 herbicides (each applied to 60 per cent of the crop area) and one molluscicide (applied to 21 per cent of the crop area)
- Timing of pesticide applications are shown in Figure 14
- There were no specified reasons given for pesticide use on calabrese
- The most common variety encountered was Parthenon, accounting for 86 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	3,309	1,198	60	Copper oxychloride (1,562)
Herbicides	2,165	1,739	60	Metazachlor (1,033)
Insecticides	1,779	146	60	Spinosad (1,428)
Molluscicides	382	79	21	Ferric phosphate (382)
All pesticides	**7,635**	**3,163**	**100**	

Figure 13 Use of pesticides on calabrese (percentage of total area treated with formulations) - 2021

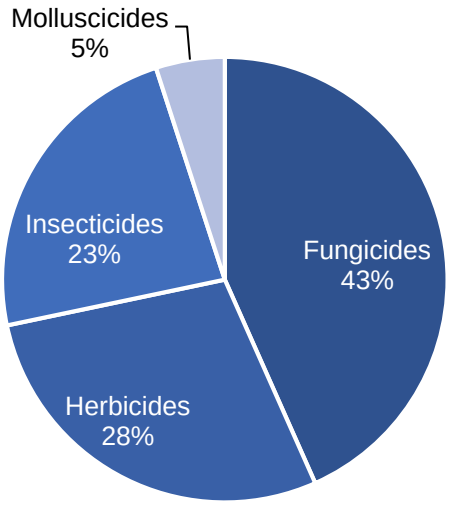
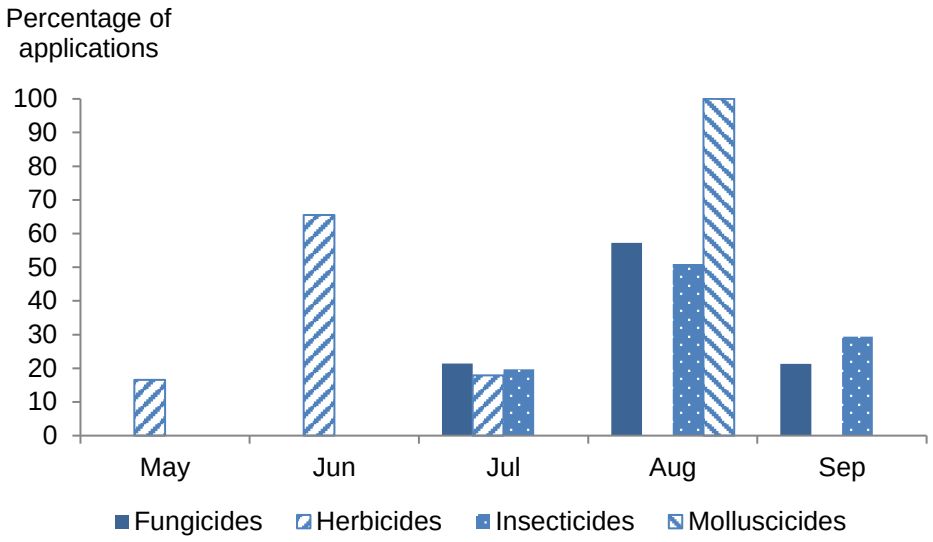


Figure 14 Timing of pesticide applications on calabrese – 2021



Other brassica crops

- Other brassica crops encountered in the 2021 survey were red, Chinese, summer/autumn and winter cabbage as well as cauliflower, kale and purple sprouting broccoli (some of which was recorded in the 'other vegetable' census category). In previous publications cabbages were reported separately but this was not possible in 2021 or 2019 due to reduced area of crop encountered in the sample
- The total estimated area of other brassica crops was 1,322 hectares
- 62 per cent of other brassica crops were grown from transplants
- 62 per cent of the other brassica crop was treated with a pesticide (see Figure 15 for types of pesticides used)
- Pesticide formulations were applied to 4,700 treated hectares with 2,795 kilograms of pesticide applied in total (see summary table below)
- The 62 per cent of other brassica crops treated with a pesticide received on average 4.7 pesticide applications (Table 1). These applications included two herbicides and 1.4 fungicides (each applied to 62 per cent of the crop area) and 1.5 molluscicides (applied to 50 per cent of the crop area)
- Timing of pesticide applications are shown in Figure 16
- Disease control and downy mildew were the only specified reasons reported for fungicide application (31 per cent and 13 per cent respectively). Reasons were supplied for 26 per cent of total herbicide use all of which was general weed control.

Summary of pesticide use on other brassica crops:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	1,174	458	62	Azoxystrobin (784)
Herbicides	2,534	2,157	62	Metazachlor (683)
Molluscicides	992	180	50	Ferric phosphate (992)
All pesticides	**4,700**	**2,795**	**62**	

Figure 15 Use of pesticides on other brassica crops (percentage of total area treated with formulations) – 2021

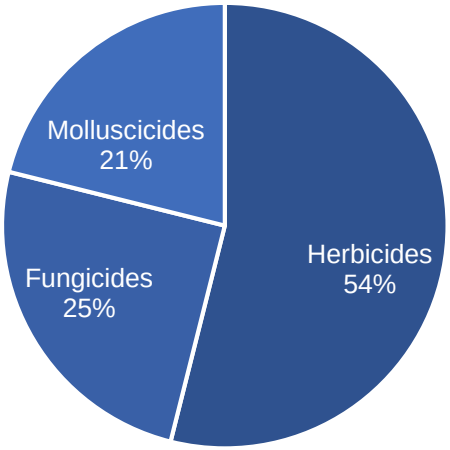
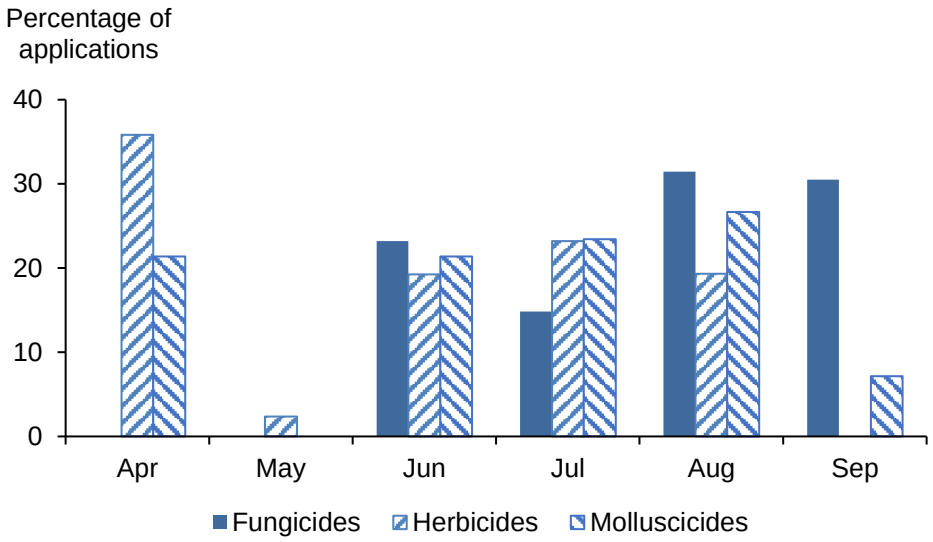


Figure 16 Timing of pesticide applications on other brassica crops – 2021



Carrots

- An estimated 3,449 hectares of carrots was grown in Scotland in 2021, an increase of three per cent since 2019
- 73 per cent of the crop was treated with a pesticide (see Figure 17 for types of pesticides used). Pesticide formulations were applied to 48,964 treated hectares with 15,611 kilograms of pesticide applied in total (see summary table below)
- The 73 per cent of carrot crop treated with a pesticide received on average 10.9 applications (Table 1). These applications included 7.1 fungicides, 4.8 insecticides, 3.3 herbicides and one physical control (applied to 71, 73, 73 and 13 per cent of the crop area respectively)
- Timing of pesticide applications is shown in Figure 18
- Reasons for fungicide applications were supplied for 47 per cent of total use; 24 per cent for *Sclerotinia*, eight per cent for disease control, six per cent for *Alternaria*, five per cent for crown rot, three per cent for cavity spot, *Botrytis* one per cent and light leaf spot less than one per cent
- Reasons for insecticide/nematicide applications were supplied for 22 per cent of total use; 20 per cent for carrot fly, one per cent for nematodes and less than one per cent for aphids and cutworms. Reasons for physical control (all garlic based) were supplied for less than one per cent of total use with the only reason supplied being for nematode control
- Reasons for herbicide applications were supplied for 31 per cent of total use; seven per cent for both annual broadleaved weeds and general weed control, six per cent for annual meadow grass, three per cent for broadleaved weeds, two per cent for mayweed and grass weed control and one per cent for both control of cover crops and volunteer cereals
- The most common variety encountered was Nairobi, accounting for 76 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	21,361	6,171	71	Prothioconazole (3,879)
Herbicides	13,203	6,592	73	Metribuzin (3,767)
Insecticides/ nematicides	12,169	311	73	Lambda-cyhalothrin (8,639)
Seed treatments	1,796	51	45	Cymoxanil/fludioxonil/ metalaxyl-M (1,064)
Physical control	435	2,487	13	Garlic (435)
All pesticides	**48,964**	**15,611**	**73**	

