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Pesticide Usage in Scotland

A National Statistics Publication for Scotland

Arable crops and Potato stores 2018

Pesticide Usage in Scotland

Arable Crops 2018

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Executive summary

This report presents information from a survey of pesticide use on arable crops grown in Scotland. The survey period covers the 2018 growing season, from post-harvest pesticide applications in 2017 through to harvest in 2018. The crop groups surveyed included cereals, oilseed rape, potatoes and legumes.

The estimated area of arable crops grown in Scotland in 2018 was ca. 489,309 hectares. Spring barley accounted for 51 per cent of the arable crop area, wheat 20 per cent, winter barley eight per cent, winter oilseed rape seven per cent and spring oats five per cent. Potatoes, legumes, winter oats and winter rye together accounted for the remaining nine per cent.

Data were collected from a total of 315 holdings, representing eight per cent of the total arable crop area grown in Scotland. Ratio raising was used to produce estimates of national pesticide use from the sampled data.

The estimated total area of arable crops treated with a pesticide formulation was ca. 4,632,066 hectares (± three per cent Relative Standard Error, RSE) with a combined weight of 1,312 tonnes (± three per cent RSE). Overall, pesticides were applied to 98 per cent of the arable crop area. Herbicides/desiccants were applied to 96 per cent of the crop area, fungicides to 93 per cent, growth regulators to 45 per cent, insecticides to 23 per cent and molluscicides to 10 per cent. Pesticide treatments were applied to 84 per cent of seed in this survey.

Taking into account changes in crop area, the 2018 total pesticide treated area was four per cent lower than that reported in 2016 and 2014. The weight of pesticide applied to arable crops in 2018 was 11 per cent lower than in 2016 and six per cent lower than 2014. The application of growth regulators, seed treatments, fungicides and herbicides/desiccants in 2018 decreased from the 2016 survey (8, 6, 4 and 2 per cent decreases in treated area respectively). Only molluscicide use increased between 2016 and 2018 both in terms of treated hectares (ten per cent) and in weight applied (12 per cent). The use of insecticides increased in terms of area treated (3 per cent) although the weight applied decreased by 30 per cent.

In terms of area treated, the most commonly used foliar fungicide active substance and the most used seed treatment was prothioconazole. The most used herbicide and insecticide was metsulfuron-methyl and lambda-cyhalothrin respectively. The herbicide imazosulfuron, the fungicides oxathiapiprolin and benzovindiflupyr and a seed treatment, sedaxane, were recorded for the first time 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 Delivery Directorate.

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

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

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

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

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

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

Structure of report and how to use these statistics

This report is intended to provide data in a useful format to a wide variety of data users. The general trends section provides commentary on recent changes in survey data and longer term trends. The pesticide usage section summarises usage on all arable crops in 2018. Appendix 1 presents all estimated pesticide usage in three formats, area and weight of formulations by crop and area and weight of active substances grouped by their mode of action. The area and weight of active substances by crop data, which were previously published in this report, are now published as supplementary data in Excel format. These different measures are provided to satisfy the needs of different data users (see Appendix 3 for examples). Appendix 2 summarises survey statistics including census and holding information, raising factors and survey response rates. Appendix 3 defines many of the terms used throughout the report. Appendix 4 describes the methods used during sampling, data collection and analysis as well as measures undertaken to avoid bias and reduce uncertainty. Any changes in method from previous survey years are also explained.

It is important to note that the figures presented in this report are produced from surveying a sample of holdings rather than a census of all the holdings in Scotland. Therefore the figures are estimates of the total pesticide use for Scotland and should not be interpreted as exact. To give an indication of the precision of estimates, the report includes relative standard errors. A full explanation of standard errors can be found in Appendix 5.

General trends

Crop area

The census area of arable crops grown in 2018 was 489,309 hectares (Table 28). This represents a one per cent decrease from 2016[(3)] to 2018 and an eight per cent decrease from 2014[(4)] to 2018. Since the last survey areas of winter rye, spring barley, winter oats, spring oats, oilseed rape and ware potatoes increased (55, 5, 4, 2 ,7 and 3 per cent respectively); while winter barley, wheat, seed potatoes and legumes have decreased (22, 9, 5 and 33 per cent respectively; Table 28, Figures 1 and 2).

In 2018, cereals accounted for 87 per cent of the arable area (51 per cent spring barley, 20 per cent wheat, eight per cent winter barley, five per cent spring oats, two per cent winter oats and one percent rye). The remaining area consisted of oilseed rape, potatoes and legumes (accounting for 7, 6 and <0.5 per cent respectively, Figure 3). The largest area of arable crops was in the Aberdeen region, followed by Angus, the Tweed Valley and Moray Firth (Figure 4).

Figure 1 Area of cereal crops grown in Scotland 2014-2018

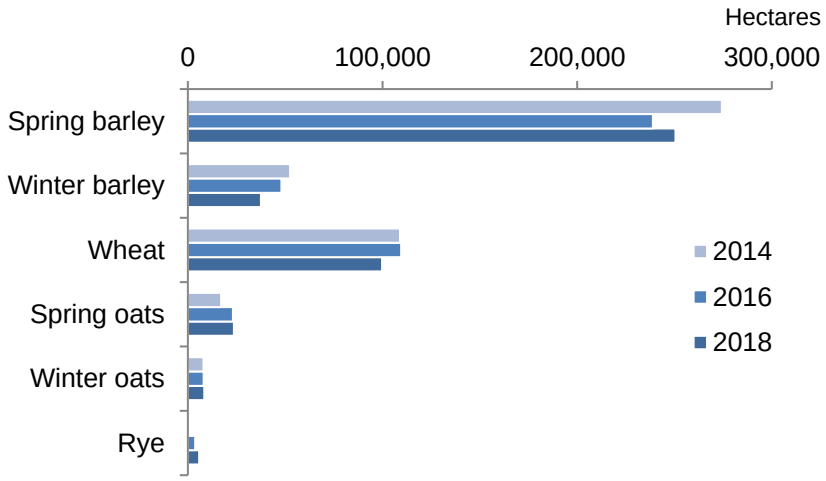
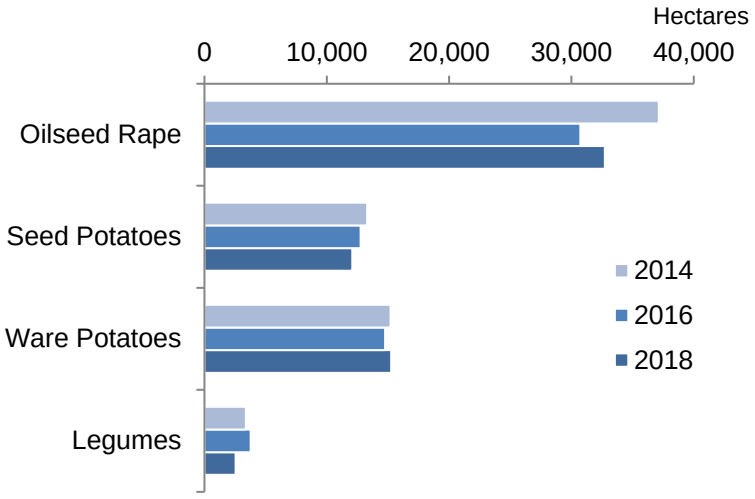
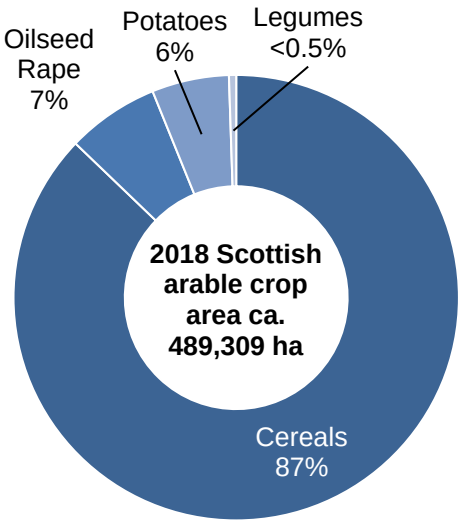


Figure 2 Area of oilseed rape, potatoes and legumes grown in Scotland 2014-2018



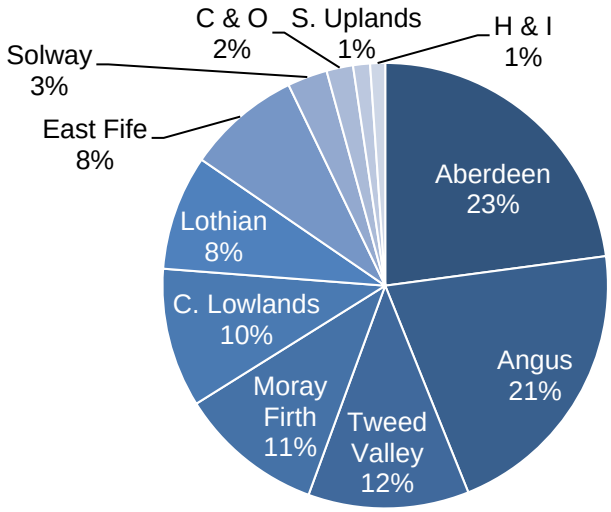
Note: oilseed rape includes winter and spring oilseed rape, legumes includes field beans and dry harvest peas

Figure 3 Arable crop areas 2018 (percentage of total area)



Note: cereals includes winter and spring barley, wheat, oats and winter rye; potatoes includes seed and ware potatoes; oilseed rape includes winter and spring oilseed rape; legumes includes field beans and dry harvest peas

Figure 4 Regional distribution of arable crops in Scotland 2018



Note: H&I = Highlands and Islands, S. Uplands = Southern Uplands, C&O = Caithness and Orkney and C. Lowlands=Central Lowlands

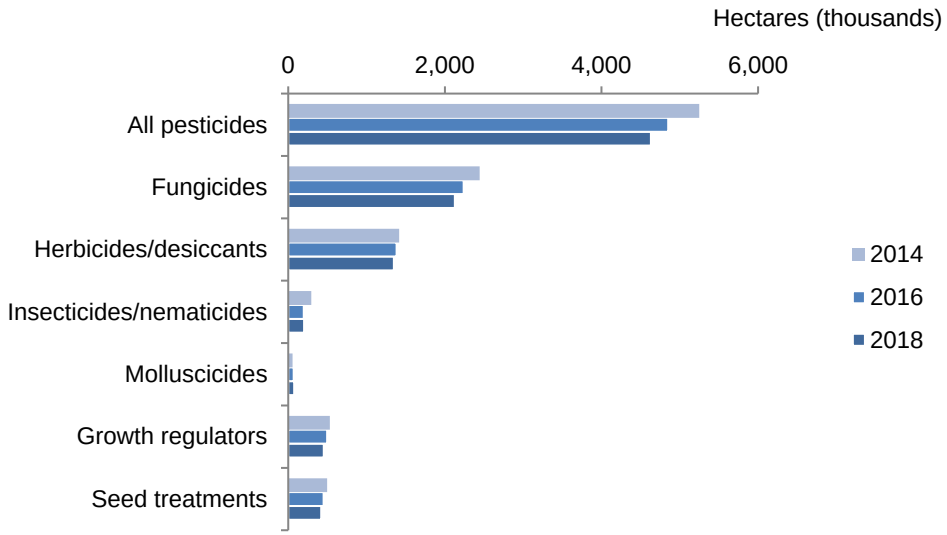
Pesticide usage

In 2018, as in 2016, the majority of arable crops (98 per cent) received a pesticide treatment.

Winter and spring barley, winter and spring wheat, winter oats, oilseed rape and ware potatoes had the highest overall proportion of crop treated with a pesticide (between 98 and 100 per cent, Table 1). Spring oats, seed potatoes and legumes had lower proportions of treated crop area (94, 89 and 72 per cent respectively). The average number of sprays applied to treated arable land, excluding seed treatments, was 3.9; a small reduction on that recorded in 2016 (average 4.2 sprays). Ware potatoes received the highest average number of sprays (12.6) and spring crops of barley, oats and wheat the lowest (2.5 each, Table 1). These figures only apply to the treated area of crops.

It is estimated that the area of arable crops treated with a pesticide formulation in 2018 was ca. 4,632,066 hectares compared with ca. 4,851,771 hectares in 2016 and ca. 5,247,614 hectares in 2014 (Table 24, Figure 5). This represents a decrease of five per cent since 2016 and 12 per cent since 2014.

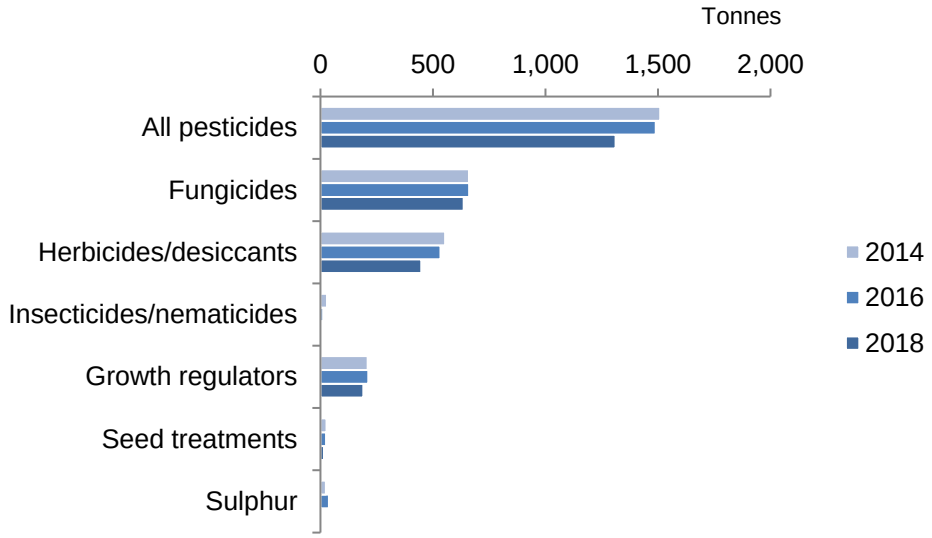
Figure 5 Area of arable crops treated with major pesticide groups in Scotland 2014-2018



Note: Sulphur is not shown as it represents <0.5 per cent of the treated area

In terms of weight of pesticide applied, 1,312 tonnes was applied in 2018, representing a decrease of 12 per cent from 2016 and 13 per cent from 2014 (Table 24, Figure 6).

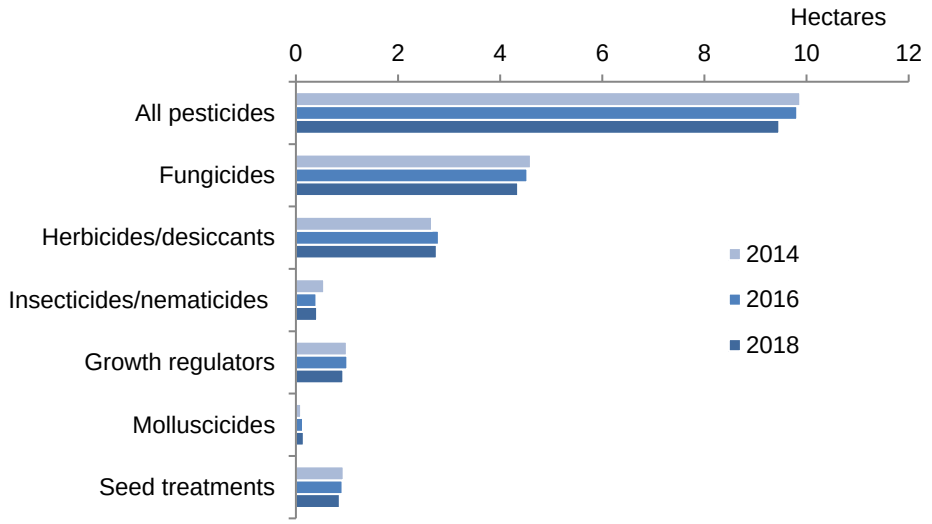
Figure 6 Quantity of major pesticide groups applied to arable crops in Scotland 2014-2018



Note: molluscicides are not shown as their use represents under 10 tonnes.

In order to make accurate comparisons between the 2018 data and the data collected in previous surveys, it is important to take into account the differences in crop area between survey 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. Once crop area is taken into account, there is reduction in area of total pesticides applied between the surveys. There was a four per cent decrease both from 2016 to 2018 and from 2014 to 2018 in terms of the total pesticide treated area per area of crop grown (Figure 7).

Figure 7 Number of pesticide treated hectares (formulations) per hectare of crop grown in Scotland 2014-2018

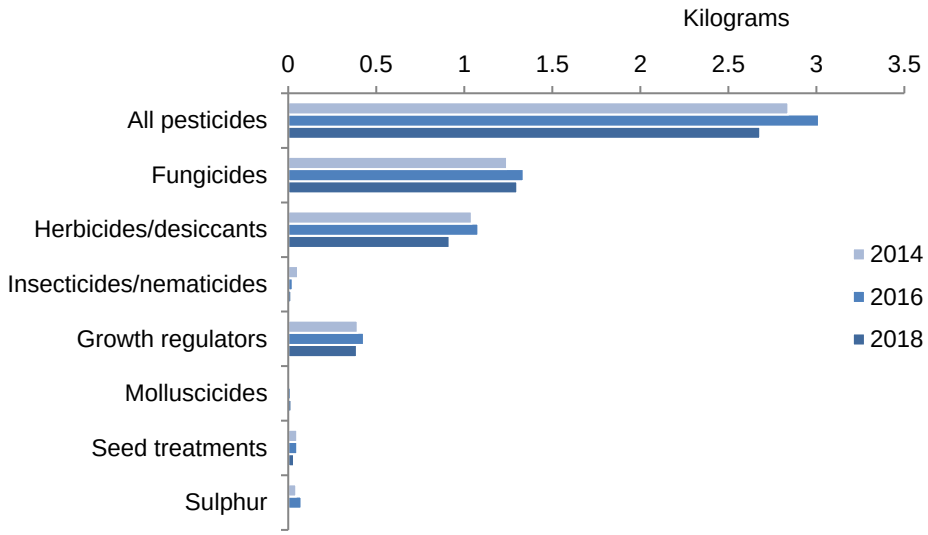


Note: sulphur is not shown as it represents <0.1 treated hectares per hectare of crop grown.

The 2018 season was challenging for farmers with a cold, wet start in spring followed by dry conditions over the summer; with some parts of Scotland receiving 75 per cent of their average annual rainfall total[5].· Delayed drilling of spring crops and the inability to spray winter sown fields may have reduced overall applications. Also, the cold spring and hot dry summer may have led to reduced pressure from weeds, pests and disease.

In terms of quantity of pesticides used per hectare of crop grown, there was a decrease of 11 per cent from 2016 to 2018 and a decrease of six per cent from 2014 to 2018 (Figure 8).

Figure 8 Weight of pesticide applied per hectare of crop grown in Scotland 2014-2018

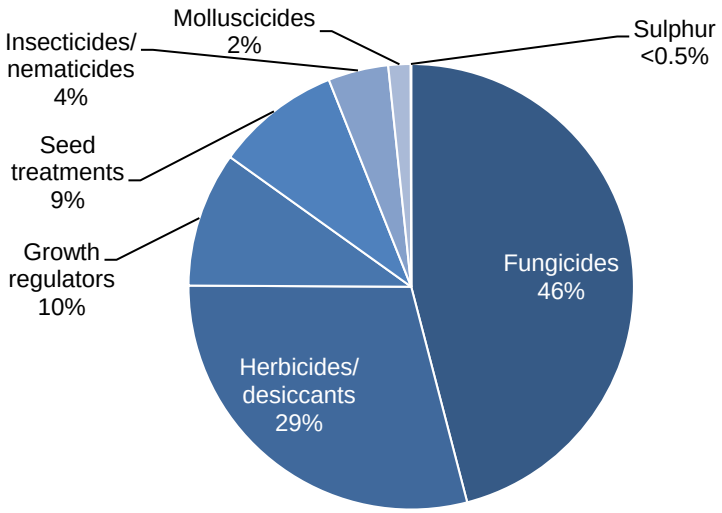


Fungicides were the most frequently used pesticides on arable crops, followed by herbicides/desiccants (Figure 5). This pattern has been observed in arable surveys for some time. In 2018, fungicides accounted for 46 per cent of the total pesticide treated area and 49 per cent of the total weight of active substances applied (Figures 9 & 10). When changes in crop area are taken into account, there was a four per cent decrease in area treated with fungicides from 2016 to 2018 and a five per cent decrease in area treated from 2014 to 2018 (Figure 7). The weight of fungicides applied per hectare decreased by three per cent from 2016 to 2018 but increased by five per cent from 2014 to 2018 (Figure 8).

In 2018, herbicides/desiccants accounted for 29 per cent of the total pesticide treated area and 34 per cent of the total weight of active substances applied (Figures 9 & 10). When changes in crop area are taken into account, there was a two per cent decrease in the area treated with herbicides/desiccants from 2016 to 2018 and a three per cent increase from 2014 to 2018. The weight of herbicides/desiccants applied fell by 15 percent from 2016 to 2018 and by 12 per cent from 2014 to 2018 (Figures 7 & 8).

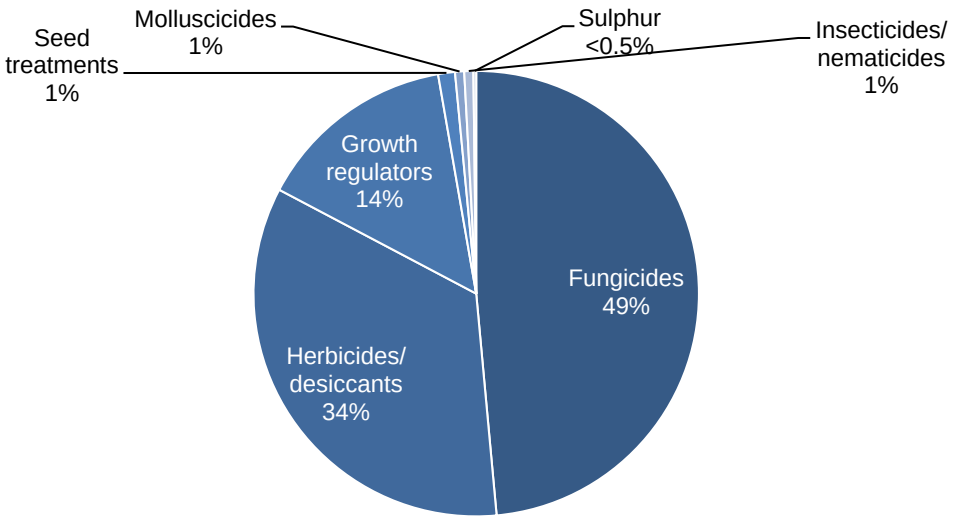
The hot dry weather conditions in the summer months may have reduced the need for use of desiccants. When corrected for area of crop grown, the glyphosate treated area decreased by 14 per cent and the weight applied decreased by 19 per cent from 2016 to 2018. In addition, the area treated with diquat decreased by 30 per cent and the weight applied decreased by 39 per cent from 2016 to 2018. The authorisation for diquat has been withdrawn with final use for the product in February 2020. The decreased use of diquat on potatoes may also have been influenced by growers trialling different methods of haulm destruction in preparation for the loss of diquat.

Figure 9 Use of pesticide on arable crops - 2018 (percentage of total area treated with formulations)



Insecticides accounted for four per cent of the total pesticide treated area and one per cent of the total weight of active substances applied (Figures 9 & 10). As in 2016, pyrethroids accounted for the largest area treated with an insecticide (87 per cent, Table 18). When changes in crop area are taken into account, there was a three per cent increase in area treated with insecticide from 2016 to 2018 and a 25 per cent decrease from 2014 to 2018 (Figure 7). The weight of insecticides applied per hectare of crop grown was found to have decreased by 30 per cent from 2016 to 2018 and by 68 per cent from 2014 to 2018 (Figure 8). The large decreases in weight of insecticides applied since the previous surveys is influenced by the loss of the active substance chlorpyrifos which was applied at high rates for the control of leatherjackets and wheat bulb fly in cereals crops. When changes in crop area are taken into account, insecticide use on oilseed rape in 2018 decreased 30 per cent by area treated since 2016. Insecticide use on oilseed rape in 2016 increased by 10 per cent by area treated from 2014 as a result of the loss of neonicotinoid seed treatments which meant growers were reliant on foliar insecticides for insect control during autumn crop establishment period.

Figure 10 Use of pesticides on arable crops - 2018 (percentage of total quantity of active substances applied)



Molluscicides accounted for two per cent of the total pesticide treated area and one per cent of the total weight of active substances applied (Figures 9 & 10). When changes in crop area are taken into account, there was a ten per cent increase in area treated from 2016 to 2018 and a 50 per cent increase from 2014 to 2018 (Figure 7). The quantity of mollusicides applied per hectare of crop grown increased by 12 per cent from 2016 to 2018 and by 77 per cent from 2014 to 2018 (Figure 8).

Growth regulators accounted for ten per cent of the total pesticide treated area and 14 per cent of the total weight of active substances applied (Figures 9 & 10). When changes in crop area are taken into account, the area treated decreased by eight per cent from 2016 to 2018 and by seven per cent from 2014 to 2018 (Figure 7). The weight of growth regulators applied per hectare of crop grown decreased by nine per cent from 2016 to 2018 and by one per cent from 2014 to 2018 (Figure 8). The cold spring and resulting slow crop growth in 2018 may have reduced the requirement for the application of growth regulators.

Seed treatments accounted for nine per cent of the total pesticide treated area and one per cent of the total weight of active substances applied (Figures 9 & 10). When changes in crop area are taken into account, there was a six per cent decrease in area treated between 2016 and 2018 and an eight per cent decrease between 2014 and 2018 (Figure 7). The weight of seed treatments applied per hectare has decreased by 36 per cent from 2016 and by 35 per cent since 2014 (Figure 8). The decrease in the use of seed treatments, may relate to the withdrawal of some cereal seed treatment formulations in 2017, including prochloraz/triticonazole.

Sulphur accounted for less than 0.5 per cent of the total pesticide treated area and the total weight of active substances applied (Figures 9 & 10). When changes in crop area are taken into account, there was an 87 per cent decrease in area treated from 2016 to 2018 and an 88 per cent decrease from 2014 to 2018 (Figure 7). The quantity of sulphur applied per hectare of crop grown decreased by 93 per cent from 2016 to 2018 and 88 per cent from 2014 to 2018 (Figure 8).

Four active substances were recorded for the first time in the 2018 arable survey (Table 18). These included the herbicide imazosulfuron (for control of broad-leaved weeds in cereal crops) and the fungicides oxathiapiprolin (for blight in potatoes) and benzovindiflupyr (for cereal diseases). There was also a fungicidal seed treatment, sedaxane, used in cereals, which was encountered for the first time in this survey.

Whilst overall use of pesticides in 2018 has reduced slightly from the previous survey, some individual active substances have exhibited considerable changes. For example, there were substantial increases in the use of the herbicide halauxifen-methyl (32,228 per cent by area treated) on winter and spring cereals since the previous survey (Table 22). This was a relatively new active in 2016 and was only recorded once in the 2016 survey. Use increased in 2018 as one of the products containing this active substance was recommended as efficacious for weed control in cool conditions such as those encountered in the spring of 2018[6].

The main molluscicide active substance, metaldehyde, decreased by 20 per cent by area treated and 15 per cent by weight applied (Tables 22 & 23). This is likely to have been influenced by changes in authorisation for molluscicides. All products containing metaldehyde formed part of an enhanced stewardship plan from 2017 reducing its use [7]. There has been an increase in ferric phosphate use (197 per cent by weight applied) in this survey as the only other chemical alternative for slug control. The herbicide, metobromuron has seen the highest increase in weight of active substance used (1,400 per cent) This active substance was included in two new products released at the beginning of 2015 for pre-emergence weed control in potatoes with some residual action[8] and was encountered in the 2016 survey on a very small area.

2018 Pesticide usage

Winter barley

- An estimated 37,541 hectares of winter barley were grown in Scotland in 2018, a decrease of 22 per cent since 2016.
- 100 per cent of the crop was treated with a pesticide (see Figure 11 for types of pesticides used)
- Pesticides were applied to 430,940 treated hectares
- 129,495 kilograms of pesticide were applied in total (see summary table)
- Winter barley received on average 4.2 pesticide sprays (Table 1). These sprays included 2.5 fungicide applications and 2.2 herbicide/desiccant applications (applied to 100 per cent and 98 per cent of the crop area respectively), 1.9 applications of growth regulators (applied to 96 per cent) and one application of insecticide (applied to 22 per cent)
- Timings of pesticide applications are shown in Figure 12
- Where reasons were given (59 per cent), 37 per cent of fungicide use was for disease control/precaution. Where the disease was specified *Rynchosporium* was the most commonly reported (seven per cent) followed by mildew (six per cent), *Ramularia* (four per cent), net blotch (two per cent), rust (one per cent) with ear diseases, eyespot and *Fusarium* all under one per cent.
- Reasons for herbicide/desiccant use were given for 62 per cent of the area. Twenty per cent was for general weed control, 11 per cent each for annual broad-leaved weeds and desiccation/harvest aid. The remaining reasons were; annual meadow grass (nine per cent), wild oats (three per cent), annual grass weeds (two per cent), cleavers, docks and chickweed (all one per cent). All other reasons (volunteer rape, couch, mayweed, groundsel, crop destruction volunteer cereals, charlock and sterile brome) were below one per cent.
- Where specified (61 per cent) all insecticide use was for aphids
- The most common varieties encountered were KWS Tower (22 per cent) followed by Pearl (12 per cent)
- The average reported yield was 7.7 t/ha

Summary of pesticide use on winter barley:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	181,531	47,352	100	Chlorothalonil (43,297)
Herbicides/ desiccants	109,351	45,193	98	Glyphosate (22,722)
Insecticides	8,361	42	22	Lambda-Cyhalothrin (4,037)
Growth regulators	93,360	34,998	96	Chlormequat (32,171)
Molluscicides	3,385	409	7	Metaldehyde (2,044)
Sulphur	297	593	1	N/A
Seed treatments	34,655	908	90	Fluopyram/prothioconazole/ tebuconazole (14,059)
All pesticides	**430,940**	**129,495**	**100**	

N/A = not applicable

Figure 11 Use of pesticides on winter barley (percentage of total area treated with formulations) – 2018

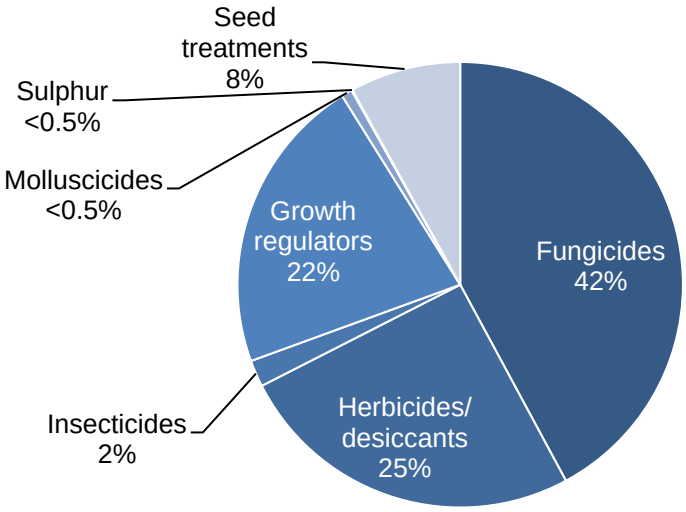
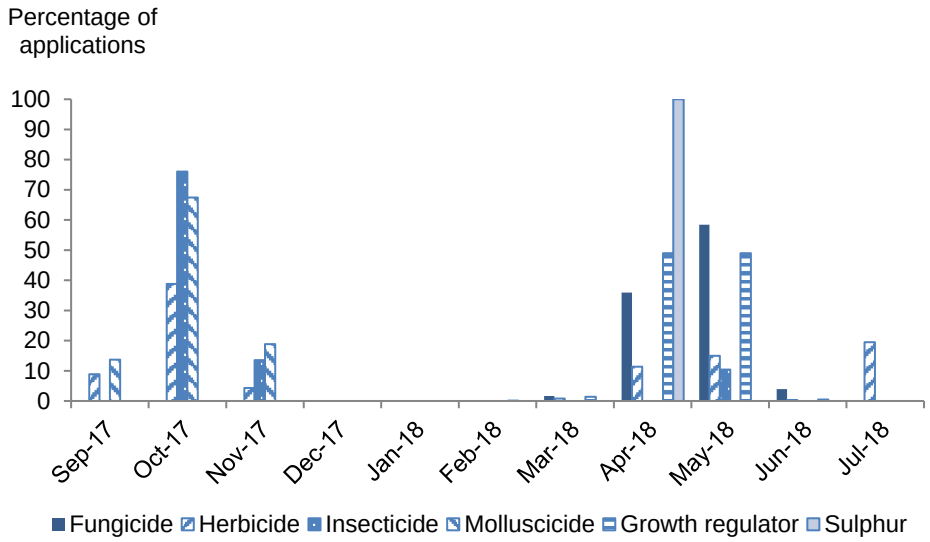


Figure 12 Timing of pesticide applications on winter barley – 2018



Note: there were small amounts (<1%) of herbicide applications on winter barley in August 2017 and 2018 which are not shown on this figure. Herbicides include desiccants.

Spring barley

- An estimated 250,476 hectares of spring barley were grown in Scotland in 2018, representing an increase of five per cent since 2016
- 97 per cent of the crop was treated with a pesticide (see Figure 13 for types of pesticide used)
- Pesticides were applied to 1,662,823 treated hectares
- 376,057 kilograms of pesticide were used in total on the crop (see summary table)
- The spring barley crop received on average 2.5 pesticide applications (Table 1). These included 1.8 fungicide applications and 1.7 herbicide/desiccant applications (applied to 92 per cent and 96 per cent of the crop area respectively) and 1.1 applications of growth regulators (applied to 22 per cent)
- Timings of pesticide applications are shown in Figure 14
- Reasons were given for 62 per cent of total fungicide use with 48 per cent being for disease control/precaution. Where the disease was specified *Rhynchosporium* was the most commonly reported (six per cent) followed by *Ramularia* (four per cent), mildew (two per cent) and net blotch (one per cent). Rust, and leaf spot were reported at below one per cent
- Reasons were supplied for 67 per cent of herbicide/desiccant use; 28 per cent was for general weed control, 17 per cent for annual broad-leaved weeds, five per cent for wild oats, six per cent desiccation/harvest aid, three per cent annual meadow grass and two per cent chickweed. Annual grass weeds, fumitory and couch were all listed at one per cent and twenty other herbicide reasons were recorded at less than one per cent
- Reasons were supplied for 51 per cent of total insecticide use. 35 per cent was for aphids, eight per cent was for cereal leaf beetle, four per cent for flea beetle, three per cent for general pests and less than 1 per cent for leaf miners.
- Concerto was still the most common variety, accounting for 40 per cent of the sample area, although it has dropped from 58 per cent in 2016
- The average reported yield was 6.0 t/ha

Summary of pesticide use on spring barley:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	706,840	175,508	92	Chlorothalonil (204,728)
Herbicides/ desiccants	650,309	177,890	96	Metsulfuron-methyl/ thifensulfuron-methyl (94,936)
Insecticides	31,852	160	12	Lambda-cyhalothrin (26,845)
Growth regulators	60,755	18,991	22	Chlormequat (23,677)
Seed treatments	213,068	3,508	85	Imazalil/ipconazole (87,085)
All pesticides	**1,662,823**	**376,057**	**98**	

Figure 13 Use of pesticides on spring barley (percentage of total area treated with formulations) – 2018

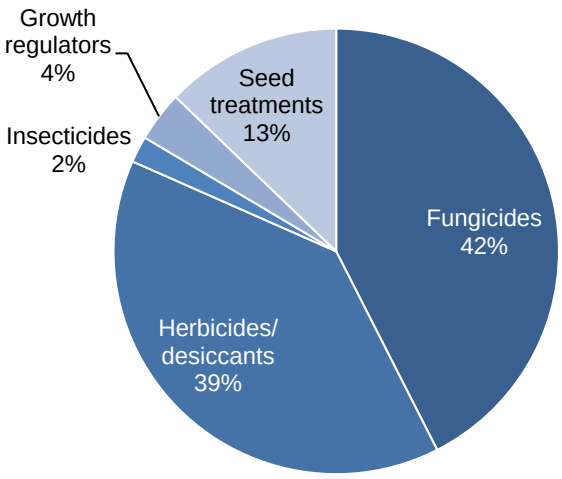
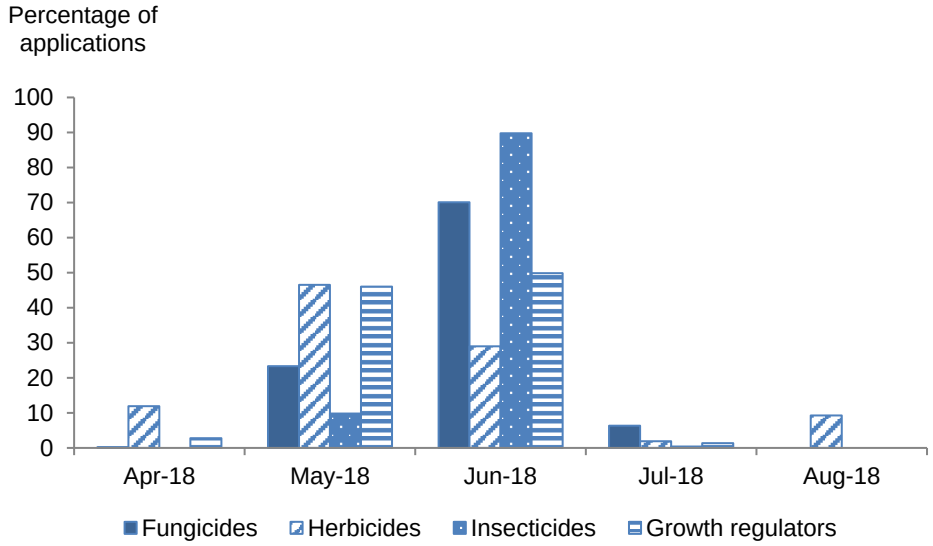


Figure 14 Timing of pesticide applications on spring barley – 2018



Note: there were small amounts (<0.5%) of herbicide applications on spring barley in September 2017, October, December, February, March and September 2018 which are not shown on this figure. Herbicides include desiccants.

Winter wheat

- An estimated 94,236 hectares of winter wheat were grown in Scotland in 2018, representing a decrease of 8 per cent since 2016
- 98 per cent of the crop was treated with a pesticide (see Figure 15 for types of pesticide used)
- Pesticides were applied to 1,373,830 treated hectares
- 406,113 kilograms of pesticide were used in total on the crop (see summary table)
- The winter wheat crop received on average 5.1 pesticide applications (Table 1). These included 3.5 fungicide applications and 2.1 herbicide/desiccant applications (applied to 97 per cent of the crop area for both groups), 1.9 applications of growth regulators (applied to 95 per cent) molluscicides and insecticides received 1.3 and 1.2 applications (applied to 20 and 21 per cent of the area respectively)
- Timings of pesticide applications are shown in Figure 16
- Reasons were given for 42 per cent of total fungicide use with 22 per cent being for disease control/precaution. Where the disease was specified *Septoria* was the most commonly reported (10 per cent) followed by mildew (four per cent), rust (three per cent) and ear disease, *Fusarium* and eyespot all below one per cent.
- Reasons were supplied for 50 per cent of herbicide/desiccant use; 19 per cent was for general weed control, 11 per cent for annual broad-leaved weeds and seven per cent for annual meadow grass. Four per cent of use was for desiccation/harvest aid. Two per cent listed wild oats with cleavers, annual grass weeds, sterile brome, brome, volunteer rape, volunteer cereals and fumitory all one per cent. Twelve other reasons for herbicide use were all recorded at below one percent to give two per cent of all reasons given.
- Reasons were supplied for 40 per cent of total insecticide use. Thirty nine per cent of which was for aphids and one per cent was for general pests
- Zulu was the most common variety, accounting for 16 per cent of the sample area, followed by KWS Leeds at 13 per cent
- The average reported yield was 8.7 t/ha

Summary of pesticide use on winter wheat:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	719,393	208,218	97	Chlorothalonil (203,311)
Herbicides/ desiccants	278,055	85,108	97	Pendimethalin/picolinafen (31,546)
Insecticides	23,559	119	21	Lambda-cyhalothrin (19,260)
Growth regulators	239,784	104,602	95	Chlormequat (96,171)
Molluscicides	25,501	2,859	20	Metaldehyde (17,968)
Sulphur	1,042	1,668	1	N/A
Seed treatments	86,497	3,539	86	Fludioxonil (34,271)
All pesticides	**1,373,830**	**406,113**	**98**	

N/A = not applicable

Figure 15 Use of pesticides on winter wheat (percentage of total area treated with formulations) – 2018

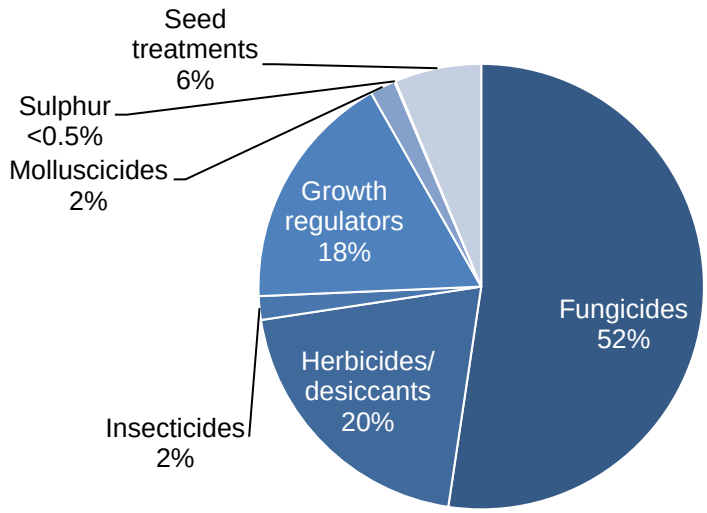
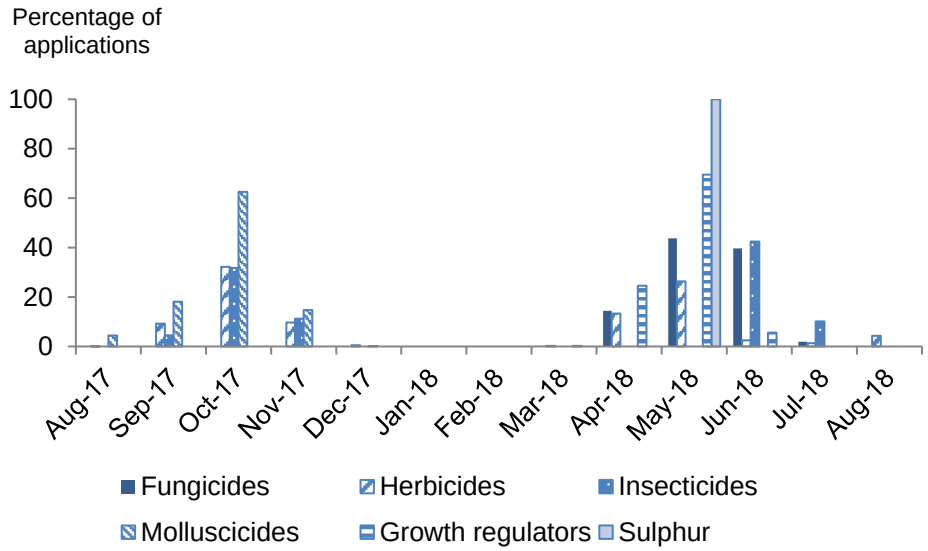


Figure 16 Timing of pesticide applications on winter wheat – 2018



Note: there were small amounts (<0.5%) of herbicide applications on winter wheat in September 2018 which are not shown on this figure. Herbicides include desiccants.

Spring wheat

This crop was not recorded separately in the Agricultural Census. Based upon the proportions of spring and winter wheat encountered in the survey it was estimated that 5,542 hectares of spring wheat were grown in Scotland in 2018, representing a decrease of 19 per cent since 2016.