Figure 17 Use of pesticides on carrots (percentage of total area treated with formulations) – 2021

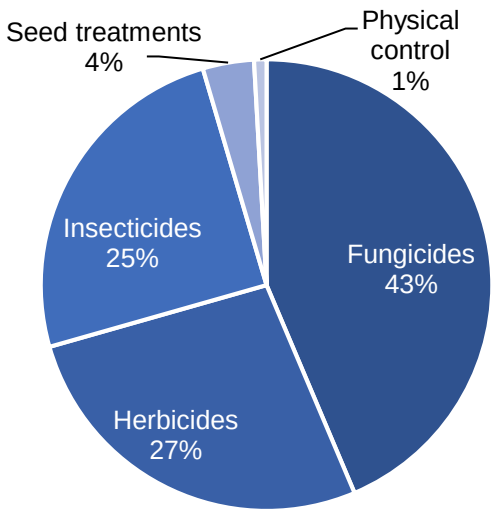
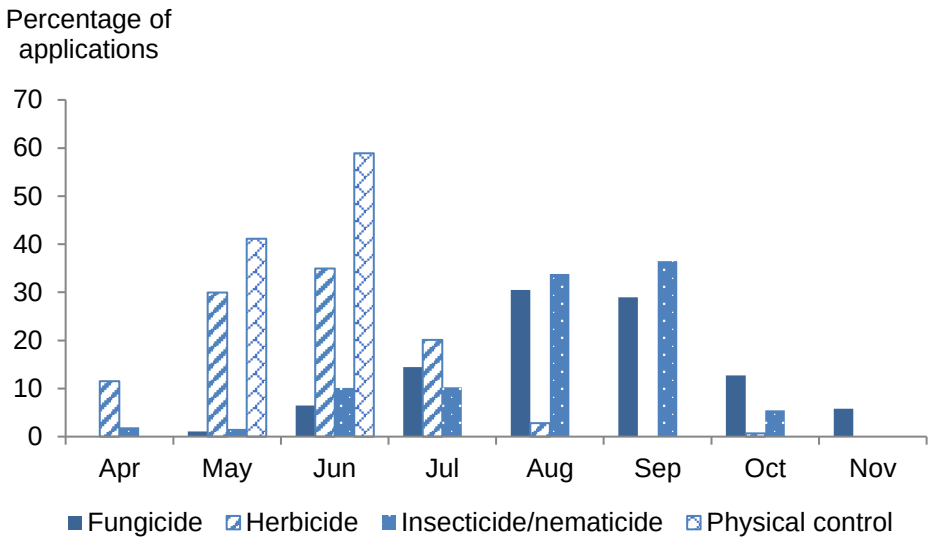


Figure 18 Timing of pesticide applications on carrots – 2021



Note: there were small amounts (< one per cent) of insecticide/nematicide application in March which are not shown on this figure.

Turnips and swedes

- The total estimated area of turnips and swedes grown in 2021 was 1,933 hectares, representing a 38 per cent increase from 2019. 1,621 hectares were recorded in the 'turnips & swedes' census category and 312 hectares were recorded in the 'other vegetable' census category
- 77 per cent of the turnip and swede crop was treated with a pesticide (see Figure 19 for types of pesticides used)
- Pesticide formulations were applied to 10,178 treated hectares with 1,878 kilograms of pesticide applied in total (see summary table below)
- The turnip and swede crop received on average 4.4 pesticide applications (Table 1). These applications included 2.4 insecticides (applied to 71 per cent of the crop area), 1.7 fungicides and one herbicide (each applied to 77 per cent of the crop area) as well as one molluscicide (applied to 33 per cent of the crop area)
- Timing of pesticide applications is shown in Figure 20
- Disease control was the only specified reason for the use of fungicides (11 per cent). Reasons for herbicide applications were supplied for 21 per cent of total use; all of which was for general weed control. There were no specified reasons given for insecticide use
- The most common varieties encountered were Magres and Tweed accounting for 57 per cent and 23 per cent of the sample area surveyed respectively

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	3,364	866	77	Prothioconazole (1,141)
Herbicides	2,737	866	77	Metazachlor (1,491)
Insecticides	3,433	52	71	Deltamethrin (2,558)
Molluscicides	644	94	33	Ferric phosphate (542)
All pesticides	**10,178**	**1,878**	**77**	

Figure 19 Use of pesticides on turnips and swedes (percentage of total area treated with formulations) – 2021

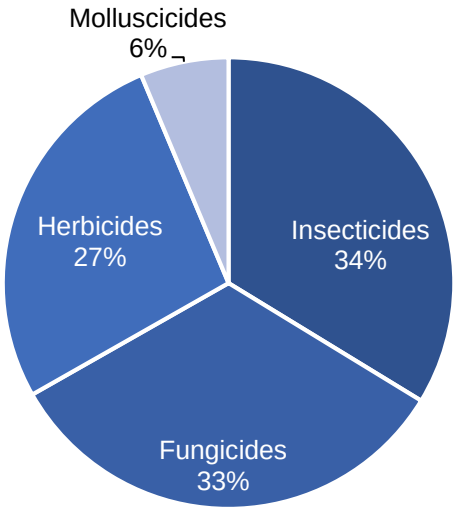
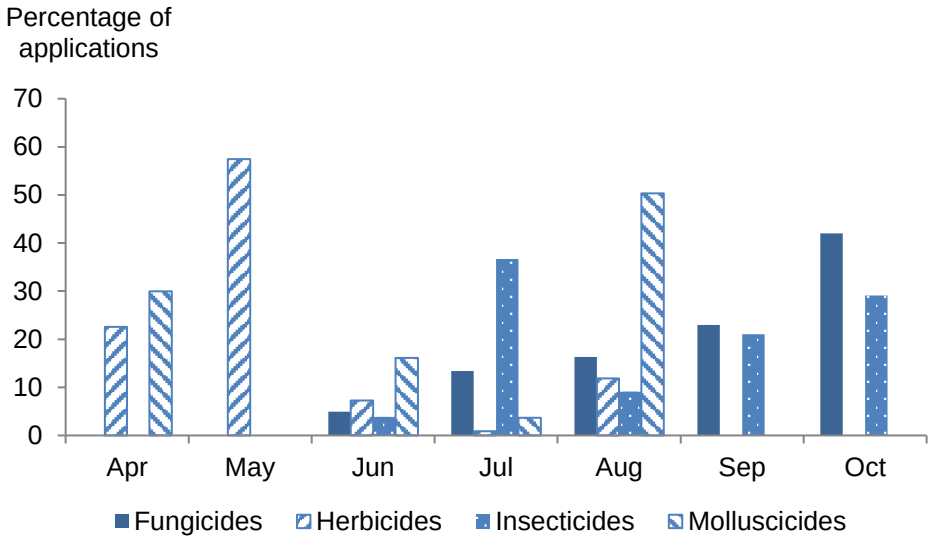


Figure 20 Timing of pesticide applications on turnips and swedes – 2021



Note: there were small amounts (< one per cent) of insecticide and fungicide applications on turnips and swedes in November 2021 which are not shown on this figure.