- 100 per cent of the crop was treated with a pesticide (see Figure 17 for types of pesticides used)
- Pesticides were applied to 41,577 treated hectares
- 11,111 kilograms of pesticide were used in total on the crop (see summary table below)
- The spring wheat crop received on average 2.5 pesticide applications (Table 1). These included 2.0 fungicide applications and 1.6 herbicide/desiccant applications (applied to 99 per cent and 100 per cent of the crop area respectively), 1.2 applications of growth regulators (applied to 38 per cent) and 1.0 applications of insecticide (applied to 20 per cent)
- Timings of pesticide applications are shown in Figure 18
- Reasons were given for 68 per cent of total fungicide use with over 67 per cent being for disease control/precaution. The only disease specified was mildew at less than 0.5 per cent.
- Reasons were supplied for 69 per cent of herbicide/desiccant use; 36 per cent was for annual broad-leaved weeds, 20 per cent for desiccation/harvest aid, eight per cent for red shank and two per cent for wild oats.
- Reasons were supplied for 28 per cent of total insecticide use, all of which was for general pest control
- The most common variety grown, accounting for 29 per cent of the sample area, was Belepi followed by Granary at 26 per cent
- The average reported yield was 6.4 t/ha

Summary of pesticide use on spring wheat:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	18,381	5,448	99	Chlorothalonil (5,635)
Herbicides/ desiccants	14,168	4,233	100	Metsulfuron-methyl/ thifensulfuron-methyl (2,230)
Insecticides	1,113	5	20	Lambda-cyhalothrin (1,064)
Growth regulators	2,902	1,370	38	Chlormequat (1,818)
Seed treatments	5,013	55	90	Fludioxonil (3,226)
All pesticides	**41,577**	**11,111**	**100**	

Figure 17 Use of pesticides on spring wheat (percentage of total area treated with formulations) – 2018

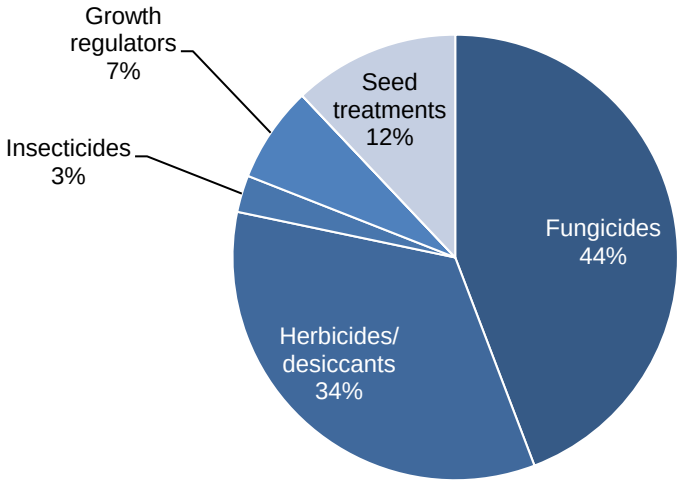
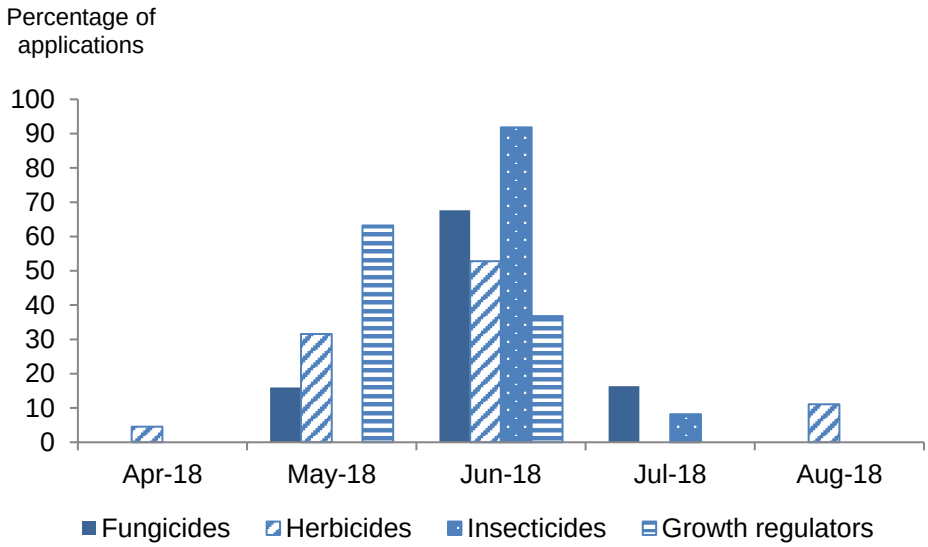


Figure 18 Timing of pesticide applications on spring wheat – 2018



Note: Herbicides include desiccants.

Winter oats

- An estimated 8,440 hectares of winter oats were gown in Scotland in 2018, an increase of four per cent since 2016.
- 99 per cent of the crop was treated with a pesticide (see Figure 19 for types of pesticides used)
- Pesticides were applied to 76,286 treated hectares
- 17,474 kilograms of pesticide were applied in total (see summary table)
- Winter oats received on average 3.8 pesticide sprays (Table 1). These sprays included 2.4 fungicide applications and 2.1 herbicide/desiccant applications (applied to 95 per cent and 96 per cent of the crop area respectively), 1.3 applications of growth regulators (applied to 97 per cent) and 1.2 applications of insecticides (applied to 30 per cent)
- Timings of pesticide applications are shown in Figure 20
- Where reasons were given (62 per cent of area treated), 30 per cent of fungicide use was for mildew, 14 per cent for disease control/precaution, seven per cent for crown rust, six per cent for rust, two per cent each for *Septoria* and eyespot and less than one per cent for *Fusarium*.
- Reasons for herbicide/desiccant use were given for 59 per cent of the area, 20 per cent was for annual broad-leaved weeds, 13 per cent for general weed control, seven per cent for annual meadow grass, seven per cent for desiccation/harvest aid, three per cent for cleavers and fumitory, two per cent for volunteer beans, one per cent each for groundsel, volunteer rape and annual grass weeds. The remainder was made up of hemp nettle and redshank at less than one per cent each.
- Where specified (44 per cent) 40 per cent of insecticide use was for aphids and four per cent for general pests
- The most common variety encountered was Gerald accounting for 50 per cent of the sample area followed by Dalguise at 27 per cent
- The average reported yield was 6.7 t/ha

Summary of pesticide use on winter oats:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	29,056	4,614	95	Fenpropimorph (7,235)
Herbicides/ desiccants	20,299	4,705	96	Diflufenican/flufenacet (4,135)
Insecticides	3,155	16	30	Lambda-cyhalothrin (2,333)
Growth regulators	16,552	7,945	97	Trinexapac-ethyl (7,512)
Molluscicides	291	22	3	Metaldehyde (201)
Seed treatments	6,934	173	82	Fludioxonil (385)
All pesticides	**76,286**	**17,474**	**99**	

Figure 19 Use of pesticides on winter oats (percentage of total area treated with formulations) – 2018

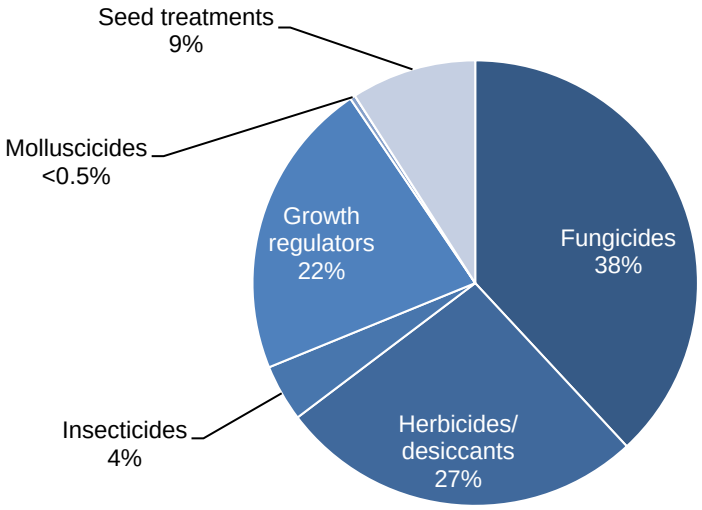
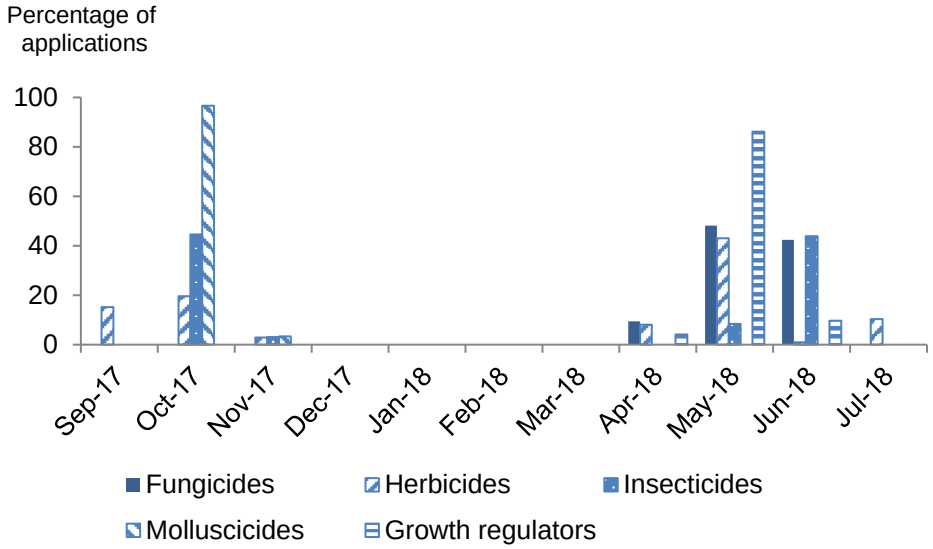


Figure 20 Timing of pesticide applications on winter oats – 2018



Note: Herbicides include desiccants.

Spring oats

- An estimated 23,662 hectares of spring oats were gown in Scotland in 2018, an increase of two per cent since 2016.
- 94 per cent of the crop was treated with a pesticide (see Figure 21 for types of pesticides used)
- Pesticides were applied to 138,929 treated hectares
- 37,337 kilograms of pesticide were applied in total (see summary table)
- Spring oats received on average 2.5 pesticide sprays (Table 1). These sprays included 1.7 fungicide applications and 1.5 herbicide/desiccant applications (applied to 80 per cent and 92 per cent of the crop area respectively), 1.1 applications of growth regulators (applied to 77 per cent) and one application of insecticides (applied to 34 per cent)
- Timings of pesticide applications are shown in Figure 22
- Where reasons were given (55 per cent), 31 per cent of fungicide use was for disease control/precaution, 16 per cent for mildew, three per cent for rust, one per cent for ear disease and *Septoria* with both crown rust and eyespot reported as less than one per cent
- Reasons for herbicide/desiccant use were given for 57 per cent of the area, 33 per cent for general weed control, 11 per cent was for annual broad-leaved weeds and 9 per cent for desiccation/harvest aid with one per cent each for annual grass weeds, couch, fumitory and cleavers. Volunteer beans, crop destruction and chickweed were all reported at below one per cent
- Where specified (44 per cent) 32 per cent of insecticide use was for aphids, seven per cent for leaf miners and five per cent for general pests
- The most common variety encountered was Canyon accounting for 40 per cent of the sample area followed by Conway at 15 per cent
- The average reported yield was 5.6 t/ha

Summary of pesticide use on spring oats:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	42,538	6,546	80	Fenpropimorph (7,651)
Herbicides/ desiccants	48,727	15,900	92	Fluroxypyr (9,050)
Insecticides	8,133	33	34	Lambda-cyhalothrin (6,132)
Growth regulators	22,864	14,617	77	Chlormequat (11,822)
Seed treatments	16,666	241	70	Prothioconazole/tebuconazole (6,043)
All pesticides	**138,929**	**37,337**	**94**	

Figure 21 Use of pesticides on spring oats (percentage of total area treated with formulations) – 2018

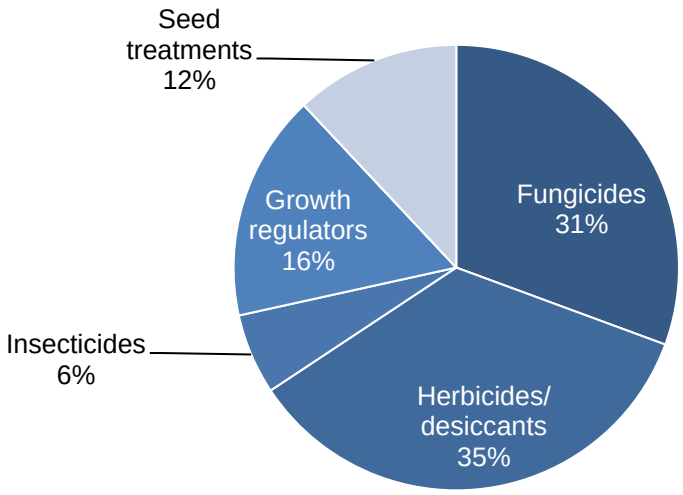
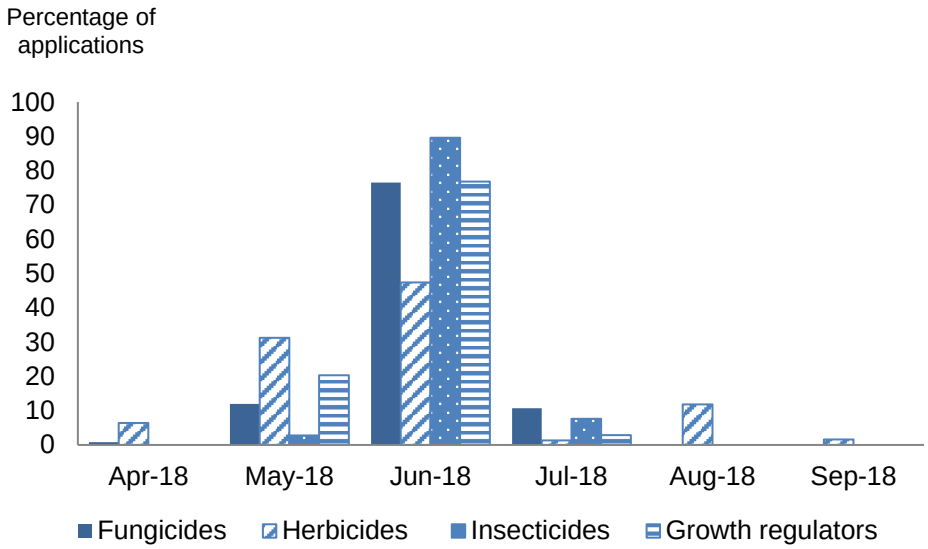


Figure 22 Timing of pesticide applications on spring oats – 2018



Note: there were small amounts (<0.5%) of herbicides/desiccants applied in September 2017 which are not presented in this figure. Note: Herbicides include desiccants.

Oilseed rape

- An estimated 32,735 hectares of oilseed rape (winter and spring) were grown in Scotland in 2018, representing an increase of nine per cent since 2016
- 100 per cent of the crop was treated with a pesticide (see Figure 23 for types of pesticides used)
- Pesticides were applied to 301,544 treated hectares
- 88,480 kilograms of pesticide were used in total on the crop (see summary table)
- The oilseed rape crop received on average 5.9 pesticide applications (Table 1). These included 2.8 fungicide applications and 2.6 herbicide/desiccant applications (applied to 98 and 99 per cent of the crop area respectively), one application of growth regulators (applied to 16 per cent) 1.2 molluscicide applications (applied to 59 per cent) and 1.6 insecticides applications to 65 per cent of the crop area
- Timings of pesticide applications are shown in Figure 24
- Reasons were given for 44 per cent of total fungicide use with 20 per cent being for light leaf spot, 13 for *Sclerotinia*, seven for disease control/precaution, with one each for *Phoma* leaf spot and *Alternaria*. Other diseases were listed at below one per cent.
- Reasons were supplied for 42 per cent of herbicide/desiccant use; nine per cent each for general weed control and desiccation/harvest aid, seven per cent for annual broad-leaved weeds, six for volunteer cereals, three each for annual meadow grass and annual grass weeds with one per cent each for brome, mayweed and sterile brome. Chickweed, thistles, cleavers, wild oats, black grass, couch and speedwell were all recorded at below one per cent.
- Reasons were supplied for 43 per cent of total insecticide use. Ten per cent of which was for winter stem weevil, nine per cent for seed weevil and eight per cent for pollen beetle, five each for weevils and cabbage stem flea beetle, four for aphids and two for flea beetle. Pod midge was recorded at below one per cent
- Anastasia was the most common variety, accounting for 20 per cent of the sample area, followed by Mentor at 19 per cent
- The average reported yield was 3.9 t/ha

Summary of pesticide use on oilseed rape:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	109,052	18933	98	Prothioconazole/ tebuconazole (27,435)
Herbicides/ desiccants	100,286	64,895	99	Glyphosate (26,942)
Insecticides	33,353	551	65	Lambda-cyhalothrin (14,318)
Growth regulators	5,139	938	16	Mepiquat chloride/ metconazole (5,139)
Molluscicides	23,917	2,439	59	Metaldehyde (15,743)
Sulphur	223	401	<0.5	N/A
Seed treatments	29,574	323	89	Prochloraz/thiram (26,764)
All pesticides	**301,544**	**88,480**	**100**	

N/A = not applicable

Figure 23 Use of pesticides on oilseed rape (percentage of total area treated with formulations) – 2018

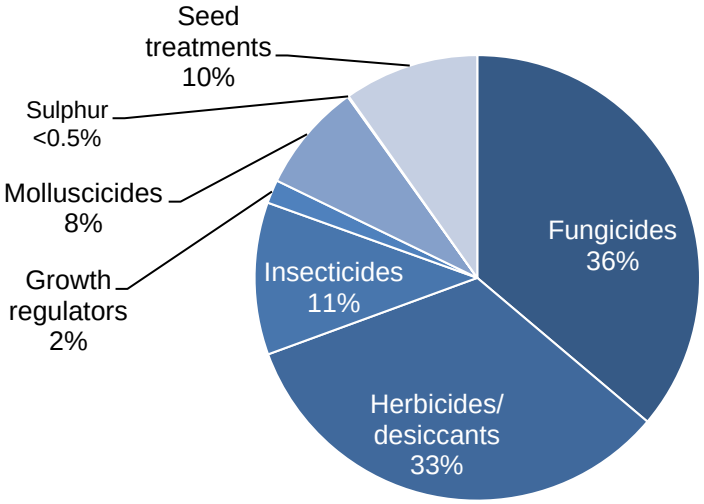
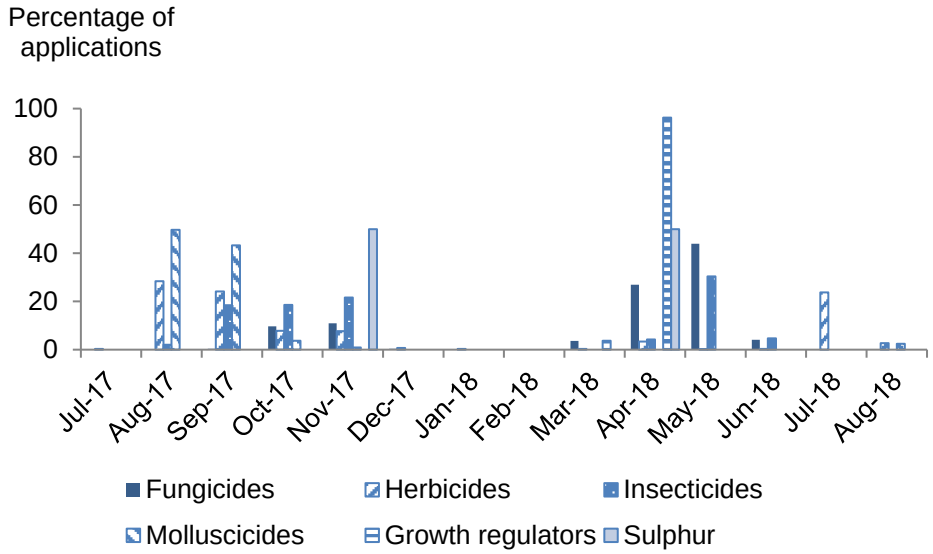


Figure 24 Timing of pesticide applications on oilseed rape – 2018



Note: Herbicides include desiccants.

Seed potatoes

- An estimated 12,091 hectares of seed potatoes were grown in Scotland in 2018, representing a decrease of five per cent since 2016
- 89 per cent of the crop was treated with a pesticide (see Figure 25 for types of pesticide used)
- Pesticides were applied to 250,155 treated hectares
- 89,460 kilograms of pesticide were used in total on the crop (see summary table below)
- The seed potato crop received on average 10.9 pesticide applications (Table 1). These included 8.8 fungicide applications and 2.2 herbicide/desiccant applications (applied to 89 per cent of the crop area for both groups), insecticides and molluscicides received 5.9 and two applications respectively (applied to 86 and 22 per cent of the area respectively)
- Timings of pesticide applications are shown in Figure 26
- Reasons were given for 34 per cent of total fungicide use, all of which was for blight.
- Reasons were given for 23 per cent of herbicide/desiccant use; ten per cent was for general weed control, nine per cent for desiccation/harvest aid and two per cent each for both annual broad leaved weeds and annual meadow grass. Annual grass weeds, volunteer cereals, couch and volunteer rape were all recorded at below one per cent.
- Reasons were supplied for 37 per cent of total insecticide/nematicide use. 35 per cent of which was for aphids and two per cent was for nematodes
- Maris Piper was the most common variety, accounting for 35 per cent of the sample area, followed by Desiree and Markies at nine per cent each
- The average reported yield was 44.1 t/ha

Summary of pesticide use on seed potatoes:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	122,259	61525	89	Cyazofamid (24,191)
Herbicides/ desiccants	44,936	16,970	89	Diquat (16,017)
Insecticides/ nematicides	67,388	6,182	86	Lambda-cyhalothrin (29,655)
Molluscicides	5,336	798	22	Metaldehyde (3,137)
Seed treatments	10,235	3,986	83	Pencycuron (4,695)
All pesticides	**250,155**	**89,460**	**89**	

Figure 25 Use of pesticides on seed potatoes (percentage of total area treated with formulations) – 2018

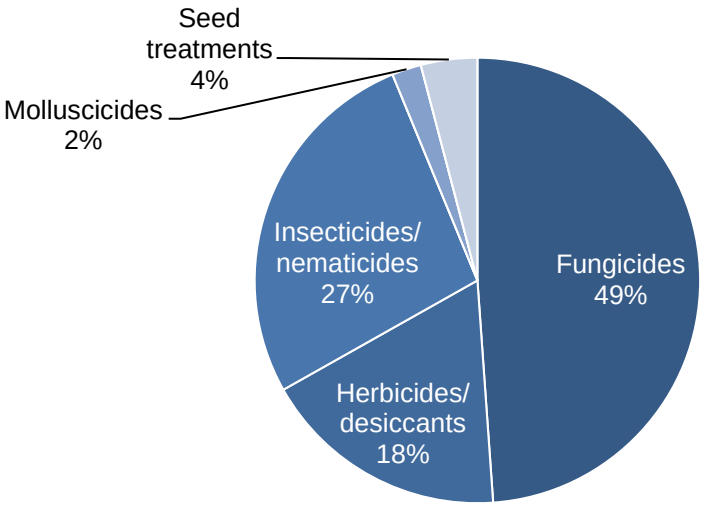
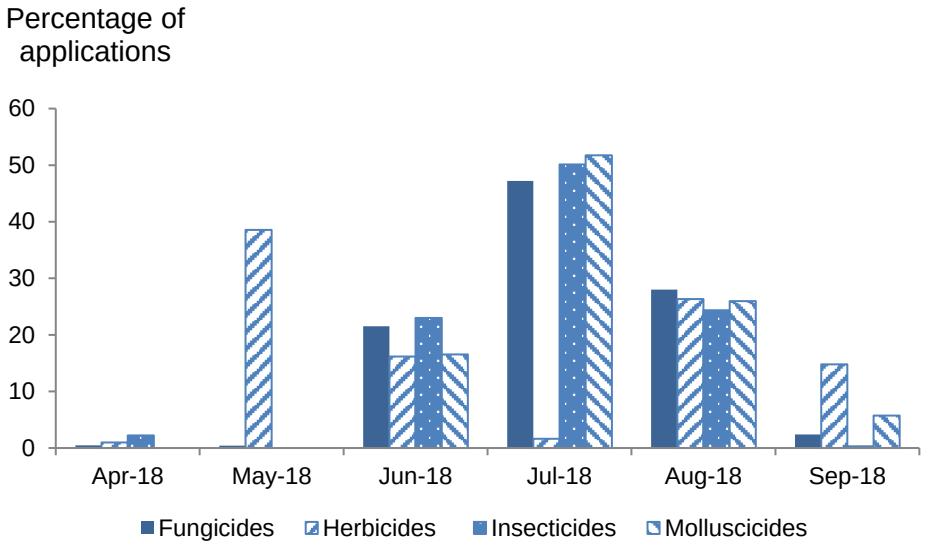


Figure 26 Timing of pesticide applications on seed potatoes – 2018



Note: Insecticides include nematicides and herbicides include desiccants.

Ware potatoes

- An estimated 15,268 hectares of ware potatoes were grown in Scotland in 2018, representing an increase of three per cent since 2016
- 98 per cent of the crop was treated with a pesticide (see Figure 27 for types of pesticide used)
- Pesticides were applied to 307,749 treated hectares with 138,304 kilograms of pesticide applied in total (see summary table below)
- The ware potato crop received on average 12.6 pesticide applications (Table 1). These included 9.6 fungicide applications and 2.5 herbicide/desiccant applications (applied to 98 and 96 per cent of the crop area respectively), insecticides and molluscicides received 2.3 applications each (applied to 64 and 47 per cent of the area respectively)
- Timings of pesticide applications are shown in Figure 28
- Reasons were given for 38 per cent of total fungicide use, most of which was for blight control and less than 0.5 per cent was for disease precaution
- Reasons were supplied for 44 per cent of herbicide/desiccant use; 20 per cent was for desiccation/harvest aid, 15 per cent for general weed control, and four per cent for annual broad leaved weeds. Annual meadow grass and couch were both recorded at two per cent with annual grass weeds given for one per cent of use
- Reasons were supplied for 19 per cent of total insecticide/nematicide use. Fourteen per cent of which was for aphids, three per cent for caterpillars and two per cent was for nematodes
- Maris Piper was the most common variety grown for ware, accounting for 41 per cent of the sample area followed by Rooster at eight per cent
- The average reported yield was 51 t/ha

Summary of pesticide use on ware potatoes:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	184,668	105,169	98	Cymoxanil/mancozeb (41,472)
Herbicides/ desiccants	68,631	26,232	96	Diquat (23,273)
Insecticides/ nematicides	23,297	1,493	64	Lambda-cyhalothrin (11,470)
Growth regulators	323	775	2	Maleic hydrazide (323)
Molluscicides	16,340	2,156	47	Metaldehyde (10,084)
Seed treatments	14,813	3,253	88	Flutolanil (5,105)
All pesticides	**308,072**	**139,079**	**98**	

Figure 27 Use of pesticides on ware potatoes (percentage of total area treated with formulations) – 2018

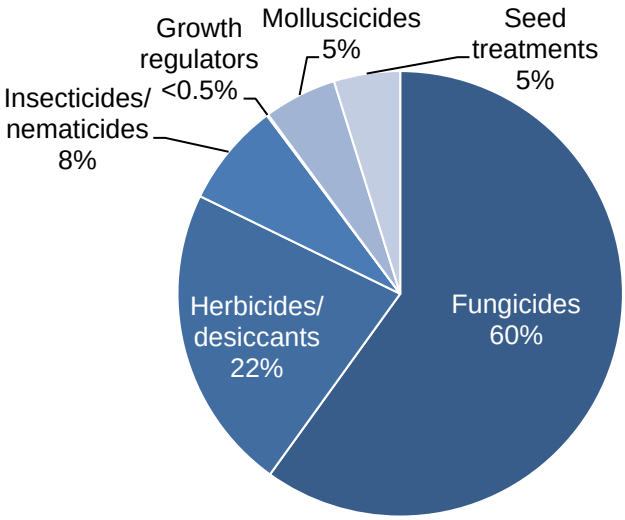
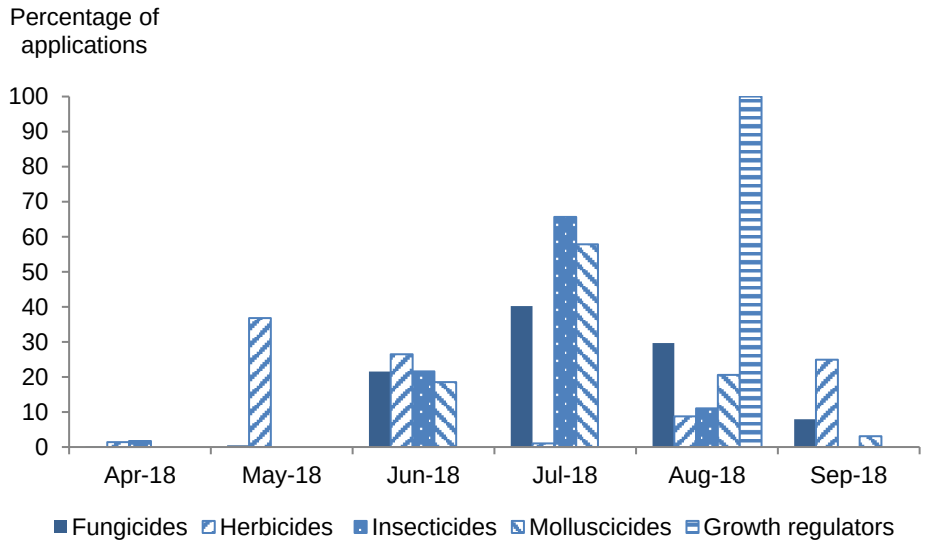


Figure 28 Timing of pesticide applications on ware potatoes – 2018



Note: there were small amounts (<1.0%) of herbicides/desiccants applied in September 2017 omitted for ease of reading. Insecticides include nematicides and herbicides include desiccants.

Legumes

The legumes category includes dry harvest peas and field beans. These crops have been combined as too few holdings were encountered to report the pesticide use for each crop separately

- An estimated 2,549 hectares of legumes were grown in Scotland in 2018, representing a decrease of 33 per cent since 2016
- 72 per cent of the crop was treated with a pesticide (see Figure 29 for types of pesticide used)
- Pesticides were applied to 7,409 treated hectares
- 4,423 kilograms of pesticide were used in total on the crop (see summary table below)
- The legume crop received on average 3.2 pesticide applications (Table 1). These included 1.7 fungicide applications and 2.2 herbicide/desiccant applications (applied to 30 and 72 per cent of the crop area respectively) and two insecticide applications to 12 per cent of the crop
- Timings of pesticide applications are shown in Figure 30
- Reasons were given for 55 per cent of total fungicide use with 31 per cent applied for chocolate spot, 20 per cent for disease control/precaution and four per cent for mildew.
- Reasons were supplied for 68 per cent of herbicide/desiccant use; 17 per cent was for annual broad-leaved weeds, 13 per cent for desiccation/harvest aid and 12 per cent for annual meadow grass.
- Reasons were supplied for 59 per cent of total insecticide use, all of which was for control of weevils
- The most common variety, accounting for 37 per cent of the sample area, was Fuego followed by Honey at 23 per cent
- The average reported yield was 3.7 t/ha

Summary of pesticide use on legumes:

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Fungicides	1,807	674	30	Chlorothalonil/cyproconazole (1,205)
Herbicides/ desiccants	4,976	3,745	72	Imazamox/pendimethalin (1,412)
Insecticides	626	5	12	Lambda-cyhalothrin (549)
All pesticides	**7,409**	**4,423**	**72**	

Note: 89 per cent of legumes in 2018 had no seed treatment; the seed treatment information for the remaining 11 per cent was unknown

Figure 29 Use of pesticides on legumes (percentage of total area treated with formulations) – 2018

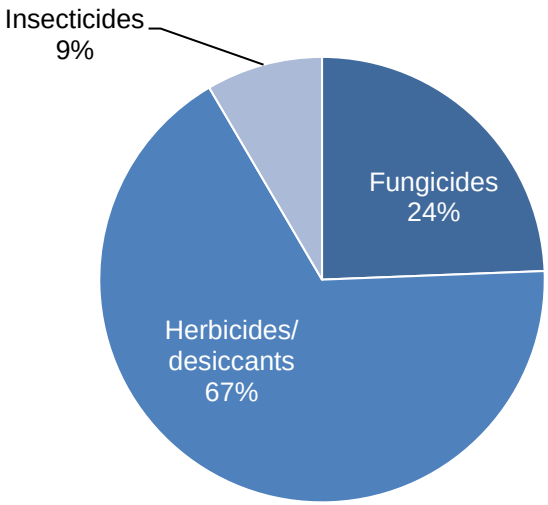
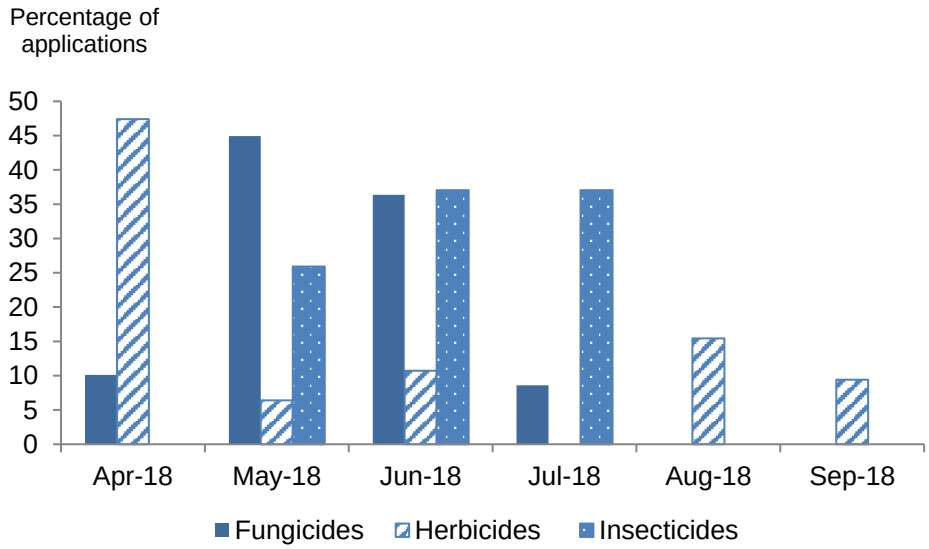


Figure 30 Timing of pesticide applications on legumes – 2018



Note: October herbicide spray (11%) omitted for ease of reading. Herbicides include desiccants.

Appendix 1 – Estimated application tables

Table 1 Percentage of each crop treated with pesticides and mean number of spray applications - 2018

Crop	Fungicides		Herbicides/ desiccants		Insecticides[2]		Molluscicide		Sulphur		Growth Regulators		Any pesticide exc. STs		Seed treatments	Any pesticide inc. STs
	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	%
Winter barley	100	2.5	98	2.2	22	1.0	7	1.3	1	1.0	96	1.9	100	4.2	90	100
Spring barley	92	1.8	96	1.7	12	1.0	0	0.0	0	0.0	22	1.1	97	2.5	85	98
Winter wheat	97	3.5	97	2.1	21	1.2	20	1.3	1	1.0	95	1.9	98	5.1	86	98
Spring wheat	99	2.0	100	1.6	20	1.0	0	0.0	0	0.0	38	1.2	100	2.5	90	100
Winter oats	95	2.4	96	2.1	30	1.2	3	1.0	0	0.0	97	1.3	99	3.8	82	99
Spring oats	80	1.7	92	1.5	34	1.0	0	0.0	0	0.0	77	1.1	93	2.5	70	94
Oilseed rape	98	2.8	99	2.6	65	1.6	59	1.2	<0.5	2.0	16	1.0	99	5.9	89	100
Seed potatoes	89	8.8	89	2.2	86	5.9	22	2.0	0	0.0	0	0.0	89	10.9	83	89
Ware potatoes	98	9.6	96	2.5	64	2.3	47	2.3	0	0.0	2	1.0	98	12.6	88	98
Legumes	30	1.7	72	2.2	12	2.0	0	0.0	0	0.0	0	0.0	72	3.2	0[3]	72
Total arable crops[1]	**93**	**2.7**	**96**	**1.9**	**23**	**1.7**	**10**	**1.4**	**<0.5**	**1.1**	**45**	**1.6**	**97**	**3.9**	**84**	**98**

(1) Includes winter rye
(2) Includes nematicides
(3) 89 per cent of legumes had no seed treatment, the seed treatment information for the remaining 11 per cent was unknown
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 Cereal seed treatment formulations - 2018

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

Seed treatments	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter Oats		Spring Oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Clothianidin	754	2	0	0	716	1	0	0	0	0	0	0	**1,471**	**140**	0	0
Clothianidin/ prothioconazole	2,460	7	786	<0.5	13,322	14	0	0	1,476	17	0	0	**18,045**	**2,160**	9,988	1,008
Cypermethrin	0	0	0	0	1,986	2	0	0	0	0	0	0	**1,986**	**275**	0	0
Difenoconazole/ fludioxonil	0	0	0	0	0	0	0	0	0	0	0	0	**73**	**0**	813	5
Difenoconazole/ fludioxonil/ tebuconazole	1,906	5	0	0	0	0	0	0	0	0	0	0	**2,732**	**47**	367	4
Fludioxonil	188	1	12,255	5	34,271	36	3,226	58	3,857	46	6,016	25	**59,813**	**612**	31,951	310
Fludioxonil/ sedaxane	0	0	0	0	4,254	5	0	0	0	0	1,661	7	**5,915**	**100**	0	0
Fludioxonil/ tefluthrin	0	0	0	0	846	1	0	0	0	0	0	0	**846**	**47**	786	38
Fluopyram/ prothioconazole/ tebuconazole	14,059	37	26,999	11	0	0	0	0	0	0	0	0	**41,058**	**773**	110,564	1,975
Fluquinconazole	0	0	0	0	744	1	0	0	0	0	0	0	**744**	**106**	1,901	271

Cont..

Table 2 Cereal seed treatment formulations – 2018 continued

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

Seed treatments	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Fluquinconazole/ prochloraz	0	0	0	0	1,932	2	0	0	0	0	0	0	**1,932**	**335**	18,736	3,308
Imazalil/ ipconazole	8,438	22	87,085	35	6,297	7	139	3	0	0	0	0	**101,960**	**1,431**	31,659	422
Prochloraz/ triticonazole	660	2	2,906	1	269	<0.5	0	0	0	0	0	0	**3,835**	**119**	144,410	4,560
Prothioconazole	1,504	4	7,295	3	4,005	4	784	14	331	4	503	2	**14,421**	**268**	13,051	276
Prothioconazole/ tebuconazole	3,189	8	59,151	24	10,982	12	100	2	626	7	6,043	26	**80,299**	**1,842**	12,704	287
Silthiofam	0	0	0	0	3,398	4	0	0	0	0	0	0	**3,398**	**179**	2,322	117
Unspecified seed treatment[4]	1,496	4	16,590	7	3,476	4	764	14	644	8	2,444	10	**27,302**	**N/A**	14,801	N/A
All seed treatments	**34,655**	**90**	**213,068**	**85**	**86,497**	**86**	**5,013**	**90**	**6,934**	**82**	**16,666**	**70**	**365,829**	**8,435**	**399,608**	**13,815**
No information seed treatment[4]	3,105	8	17,346	7	9,636	10	529	10	1,110	13	3,547	15	**36,772**	**N/A**	6,340	N/A
No seed treatment	536	1	18,876	8	3,492	4	0	0	396	5	3,450	15	**28,039**	**N/A**	27,732	N/A
Area grown	37,541		250,476		94,236		5,542		8,440		23,662		**425,674**		432,077	

(1) Includes winter rye
(2) Includes winter rye and triticale
(3) For full list of formulations recorded in 2016 please refer to the 2016 report[3]
(4) Refer to Appendix 3 for definitions
N/A = not applicable

Table 3 Cereal insecticide and molluscicide formulations - 2018

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

Insecticides	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Cypermethrin	167	<0.5	0	0	0	0	0	0	0	0	0	0	**167**	**3**	3,008	72
Deltamethrin	259	1	1,086	<0.5	99	<0.5	0	0	286	3	1,105	5	**2,835**	**11**	1,649	10
Esfenvalerate	3,600	10	1,685	1	3,029	3	48	1	303	4	0	0	**8,666**	**30**	4,310	12
Lambda-cyhalothrin	4,037	10	26,845	10	19,260	18	1,064	19	2,333	24	6,132	26	**61,626**	**281**	62,763	282
Tau-fluvalinate	0	0	614	<0.5	479	1	0	0	0	0	0	0	**1,092**	**28**	0	0
Unspecified insecticide[4]	0	0	0	0	0	0	0	0	0	0	538	2	**538**	**N/A**	0	N/A
Zeta-cypermethrin	299	1	1,622	1	692	1	0	0	232	3	358	2	**3,203**	**32**	1,791	22
All insecticides	**8,361**	**22**	**31,852**	**12**	**23,559**	**21**	**1,113**	**20**	**3,155**	**30**	**8,133**	**34**	**78,127**	**385**	**75,473**	**1,447**
Molluscicides																
Ferric phosphate	1,341	4	0	0	7,533	8	0	0	90	1	0	0	**9,227**	**1,196**	2,765	370
Metaldehyde	2,044	4	0	0	17,968	15	0	0	201	2	0	0	**20,213**	**2,126**	15,733	2,064
All molluscicides	**3,385**	**7**	**0**	**0**	**25,501**	**20**	**0**	**0**	**291**	**3**	**0**	**0**	**29,439**	**3,322**	**18,520**	**2,436**
Area grown	37,541		250,476		94,236		5,542		8,440		23,662		425,674		432,077	

(1) Includes winter rye
(2) Includes winter rye and triticale
(3) For full list of formulations recorded in 2016 please refer to the 2016 report[3]
(4) Refer to Appendix 3 for definitions
N/A = not applicable

Table 4 Cereal fungicide and sulphur formulations - 2018

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

Fungicides	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Azoxystrobin	157	<0.5	1,300	1	796	1	0	0	135	2	432	2	**2,821**	**417**	3,221	422
Azoxystrobin/ chlorothalonil	1,482	4	3,176	1	8,212	8	0	0	0	0	436	2	**13,306**	**8,625**	17,232	7,325
Azoxystrobin/ cyproconazole	0	0	0	0	1,873	2	0	0	678	8	0	0	**2,551**	**538**	2,117	338
Benzovindiflupyr	2,722	7	7,488	3	9,631	10	316	6	0	0	0	0	**21,164**	**1,066**	0	0
Benzovindiflupyr/ prothioconazole	1,102	3	0	0	2,330	2	0	0	0	0	0	0	**3,665**	**614**	0	0
Bixafen	3,236	9	6,960	3	0	0	0	0	0	0	0	0	**10,196**	**289**	0	0
Bixafen/ fluopyram/ prothioconazole	0	0	0	0	2,286	2	0	0	0	0	0	0	**2,286**	**670**	0	0
Bixafen/ fluoxastrobin/ prothioconazole	0	0	0	0	6,289	7	1,771	32	0	0	72	0	**8,132**	**1,952**	5,664	1,276
Bixafen/ prothioconazole	8,804	20	23,651	8	4,993	4	0	0	0	0	942	4	**38,391**	**4,755**	53,133	8,335
Bixafen/ prothioconazole/ spiroxamine	0	0	0	0	14,924	15	127	2	0	0	0	0	**15,051**	**7,642**	19,872	9,757
Bixafen/ prothioconazole/ tebuconazole	0	0	0	0	8,071	8	0	0	0	0	0	0	**8,071**	**2,308**	9,655	2,747

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Table 4 Cereal fungicide and sulphur formulations – 2018 continued