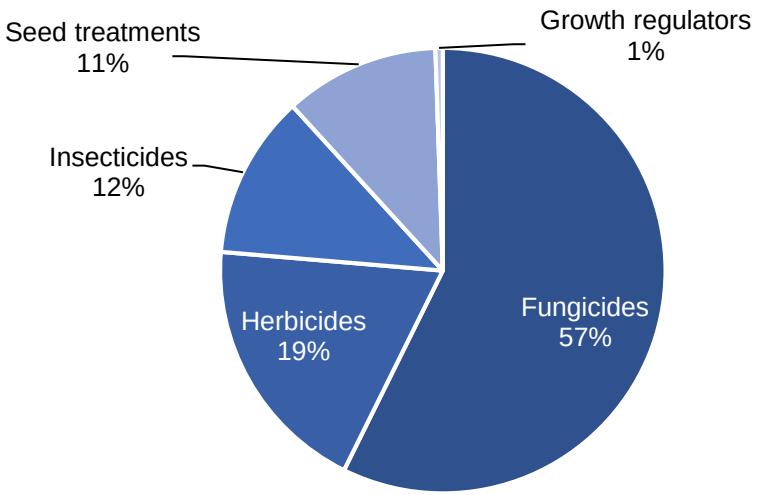
Other vegetable crops

- Other vegetable crops encountered in the 2021 survey were broad beans, leeks, lettuce, celery, fennel, French beans, Jerusalem artichoke, pumpkin, runner beans, spring onions, beetroot, chard, parsnips, onions and rhubarb
- The total estimated area of other vegetable crops was 2,945 hectares. No multi-cropping was encountered during the 2021 survey
- Nine per cent of other vegetable crops were grown from transplants
- 88 per cent of other vegetable crops were treated with a pesticide (see Figure 21 for types of pesticides used)
- Pesticide formulations were applied to 20,475 treated hectares with 9,281 kilograms of pesticide applied in total (see summary table below)
- The 88 per cent of the other vegetable crop treated with a pesticide received on average 6.4 pesticide applications (Table 1). These applications included 4.3 fungicides 1.2 herbicides (each applied to 88 per cent of the crop area) and one insecticide (applied to 80 per cent of the crop area)
- Timing of pesticide applications is shown in Figure 22
- The only reason supplied for herbicide applications was general weed control (65 per cent). General disease control (79 per cent), downy mildew and *Botrytis* (one per cent or less each) were the only specified reasons for fungicide use. The only stated reason for insecticide applications was for aphids (100 per cent)

Summary of pesticide use on other vegetable crops:

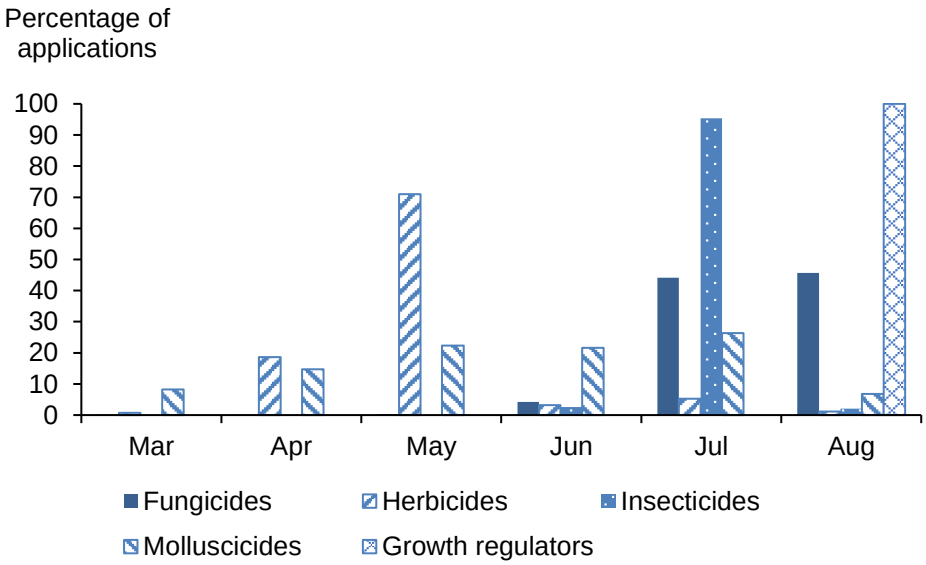
Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	11,688	5,358	88	Cyprodinil/fludioxonil (4,615)
Herbicides	3,879	3,103	88	Imazamox/pendimethalin (2,293)
Insecticides	2,422	329	80	Pirimicarb (2,293)
Growth regulators	109	262	4	Maleic hydrazide (109)
Molluscicides	84	18	3	Ferric phosphate (84)
Seed treatments	2,293	212	78	Cymoxanil/fludioxonil/ metalaxyl-M (2,293)
All pesticides	**20,475**	**9,281**	**88**	

Figure 21 Use of pesticides on other vegetable crops (percentage of total area treated with formulations) – 2021



Note: molluscicides have been excluded as their use represents < 0.5 per cent quantity applied.

Figure 22 Timing of pesticide applications on other vegetable crops – 2021



Note: there were small amounts (< two per cent) of fungicide applications on other vegetable crops in September, October, December 2021 & March 2022 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 applications - 2021

Crop	Fungicides		Herbicides		Insecticides/ nematicides		Molluscicides		Physical control		Growth regulator		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	74	1.0	94	1.3	9	1.0	0	0.0	0	0.0	0	0.0	94	2.1	23	97
Brussels sprouts	100	6.8	100	3.1	100	5.6	100	6.9	0	0.0	0	0.0	100	17.4	0	100
Calabrese	60	3.1	60	1.7	60	1.7	21	1.0	0	0.0	0	0.0	100	3.9	0	100
Other brassica crops	62	1.4	62	2.0	0	0.0	50	1.5	0	0.0	0	0.0	62	4.7	0	62
Carrots	71	7.1	73	3.3	73	4.8	0	0.0	13	1.0	0	0.0	73	10.9	45	73
Turnips & swedes	77	1.7	77	1.0	71	2.4	33	1.0	0	0.0	0	0.0	77	4.4	0	77
Other vegetable crops	88	4.3	88	1.2	80	1.0	3	1.0	0	0.0	4	1.0	88	6.4	78	88
All vegetable crops	**75**	**3.0**	**84**	**1.7**	**42**	**2.9**	**13**	**3.5**	**2**	**1.0**	**<0.5**	**1.0**	**87**	**5.2**	**28**	**89**

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 Vining peas seed treatment formulations - 2021

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

Seed treatment	Vining peas 2021			Vining peas 2019		
	ha	%	kg	ha	%	kg
Cymoxanil/fludioxonil/metalaxyl-M	2,217	23	288	7,364	90	870
All seed treatments	**2,217**	**23**	**288**	**8,142**	**100**	**973**
No seed treatment	7,241	77	[z]	0	0	[z]
Area grown (ha)	9,458			8,142		

Note: Some shorthand is used in this table: [z] = not applicable

Table 3 Vining peas insecticide formulations - 2021

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

Insecticides	Vining peas 2021			Vining peas 2019[(1)]		
	ha	%	kg	ha	%	kg
Pirimicarb	822	9	115	4,846	60	678
All insecticides	**822**	**9**	**115**	**5,712**	**60**	**739**
Area grown (ha)	9,458			8,142		

(1) For full list of formulations recorded in 2019 please refer to the 2019 report[(3)]

Table 4 Vining peas fungicide formulations - 2021

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

Fungicides	Vining peas 2021			Vining peas 2019[1]		
	ha	%	kg	ha	%	kg
Boscalid/pyraclostrobin	6,975	74	1,796	3,583	44	1,058
All fungicides	**6,975**	**74**	**3,583**	**6,050**	**74**	**1,675**
Area grown (ha)	9,458			8,142		

Note: no sulphur was encountered on vining peas in 2021

(1) For full list of formulations recorded in 2019 please refer to the 2019 report[3]

Table 5 Vining peas herbicide formulations – 2021

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

Herbicides	Vining peas 2021			Vining peas 2019[1]		
	ha	%	kg	ha	%	kg
Bentazone	1,826	19	1,748	2,612	32	2,457
Fluazifop-P-butyl	301	3	38	0	0	0
Glyphosate	192	2	207	936	11	705
Imazamox/pendimethalin	8,893	94	8,301	7,490	92	6,844
MCPB	1,311	14	1,244	1,938	24	2,836
All herbicides	**12,522**	**94**	**11,538**	**12,976**	**96**	**12,842**
Area grown (ha)	9,458			8,142		

(1) For full list of formulations recorded in 2019 please refer to the 2019 report[3]