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

Fungicides	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Boscalid/ poxiconazole	134	<0.5	2,960	1	38,800	40	0	0	0	0	404	2	**42,733**	**11,869**	46,487	12,560
Boscalid/ epoxiconazole/ pyraclostrobin	0	0	0	0	644	1	0	0	0	0	0	0	**853**	**300**	644	157
Chlorothalonil	43,297	84	204,728	66	203,311	92	5,636	67	0	0	186	1	**458,712**	**224,660**	397,294	187,731
Chlorothalonil/ cyproconazole	962	2	1,167	0	9,858	10	0	0	0	0	0	0	**11,987**	**5,090**	8,841	3,312
Chlorothalonil/ cyproconazole/ propiconazole	236	1	0	0	1,962	2	0	0	0	0	0	0	**2,198**	**1,048**	9,813	5,079
Chlorothalonil/ fluxapyroxad	0	0	23,194	9	2,288	2	284	5	0	0	0	0	**25,765**	**9,611**	0	0
Chlorothalonil/ penthiopyrad	3,179	5	3,879	2	11,352	9	0	0	0	0	0	0	**18,411**	**6,924**	23,680	8,637
Chlorothalonil/ picoxystrobin	527	1	307	<0.5	522	1	0	0	0	0	0	0	**1,356**	**550**	42,605	18,125
Chlorothalonil/ propiconazole	0	0	0	0	14	<0.5	0	0	0	0	0	0	**14**	**2**	1,306	285
Chlorothalonil/ proquinazid	2,553	7	3,885	2	3,877	3	0	0	0	0	212	1	**10,527**	**5,090**	11,073	4,465
Chlorothalonil/ tebuconazole	0	0	0	0	20,846	20	0	0	0	0	0	0	**20,846**	**11,296**	29,532	14,915

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Table 4 Cereal fungicide and sulphur formulations – 2018 continued

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

Fungicides	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Cyflufenamid	2,045	5	3,078	1	35,563	30	315	6	3,593	38	3,987	17	**49,159**	**431**	16,606	713
Cyproconazole/ penthiopyrad	0	0	0	0	2,695	3	0	0	0	0	0	0	**2,695**	**362**	4,530	9
Cyprodinil/ isopyrazam	1,513	4	11,261	3	0	0	0	0	0	0	0	0	**12,775**	**2,579**	26,006	6,324
Dimoxystrobin/ epoxiconazole	0	0	0	0	150	0	0	0	0	0	0	0	**150**	**18**	972	92
Epoxiconazole	0	0	20,992	8	35,638	28	406	7	3,949	43	5,503	17	**68,924**	**4,333**	55,300	3,402
Epoxiconazole/ fenpropimorph	1,988	5	20,333	8	11,391	11	2,424	44	196	2	708	3	**37,041**	**8,805**	14,379	4,040
Epoxiconazole/ fenpropimorph/ kresoxim-methyl	320	1	11,842	5	2,531	2	1,680	15	1,432	13	2,832	12	**20,637**	**4,417**	8,699	1,483
Epoxiconazole/ fenpropimorph/ metrafenone	297	1	2,884	1	3,661	4	436	4	1,022	11	3,714	11	**14,523**	**4,071**	14,960	3,497
Epoxiconazole/ fluxapyroxad	4,263	11	3,901	2	43,745	32	91	2	0	0	0	0	**51,999**	**6,302**	54,199	6,504
Epoxiconazole/ fluxapyroxad/ pyraclostrobin	1,512	4	10,584	4	5,661	6	47	1	215	3	1,207	5	**19,226**	**3,071**	32,085	5,301

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Table 4 Cereal fungicide and sulphur formulations – 2018 continued

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

Fungicides	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Epoxiconazole/ folpet	107	<0.5	0	0	1,511	2	0	0	0	0	0	0	**1,618**	**810**	3,670	1,675
Epoxiconazole/ isopyrazam	555	1	0	0	396	0	0	0	0	0	0	0	**951**	**82**	392	75
Epoxiconazole/ metrafenone	1,089	3	1,982	1	5,791	6	0	0	1,368	9	2,481	10	**12,710**	**1,665**	5,785	789
Epoxiconazole/ pyraclostrobin	0	0	1,671	1	1,763	2	0	0	471	4	919	4	**4,825**	**487**	10,030	998
Fenpropidin/ prochloraz/ tebuconazole	0	0	0	0	1,492	2	0	0	0	0	0	0	**1,492**	**671**	0	N/A
Fenpropimorph	6,441	16	9,090	4	8,837	9	91	2	7,235	50	7,615	21	**39,691**	**7,907**	41,866	9,971
Fenpropimorph/ pyraclostrobin	4,364	12	11,233	4	368	<0.5	315	5	960	11	422	2	**17,661**	**5,551**	23,173	7,527
Fluoxastrobin/ prothioconazole	1,090	3	6,249	2	5,430	5	573	10	290	3	1,559	7	**15,423**	**2,030**	13,835	2,015
Fluoxastrobin/ prothioconazole/ trifloxystrobin	10,021	17	46,188	13	166	<0.5	383	7	0	0	186	1	**56,944**	**6,674**	75,684	8,987
Fluxapyroxad	4,532	7	21,592	8	23,322	22	92	2	0	0	436	2	**49,974**	**2,337**	36,724	1,921
Fluxapyroxad/ metconazole	0	0	0	0	1,379	1	0	0	0	0	0	0	**1,379**	**189**	4,750	437
Fluxapyroxad/ pyraclostrobin	4,795	11	10,828	4	5,187	6	0	0	0	0	0	0	**20,810**	**2,748**	10,838	1,627

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Table 4 Cereal fungicide and sulphur formulations – 2018 continued

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

Fungicides	Winter barley		Spring barley		Winter wheat		Spring Wheat		Winter Oats		Spring Oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Folpet	4,550	12	7,103	3	8,547	7	0	0	0	0	0	0	**20,200**	**9,114**	50,191	21,122
Isopyrazam	206	1	559	<0.5	0	0	0	0	0	0	0	0	**765**	**38**	14,877	868
Mancozeb	0	0	0	0	7,554	6	0	0	0	0	0	0	**7,554**	**5,734**	1,642	1,397
Metconazole	0	0	0	0	918	1	0	0	0	0	0	0	**918**	**37**	380	11
Penthiopyrad/ picoxystrobin	0	0	35	<0.5	755	1	0	0	0	0	0	0	**790**	**112**	86	10
Prochloraz/ proquinazid/ tebuconazole	1,090	3	5,718	2	11,205	12	0	0	0	0	198	1	**18,211**	**4,939**	29,556	7,485
Prochloraz/ tebuconazole	892	2	5,495	2	6,552	6	657	12	0	0	0	0	**13,596**	**4,612**	14,921	4,955
Proquinazid	1,585	4	1,263	1	10,155	10	316	6	621	7	2,711	11	**16,651**	**502**	32,961	846
Prothioconazole	9,837	20	26,188	9	28,674	30	0	0	2,478	29	1,388	6	**68,565**	**5,944**	64,057	5,607
Prothioconazole/ spiroxamine	12,689	27	33,827	12	6,251	6	255	5	360	4	730	3	**54,938**	**12,208**	135,970	30,320
Prothioconazole/ spiroxamine/ tebuconazole	0	0	426	<0.5	1,761	1	0	0	0	0	0	0	**2,187**	**400**	4,192	567
Prothioconazole/ tebuconazole	13,656	27	65,861	23	26,314	25	945	15	581	7	1,304	6	**110,355**	**14,593**	95,591	12,899
Prothioconazole/ trifloxystrobin	11,038	23	58,054	17	7,138	8	230	4	0	0	0	0	**76,459**	**9,351**	50,794	6,260

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Table 4 Cereal fungicide and sulphur formulations – 2018 continued

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

Fungicides	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Pyraclostrobin	0	0	1,115	<0.5	3,157	3	315	6	606	7	0	0	**6,199**	**510**	4,632	324
Spiroxamine	341	1	0	0	0	0	0	0	0	0	0	0	**341**	**107**	3,970	813
Tebuconazole	0	0	93	<0.5	37,011	36	266	5	2,866	34	1,955	8	**42,191**	**5,314**	38,372	4,808
Trifloxystrobin	2,726	7	11,776	5	918	1	0	0	0	0	0	0	**15,420**	**1,204**	11,587	973
All fungicides	**181,531**	**100**	**706,840**	**92**	**719,393**	**97**	**18,381**	**99**	**29,056**	**95**	**42,538**	**80**	**1,710,838**	**450,428**	**1,762,377**	**463,707**
Sulphur	**297**	**1**	**0**	**0**	**1,042**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**1,339**	**2,261**	**8,412**	**22,980**
Area grown	37,541		250,476		94,236		5,542		8,440		23,662		**425,674**		432,077	

(1) Includes winter rye
(2) Includes winter rye and triticale
(3) For full list of formulations recorded in 2016 please refer to the 2016 report[3]

Table 5 Cereal herbicide/desiccant and growth regulator formulations – 2018

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

Herbicides/ desiccants	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
2,4-D/ Glyphosate	0	0	4	<0.5	4	<0.5	0	0	0	0	0	0	**7**	**15**	0	0
2,4-D/MCPA	0	0	111	<0.5	0	0	416	8	0	0	0	0	**527**	**836**	2,975	5,021
2,4-DB	0	0	5,581	2	0	0	255	5	0	0	60	<0.5	**5,897**	**5,484**	5,742	4,528
2,4-DB/MCPA	0	0	322	<0.5	0	0	0	0	0	0	0	0	**322**	**460**	473	926
Amidosulfuron/ iodosulfuron-methyl-sodium	0	0	868	<0.5	0	0	0	0	0	0	0	0	**868**	**17**	1,250	31
Bromoxynil/ diflufenican	0	0	0	0	480	1	657	12	0	0	0	0	**1,137**	**64**	0	0
Carfentrazone-ethyl/ flupyrsulfuron-methyl	0	0	0	0	0	0	0	0	185	2	0	0	**185**	**2**	324	6
Chlorotoluron/ diflufenican/ pendimethalin	3,931	10	5,347	2	2,569	3	0	0	0	0	0	0	**11,847**	**13,235**	7,798	7,865
Clodinafop-propargyl	0	0	0	0	9,716	10	99	2	0	0	0	0	**9,815**	**272**	9,695	274

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Table 5 Cereal herbicide/desiccant and growth regulator formulations – 2018 continued

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

Herbicides/ desiccants	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Clopyralid	0	0	0	0	426	<0.5	0	0	0	0	0	0	**426**	**25**	522	37
Clopyralid/ florasulam/ fluroxypyr	0	0	10,336	4	1,687	2	0	0	0	0	872	4	**12,896**	**1,856**	29,842	4,581
Dicamba/ MCPA/ mecoprop-P	0	0	1,236	<0.5	0	0	0	0	0	0	65	<0.5	**1,301**	**1,072**	1,766	1,467
Dicamba/ mecoprop-P	1,076	3	31,767	13	1,154	1	2,018	36	0	0	2,351	10	**38,364**	**19,363**	67,117	34,957
Dichlorprop-P/ MCPA/ mecoprop-P	0	0	5,607	2	0	0	0	0	0	0	633	3	**6,240**	**5,362**	7,049	6,227
Diflufenican	8,085	22	23,739	9	26,748	28	0	0	470	6	2,583	11	**64,562**	**4,324**	60,583	3,369
Diflufenican/ florasulam	0	0	6,100	2	604	1	47	1	0	0	0	0	**6,752**	**231**	1,326	55
Diflufenican/ flufenacet	10,546	28	21,163	8	22,889	24	315	6	4,135	49	0	0	**60,984**	**9,307**	61,054	10,713
Diflufenican/ flufenacet/ flurtamone	908	2	0	0	3,307	4	0	0	0	0	0	0	**4,215**	**1,359**	15,889	3,257
Diflufenican/ flupyrsulfuron-methyl	0	0	0	0	6,409	7	0	0	1,779	21	0	0	**8,188**	**432**	5,211	246

Cont..

Table 5 Cereal herbicide/desiccant and growth regulator formulations – 2018 continued

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

Herbicides/ desiccants	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Diflufenican/ flufenacet/ flurtamone	908	2	0	0	3,307	4	0	0	0	0	0	0	**4,215**	**1,359**	15,889	3,257
Diflufenican/ flupyrsulfuron-methyl	0	0	0	0	6,409	7	0	0	1,779	21	0	0	**8,188**	**432**	5,211	246
Diflufenican/ flurtamone	1,246	3	108	<0.5	1,928	2	0	0	0	0	0	0	**3,281**	**437**	3,668	426
Diflufenican/ iodosulfuron-methyl-sodium/ mesosulfuron-methyl	0	0	0	0	4,021	4	0	0	0	0	0	0	**4,021**	**184**	11,253	560
Diflufenican/ pendimethalin	1,315	4	566	<0.5	4,329	5	0	0	0	0	0	0	**6,209**	**4,074**	4,649	3,323
Fenoxaprop-P-ethyl	0	0	8,185	3	915	1	127	2	0	0	31	<0.5	**9,258**	**532**	5,542	300
Florasulam	1,535	4	1,550	<0.5	2,267	2	0	0	0	0	0	0	**5,352**	**15**	4,880	23
Florasulam/ fluroxypyr	2,909	8	8,854	4	4,080	4	126	2	1,755	21	1,629	7	**20,068**	**1,471**	29,769	2,457
Florasulam/ halauxifen-methyl	4,342	12	21,819	8	11,959	13	548	10	0	0	0	0	**38,669**	**240**	0	0

Cont..

Table 5 Cereal herbicide/desiccant and growth regulator formulations – 2018 continued

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

Herbicides/ desiccants	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Florasulam/ pyroxsulam	0	0	0	0	4,635	5	0	0	0	0	0	0	**4,635**	**103**	2,943	65
Flufenacet	840	2	0	0	1,451	2	0	0	0	0	0	0	**2,291**	**248**	1,155	142
Flufenacet/ pendimethalin	2,281	6	6	<0.5	3,881	4	0	0	0	0	0	0	**6,167**	**4,240**	6,935	5,577
Flufenacet/ picolinafen	3,682	10	0	0	8,743	9	0	0	0	0	0	0	**12,658**	**2,316**	143	21
Flumioxazine	0	0	0	0	0	0	0	0	81	1	0	0	**81**	**2**	0	0
Flupyrsulfuron-methyl	1,077	3	0	0	12,172	13	0	0	466	6	0	0	**13,715**	**87**	21,541	133
Flupyrsulfuron-methyl/ thifensulfuron-methyl	0	0	0	0	0	0	0	0	196	2	0	0	**196**	**10**	994	85
Fluroxypyr	3,301	9	53,709	21	15,221	16	2,193	40	1,123	13	9,050	34	**84,597**	**10,405**	83,242	10,826
Fluroxypyr/ halauxifen-methyl	955	3	39,301	16	3,962	4	842	15	0	0	0	0	**45,060**	**4,403**	259	28
Fluroxypyr/ mesosulfuron-methyl/ thifensulfuron-methyl	908	2	29	<0.5	89	<0.5	0	0	0	0	0	0	**1,026**	**91**	0	0
Glyphosate	22,722	59	80,528	30	20,048	21	1,571	28	2,435	28	7,681	29	**134,985**	**96,176**	171,119	135,969

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Table 5 Cereal herbicide/desiccant and growth regulator formulations – 2018 continued

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

Herbicides/ desiccants	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Imazosulfuron	303	1	0	0	0	0	0	0	0	0	0	0	**303**	**3**	0	0
Iodosulfuron-methyl-sodium/ mesosulfuron-methyl	0	0	0	0	5,983	6	0	0	0	0	0	0	**6,245**	**77**	3,650	43
MCPA	0	0	2,679	1	0	0	88	2	0	0	1,796	8	**4,563**	**3,423**	4,498	2,241
Mecoprop-P	1,904	5	51,235	20	14,679	16	599	11	2,816	33	8,746	37	**79,978**	**49,935**	117,839	78,399
Mesosulfuron-methyl/ propoxycarbazone-sodium	0	0	0	0	394	<0.5	0	0	0	0	0	0	**394**	**15**	0	0
Metsulfuron-methyl	947	3	6,903	3	4,618	5	438	8	756	9	12	<0.5	**13,674**	**57**	14,528	64
Metsulfuron-methyl/ thifensulfuron-methyl	2,712	7	94,936	38	9,261	10	2,230	40	302	4	448	2	**109,890**	**3,228**	102,747	3,065
Metsulfuron-methyl/ tribenuron-methyl	1,699	5	35,910	14	6,111	6	304	5	2,889	34	7,185	30	**54,098**	**478**	55,577	543
Pendimethalin	6,881	18	15,714	6	13,902	15	0	0	0	0	0	0	**37,066**	**28,111**	39,493	27,532
Pendimethalin/ picolinafen	14,371	38	26,197	10	31,546	33	0	0	0	0	0	0	**74,828**	**54,317**	74,303	58,964

Cont..

Table 5 Cereal herbicide/desiccant and growth regulator formulations – 2018 continued

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

Herbicides/ dessicants	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Pinoxaden	4,893	12	39,112	16	4,038	4	0	0	0	0	0	0	**48,042**	**1,167**	45,012	1,156
Prosulfocarb	257	1	1,694	1	2,319	2	0	0	0	0	0	0	**4,271**	**5,431**	2,248	3,596
Pyroxsulam	0	0	0	0	1,042	1	0	0	0	0	0	0	**1,042**	**20**	0	0
Sulfosulfuron	0	0	0	0	559	1	0	0	0	0	0	0	**559**	**11**	132	3
Thifensulfuron-methyl	0	0	614	<0.5	762	1	0	0	0	0	0	0	**1,375**	**31**	2,607	77
Thifensulfuron-methyl/ tribenuron-methyl	2,438	6	41,992	17	4,428	5	1,041	16	910	11	5,201	22	**56,272**	**1,473**	49,597	1,202
Tribenuron-methyl	916	2	6,487	3	2,719	3	255	5	0	0	386	2	**10,763**	**58**	18,164	146
Unspecified herbicide[4]	372	1	0	0	0	0	0	0	0	0	0	0	**372**	**N/A**	1,392	N/A
All herbicides/ desiccants	**109,351**	**98**	**650,309**	**96**	**278,055**	**97**	**14,168**	**100**	**20,299**	**96**	**48,727**	**92**	**1,130,538**	**336,584**	**1,163,254**	**421,484**

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Table 5 Cereal herbicide/desiccant and growth regulator formulations – 2018 continued

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

Growth regulators	Winter barley		Spring barley		Winter wheat		Spring wheat		Winter oats		Spring oats		Total 2018[1]	Total 2018[1]	2016[2,3]	2016[2,3]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
2-Chloroethylphosphonic acid/chlormequat	6,930	18	1,149	<0.5	3,677	4	0	0	0	0	0	0	**11,757**	**5,015**	17,687	7,294
2-Chloroethylphosphonic acid/chlormequat chloride	1,489	4	82	<0.5	2,145	2	0	0	0	0	0	0	**3,715**	**1,517**	4,891	1,865
2-Chloroethylphosphonic acid/mepiquat	481	1	0	0	81	<0.5	0	0	0	0	0	0	**562**	**346**	5,617	2,406
Chlormequat	32,171	75	23,677	9	96,171	84	1,818	31	6,873	78	11,822	47	**177,045**	**154,752**	3,619	161,243
Chlormequat chloride	0	0	0	0	1,416	1	0	0	0	0	0	0	**1,416**	**892**	195,441	2,528
Chlormequat/imazaquin	0	0	0	0	10,296	8	0	0	0	0	0	0	**12,448**	**5,451**	2,941	8,056
Mepiquat chloride/ prohexadione-calcium	10,373	23	14,649	6	18,727	18	91	2	1,769	19	4,935	21	**51,548**	**7,642**	17,959	6,560
Prohexadione-calcium/trinexapac-ethyl	926	2	2,728	1	5,388	4	0	0	398	5	289	1	**9,962**	**326**	41,784	45
Trinexapac-ethyl	28,816	62	10,040	4	80,843	67	992	17	7,512	77	5,818	25	**138,678**	**4,984**	1,785	4,997
All growth regulators	**93,360**	**96**	**60,755**	**22**	**239,784**	**95**	**2,902**	**38**	**16,552**	**97**	**22,864**	**77**	**448,775**	**188,943**	**156,509**	**204,053**
Area grown	37,541		250,476		94,236		5,542		8,440		23,662		**425,674**		432,077	

(1) Includes winter rye
(2) Includes winter rye and triticale
(3) For full list of formulations recorded in 2016 please refer to the 2016 report[3]
(4) Refer to Appendix 3 for definitions

Table 6 Oilseed rape seed treatment formulations - 2018

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

Seed treatments	Oilseed Rape 2018[1]		Oilseed Rape 2018[1]	2016	2016
	ha	%	kg	ha	kg
Prochloraz/thiram	26,764	82	315	25,368	290
Thiram	1,430	4	8	1,021	8
Unspecified seed treatment[2]	1,380	4	N/A	400	N/A
All seed treatments	**29,574**	**89**	**323**	**26,789**	**298**
No information seed treatment[2]	3,091	9	N/A	759	N/A
No seed treatment	456	1	N/A	2,594	N/A
Area grown	32,735			30,142	

(1) Oilseed rape figures from 2018 include spring oilseed rape. No spring oilseed rape crops were sampled in 2016
(2) Refer to Appendix 3 for definitions

Table 7 Oilseed rape insecticide and molluscicide formulations - 2018

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

Insecticides	Oilseed Rape 2018[1]		Oilseed Rape 2018[1]	2016[2]	2016[2]
	ha	%	kg	ha	kg
Deltamethrin	1,701	5	10	326	2
Indoxacarb	199	1	4	589	12
Lambda-cyhalothrin	14,318	32	84	22,438	132
Tau-fluvalinate	10,667	30	389	11,035	437
Zeta-cypermethrin	6,468	18	64	4,986	49
All insecticides	**33,353**	**65**	**551**	**43,782**	**805**
Molluscicides					
Ferric phosphate	8,174	23	926	1,187	138
Metaldehyde	15,743	41	1,513	14,353	1,647
All molluscicides	**23,917**	**59**	**2,439**	**16,234**	**1,846**
Area grown	32,735			30,142	

(1) Oilseed rape figures from 2018 include spring oilseed rape. No spring oilseed rape crops were sampled in 2016
(2) For full list of formulations recorded in 2016 please refer to the 2016 report[3]

Table 8 Oilseed rape fungicide and sulphur formulations - 2018

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

Fungicides	Oilseed Rape 2018[1]		Oilseed Rape 2018[1]	2016[2]	2016[2]
	ha	%	kg	ha	kg
Azoxystrobin	6,756	21	1,089	4,577	562
Azoxystrobin/cyproconazole	4,427	14	940	860	219
Azoxystrobin/isopyrazam	294	1	72	700	171
Azoxystrobin/tebuconazole	114	<0.5	36	0	0
Bixafen/prothioconazole/tebuconazole	3,069	9	768	3,193	857
Boscalid	10,917	33	2,010	7,931	1,698
Boscalid/dimoxystrobin	1,296	4	259	1,251	250
Boscalid/metconazole	3,463	11	612	4,873	870
Difenoconazole	777	2	54	209	9
Fluopyram/prothioconazole	8,103	22	1,650	6,756	1,344
Fluxapyroxad/pyraclostrobin	100	<0.5	11	0	0
Metconazole	1,869	5	28	0	0
Penthiopyrad/picoxystrobin	3,706	11	465	4,569	553
Picoxystrobin	897	3	173	5,380	1,017
Prochloraz/tebuconazole	6,186	18	1,990	9,425	3,303
Prothioconazole	24,563	48	3,093	17,112	1,994
Prothioconazole/tebuconazole	27,435	48	4,797	18,510	3,241
Tebuconazole	4,172	13	604	8,645	1,241
Thiophanate-methyl	909	3	281	2,163	517
All fungicides	**109,052**	**98**	**18,933**	**100,681**	**19,361**
Sulphur	**223**	**<0.5**	**401**	**2,973**	**12,995**
Area grown	32,735			30,142	

(1) Oilseed rape figures from 2018 include spring oilseed rape. No spring oilseed rape crops were sampled in 2016

(2) For full list of formulations recorded in 2016 please refer to the 2016 report[3]

Table 9 Oilseed rape herbicide/desiccant and growth regulator formulations - 2018

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

Herbicides/desiccants	Oilseed Rape 2018[1]		Oilseed Rape 2018[1]	2016[2]	2016[2]
	ha	%	kg	ha	kg
Aminopyralid/metazachlor/picloram	1,073	3	834	0	0
Aminopyralid/propyzamide	878	3	739	1,528	901
Bifenox	270	1	129	0	0
Clomazone	10,295	31	607	9,617	561
Clomazone/metazachlor	3,988	12	2,679	296	155
Clopyralid	845	3	117	23	3
Clopyralid/picloram	2,074	6	225	2,075	229
Cycloxydim	55	<0.5	8	0	0
Dimethenamid-P/metazachlor	592	2	557	2,552	1,867
Dimethenamid- P/ metazachlor/quinmerac	6,128	19	6,285	1,093	1,367
Diquat	824	3	495	1,021	613
Fluazifop-P-butyl	2,243	7	211	4,135	374
Glyphosate	26,942	80	35,098	23,010	30,707
Metazachlor	17,222	53	10,600	14,501	9,556
Metazachlor/quinmerac	1,627	5	1,392	6,420	5,521
Propaquizafop	11,854	35	593	12,589	613
Propyzamide	6,328	19	4,088	3,597	2,638
Quizalofop-P-ethyl	4,690	14	177	3,475	110
Quizalofop-P-tefuryl	2,122	6	60	3,490	105
Unspecified herbicide[3]	237	1	N/A	0	0
All herbicides/desiccants	**100,286**	**99**	**64,895**	**90,409**	**56,768**
Growth regulators					
Mepiquat chloride/metconazole	5,139	16	938	5,965	1,098
All growth regulators	**5,139**	**16**	**938**	**5,965**	**1,098**
Area grown	32,735			30,142	

(1) Oilseed rape figures from 2018 include spring oilseed rape. No spring oilseed rape crops were sampled in 2016
(2) For full list of formulations recorded in 2016 please refer to the 2016 report[3]
(3) Refer to Appendix 3 for definitions

Table 10 Potato seed treatment formulations - 2018

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

Seed treatments	Seed potatoes		Ware potatoes		Total 2018	Total 2018	2016	2016
	ha	%	ha	%	**ha**	**kg**	ha	kg
Fludioxonil	1,123	9	1,451	10	**2,574**	**278**	1,025	99
Flutolanil	2,264	19	5,105	33	**7,369**	**2,166**	4,288	1,455
Imazalil	1,037	9	2,354	15	**3,391**	**153**	1,484	50
Pencycuron	4,695	39	4,626	30	**9,321**	**4,642**	14,716	8,828
Unspecified seed treatment(1)	1,116	9	1,278	8	**2,394**	**N/A**	169	N/A
All seed treatments	**10,235**	**83**	**14,813**	**88**	**25,048**	**7,239**	**24,828**	**11,014**
No information seed treatment(1)	465	4	984	6	**1,449**	**N/A**	869	N/A
No seed treatment	1,625	13	797	5	**2,423**	**N/A**	2,835	N/A
Area grown	12,091		15,268				27,526	

(1) Refer to Appendix 3 for definitions

Table 11 Potato insecticide and molluscicide formulations - 2018

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

Insecticides/nematicides	**Seed potatoes**		**Ware potatoes**		**Total 2018**	**Total 2018**	**2016[1]**	**2016[1]**
	ha	%	ha	%	**ha**	**kg**	ha	kg
Acetamiprid	222	1	523	3	**746**	**37**	1,996	97
Esfenvalerate	18,034	63	4,567	23	**22,601**	**109**	26,467	126
Flonicamid	4,664	34	2,121	7	**6,785**	**447**	3,852	306
Fosthiazate	0	0	108	1	**108**	**162**	2,415	5,370
Lambda-cyhalothrin	29,655	70	11,470	41	**41,126**	**280**	27,729	189
Oxamyl	1,493	12	293	2	**1,786**	**5,033**	761	2,478
Pymetrozine	3,284	26	195	1	**3,479**	**493**	7,035	976
Thiacloprid	9,012	69	3,420	15	**12,432**	**1,093**	6,773	591
Thiamethoxam	1,023	8	600	4	**1,622**	**21**	1,101	22
All insecticides/nematicides	**67,388**	**86**	**23,297**	**64**	**90,685**	**7,675**	**78,719**	**10,166**
Molluscicides								
Ferric phosphate	2,200	11	6,256	19	**8,456**	**1,330**	6,068	653
Metaldehyde	3,137	17	10,084	38	**13,220**	**1,624**	27,364	2,854
All molluscicides	**5,336**	**22**	**16,340**	**47**	**21,676**	**2,955**	**33,432**	**3,506**
Area grown	12,091		15,268		**27,359**		27,526	

(1) For full list of formulations recorded in 2016 please refer to the 2016 report[3]

Table 12 Potato fungicide formulations - 2018

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

Fungicides	Seed potatoes		Ware potatoes		Total 2018	Total 2018	2016[1]	2016[1]
	ha	%	ha	%	**ha**	**kg**	ha	kg
Ametoctradin/dimethomorph	9,325	55	11,269	40	**20,594**	**8,650**	15,299	6,403
Amisulbrom	10,148	46	15,169	41	**25,318**	**2,210**	18,082	1,787
Azoxystrobin	0	0	2,907	14	**2,907**	**972**	4,098	2,531
Benthiavalicarb isopropyl/mancozeb	6,097	34	3,214	16	**9,311**	**10,612**	9,039	10,313
Chlorothalonil/cymoxanil	0	0	178	1	**178**	**152**	299	254
Cyazofamid	24,191	83	30,339	89	**54,530**	**4,382**	62,104	4,958
Cymoxanil	6,485	26	15,215	36	**21,699**	**1,982**	60,143	4,893
Cymoxanil/fluazinam	3,080	25	413	3	**3,493**	**749**	5,842	1,825
Cymoxanil/mancozeb	17,872	60	41,472	83	**59,343**	**74,762**	53,813	69,219
Cymoxanil/mandipropamid	330	3	1,404	4	**1,734**	**446**	2,534	648
Cymoxanil/propamocarb hydrochloride	1,843	12	2,903	8	**4,746**	**4,276**	9,927	8,565
Cymoxanil/zoxamide	0	0	323	2	**323**	**96**	4,773	1,290
Difenoconazole/mandipropamid	0	0	886	3	**886**	**266**	2,331	699
Dimethomorph	817	3	2,301	8	**3,118**	**468**	0	0
Dimethomorph/fluazinam	0	0	1,156	8	**1,156**	**347**	3,531	1,063
Dimethomorph/mancozeb	4,339	36	6,325	35	**10,663**	**18,628**	13,549	23,250
Dimethomorph/zoxamide	3,032	24	4,754	18	**7,786**	**2,677**	0	0

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Table 12 Potato fungicide formulations – 2018 continued

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

Fungicides	**Seed potatoes**		**Ware potatoes**		**Total 2018**	**Total 2018**	**2016[1]**	**2016[1]**
	ha	%	ha	%	**ha**	**kg**	ha	kg
Fenamidone/propamocarb hydrochloride	1,858	15	367	2	**2,224**	**1,990**	5,242	4,651
Fluopicolide/propamocarb hydrochloride	5,646	28	8,335	29	**13,981**	**14,592**	11,718	12,359
Mancozeb	3,998	10	3,661	12	**7,659**	**8,749**	4,141	4,028
Mancozeb/metalaxyl-M	0	0	178	1	**178**	**230**	74	95
Mancozeb/zoxamide	365	3	426	3	**791**	**1,068**	1,874	2,077
Mandipropamid	15,877	80	14,256	40	**30,132**	**4,346**	35,131	5,110
Oxathiapiprolin	4,265	25	5,835	25	**10,100**	**149**	0	0
All fungicides	**122,259**	**89**	**184,668**	**98**	**306,927**	**166,694**	**370,696**	**175,215**
Area grown	12,091		15,268		**27,359**		27,526	

(1) For full list of formulations recorded in 2016 please refer to the 2016 report[3]

Table 13 Potato herbicide/desiccant and growth regulator formulations – 2018

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

Herbicides/desiccants	Seed potatoes		Ware potatoes		Total 2018	Total 2018	2016[(1)]	2016[(1)]
	ha	%	ha	%	**ha**	**kg**	ha	kg
Carfentrazone-ethyl	12,938	75	8,011	39	**20,949**	**1,001**	18,902	946
Clomazone	319	3	413	3	**733**	**37**	2,002	159
Clomazone/pendimethalin	0	0	323	2	**323**	**176**	0	0
Cycloxydim	275	2	1,999	13	**2,274**	**436**	1,950	422
Diquat	16,017	74	23,273	85	**39,290**	**13,161**	56,204	21,598
Flufenacet/metribuzin	940	8	2,682	18	**3,621**	**3,524**	3,172	2,980
Glyphosate	1,129	9	2,000	13	**3,129**	**2,000**	206	173
Linuron	1,186	10	2,410	16	**3,596**	**2,023**	16,329	9,147
Metobromuron	3,017	25	4,542	30	**7,559**	**7,876**	525	525
Metribuzin	7,960	66	11,694	77	**19,655**	**9,638**	18,911	8,895
Pendimethalin	0	0	702	5	**702**	**730**	947	809
Propaquizafop	0	0	391	3	**391**	**31**	284	43
Prosulfocarb	622	5	171	1	**793**	**2,421**	1,140	3,649
Pyraflufen-ethyl	533	4	6,154	26	**6,687**	**104**	850	18
Rimsulfuron	0	0	3,866	25	**3,866**	**44**	505	5
All herbicides/desiccants	**44,936**	**89**	**68,631**	**96**	**113,567**	**43,202**	**121,927**	**49,369**

Cont…

Table 13 Potato herbicide/desiccant and growth regulator formulations – 2018 continued

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

Growth regulators	Seed potatoes		Ware potatoes		Total 2018	Total 2018	2016[1]	2016[1]
	ha	%	ha	%	ha	kg	ha	kg
Maleic hydrazide	0	0	323	2	323	775	2,515	7,338
All growth regulators	**0**	**0**	**323**	**2**	**323**	**775**	**2,515**	**7,338**
Area grown	12,091		15,268		27,359		27,526	

(1) For full list of formulations recorded in 2016 please refer to the 2016 report[3]

Table 14 Legume seed treatment formulations - 2018

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

Seed treatments	Legumes 2018		Legumes 2018	2016[1]	2016[1]
	ha	%	kg	ha	kg
All seed treatments	**0**	**0**	0	**164**	**25**
No information seed treatment	281	11	N/A	387	N/A
No seed treatment	2,268	89	N/A	3,226	N/A
Area grown	2,549			3,777	

(1) For full list of formulations recorded in 2016 please refer to the 2016 report[3]
Please note: 89 per cent of legumes in 2018 had no seed treatment, the seed treatment information for the remaining 11 per cent was unknown
Legumes includes field beans and dry harvest peas

Table 15 Legume insecticide formulations - 2018

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

Insecticides	Legumes 2018		Legumes 2018	2016[1]	2016[1]
	ha	%	kg	ha	kg
Lambda-cyhalothrin	549	9	4	472	3
Zeta-cypermethrin	78	3	1	439	6
All insecticides	**626**	**12**	**5**	**989**	**10**
Area grown	2,549			3,777	

(1) For full list of formulations recorded in 2016 please refer to the 2016 report[3]
Note: legumes includes field beans and dry harvest peas. No molluscicides were recorded on legumes.

Table 16 Legume fungicide formulations - 2018

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

Fungicides	Legumes 2018		Legumes 2018	2016[1]	2016[1]
	ha	%	kg	ha	kg
Azoxystrobin	524	13	58	1,047	119
Chlorothalonil	78	3	49	219	157
Chlorothalonil/cyproconazole	1,205	30	567	3,503	2,004
All fungicides	**1,807**	**30**	**674**	**6,042**	**2,525**
Area grown	2,549			3,777	

(1) For full list of formulations recorded in 2016 please refer to the 2016 report[3]
Note: legumes includes field beans and dry harvest peas

Table 17 Legume herbicide/desiccant formulations - 2018

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

Herbicides/desiccants	Legumes 2018		Legumes 2018	2016[1]	2016[1]
	ha	%	kg	ha	kg
Clomazone	916	36	58	748	45
Clomazone/pendimethalin	78	3	85	364	323
Cycloxydim	116	5	23	0	0
Diquat	197	8	116	651	368
Glyphosate	1,304	41	1,596	1,908	1,860
Imazamox/pendimethalin	1,412	55	1,483	1,148	1,071
Linuron	116	5	17	811	409
Pendimethalin	339	13	339	1,394	1,089
Propaquizafop	159	6	11	326	23
Quizalofop-P-tefuryl	339	13	16	0	0
All herbicides/desiccants	**4,976**	**72**	**3,745**	**8,053**	**6,107**
Area grown	2,549			3,777	

(1) For full list of formulations recorded in 2016 please refer to the 2016 report[3]
Note: legumes includes field beans and dry harvest peas

Table 18 Compounds encountered in the arable survey for the first time in 2018

Active substance	Type[1]	Area treated (ha)	Amount used (kg)
Benzovindiflupyr	F	24,829	1,271
Imazosulfuron	H	303	3
Oxathiapiprolin	F	10,100	149
Sedaxane	S	5,915	179

(1) Pesticide type = F: Fungicide, H: Herbicide and S: Seed Treatment

Table 19 Mode of action/chemical group of insecticide/nematicide active substances on all arable crops - 2018

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

Mode of Action	Active Substance	Chemical Group	IRAC Group	Total Arable 2018	Total Arable 2018
				ha	kg
Acetylcholinesterase (AChE) inhibitor	Oxamyl	Carbamate	1A	1,786	5,033
	Fosthiazate	Organophosphate	1B	108	162
All acetylcholinesterase (AChE) inhibitors				**1,894**	**5,194**
Sodium channel modulators	Cypermethrin	Pyrethroid	3A	167	3
	Deltamethrin	Pyrethroid	3A	4,537	21
	Esfenvalerate	Pyrethroid	3A	31,267	138
	Lambda-cyhalothrin	Pyrethroid	3A	117,619	649
	Tau-Fluvalinate	Pyrethroid	3A	11,759	418
	Zeta-cypermethrin	Pyrethroid	3A	9,748	98
All sodium channel modulators				**175,097**	**1,327**
Nicotinic acetylcholine receptor (nAChR) competitive modulators	Acetamiprid	Neonicotinoid	4A	746	37
	Thiacloprid	Neonicotinoid	4A	12,432	1,093
	Thiamethoxam	Neonicotinoid	4A	1,622	21
All nAChR competitive modulators				**14,800**	**1,151**
Chordontonal organ TRPV channel modulators	Pymetrozine	Pyridine azomethine derivative	9B	3,479	493

Cont…

Table 19 Mode of action/chemical group of insecticide/nematicide active substances on all arable crops – 2018 continued

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

Mode of Action	Active Substance	Chemical Group	IRAC Group	Total Arable 2018	Total Arable 2018
				ha	kg
Voltage-dependent sodium channel blocker	Indoxacarb	Oxadiazines	22A	199	4
Chordontonal organ modulators - undefined target site	Flonicamid	Pyridine compound	29	6,785	447
All other modes of action				**10,463**	**944**
All insecticides				**202,254**	**8,616**
Area grown				488,318	

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

Table 20 Mode of action/chemical group of fungicide active substances on all arable crops - 2018

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

Mode of Action	Active Substance	Group Name	Chemical Group	FRAC Group	Total Arable 2018	Total Arable 2018
					ha	kg
Nucleic Acid Synthesis	Metalaxyl-M	Phenylamide	Acylalanine	4	178	13
Cytoskeleton and motor proteins	Thiophanate-methyl	Methyl benzimidazole carbamate	Thiophanate	1	909	281
	Zoxamide	Benzamide	Toluamides	22	8,899	1,505
	Fluopicolide	Benzamide	Pyridinylmethyl-benzamide	43	13,981	1,327
All cytoskeleton and motor proteins					**23,789**	**3,112**
Respiration	Benzovindiflupyr	SDHI	Pyrazole-4-carboxamides	7	24,829	1,271
	Bixafen	SDHI	Pyrazole-4-carboxamides	7	85,195	3,810
	Boscalid	SDHI	Pyridine-carboxamides	7	59,262	11,572
	Fluopyram	SDHI	Pyridinyl-ethyl-benzamides	7	10,389	992
	Fluxapyroxad	SDHI	Pyrazole-4-carboxamides	7	169,253	8,225
	Isopyrazam	SDHI	Pyrazole-4-carboxamides	7	14,784	756
	Penthiopyrad	SDHI	Pyrazole-4-carboxamides	7	25,601	2,614
	Azoxystrobin	Qo inhibitors	Strobilurin	11	33,454	5,087
	Dimoxystrobin	Qo inhibitors	Strobilurin	11	1,446	143
	Fluoxastrobin	Qo inhibitors	Strobilurin	11	80,500	3,029

Cont…

Table 20 Mode of action/chemical group of fungicide active substances on all arable crops – 2018 continued

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

Mode of Action	Active Substance	Group Name	Chemical Group	FRAC Group	Total Arable 2018	Total Arable 2018
					ha	kg
	Kresoxim-methyl	Qo inhibitors	Strobilurin	11	20,637	1,380
	Picoxystrobin	Qo inhibitors	Strobilurin	11	6,749	457
	Pyraclostrobin	Qo inhibitors	Strobilurin	11	69,674	5,201
	Trifloxystrobin	Qo inhibitors	Strobilurin	11	148,824	6,330
	Fenamidone	Qo inhibitor	Imidazolinones	11	2,224	332
	Cyazofamid	Qi inhibitor	Cyano-imidazole	21	54,530	4,382
	Amisulbrom	Qi inhibitor	Sulfamoyl-triazole	21	25,318	2,210
	Fluazinam	Phenylpyridinamine	2,6-dinitro-anilines	29	18,726	4,518
	Ametoctradin	Qo inhibitor, stigmatellin binding type	Triazolo-pyrimidine	45	20,594	4,943
All respiration					**871,990**	**67,252**
Amino acids and protein synthesis	Cyprodinil	Anilino - pyrimidine	Anilino - pyrimidine	9	35,298	6,017
Signal transduction	Proquinazid	Aza-Naphthalenes	Quinazolinone	13	45,388	1,124

Cont…

Table 20 Mode of action/chemical group of fungicide active substances on all arable crops – 2018 continued

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

Mode of Action	Active Substance	Group Name	Chemical Group	FRAC Group	Total Arable 2018	Total Arable 2018
					ha	kg
Lipid synthesis and membrane integrity	Propamocarb Hydrochloride	Carbamate	Carbamate	28	20,951	18,725
	Oxathiapiprolin	OSBPI	Piperidinyl-thiazole-isoxazolines	49	10,100	149
All Lipid synthesis and membrane integrity					**31,051**	**18,874**
Sterol biosynthesis in membranes	Cyproconazole	Demethylation inhibitor	Triazoles	3	25,062	1,178
	Difenoconazole	Demethylation inhibitor	Triazoles	3	1,663	187
	Epoxiconazole	Demethylation inhibitor	Triazoles	3	275,836	17,368
	Metconazole	Demethylation inhibitor	Triazoles	3	20,964	661
	Prochloraz	Demethylation inhibitor	Imidazoles	3	39,485	7,745

Cont…

Table 20 Mode of action/chemical group of fungicide active substances on all arable crops – 2018 continued

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

Mode of Action	Active Substance	Group Name	Chemical Group	FRAC Group	Total Arable 2018	Total Arable 2018
					ha	kg
	Propiconazole	Demethylation inhibitor	Triazoles	3	2,212	135
	Prothioconazole	Demethylation inhibitor	Triazolinthiones	3	522,760	44,558
	Tebuconazole	Demethylation inhibitor	Triazoles	3	256,588	21,847
	Fenpropimorph	Morpholines	Morpholines	5	128,319	22,949
	Fenpropidin	Morpholines	Piperidines	5	1,492	224
	Spiroxamine	Morpholines	Spiroketal-amines	5	72,516	13,066
All sterol biosynthesis in membranes					**1,346,899**	**129,916**
Cell wall biosynthesis	Dimethomorph	Carboxylic acid amide	Morpholines	40	43,317	7,570
	Mandipropamid	Carboxylic acid amide	Mandelic acid amides	40	32,737	4,738
	Benthiavalicarb isopropyl	Carboxylic acid amide	Valinamide carbamate	40	9,311	259
All cell wall biosynthesis					**85,365**	**12,567**

Cont…

Table 20 Mode of action/chemical group of fungicide active substances on all arable crops – 2018 continued