Table 6 Leaf brassica insecticide and molluscicide formulations - 2021

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

Insecticides	**Brussels sprouts**		**Calabrese**		**Other brassica crops[1]**		**Total 2021**	**Total 2021**	**2019[2]**	**2019[2]**
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Acetamiprid	762	65	0	0	0	0	**762**	**38**	755	38
Cyantraniliprole	306	26	0	0	0	0	**306**	**23**	0	0
Deltamethrin	1,344	65	0	0	0	0	**1,344**	**10**	847	6
Flonicamid	1,486	70	0	0	0	0	**1,486**	**104**	0	0
Indoxacarb	1,524	65	350	20	0	0	**1,874**	**48**	4,719	120
Lambda-cyhalothrin	3,305	98	0	0	0	0	**3,305**	**18**	3,086	17
Spinosad	0	0	1,428	40	0	0	**1,428**	**137**	1,504	144
Spirotetramat	2,260	100	0	0	0	0	**2,260**	**170**	1,767	132
All insecticides	**10,988**	**100**	**1,779**	**60**	**0**	**0**	**12,767**	**548**	**16,767**	**1,028**
Molluscicides										
Ferric phosphate	5,097	100	382	21	992	50	**6,472**	**1,017**	5,051	745
Metaldehyde	3,104	65	0	0	0	0	**3,104**	**455**	2,716	407
All molluscicides	**8,201**	**100**	**382**	**21**	**992**	**50**	**9,575**	**1,472**	**7,767**	**1,153**
Area grown (ha)	1,173		1,786		1,322		4,281		3,048	

(1) Other brassica crops include cabbage (summer/autumn, winter, red & Chinese), cauliflower, purple sprouting broccoli and kale
(2) For full list of formulations recorded in 2019 please refer to the 2019 report[3]

Table 7 Leaf brassica fungicide formulations - 2021

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

Fungicides	Brussels sprouts		Calabrese		Other brassica crops[1]		Total 2021	Total 2021	2019[2]	2019[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Azoxystrobin	1,140	82	1,065	60	784	59	**2,988**	**730**	2,677	669
Azoxystrobin/difenoconazole	871	72	0	0	0	0	**871**	**283**	1,868	607
Boscalid/pyraclostrobin	2,559	100	0	0	71	5	**2,630**	**879**	1,662	555
Copper oxychloride	0	0	1,562	42	85	6	**1,647**	**886**	2,751	1,032
Difenoconazole	776	66	0	0	0	0	**776**	**75**	831	62
Difenoconazole/fluxapyroxad	425	36	0	0	0	0	**425**	**53**	0	0
Fluopicolide/propamocarb hydrochloride	0	0	0	0	155	12	**155**	**171**	5	5
Mandipropamid	0	0	683	38	79	6	**761**	**114**	249	37
Prothioconazole	2,905	100	0	0	0	0	**2,905**	**558**	2,367	454
Tebuconazole/trifloxystrobin	2,013	98	0	0	0	0	**2,013**	**544**	1,507	407
All fungicides	**10,688**	**100**	**3,309**	**60**	**1,174**	**62**	**15,171**	**4,292**	**13,920**	**3,832**
Area grown (ha)	1,173		1,786		1,322		4,281		3,048	

(1) Other brassica crops include cabbage (summer/autumn, winter, red & Chinese), cauliflower, purple sprouting broccoli and kale
(2) For full list of formulations recorded in 2019 please refer to the 2019 report[3]
Note: No sulphur was encountered on leaf brassicas in 2021

Table 8 Leaf brassica herbicide formulations - 2021

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

Herbicides	Brussels sprouts		Calabrese		Other brassica crops[1]		Total 2021	Total 2021	2019[2]	2019[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Clethodim	89	8	0	0	0	0	**89**	**16**	0	0
Clomazone	1,172	100	0	0	447	34	**1,620**	**116**	1,007	73
Clopyralid	558	42	359	20	170	13	**1,088**	**247**	0	0
Cycloxydim	217	18	0	0	0	0	**217**	**73**	0	0
Dimethenamid-P/pendimethalin	0	0	32	2	212	16	**244**	**451**	459	694
Glyphosate	485	41	391	22	574	43	**1,450**	**1,551**	1,306	1,625
Metazachlor	1,172	100	1,033	58	683	52	**2,888**	**2,134**	2,084	1,557
Pendimethalin	1,172	100	350	20	447	34	**1,970**	**2,224**	1,168	1,306
All herbicides	**4,866**	**100**	**2,165**	**60**	**2,534**	**62**	**9,565**	**6,811**	**6,033**	**5,263**
Area grown (ha)	1,173		1,786		1,322		4,281		3,048	

(1) Other brassica crops include cabbage (summer/autumn, winter, red & Chinese), cauliflower, purple sprouting broccoli and kale
(2) For full list of formulations recorded in 2019 please refer to the 2019 report[3]

Table 9 Vegetables (excluding vining peas and leaf brassicas) seed treatment formulations - 2021

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 2021	Total 2021	2019[2]	2019[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Cymoxanil/fludioxonil/metalaxyl-M	1,064	31	0	0	2,293	78	**3,358**	**215**	2,965	8
Tefluthrin	732	21	0	0	<0.5	0	**732**	**48**	1,357	83
All seed treatments	**1,796**	**45**	**0**	**0**	**2,293**	**78**	**4,090**	**263**	**4,322**	**91**
Crops grown from transplant	0	0	0	0	257	9	**257**	**[z]**	273	[z]
No seed treatment	1,626	47	1,933	100	315	11	**3,875**	**[z]**	775	[z]
No information seed treatment[3]	283	8	0	0	0	0	**283**	**[z]**	149	[z]
Area grown (ha)	3,449		1,933		2,945		8,327		5,641	

(1) In 2021 other vegetable crops included broad beans, leeks, lettuce, celery, fennel, French beans, French dwarf beans, Jerusalem artichoke, pumpkin, runner beans, spring onions, beetroot, chard, parsnips, onions and rhubarb (some of which was perennial). Please note broad beans have been included under other vegetable crops for the first time due to a limited number of crops being encountered during the survey
(2) For full list of formulations recorded in 2019 please refer to the 2019 report[3]
(3) No information seed treatment refers to occasions where the grower was unable to confirm whether the seed had received a treatment
Note: Some shorthand is used in this table: [z] = not applicable

Table 10 Vegetables (excluding vining peas & leaf brassicas) insecticide, nematicide, molluscicide and physical control formulations - 2021

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

Insecticides/nematicides	Carrots		Turnips & swedes		Other vegetable crops[1]		Total 2021	Total 2021	2019[2]	2019[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Acetamiprid	0	0	0	0	60	2	**60**	**3**	0	0
Cyantraniliprole	759	22	191	5	0	0	**950**	**70**	137	10
Cypermethrin	198	6	0	0	0	0	**198**	**5**	0	0
Deltamethrin	1,667	29	2,558	45	0	0	**4,225**	**14**	2,932	9
Flonicamid	198	6	0	0	0	0	**198**	**14**	0	0
Fluopyram	468	14	0	0	0	0	**468**	**117**	0	0
Lambda-cyhalothrin	8,639	71	180	5	0	0	**8,819**	**100**	10,255	124
Pirimicarb	0	0	0	0	2,293	78	**2,293**	**321**	0	0
Spirotetramat	239	7	504	22	68	2	**811**	**49**	59	59
All insecticides/nematicides	**12,169**	**73**	**3,433**	**71**	**2,422**	**80**	**18,023**	**692**	**16,845**	**2,159**
Molluscicides										
Ferric phosphate	0	0	542	28	84	0	**626**	**90**	495	96
Metaldehyde	0	0	102	5	0	0	**102**	**21**	413	77
All molluscicides	**0**	**0**	**644**	**33**	**84**	**3**	**728**	**112**	**907**	**173**
Physical control										
Garlic	435	13	0	0	0	0	**435**	**2,487**	125	782
Area grown (ha)	3,449		1,933		2,945		8,327		5,641	

(1) In 2021 other vegetable crops included broad beans, leeks, lettuce, celery, fennel, French beans, Jerusalem artichoke, pumpkin, runner beans, spring onions, beetroot, chard, parsnips, onions and rhubarb

(2) For full list of formulations recorded in 2019 please refer to the 2019 report[3]

Please note broad beans have been included under other veg crops for the first time due to a limited number of crops being encountered during the survey

Table 11 Vegetables (excluding vining peas and leaf brassicas) fungicide formulations - 2021

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

Fungicides	Carrots		Turnips & swedes		Other vegetable crops[1]		Total 2021	Total 2021	2019[2]	2019[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Azoxystrobin	2,360	42	1,136	59	2,639	85	**6,135**	**1,278**	6,292	1,096
Azoxystrobin/difenoconazole	1,610	31	0	0	98	3	**1,708**	**468**	3,219	898
Benthiavalicarb/oxathiapiprolin	0	0	0	0	218	4	**218**	**11**	0	0
Benthiavalicarb isopropyl/mancozeb	0	0	0	0	109	4	**109**	**125**	0	0
Boscalid/pyraclostrobin	3,235	70	1,088	33	2,550	84	**6,874**	**2,107**	3,928	1,298
Cyprodinil/fludioxonil	3,518	70	0	0	4,615	79	**8,133**	**4,657**	2,412	1,205
Dimethomorph/mancozeb	0	0	0	0	109	4	**109**	**199**	84	125
Fluopicolide/propamocarb hydrochloride	0	0	0	0	97	3	**97**	**101**	12	14
Fluoxastrobin/prothioconazole	0	0	0	0	327	4	**327**	**82**	0	0
Isopyrazam	2,535	51	0	0	0	0	**2,535**	**317**	4,791	598
Mancozeb	0	0	0	0	327	4	**327**	**490**	256	353
Mandipropamid	0	0	0	0	86	2	**86**	**13**	68	10
Metalaxyl-M	1,536	45	0	0	0	0	**1,536**	**898**	1,673	940
Oxathiapiprolin	0	0	0	0	126	4	**126**	**2**	0	0
Prothioconazole	3,879	70	1,141	33	288	3	**5,308**	**1,017**	6,503	1,241
Tebuconazole	535	16	0	0	0	0	**535**	**119**	355	71
Tebuconazole/trifloxystrobin	2,152	37	0	0	98	3	**2,250**	**511**	1,012	206
All fungicides	**21,361**	**71**	**3,364**	**77**	**11,688**	**88**	**36,413**	**12,395**	**33,587**	**9,817**
Area grown (ha)	3,449		1,933		2,945		8,327		5,641	

(1) In 2021 other vegetable crops included broad beans, leeks, lettuce, celery, fennel, French beans, French dwarf beans, Jerusalem artichoke, pumpkin, runner beans, spring onions, beetroot, chard, parsnips, onions and rhubarb

(2) For full list of formulations recorded in 2019 please refer to the 2019 report[3]

Note: No sulphur was encountered on vegetables in 2021

Table 12 Vegetables (excluding vining peas and leaf brassicas) herbicide and growth regulator formulations - 2021

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

Herbicides	Carrots		Turnips & swedes		Other vegetable crops[1]		Total 2021	Total 2021	2019[2]	2019[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Aclonifen	1,715	47	0	0	219	4	**1,934**	**1,230**	1,357	1,247
Bentazone	0	0	0	0	109	4	**109**	**28**	0	0
Bromoxynil	0	0	0	0	218	4	**218**	**6**	0	0
Clethodim	1,124	33	0	0	162	6	**1,287**	**212**	1,225	204
Clomazone	2,139	62	1,136	59	0	0	**3,274**	**181**	4,215	253
Clopyralid	0	0	0	0	34	1	**34**	**5**	314	54
Cycloxydim	0	0	0	0	30	1	**30**	**7**	0	0
Diflufenican	534	15	0	0	0	0	**534**	**29**	1,422	78
Dimethenamid-P/pendimethalin	0	0	0	0	203	7	**203**	**249**	69	74
Fluroxypyr	0	0	0	0	109	4	**109**	**7**	0	0
Glyphosate	971	26	0	0	64	2	**1,035**	**1,112**	585	494
Imazamox/pendimethalin	0	0	0	0	2,293	78	**2,293**	**2,141**	0	0
Isoxaben	0	0	0	0	30	1	**30**	**4**	0	0
Metazachlor	0	0	1,491	77	0	0	**1,491**	**746**	1,179	590
Metribuzin	3,767	68	0	0	0	0	**3,767**	**512**	3,619	503

Cont…

Table 12 Vegetables (excluding vining peas 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 2021	Total 2021	2019[2]	2019[2]
	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Pendimethalin	2,385	68	0	0	114	4	**2,498**	**3,398**	4,116	6,167
Propaquizafop	442	13	0	0	0	0	**442**	**60**	337	39
Propyzamide	0	0	0	0	84	3	**84**	**118**	108	151
Prosulfocarb	125	4	0	0	139	5	**264**	**409**	1,332	1,715
S-metolachlor	0	0	110	3	72	1	**183**	**107**	385	444
All herbicides	**13,203**	**73**	**2,737**	**77**	**3,879**	**88**	**19,819**	**10,561**	**21,309**	**13,050**
Growth regulators										
Maleic hydrazide	0	0	0	0	109	4	**109**	**262**	284	682
Area grown (ha)	3,449		1,933		2,945		8,327		5,641	

(1) In 2021 other vegetable crops included broad beans, leeks, lettuce, celery, fennel, French beans, French dwarf beans, Jerusalem artichoke, pumpkin, runner beans, spring onions, beetroot, chard, parsnips, onions and rhubarb
(2) For full list of formulations recorded in 2019 please refer to the 2019 report[3]

Table 13 Compounds encountered in the vegetable survey for the first time in 2021

Active substance	Type[1]	Area (ha)	Weight (kg)
Fluopyram	I	468	117
Fluxapyroxad	F	425	32
Oxathiapiprolin	F	344	6
Benthiavalicarb	F	218	8
Bromoxynil	H	218	6

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

Table 14 Mode of action/chemical group of insecticide/nematicide active substances - 2021

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	Pirimicarb	Carbamate	1A	3,115	436
All acetylcholinesterase (AChE) inhibitors				**3,115**	**436**
Sodium channel modulators	Cypermethrin	Pyrethroid	3A	198	5
	Deltamethrin	Pyrethroid	3A	5,570	24
	Lambda-cyhalothrin	Pyrethroid	3A	12,124	118
All sodium channel modulators				**17,892**	**147**
Nicotinic acetylcholine receptor (nAChR) competitive modulators	Acetamiprid	Neonicotinoid	4A	822	41
All nAChR competitive modulators				**822**	**41**
Ryanodine receptor modulators	Cyantraniliprole	Diamide	28	1,256	93
All ryanodine receptor modulators				**1,256**	**93**
Nicotinic acetylcholine receptor (nAChR) allosteric modulators	Spinosad	Spinosyns	5	1,428	137
Voltage-dependent sodium channel blocker	Indoxacarb	Oxadiazine	22A	1,874	48
Inhibitors of acetyl CoA carboxylase	Spirotetramat	Tetramic acid	23	3,071	218
Chordontonal organ modulators - undefined target site	Flonicamid	Flonicamid	29	1,684	118

Cont…

Table 14 Mode of action/chemical group of insecticide/nematicide active substances – 2021 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
Mitochondrial complex II electron transport inhibitors. Succinate-coenzyme Q reductase	Fluopyram(1)	Pyridinyl-ethyl benzamides	FRAC 7(1)	468	117
All other modes of action				**8,526**	**638**
All insecticides				**31,611**	**1,355**
Area grown				22,066	

(1) Fluopyram is classed as a broad-spectrum fungicide but also has nematicide activity, hence the reason it has a FRAC group code rather than an IRAC code. Fluopyram was only used as a nematicide on veg crops in 2021

Note: Active substances have been grouped by their mode of action. Full details on insecticide and nematicide mode of action classification can be found on the Insecticide Resistance Action Committee (IRAC) webpage(8)

Table 15 Mode of action/chemical group of fungicide active substances - 2021

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	8,133	2,789
All amino acids & protein synthesis					**8,133**	**2,789**
Cell wall biosynthesis	Benthiavalicarb	Carboxylic acid amide	Valinamide carbamate	40	218	8
	Benthiavalicarb isopropyl	Carboxylic acid amide	Valinamide carbamate	40	109	3
	Dimethomorph	Carboxylic acid amide	Morpholine	40	109	20
	Mandipropamid	Carboxylic acid amide	Mandelic acid amide	40	847	127
All cell wall biosynthesis					**1,283**	**158**
Cytoskeleton and motor proteins	Fluopicolide	Benzamide	Pyridinylmethyl-benzamide	43	253	25
All cytoskeleton and motor proteins					**253**	**25**
Lipid synthesis and membrane integrity	Propamocarb hydrochloride	Carbamate	Carbamate	28	253	248
	Oxathiapiprolin	OSBPI oxysterol binding protein homologue inhibition	Piperidinyl-thiazole-isoxazolines	49	344	6
All lipid synthesis and membrane integrity					**597**	**253**
Multi-site contact activity	Copper oxychloride	Inorganic	Inorganic	M01	1,647	886
	Mancozeb	Dithio-carbamate	Dithio-carbamate	M03	545	791
All multi-site contact activity					**2,192**	**1,677**