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

Mode of Action	Active Substance	Group Name	Chemical Group	FRAC Group	Total Arable 2018	Total Arable 2018
					ha	kg
Unknown mode of action	Cyflufenamid	Phenyl-acetamide	Phenyl-acetamide	U 06	49,159	431
	Cymoxanil	Cyanoacetamide oxime	Cyanoacetamide oxime	27	89,719	7,953
	Metrafenone	Aryl-phenyl-ketone	Benzophenone	U 08	27,232	1,815
All unknown mode of action					**166,110**	**10,199**
Chemicals with multi-site activity	Mancozeb	Dithio-carbamate	Dithio-carbamate	M 03	94,296	112,566
	Folpet	Phthalimide	Phthalimide	M 04	21,818	9,829
	Chlorothalonil	Chloronitrile	Chloronitrile	M 05	551,197	265,259
All chemicals with multi-site activity					**667,311**	**387,654**
All fungicides					**3,273,378**	**636,729**
Sulphur					**1,562**	**2,662**
Area grown					488,318	

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[10]

Table 21 Mode of action/chemical group of herbicide/desiccant active substances on all arable crops – 2018

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

Mode of Action	Active substance	Chemical Group	HRAC Group	Total Arable 2018	Total Arable 2018
				ha	kg
Inhibition of acetyl CoA carboxylase	Clodinafop-propargyl	Aryloxyphenoxy-propionate 'FOPS'	A	9,815	272
	Fenoxaprop-P-ethyl	Aryloxyphenoxy-propionate 'FOPS'	A	9,258	532
	Fluazifop-P-butyl	Aryloxyphenoxy-propionate 'FOPS'	A	2,243	211
	Propaquizafop	Aryloxyphenoxy-propionate 'FOPS'	A	12,403	635
	Quizalofop-P-ethyl	Aryloxyphenoxy-propionate 'FOPS'	A	4,690	177
	Quizalofop-P-tefuryl	Aryloxyphenoxy-propionate 'FOPS'	A	2,461	76
	Cycloxydim	Cyclohexanedione 'DIMS'	A	2,446	468
	Pinoxaden	Phenylpyrazoline	A	48,042	1,167
All Inhibition of acetyl CoA carboxylase				**91,359**	**3,536**
Inhibition of acetolactate synthase ALS	Imazamox	Imidazolinone	B	1,412	93
	Amidosulfuron	Sulfonylurea	B	868	15

Cont…

Table 21 Mode of action/chemical group of herbicide/desiccant active substances on all arable crops – 2018 continued

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

Mode of Action	Active substance	Chemical Group	HRAC Group	Total Arable 2018	Total Arable 2018
				ha	kg
	Flupyrsulfuron-methyl	Sulfonylurea	B	22,123	145
	Imazosulfuron	Sulfonylurea	B	303	3
	Iodosulfuron-methyl-sodium	Sulfonylurea	B	11,135	24
	Mesosulfuron-methyl	Sulfonylurea	B	11,686	94
	Metsulfuron-methyl	Sulfonylurea	B	177,661	610
	Rimsulfuron	Sulfonylurea	B	3,866	44
	Sulfosulfuron	Sulfonylurea	B	559	11
	Thifensulfuron-methyl	Sulfonylurea	B	168,760	3,767
	Tribenuron-methyl	Sulfonylurea	B	121,133	973
	Propoxycarbazone-sodium	Sulfonylaminocarbonyl-triazolinone	B	394	9
	Florasulam	Triazolopyrimidine	B	86,765	236

Cont…

Table 21 Mode of action/chemical group of herbicide/desiccant active substances on all arable crops – 2018 continued

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

Mode of Action	Active substance	Chemical Group	HRAC Group	Total Arable 2018	Total Arable 2018
				ha	kg
	Pyroxsulam	Triazolopyrimidine	B	5,677	105
All inhibition of acetolactate synthase ALS				**612,343**	**6,130**
Inhibition of photosynthesis at photosystem II	Metribuzin	Triazinone	C1	23,122	11,124
	Chlorotoluron	Urea	C2	11,847	5,608
	Linuron	Urea	C2	3,712	2,040
	Metobromuron	Urea	C2	7,559	7,876
	Bromoxynil	Nitrile	C3	1,137	55
All inhibition of photosynthesis at photosystem II				**47,378**	**26,702**
Photosystem-I-electron diversion	**Diquat**	**Bipyridylium**	**D**	**40,311**	**13,772**
Inhibition of protoporphyrinogen oxidase	Bifenox	Diphenylether (PPO)	E	270	129
	Carfentrazone-ethyl	Triazolone	E	21,133	1,002
	Flumioxazine	N-phenylphthalimide	E	81	2
	Pyraflufen-ethyl	Phenylpyrazole	E	6,687	104
All inhibition of protoporphyrinogen oxidase				**28,171**	**1,238**
Bleaching: Inhibition of carotenoid biosynthesis	Diflufenican	Pyridinecarboxamide	F1	154,594	8,792
	Flurtamone	Other	F1	7,496	675
	Picolinafen	Pyridinecarboxamide	F1	87,485	2,577

Cont…

Table 21 Mode of action/chemical group of herbicide/desiccant active substances on all arable crops – 2018 continued

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

Mode of Action	Active substance	Chemical Group	HRAC Group	Total Arable 2018	Total Arable 2018
				ha	kg
All bleaching: Inhibition of carotenoid biosynthesis				**249,575**	**12,044**
Bleaching: DOXP inhibitors	**Clomazone**	**Isoxazolidinone**	**F4**	**16,333**	**1,039**
Inhibition of EPSP synthase	**Glyphosate**	**Glycine**	**G**	**166,367**	**134,879**
Microtubule assembly inhibition	Pendimethalin	Dinitroaniline	K1	129,881	97,115
	Propyzamide	Benzamide	K1	7,206	4,818
All microtubule assembly inhibition				**137,087**	**101,934**
Inhibition of VLCFAs	Dimethenamid-P	Chloroacetamide	K3	6,720	1,848
	Metazachlor	Chloroacetamide	K3	27,350	18,549
	Flufenacet	Oxyacetamide	K3	87,023	12,685
All inhibition of VLCFAs				**121,093**	**33,083**
Inhibition of lipid synthesis	**Prosulfocarb**	**Thiocarbamate**	**N**	**5,064**	**7,853**
Action like indole acetic acid	2,4-D	Phenoxy-carboxylic acid	O	534	452
	2,4-DB	Phenoxy-carboxylic acid	O	6,219	5,878
	Dichlorprop-P	Phenoxy-carboxylic acid	O	6,240	2,770
	MCPA	Phenoxy-carboxylic acid	O	12,953	6,162
	Mecoprop-P	Phenoxy-carboxylic acid	O	125,883	68,278

Cont…

Table 21 Mode of action/chemical group of herbicide/desiccant active substances on all arable crops – 2018 continued

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

Mode of Action	Active substance	Chemical Group	HRAC Group	Total Arable 2018	Total Arable 2018
				ha	kg
	Dicamba	Benzoic acid	O	39,665	2,400
	Aminopyralid	Pyridine carboxylic acid	O	1,951	18
	Clopyralid	Pyridine carboxylic acid	O	16,134	1,136
	Fluroxypyr	Pyridine carboxylic acid	O	163,448	17,135
	Picloram	Pyridine carboxylic acid	O	3,147	67
	Quinmerac	Quinoline carboxylic acid	O	7,536	1,605
	Halauxifen-methyl	Arylpicolinate	O	83,729	314
All action like indole acetic acid				**467,439**	**106,214**
All herbicides				**1,982,520**	**448,424**
Area grown				488,318	

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[11]

Table 22 Principal active substances by area treated

Area treated (1000 ha) with the 50 most used active substances, including seed treatments, on all crops surveyed

	Active substance	Type[1]	2018	2016	% change
1	Prothioconazole	S/F	677	719	-6
2	Chlorothalonil	F	551	532	4
3	Tebuconazole	S/F	381	383	-1
4	Epoxiconazole	F	276	256	8
5	Chlormequat	G	201	231	-13
6	Metsulfuron-methyl	H	178	173	3
7	Fluxapyroxad	F	169	139	22
8	Thifensulfuron-methyl	H	169	155	9
9	Glyphosate	H	166	196	-15
10	Fluroxypyr	H	163	142	15
11	Diflufenican	H	155	158	-2
12	Trifloxystrobin	F	149	138	8
13	Trinexapac-ethyl	G	148	158	-7
14	Pendimethalin	H	130	127	2
15	Fenpropimorph	F	128	102	26
16	Mecoprop-P	H	126	191	-34
17	Tribenuron-methyl	H	121	123	-2
18	Lambda-cyhalothrin	I	118	113	4
19	Imazalil	S	105	36	190
20	Ipconazole	S	102	32	220
21	Mancozeb	F	94	82	15
22	Cymoxanil	F	90	137	-34
23	Picolinafen	H	87	75	17
24	Flufenacet	H	87	87	<0.5
25	Florasulam	H	87	70	24
26	Bixafen	F	85	92	-7
27	Halauxifen-methyl	H	84	0.26	32,228
28	Fluoxastrobin	F	81	95	-15
29	Spiroxamine	F	73	164	-56
30	Prochloraz	S/F	72	258	-72
31	Fludioxonil	S	72	35	106
32	Pyraclostrobin	F	70	82	-15
33	Prohexadione-calcium	G	62	44	41
34	Boscalid	F	59	62	-4
35	2-Chloroethylphosphonic acid	G	58	73	-21
36	Mepiquat chloride	G	57	51	10
37	Cyazofamid	F	55	62	-12
38	Fluopyram	S/F	51	119	-57
39	Metaldehyde	M	49	58	-15
40	Cyflufenamid	F	49	17	196
41	Pinoxaden	H	48	45	7
42	Proquinazid	F	45	73	-38
43	Dimethomorph	F	43	32	34
44	Diquat	H	40	58	-30
45	Dicamba	H	40	69	-42
46	Cyprodinil	F	35	51	-31
47	Azoxystrobin	F	33	34	-1
48	Mandipropamid	F	33	40	-18
49	Esfenvalerate	I	31	31	1
50	Thiram	S	28	32	-13

(1) Pesticide type = F: Fungicide, G: Growth regulator, H: Herbicide, I: Insecticide, M: Molluscicide, S: Seed treatment.

Table 23 Principal active substances by weight

Quantity (tonnes) of the 50 most used active substances, including seed treatments, on all crops surveyed

	Active substance	Type[1]	2018	2016	% change
1	Chlorothalonil	F	265	240	11
2	Chlormequat	G	164	174	-6
3	Glyphosate	H	135	169	-20
4	Mancozeb	F	113	103	9
5	Pendimethalin	H	97	99	-2
6	Mecoprop-P	H	68	111	-38
7	Prothioconazole	F/S	47	50	-6
8	Fenpropimorph	F	23	22	6
9	Tebuconazole	F/S	22	24	-7
10	Propamocarb hydrochloride	F	19	23	-18
11	Metazachlor	H	19	15	21
12	Epoxiconazole	F	17	16	9
13	Fluroxypyr	H	17	16	9
14	Diquat	H	14	23	-39
15	Spiroxamine	F	13	27	-52
16	Flufenacet	H	13	13	-1
17	Boscalid	F	12	12	-4
18	Metribuzin	H	11	10	10
19	2-Chloroethylphosphonic acid	G	10	12	-13
20	Folpet	F	10	23	-57
21	Diflufenican	H	9	8	9
22	Fluxapyroxad	F	8	7	11
23	Prochloraz	F/S	8	17	-53
24	Cymoxanil	F	8	12	-35
25	Metobromuron	H	8	1	1,400
26	Prosulfocarb	H	8	7	8
27	Dimethomorph	F	8	6	35
28	Mepiquat chloride	G	7	8	-4
29	Trifloxystrobin	F	6	5	16
30	MCPA	H	6	8	-18
31	Cyprodinil	F	6	10	-40
32	2,4-DB	H	6	5	10
33	Chlorotoluron	H	6	4	53
34	Metaldehyde	M	5	7	-20
35	Pyraclostrobin	F	5	6	-13
36	Trinexapac-ethyl	G	5	5	3
37	Azoxystrobin	F	5	5	-5
38	Oxamyl	I	5	2	103
39	Ametoctradin	F	5	4	35
40	Propyzamide	H	5	4	37
41	Mandipropamid	F	5	6	-19
42	Pencycuron	S	5	9	-48
43	Fluazinam	F	5	9	-50
44	Cyazofamid	F	4	5	-12
45	Bixafen	F	4	5	-19
46	Thifensulfuron-methyl	H	4	4	6
47	Ferric phosphate	M	3	1	197
48	Fluoxastrobin	F	3	3	-13
49	Dichlorprop-P	H	3	3	-14
50	Sulphur	F	3	37	-93

(1) Pesticide type = F: Fungicide, G: Growth regulator, H: Herbicide, I: Insecticide, M: Molluscicide, S: Seed treatment.

Table 24 Total arable crop, comparison with previous years

Pesticide usage in 2014, 2016 and 2018, area treated with formulations and active substances (a.s.) and the weight (kg) applied

	2014			2016			2018		
	Formulations	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**
	ha	**ha**	**kg**	**ha**	**ha**	**kg**	**ha**	**ha**	**kg**
Insecticides/nematicides	293,363	293,363	29,389	198,964	198,964	12,428	202,792	202,792	8,616
Molluscicides	54,171	54,171	5,333	68,645	68,645	7,843	75,033	75,033	8,716
Fungicides	2,445,034	3,852,458	660,121	2,239,796	3,550,384	660,809	2,128,624	3,273,378	636,729
Sulphur	11,468	11,468	24,353	11,879	11,879	37,467	1,562	1,562	2,662
Herbicides/desiccants	1,416,298	2,060,274	553,963	1,383,643	1,997,906	533,728	1,349,368	1,983,129	448,425
Growth regulators	530,753	644,131	209,708	497,456	596,763	212,489	454,237	548,541	190,656
Seed treatments	496,527	996,382	26,838	451,389	926,172	25,150	420,451	747,314	15,997
All pesticides	**5,247,614**	**7,912,247**	**1,509,705**	**4,851,771**	**7,350,712**	**1,489,914**	**4,632,066**	**6,831,748**	**1,311,801**
Total area grown (ha)	531,269			494,167			489,309		

Note: Unspecified treatments have been included in the formulation and active substance areas, however as their weights are unknown they cannot be included in the quantities applied. Total arable crop includes cereals, oilseed rape, potatoes and legumes. It should be noted that there may be minor differences in the range of crops surveyed between years.

Table 25 Cereals, comparison with previous years

Pesticide usage in 2014, 2016 and 2018, area treated with formulations and active substances (a.s.) and the weight (kg) applied

	2014			2016			2018		
	Formulations	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**
	ha	**ha**	**kg**	**ha**	**ha**	**kg**	**ha**	**ha**	**kg**
Insecticides	141,647	141,647	17,127	75,473	75,473	1,447	78,127	78,127	385
Molluscicides	11,155	11,155	1,184	18,520	18,520	2,436	29,439	29,439	3,322
Fungicides	1,877,867	3,069,096	454,831	1,762,377	2,879,227	463,707	1,710,838	2,659,346	450,428
Sulphur	9,482	9,482	19,050	8,412	8,412	22,980	1,339	1,339	2,261
Herbicides/desiccants	1,187,398	1,811,144	435,914	1,163,254	1,759,278	421,484	1,130,538	1,739,063	336,584
Growth regulators	525,448	635,135	204,358	488,976	582,317	204,053	448,775	537,939	188,943
Seed treatments	415,382	854,612	14,291	399,608	845,878	13,815	365,829	666,313	8,435
All pesticides	**4,168,379**	**6,532,270**	**1,146,754**	**3,916,621**	**6,169,106**	**1,129,922**	**3,764,885**	**5,711,567**	**990,358**
Area grown (ha)	461,474			432,077			425,674		

Note: Unspecified treatments have been included in the formulation and active substance areas, however as their weights are unknown they cannot be included in the quantities applied. Cereals crops include winter barley, spring barley, winter wheat, spring wheat, winter oats, spring oats and winter rye. It should be noted that there may be minor differences in the range of crops surveyed between years.

Table 26 Potatoes comparison with previous years

Pesticide usage in 2014, 2016 and 2018, area treated with formulations and active substances (a.s.) and the weight (kg) applied

	2014			2016			2018		
	Formulations	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**
	ha	**ha**	**kg**	**ha**	**ha**	**kg**	**ha**	**ha**	**kg**
Insecticides/nematicides	102,147	102,147	11,361	78,719	78,719	10,166	90,685	90,685	7,675
Molluscicides	24,918	24,918	2,445	33,432	33,432	3,506	21,676	21,676	2,955
Fungicides	402,924	539,323	176,009	370,696	506,007	175,215	306,927	441,298	166,694
Sulphur	0	0	0	265	265	424	0	0	0
Herbicides/desiccants	115,397	116,130	47,548	121,927	124,952	49,369	113,567	117,357	43,202
Growth regulators	1,613	1,613	4,648	2,515	2,515	7,338	323	323	775
Seed treatments	29,663	35,752	11,911	24,828	27,973	11,014	25,048	25,048	7,239
All pesticides	**676,664**	**819,884**	**253,922**	**632,381**	**773,863**	**257,032**	**558,227**	**696,387**	**228,539**
Area grown (ha)	28,511			27,526			27,359		

Note: Unspecified treatments have been included in the formulation and active substance areas, however as their weights are unknown they cannot be included in the quantities applied. Potatoes include seed potatoes and ware potatoes.

Table 27 Oilseed rape, comparison with previous years

Pesticide usage in 2014, 2016 and 2018, area treated with formulations and active substances (a.s.) and the weight (kg) applied

	2014			2016			2018		
	Formulations	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**
	ha	**ha**	**kg**	**ha**	**ha**	**kg**	**ha**	**ha**	**kg**
Insecticides	47,987	47,987	886	43,782	43,782	805	33,353	33,353	551
Molluscicides	18,098	18,098	1,705	16,234	16,234	1,846	23,917	23,917	2,439
Fungicides	160,020	237,183	27,642	100,681	154,974	19,361	109,052	169,723	18,933
Sulphur	1,072	1,072	3,426	2,973	2,973	12,995	223	223	401
Herbicides/desiccants	105,740	123,196	64,310	90,409	104,526	56,768	100,286	120,243	64,895
Growth regulators	3,692	7,383	702	5,965	11,931	1,098	5,139	10,279	938
Seed treatments	50,288	104,457	534	26,789	52,157	298	29,574	55,953	323
All pesticides	**386,898**	**539,378**	**99,205**	**286,833**	**386,577**	**93,171**	**301,544**	**413,690**	**88,480**
Area planted (ha)	36,419			30,142			32,735		

Note: Unspecified treatments have been included in the formulation and active substance areas, however as their weights are unknown they cannot be included in the quantities applied. Oilseed rape includes winter oilseed rape and spring oilseed rape. It should be noted that there may be minor differences in the range of crops surveyed between years.

Appendix 2 – Survey statistics

Census and sample information

Table 28 Regional distribution of arable crops in 2018

Census area (ha) of arable crops grown in Scotland

	H&I (1)	C&O (1)	Moray Firth	Abdn (1)	Angus	East Fife	Lothian	C. Low-lands (1)	Tweed Valley	S. Uplands (1)	Solway	Scotland 2018	Scotland 2016	% change
Winter barley	65	213	1,557	10,854	5,886	3,239	3,568	3,060	6,247	795	2,060	**37,542**	48,031	-22
Spring barley	4,366	7,332	37,489	77,291	46,816	12,434	12,030	27,817	13,835	3,345	7,719	**250,476**	238,899	5
Wheat	104	*	4,432	7,676	22,469	14,150	17,577	8,234	21,388	*	2,770	**99,778**	109,594	-9
Winter oats	*	*	*	212	1,340	2,230	597	663	2,748	412	134	**8,439**	8,091	4
Spring oats	462	1,810	1,772	4,758	3,372	2,706	1,102	4,231	2,347	472	630	**23,661**	23,119	2
Winter Rye	*	*	563	718	1,812	837	*	679	869	0	201	**5,786**	3,725	55
Triticale	*	0	65	291	33	0	0	292	118	*	118	**956**	614	56
Winter Oilseed Rape	*	0	2,646	7,308	7,668	2,002	3,948	1,614	6,833	*	148	**32,284**	30,141	7
Spring Oilseed Rape(2)	*	0	66	*	168	*	*	79	*	*	*	**454**	590	-23
Seed potatoes	189	*	1,723	2,032	5,947	427	109	1,101	485	*	*	**12,092**	12,760	-5
Ware potatoes	79	27	893	592	7,109	2,130	1,345	1,286	1,607	16	183	**15,268**	14,766	3
Field Beans	*	0	126	*	191	275	395	344	543	0	159	**2,034**	776	162
Dry Harvest Peas	*	*	*	120	50	77	73	*	85	*	*	**515**	3,002	-83
Lupins	*	0	0	*	0	0	0	*	0	0	0	*****	43	-89
Mixed grain	*	*	*	*	0	0	0	*	0	*	0	**18**	18	1
Totals	**5,312**	**9,426**	**51,434**	**111,883**	**102,860**	**40,526**	**40,858**	**49,412**	**57,120**	**6,306**	**14,173**	**489,309**	**494,167**	-1

* To prevent disclosure of information about individual holdings, entries relating to fewer than five holdings are not reported
(1) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, C. Lowlands = Central Lowlands, S. Uplands = Southern Uplands
(2) Includes linseed

Table 29 Distribution of arable sample - 2018

Number of holdings surveyed in each region and size group

Size (ha)	H&I[1]	C&O[1]	Moray Firth	Abdn[1]	Angus	East Fife	Lothian	C. Low-lands[1]	Tweed Valley	S. Uplands[1]	Solway	Scotland
0.1-19.99	3	2	1	4	1	1	0	5	1	1	2	**21**
20-49.9	1	1	3	13	5	4	2	7	2	1	3	**42**
50-99.9	1	1	8	19	15	7	7	7	4	1	1	**71**
100-149.9	0	3	6	20	14	4	9	4	13	1	1	**75**
150+	0	0	14	13	22	11	13	11	19	2	1	**106**
All sizes	**5**	**7**	**32**	**69**	**57**	**27**	**31**	**34**	**39**	**6**	**8**	**315**

(1) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, C. Lowlands = Central Lowlands, S. Uplands = Southern Uplands