Cont…

Table 15 Mode of action/chemical group of fungicide active substances - 2021 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
Nucleic acid synthesis	Metalaxyl-M	Phenylamide	Acylalanines	4	1,536	898
All nucleic acid synthesis					**1,536**	**898**
Respiration	Boscalid	SDHI	Pyridine-carboxamides	7	16,479	3,823
	Fluxapyroxad	SDHI	Pyrazole-4-carboxamides	7	425	32
	Isopyrazam	SDHI	Pyrazole-4-carboxamides	7	2,535	317
	Azoxystrobin	Qo inhibitor	Strobilurin	11	11,702	2,470
	Fluoxastrobin	Qo inhibitor	Strobilurin	11	327	41
	Pyraclostrobin	Qo inhibitor	Strobilurin	11	16,479	959
	Trifloxystrobin	Qo inhibitor	Strobilurin	11	4,263	351
All respiration					**52,209**	**7,993**
Signal transduction	Fludioxonil	Phenylpyrroles	Phenylpyrroles	12	8,133	1,868
All signal transduction					**8,133**	**1,868**
Sterol biosynthesis in membranes	Difenoconazole	DeMethylation inhibitor	Triazole	3	3,780	385
	Prothioconazole	DeMethylation inhibitor	Triazolinthione	3	8,539	1,615
	Tebuconazole	DeMethylation inhibitor	Triazole	3	4,798	821
All sterol biosynthesis in membranes					**17,117**	**2,822**
All fungicides					**91,454**	**18,483**
Area grown					22,066	

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[9]

Table 16 Mode of action/chemical group of herbicide active substances - 2021

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	Fluazifop-P-butyl	Aryloxyphenoxy-propionates (FOPs)	1	301	38
	Propaquizafop	Aryloxyphenoxy-propionates (FOPs)	1	442	60
	Clethodim	Cyclohexanediones (DIMs)	1	1,376	228
	Cycloxydim	Cyclohexanediones (DIMs)	1	247	81
All inhibition of acetyl CoA carboxylase				**2,365**	**406**
Inhibition of acetolactate synthase ALS	Imazamox	Imidazolinone	2	11,186	654
All inhibition of acetolactate synthase ALS				**11,186**	**654**
Inhibition of microtubule assembly	Pendimethalin	Dinitroanilines	3	16,101	15,788
	Propyzamide	Benzamides	3	84	118
All inhibition of microtubule assembly				**16,185**	**15,906**
Auxin mimics	Clopyralid	Pyridine-carboxylates	4	1,122	251
	Fluroxypyr	Pyridyloxy-carboxylates	4	109	7
	MCPB	Phenoxy-carboxylates	4	1,311	1,244
All auxin mimics				**2,542**	**1,503**

Cont…

Table 16 Mode of action/chemical group of herbicide active substances - 2021 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
Inhibition of photosynthesis at photosystem II (-serine 264 binders)	Metribuzin	Triazinones	5	3,767	512
All inhibition of photosynthesis at photosystem II (-serine 264 binders)				**3,767**	**512**
Inhibition of photosynthesis at photosystem II (-histidine 215 binders)	Bentazone	Benzothiadiazinone	6	1,935	1,776
	Bromoxynil	Nitriles	6	218	6
All inhibition of photosynthesis at photosystem II (-histidine 215 binders)				**2,152**	**1,782**
Inhibition of EPSP synthase	Glyphosate	Glycine	9	2,677	2,870
All inhibition of EPSP synthase				**2,677**	**2,870**
Inhibition of phytoene desaturase	Diflufenican	Phenyl ethers	12	534	29
All inhibition of phytoene desaturase				**534**	**29**
Inhibition of deoxy-D-xyulose phosphate synthase	Clomazone	Isoxazolidinone	13	4,894	296
All inhibition of deoxy-D-xyulose phosphate synthase				**4,894**	**296**
Inhibition of VLCFAs	Dimethenamid-P	α-chloroacetamides	15	446	322
	Metazachlor	α-chloroacetamides	15	4,380	2,880
	S-metolachlor	α-chloroacetamides	15	183	107
	Prosulfocarb	Thiocarbamates	15	264	409
All inhibition of VLCFAs				**5,272**	**3,718**

Cont…

Table 16 Mode of action/chemical group of herbicide active substances - 2021 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
Inhibition of cell wall synthesis	Isoxaben	Benzamides	29	30	4
All inhibition of cell wall synthesis				**30**	**4**
Inhibition of solanesyl diphosphate synthase	Aclonifen	Diphenyl ether	32	1,934	1,230
All inhibition of solanesyl diphosphate synthase				**1,934**	**1,230**
All herbicides				**53,539**	**28,910**
Area grown				22,066	

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[10].

Table 17 Principal active substances by area treated

Area treated (ha) of the 20 most used active substances on all vegetable crops surveyed in 2021 and percentage change

	Active substance	Type[(1)]	2021 (ha)	2019 (ha)	% change
1	Boscalid	F	16,479	10,973	50
2	Pyraclostrobin	F	16,479	10,973	50
3	Pendimethalin	H	16,101	15,101	7
4	Fludioxonil	F/S	13,708	15,812	-13
5	Lambda-cyhalothrin	I	12,124	16,941	-28
6	Azoxystrobin	F	11,702	17,579	-33
7	Imazamox	H	11,186	9,290	20
8	Prothioconazole	F	8,539	8,870	-4
9	Cyprodinil	F	8,133	5,483	48
10	Metalaxyl-M	F/S	7,111	13,094	-46
11	Ferric phosphate	M	7,098	5,546	28
12	Cymoxanil	S	5,575	10,329	-46
13	Deltamethrin	I	5,570	4,308	29
14	Clomazone	H	4,894	5,223	-6
15	Tebuconazole	F	4,798	3,930	22
16	Metazachlor	H	4,380	3,411	28
17	Trifloxystrobin	F	4,263	2,519	69
18	Difenoconazole	F	3,780	5,917	-36
19	Metribuzin	H	3,767	3,619	4
20	Metaldehyde	M	3,206	3,128	2

Table 18 Principal active substances by weight

Weight (kg) of the 20 most used active substances on all vegetable crops surveyed in 2021 and percentage change

	Active substance	Type[(1)]	2021 (kg)	2019 (kg)	% change
1	Pendimethalin	H	15,788	16,162	-2
2	Boscalid	F	3,823	2,779	38
3	Metazachlor	H	2,880	2,204	31
4	Glyphosate	H	2,870	3,004	-4
5	Cyprodinil	F	2,789	1,838	52
6	Garlic	P	2,487	782	218
7	Azoxystrobin	F	2,470	3,374	-27
8	Fludioxonil	F/S	1,945	1,365	42
9	Bentazone	H	1,776	2,457	-28
10	Prothioconazole	F	1,615	1,695	-5
11	MCPB	H	1,244	2,836	-56
12	Aclonifen	H	1,230	1,247	-1
13	Metalaxyl-M	F/S	1,169	1,494	-22
14	Ferric phosphate	M	1,107	841	32
15	Pyraclostrobin	F	959	697	38
16	Copper oxychloride	F	886	1,032	-14
17	Tebuconazole	F	821	743	11
18	Mancozeb	F	791	503	57
19	Imazamox	H	654	553	18
20	Metribuzin	H	512	503	2

(1) Pesticide type = F: Fungicide, H: Herbicide, I: Insecticide, M: Molluscicide, P: Physical control, S: Seed treatment

Table 19 Total vegetable crop, comparison with previous years

Pesticide usage in 2017, 2019 and 2021, area treated with formulations and active substances (a.s.) and the weight (kg) applied

	2017			2019			2021		
	Formulations	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**
	ha	**ha**	**kg**	**ha**	**ha**	**kg**	**ha**	**ha**	**kg**
Insecticides	41,722	41,722	3,641	45,253	45,253	4,210	31,611	31,611	1,355
Molluscicides	10,512	10,512	1,654	8,674	8,674	1,326	10,304	10,304	1,584
Biological agents(1)	0	0	0	63	63	[z]	0	0	0
Fungicides	53,977	75,061	18,356	61,599	86,853	19,218	58,560	91,454	18,483
Sulphur	2,429	2,429	7,174	3,110	3,110	11,826	0	0	0
Herbicides	46,357	56,166	31,340	42,306	52,270	33,319	41,907	53,539	28,910
Growth regulators	0	0	0	284	284	682	109	109	262
Physical control	314	314	2,117	125	125	782	435	435	2,487
Seed treatments(1)	15,552	36,464	1,293	14,787	35,446	1,222	6,307	17,456	552
All pesticides	**170,863**	**222,668**	**65,575**	**176,200**	**232,078**	**72,584**	**149,232**	**204,909**	**53,632**
Area grown (ha)	19,359(2)			18,634(3)			22,066(4)		

(1) No weights can be calculated for biological control agents
(2) Includes 23 hectares of multi-cropping
(3) Includes 10 hectares of multi-cropping
(4) No multi-cropping was encountered in 2021

Appendix 2 – Survey statistics

Census and sample information

Table 20 Census crop areas 2021

Census area (ha) of vegetable crops grown in Scotland

	Scotland 2021	Scotland 2019	% change
Vining peas	9,458	8,142	16
Broad beans	2,294	1,800	27
Brussels sprouts	1,173	930	26
Cabbages	275	228	21
Calabrese	1,779	1,487	20
Carrots	3,450	3,325	4
Cauliflower	588	298	97
Leeks	100	69	46
Lettuce	103	97	5
Rhubarb	79	72	9
Turnips & swedes	1,621	1,359	19
All vegetable crops[1]	**22,066**	**18,624**	**18**

(1) Includes other vegetable crops
Note: Data taken from the 2021 and 2019 June Agricultural Census[11][12]
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	2	0	2	1	1	0	0	1	0	**7**
10-19.9	0	0	1	1	4	3	1	1	2	**13**
20-29.9	0	0	1	1	4	3	2	1	0	**12**
30-39.9	0	0	1	0	1	2	0	0	0	**4**
>40	0	0	0	0	3	4	5	1	2	**15**
All sizes	**2**	**0**	**5**	**3**	**13**	**12**	**8**	**4**	**4**	**51**

(1) Refers to area of vegetable crops (excluding vining peas) grown on holding
Note: vegetable data was also collected from six holdings in the pea sample

Table 22 Distribution of pea sample

Number of holdings surveyed in each region and size group

Size[1] (ha)	Angus	Lothian	Central Lowlands	Tweed Valley	Scotland
0.1-9.9	2	0	1	0	**3**
10-19.9	4	0	1	1	**6**
20-29.9	3	1	0	2	**6**
30-39.9	0	1	0	1	**2**
>40	2	0	1	2	**5**
All sizes	**11**	**2**	**3**	**6**	**22**

(1) Refers to area of vining peas grown on holding
Note: pea data was also collected from nine holdings in the vegetable sample

Table 23 Sampled areas (vegetables excluding peas)

Areas (ha) of vegetable crops grown in sample

Size[1] (ha)	Scotland[2]
0.1-9.9	50
10-19.9	163
20-29.9	244
30-39.9	111
>40	753
All sizes	**1,321**

Table 24 Census areas (vegetables excluding peas)

Areas (ha) of vegetable crops grown in Scotland

Size[1] (ha)	Scotland[2]
0.1-9.9	1,885
10-19.9	3,792
20-29.9	2,488
30-39.9	1,414
>40	3,031
All sizes	**12,609**

Table 25 Sampled areas (peas)

Areas (ha) of peas grown in sample

Size[3] (ha)	Scotland[2]
0.1-9.9	31
10-19.9	153
20-29.9	165
30-39.9	75
>40	415
All sizes	**839**

Table 26 Census areas (peas)

Areas (ha) of peas grown in Scotland

Size[3] (ha)	Scotland[2]
0.1-9.9	1,054
10-19.9	3,027
20-29.9	2,078
30-39.9	1,187
>40	2,111
All sizes	**9,458**

(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	23.34	[z]	21.21	48.63	54.36	[z]	[z]	10.73	[z]
10-19.9	[z]	[z]	39.46	27.07	22.76	15.24	28.28	26.43	23.66
20-29.9	[z]	[z]	14.51	13.06	10.33	8.09	8.29	2.27	[z]
30-39.9	[z]	[z]	4.51	[z]	25.56	6.82	[z]	[z]	[z]
>40	[z]	[z]	[z]	[z]	3.79	5.46	4.09	4.07	1.57

(1) Size refers to area of vegetable crops (excluding peas) grown on holding
Note: Some shorthand is used in this table: [z] = not applicable

Table 28 Raising factors (peas)

Size[1] (ha)	Angus	Lothian	Central Lowlands	Tweed Valley
0.1-9.9	29.82	[z]	27.26	[z]
10-19.9	20.40	[z]	15.23	9.76
20-29.9	10.75	3.78	[z]	11.78
30-39.9	[z]	2.76	[z]	6.37
>40	12.64	1.00	10.17	1.77

(1) Size refers to area of peas grown on holding
Note: Raising factors are calculated by comparing the sampled crop area to the census crop area. Please see Appendix 4 for a full explanation
Note: Some shorthand is used in this table: [z] = not applicable

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	4.78	[z]	[z]	[z]	0.99	[z]	[z]	[z]	[z]	1.90
Brussels sprouts	3.56	[z]	[z]	[z]	[z]	0.31	0.68	[z]	1.54	1.15
Cabbage	73.68	[z]	[z]	[z]	[z]	1.50	[z]	0.27	[z]	2.60
Calabrese	[z]	[z]	[z]	[z]	6.56	1.24	[z]	[z]	[z]	1.09
Carrots	101.01	[z]	0.86	0.81	1.05	0.87	0.79	0.48	[z]	1.02
Cauliflower	29.21	[z]	[z]	[z]	0.84	0.83	[z]	[z]	[z]	1.03
Leeks	4.82	[z]	[z]	[z]	[z]	[z]	0.55	[z]	1.36	1.04
Lettuce	26.02	[z]	[z]	[z]	[z]	0.47	[z]	[z]	[z]	1.51
Other vegetables	4.40	[z]	3.01	[z]	[z]	0.99	[z]	[z]	5.90	1.87
Rhubarb	0.09	[z]	[z]	[z]	[z]	[z]	[z]	[z]	[z]	19.19
Turnips & swedes	111.22	[z]	[z]	[z]	0.40	[z]	0.44	1.08	1.08	1.24
Vining peas	[z]	[z]	[z]	[z]	1.10	[z]	1.69	1.48	1.01	1.11

Note: Some shorthand is used in this table: [z] = not applicable

Response rates

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

Table 30 Response rate

	2021	% total
Target sample vegetables	60	100
Target sample vining peas	30	100
Total achieved vegetables	**51**	**85**
Total achieved vining peas	**22**	**73**
Total number of refusals/non-contact	47	
Total number of farms approached	**120**	

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 2021 outdoor vegetable crop survey placed on those providing the information, the surveyors recorded the time that 73 respondents spent providing the data during the surveys. This sample represents 83 per cent of growers surveyed. The median time taken to provide the information was 15 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 £16.07)[13]

The total financial burden to all growers resulting from participation in the 2021 outdoor vegetable crop survey was calculated to be £293.

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**[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.

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**. No multi-cropping was encountered during the 2021 survey.

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 2019[3] and 2017[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 brassica crops. Other brassica crops include cabbage (summer/autumn, winter, red & Chinese), cauliflower, purple sprouting broccoli and kale. Crops encountered in the 'other vegetable' category in the 2021 survey were broad beans, celery, fennel, French beans (including French dwarf beans), Jerusalem artichoke, pumpkin, runner beans, spring onions, beetroot, chard, parsnips and onions. 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.

Appendix 4 – Survey methodology

Sampling and data collection

Using the June 2021 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 23). 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.

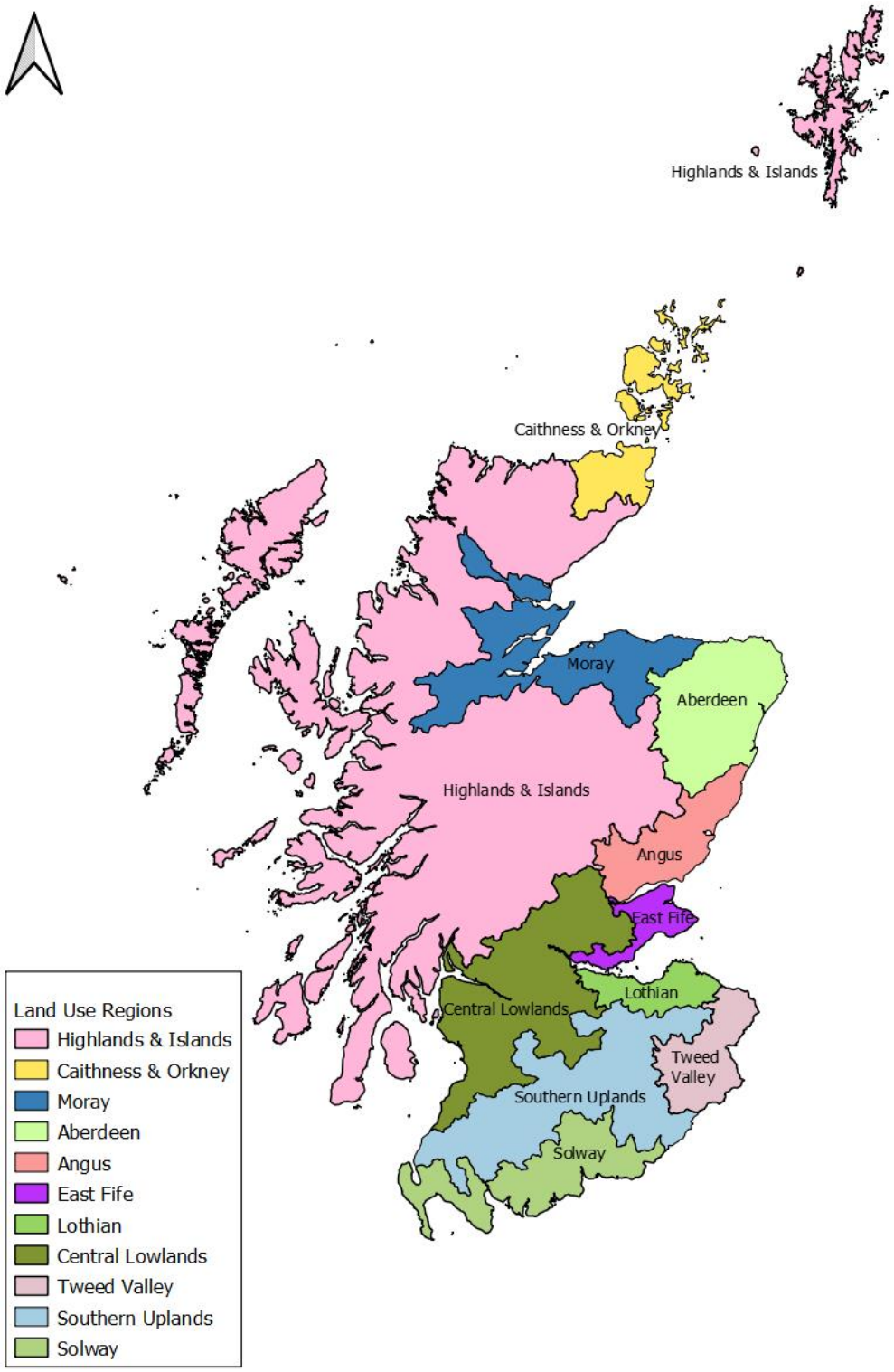
The survey covered pesticide applications to vegetable crops where all or the majority of the growing season was in 2021. As well as recording treatments applied directly to the crop, data was also collected on land preparation treatments prior to sowing or planting the crop.

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 51 holdings growing vegetable crops and 22 holdings growing only peas (Tables 21 & 22), (with a further five pea holdings also growing veg, 9 veg holdings also growing peas, and one pea holding with no peas, growing only veg). These 73 holdings represent 10 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 23 Land use regions of Scotland[14]



Changes from previous years

There are a number of changes which should be noted when comparing the 2021 data with the previous survey.

For the first time, broad beans have been included in the 'other vegetables' category. This is due to too few crops being encountered in the holdings sampled in 2021 to adequately represent usage. This must be taken into account when comparing both legume and other vegetable data between surveys.

In contrast to previous years, relative standard errors are not reported for constituent crop groups due to the small sample size of some crops encountered in some regions which presented issues with RSE calculation. Alternative methods for calculating RSEs for minor crops with low sample numbers are being investigated.

The previous reports in 2015 and 2019 contained information about grower adoption of Integrated Pest Management (IPM). IPM data was not collected during the 2021 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.

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, relative standard errors (RSE) for total pesticide use on vegetable crops for both area and weight have been calculated. 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 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 in 2021 was nine per cent for both area and weight, compared with five per cent for both area and weight in 2019. In contrast to previous years, RSE are not reported for constituent crop groups due to the small sample size of some crops encountered in some regions which presented issues with RSE calculation. Alternative methods for calculating RSEs for minor crops with low sample numbers are being investigated.

Acknowledgements

The authors would like to thank all the farmers, agronomists, contractors and seed merchants who agreed to provide information for this survey. Thanks are also due to Jackie Hughes (SASA), Fiona Burnett (SRUC), Sarah Cook, Philip Walker and Duncan Coston (ADAS), Lucy Darnton (HSE) and Rosemary Anfield (SASA) for editorial assistance. In addition, the authors are grateful for support and advice from David Garthwaite, Elena Stroda and Lewis Ridley at Fera Science Ltd, Paul Gavin at the Scottish Government's Agricultural Census Analysis Team and Adrian Roberts of Biomathematics & Statistics Scotland.

References

1. Food and Environment Protection Act 1985: https://www.legislation.gov.uk/ukpga/1985/48 [Accessed 13 Sep 2022]

2. EU Statistics Regulation (1185/2009/EC) Regulation (EC) No 1185/2009 of the European Parliament and of the Council of 25 November 2009 concerning statistics on pesticides (Text with EEA relevance) (legislation.gov.uk) [Accessed 13 Sep 2022]

3. Wardlaw, J., Davis, C., Monie C. & Reay, G (2019) Pesticide Usage in Scotland, Outdoor Vegetable Crops 2019, SGARE, Edinburgh 2020. https://www.sasa.gov.uk/document-library/outdoor-vegetable-crops-2019 [Accessed 13 Sep 2022]

4. Reay, G., Monie, C., Wardlaw, J. & Hughes, J. Pesticide Usage in Scotland, Outdoor Vegetable Crops 2017, SGARE, Edinburgh 2018. https://www.sasa.gov.uk/document-library/outdoor-vegetable-crops-2017

5. Met Office Regional Rainfall and Mean Temperature Datasets https://www.metoffice.gov.uk/research/climate/maps-and-data/uk-and-regional-series [Accessed 13 Sep 2022]

6. The Voluntary Initiative https://www.sasa.gov.uk/document-library/outdoor-vegetable-crops-2019 https://voluntaryinitiative.org.uk/news-events/2021/better-bentazone-together-group-launch-new-stewardship-campaign/ [Accessed 13 Sep 2022]

7. Pelletwise Metaldehyde Stewardship Scheme https://www.getpelletwise.co.uk/ [Accessed 13 Sep 2022]

8. Insecticide Resistance Action Committee (IRAC) http://www.irac-online.org/ [Accessed 13 Sep 2022]

9. Fungicide Resistance Action Committee (FRAC) http://www.frac.info/home [Accessed 13 Sep 2022]

10. Herbicide Resistance Action Committee (HRAC) http://hracglobal.com/ [Accessed 13 Sep 2022]

11. Agricultural Statistics, Scotland 2021. HMSO, Edinburgh 2021 https://www.gov.scot/publications/results-scottish-agricultural-census-june-2021/documents/ [Accessed 13 Sep 2022]

12. Agricultural Statistics, Scotland 2019. HMSO, Edinburgh 2019. https://www.gov.scot/publications/final-results-june-2019-agricultural-census/ [Accessed 13 Sep 2022]

13. Annual Survey of Hours and Earnings (ASHE) 2021 (Page one) https://www.ons.gov.uk/employmentandlabourmarket/peopleinwork/earningsandworkinghours/datasets/regionbyoccupation2digitsocashetable3 [Accessed 13 Sep 2022]

14. Wood, H.J. An Agricultural Atlas of Scotland. George Gill and Sons, London, 1931.

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ISBN 978-1-80525-015-9 (Web only)

Scottish Government
Riaghaltas na h-Alba

This publication is available at **www.gov.scot**

Any enquiries regarding this publication should be sent to us at

The Scottish Government
St Andrew's House
Edinburgh
EH1 3DG

ISBN: 978-1-80525-015-9 (web only)

Published by The Scottish Government, October 2022

Produced for The Scottish Government by APS Group Scotland, 21 Tennant Street, Edinburgh EH6 5NA
PPDAS1166342 (10/22)