Table 30 Sampled area - 2018

Area (ha) of arable crops grown in sample

Size (ha)	H&I[1]	C&O[1]	Moray Firth	Abdn[1]	Angus	East Fife	Lothian	C. Low-lands[1]	Tweed Valley	S. Uplands[1]	Solway	Scotland
0.1-19.99	24	10	5	36	4	17	0	49	4	20	20	**188**
20-49.9	21	29	110	445	152	119	88	178	75	25	77	**1,319**
50-99.9	48	81	587	1,416	1,037	393	498	686	277	54	68	**5,145**
100-149.9	0	421	804	2,505	1,823	455	1,278	427	1,677	90	120	**9,600**
150+	0	0	3,065	3,184	5,023	2,881	2,666	1,996	5,093	430	204	**24,541**
All sizes	**92**	**541**	**4,570**	**7,587**	**8,038**	**3,863**	**4,531**	**3,337**	**7,126**	**618**	**489**	**40,793**

(1) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, C. Lowlands = Central Lowlands, S. Uplands = Southern Uplands

Table 31 Census area - 2018

Area (ha) of arable crops grown in Scotland

Size (ha)	H&I[1]	C&O[1]	Moray Firth	Abdn[1]	Angus	East Fife	Lothian	C. Low-lands [1]	Tweed Valley	S. Uplands[1]	Solway	Scotland
0.1-19.99	1,553	3,601	2,853	7,601	2,473	944	909	4,646	1,029	663	2,663	**28,935**
20-49.9	1,577	2,422	7,667	18,539	10,890	3,675	2,635	9,174	3,107	1,204	4,913	**65,802**
50-99.9	1,338	1,540	11,129	30,077	20,868	9,456	6,951	13,086	7,460	1,490	3,577	**106,972**
100-149.9	845	*	9,799	18,748	18,525	9,151	9,405	7,622	10,979	968	*	**88,411**
150+	0	*	19,986	36,918	50,105	17,299	20,959	14,883	34,545	1,981	*	**199,189**
All sizes	**5,312**	**9,426**	**51,434**	**111,883**	**102,860**	**40,526**	**40,858**	**49,412**	**57,120**	**6,306**	**14,173**	**489,309**

* To prevent disclosure of information about individual holdings, entries relating to fewer than five holdings are not reported
(1) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, C. Lowlands = Central Lowlands, S. Uplands = Southern Uplands

Table 32 Raising factors - 2018

Size (ha)	H&I[1]	C&O[1]	Moray Firth	Abdn[1]	Angus	East Fife	Lothian	C. Low-lands[1]	Tweed Valley	S. Uplands[1]	Solway
0.1-19.99	66.0664	371.6574	588.2639	210.2160	564.6233	57.0139	N/A	94.2790	286.5905	33.1470	133.5396
20-49.9	76.6582	83.3300	69.6139	41.6764	71.6331	30.9618	29.9873	51.4386	41.2409	48.6347	63.4309
50-99.9	27.8767	18.9085	18.9689	21.2360	20.1305	24.0827	13.9493	19.0766	26.9040	27.5141	52.9074
100-149.9	N/A	2.5937	12.1861	7.4834	10.1636	20.1150	7.3571	17.8518	6.5455	10.7893	10.6439
150+	N/A	N/A	6.5214	11.5930	9.9757	6.0055	7.8610	7.4560	6.7833	4.6082	8.5576

(1) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, C. Lowlands = Central Lowlands, S. Uplands = Southern Uplands

Table 33 First and second adjustment factors - 2018

	H&I (1)	C&O (1)	Moray Firth	Abdn (1)	Angus	East Fife	Lothian	C. Low-lands (1)	Tweed Valley	S. Uplands (1)	Solway	ADJ2
Winter Barley	N/A	N/A	1.6050	1.1149	0.8158	0.5949	1.3696	0.7766	0.8828	2.4206	1.4799	1.0074
Spring Barley	0.9788	0.8835	0.9027	0.9647	0.9563	1.1972	1.0608	0.9940	0.8546	0.6635	0.8656	1.0000
Total wheat	N/A	0.2516	1.9180	0.8486	0.9851	0.8908	0.9051	0.8537	1.1641	1.3234	1.0605	1.0010
Winter Oats	N/A	N/A	N/A	1.9051	5.2649	0.6041	1.2361	0.3817	0.8783	2.4806	0.3197	1.0124
Spring Oats	N/A	6.2761	0.6655	1.3321	0.9741	3.0772	2.6478	0.9606	1.2922	N/A	2.4234	1.0411
Winter Rye	N/A	N/A	3.3569	0.4661	0.8875	1.0378	N/A	N/A	1.5760	N/A	0.3500	1.1572
Spring Oilseed Rape	N/A	N/A	0.1824	N/A	N/A	N/A	N/A	N/A	N/A	N/A	N/A	6.8779
Winter Oilseed Rape	N/A	N/A	1.2558	1.0791	0.8906	0.9202	1.1419	2.2734	0.7610	N/A	N/A	1.0083
Seed Potatoes	28.6606	N/A	2.5019	2.6935	0.8812	0.9987	N/A	N/A	1.1313	1.4829	N/A	1.1132
Ware Potatoes	N/A	2.4530	1.7376	2.5105	2.6076	3.6401	1.4700	1.3007	N/A	N/A	N/A	1.1409
Dry harvest peas	N/A	N/A	N/A	N/A	1.2579	N/A	0.4524	N/A	N/A	N/A	N/A	4.1948
Field Beans	N/A	N/A	1.0147	N/A	N/A	1.1237	0.3429	N/A	0.9418	N/A	N/A	1.5186

(1) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, C. Lowlands = Central Lowlands, S. Uplands = Southern Uplands
N/A = not applicable

Response rates

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

Table 34 Response rate

	2018	% total
Target sample	350	100
Total achieved	**315**	**90**
Total number of refusals/non-contact	248	
Total number of farms approached	**563**	

Financial burden to farmers

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

To determine the total burden that the 2018 arable crop survey placed on those providing the information, the surveyors recorded the time that 253 respondents spent providing the data during the surveys. This sample represents 80 per cent of growers surveyed. The median time taken to provide the information was 22 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 £14.38)[12]

The total financial burden to all growers resulting from participation in the 2018 arable crop survey was calculated to be £1,661.

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

5) A **herbicide** is a pesticide used to control unwanted vegetation (weed killer). A **desiccant** is a pesticide used to dry out unwanted plant material.

6) A **growth regulator** is a pesticide used to regulate the growth of the plant, for example to prevent the crop from growing too tall.

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

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

9) 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.

10) 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.

11) 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.

12) **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.

13) **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.

14) 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.

15) 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.

16) 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.

17) The **June Agricultural Census**[13] is conducted annually by the Scottish Government's Rural and Environmental Science Analytical Services (RESAS). The June Agricultural Census collects data on land use, crop areas, livestock and the number of people working on agricultural holdings. For this report the June Agricultural Census was used to draw a sample of farmers growing the relevant crops to participate in the survey.

18) 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.

19) During the survey, the wheat crop is differentiated as either winter wheat or spring wheat. In the census, wheat is not subdivided. Any data from the census refers to the wheat crop as ‘total wheat’, but the survey data refers to winter and spring wheat.

20) 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.

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

22) Data from the 2014[4] and 2016[3] surveys are provided for comparison purposes in some of the tables, although it should be noted that there may be minor differences in the range of crops surveyed, together with changes in areas of each of the crops grown. Changes from previous surveys are described in Appendix 4. When comparisons are made between surveys it is important consider changes in the area of crop grown. In order to take this into account, comparisons have been made on a per hectare grown basis, i.e. the number of hectares that have been sprayed (treated hectares) has been divided by the area of crop grown for each survey, and the weight (kilograms) applied has also been divided by the area of crop grown. This is to enable like for like comparisons between surveys, so that changes in pesticide use patterns are not masked by changes in crop area.

23) 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.

24) There were a limited number of holdings with winter rye sampled. Therefore, no details of pesticide use on winter rye is reported separately, however it is included in the totals for 'all cereals' in the pesticide usage tables.

25) The crop type '**dry harvest peas'** is used for consistency with the Fera Science Ltd UK pesticide usage reports. This equates to peas for combining on the Scottish Agricultural Census form and is synonymous with 'combine peas' which appeared in previous Scottish reports.

Appendix 4 – Survey methodology

Sampling and data collection

Using the June 2018 Agricultural Census[13], a sample was drawn representing arable cultivation in Scotland. The country was divided into 11 land-use regions (Figure 31). Each sample was stratified by these land-use regions and according to holding size. 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.

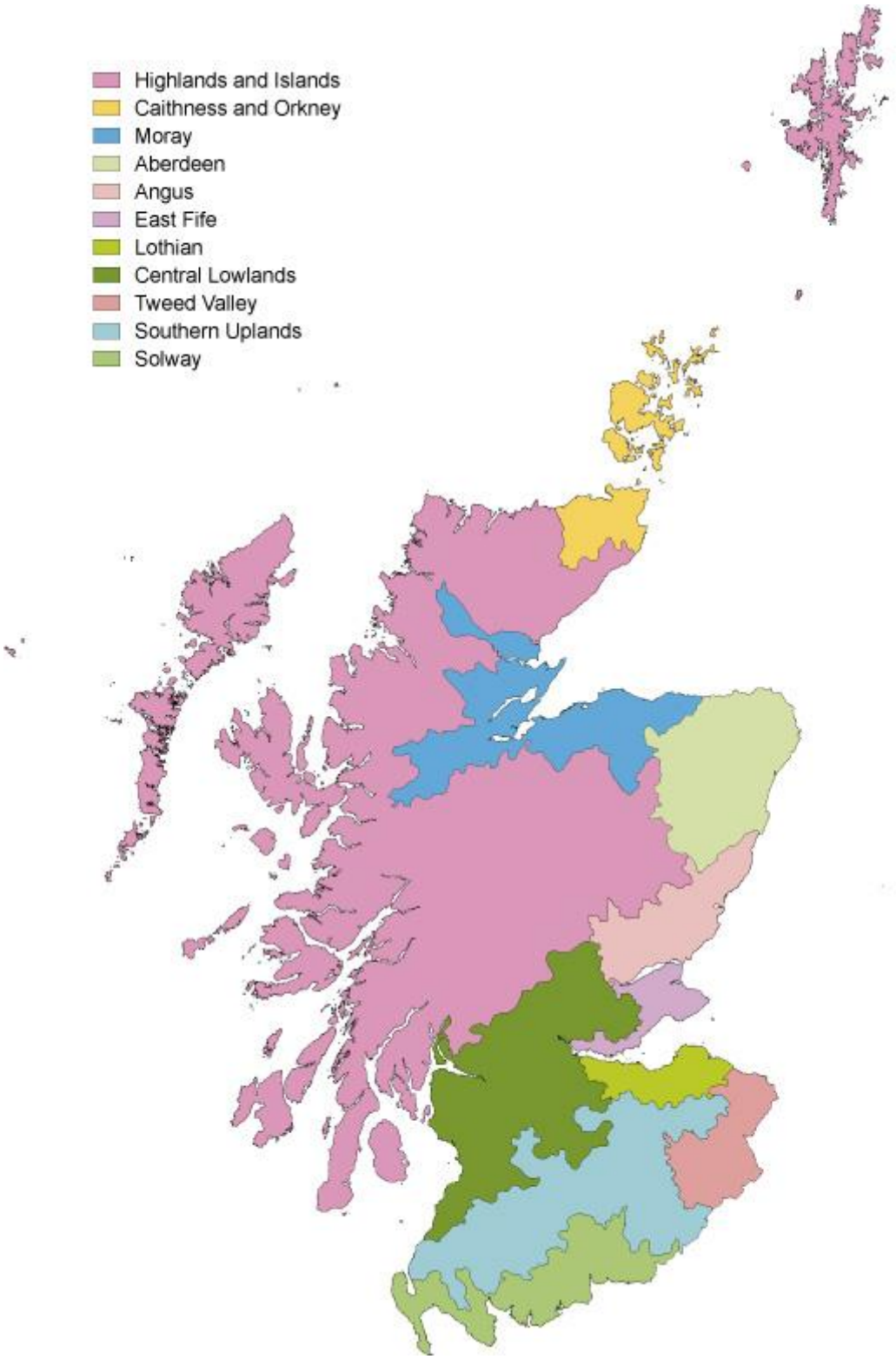
The survey covered pesticide applications to arable crops where all or the majority of the growing season was in 2018. As well as recording treatments applied directly to the crop, data was also collected on land preparation treatments prior to sowing or planting the crop.

Following an introductory letter and phone call, data were collected either by personal interview during a visit to the holding or during a phone interview or by email. Where necessary, information was also collected from agronomists and contractors. In total, information was collected from 315 holdings growing arable crops (Table 29). These holdings represent 8 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 32). 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 33) 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 31 Land use regions of Scotland[14]



Changes from previous years

There are a number of changes which should be noted when comparing the 2018 data with the previous survey.

The areas and weights treated with individual active substances are no longer included at crop level in this report. These data are now published separately as supplementary tables in Excel format to allow continued user access to the full dataset. In this report, the areas treated and weights of pesticide formulations (mixture of active substances in a product) by crop are presented in Tables 2-17 and summary active substance data are presented in Tables 19 to 27. The aim of this change is to focus on the key metrics at crop level and reduce the size of the published report. This approach is consistent with the output from the other UK pesticide survey teams.

The previous report contained information about grower adoption of Integrated Pest Management (IPM). IPM data was not collected during the 2018 survey. It is anticipated that IPM data will be collected and published every 4 years. This allows IPM uptake to be monitored over time but reduces the burden on, growers and surveyors.

It should also be noted that the total number of refusals to participate in this voluntary survey increased from 36 per cent in 2016 to 44 per cent in 2018. This has resulted in a 2018 sample ten per cent lower than target. However, this is an improvement on the 2016 sample that was 18 per cent below the desired size. This trend in decreased participation has been noted in our surveys in all crop sectors and it is possible that reduced sample size has influenced the estimates made in this report (please refer to appendix 5).

Data quality assurance

The dataset undergoes several validation processes as follows; (i) checking for any obvious errors upon data receipt (ii) checking and identifying inconsistencies with use and pesticide approval conditions once entered into the database (iii) 100 per cent checking of data held in the database against the raw data. Where inconsistencies are found these are checked against the records and with the grower if necessary. Additional quality assurance is provided by sending reports for review to members of the Working Party on Pesticide Usage Surveys and other agricultural experts. In addition, the Scottish pesticide survey unit is accredited to ISO 9001:2015. All survey related processes are documented in Standard Operating Procedures (SOPs) and our output is audited against these SOPs by internal auditors annually and by external auditors every three years.

Main sources of bias

The use of a random stratified sample is an appropriate survey methodology. A stratified random sample, grouped by farm size and region, is used to select holdings used in this survey. Sampling within size groups is based on area rather than numbers of holdings, so that smaller size groups are not over-represented in the sample. The pesticide survey may be subject to measurement bias as it is reliant on farmers/growers recording data accurately. As this survey is not compulsory it may also subject to non-

response bias, as growers on certain farm/holding types may be more likely to respond to the survey than others. Reserve lists of holdings are held for each stratum to allow non-responding holdings to be replaced with similar holdings.

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

Appendix 5 – Standard errors

The figures presented in this report are produced from surveying a sample of holdings rather than a census of all the holdings in Scotland. Therefore the figures are estimates of the total pesticide use for Scotland and should not be interpreted as exact. To give an idea of the precision of estimates, the report includes relative standard errors (RSE) (Table 35). Standard errors are produced using the raising factors. An overall variance is calculated by summing the variance estimates for individual strata (region and size group) multiplied by the square of their raising factors. These variance estimates include a finite population correction. The overall standard error is calculated from the overall variance by taking its square root. This method of standard estimation was implemented as it is both relatively straightforward and has advantages over ratio estimator methods when within-strata sample sizes are small.

Standard errors are expressed as percentage relative standard errors (Table 35) 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 arable crops (Table 35) was three per cent for both area and weight, compared with three and four per cent respectively in 2016. For constituent crop groups, the RSE varied from four to 44 per cent for area and five to 77 per cent for weight, varying with sample size and uniformity of pesticide regime encountered. For dry harvest peas a standard error could not be calculated due to too few active ingredients being recorded; therefore pesticide estimates for these crops should be treated with caution. Higher standard errors mean that there is more uncertainty associated with estimates of pesticide use.

Table 35 Relative standard errors

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

	Area SE (%)	Weight SE (%)
Winter barley[1]	6	6
Spring barley	4	5
Wheat (winter and spring)[1]	5	5
Winter oats[1]	18	27
Spring oats[1]	11	13
Winter rye	44	50
Winter oilseed rape	6	6
Spring oilseed rape	40	77
Seed potatoes[1]	12	12
Maincrop potatoes[1]	12	11
Dry harvest peas[2]	NC	NC
Field beans[1]	11	16
All Pesticides	**3**	**3**

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

(2) Standard errors could not be calculated (NC) for dry harvest peas because there were too few active substances recorded. Therefore estimates for these crops should be treated with caution

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 and Stuart Wale (SRUC), Sarah Cook, Frances Pickering, Faye Ritchie and Sacha White (ADAS) for editorial assistance. In addition, the authors are grateful for support and advice from Abigail Mace and her colleagues at Fera Science Ltd, Paul Gavin at the Scottish Government's Agricultural Census Analysis Team and Adrian Roberts of Biomathematics & Statistics Scotland.

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Pesticide Usage in Scotland

Potato Stores 2018

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Executive summary

This report presents information from a survey of pesticide use on stored potatoes harvested in Scotland in 2018. Data were collected from 57 growers, who collectively cultivated 29 per cent of the area of potatoes grown in Scotland. Pesticide use in potato stores was recorded for crops grown for seed production and for consumption (ware potatoes). Ratio raising was used to produce estimates of national pesticide usage from the sample data.

The overall estimated quantity of potatoes stored in 2018 was approximately 1,105,891 tonnes, a slight decrease of three per cent compared with the 2016 survey. Seed potato tonnage decreased by an estimated one per cent to ca. 408,870 tonnes and ware potatoes by four per cent to ca. 697,021.

Sixty-seven per cent of seed and 80 per cent of ware potatoes sampled in 2018 were stored in refrigerated stores. The majority of the remaining stores were ambient ventilated stores. All the potatoes surveyed were stored in boxes.

The proportion of stored seed potatoes treated in 2018 was 28 per cent, significantly lower than the 47 per cent treated in 2016 and 2014. The proportion of stored ware potatoes treated increased from 11 per cent in 2016 to 13 per cent in 2018.

The principal pesticide encountered on seed potatoes in 2018 was the fungicide imazalil, which was applied to an estimated 26 per cent of the stored crop for control of a range of tuber diseases. The only other pesticide encountered was the fungicide thiabendazole, which was applied to eight per cent. Imazalil and thiabendazole were also the only fungicides used on seed potatoes in the previous two surveys. As in 2016 and 2014, a small proportion of the seed crop was treated with ethylene (<0.5 per cent). Ethylene is approved as a commodity substance for plant growth regulation in post-harvest crops under the Control of Pesticide regulations (COPR).

The sprout suppressant chlorpropham (CIPC), remains the most commonly used formulation on ware potatoes However use has decreased, with 11 per cent of the stored crop treated compared to 17 per cent in 2016, but is similar to levels of use in 2014 (seven per cent treated). In contrast, the use of ethylene increased with eight per cent of the stored crop treated, compared to one per cent in the previous survey. Ethylene was not encountered on ware crops in 2014. The sprout suppressant spearmint oil was encountered for the first time, applied to two per cent of the stored ware crop. The increase in use of non-CIPC growth regulators may have been influenced by the impending loss of chlorpropham which may have encouraged growers to use other growth regulating active substances. Thiabendazole was the only fungicidal formulation recorded, applied to <0.05 per cent of the stored ware crop, the lowest level of fungicide use in stored ware potatoes since 2012.

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 Delivery Directorate.

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

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

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

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

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

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

Structure of report and how to use these statistics

This report is intended to provide data in a useful format to a wide variety of data users. The general trends section provides commentary on recent changes in survey data and longer-term trends. The 2018 pesticide usage section summarises pesticide use on stored potatoes in 2018. Appendix 1 presents estimated pesticide usage data. Appendix 2 summarises survey statistics including census and holding information, raising factors and the financial burden to farmers. 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.

General trends

Scottish potato storage

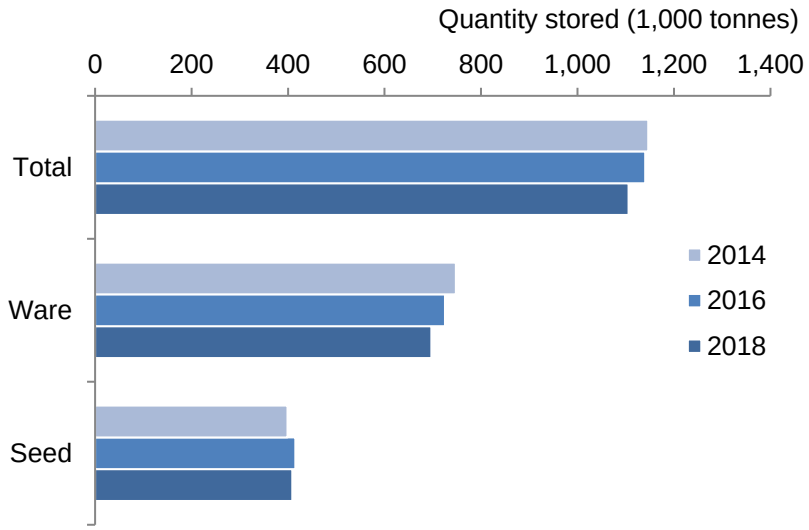
The total estimated quantity of potatoes stored in Scotland in 2018 was 1,105,891 tonnes. This is three per cent less than that reported in 2016[(3)] (1,140,286 tonnes) and four per cent less than in 2014[(4)] (1,146,682 tonnes). 2018 was a challenging year for potato growers with one of the hottest driest summers on record. However, Scotland avoided the worst of the droughts with production only down slightly. Yields in Scotland were better (49.2 t/ha on average) than those in England due to Scotland's slightly damper summer[(5)].

The quantity of seed and ware potatoes stored was estimated to be 408,870 and 697,021 tonnes respectively (Table 1). This represents a one per cent decrease in stored seed potatoes and a four per cent reduction in storage of ware potatoes, from the previous survey in 2016 (Figure 1).

In 2018, all potatoes surveyed were stored in boxes. In previous surveys, very few bulk stores were encountered (<0.5 per cent of stored crops in 2016 and <0.05 per cent in 2014). Seed crops were mainly held in refrigerated stores (67 per cent) with the remainder in ambient ventilated stores (33 per cent) and a very small proportion in unventilated stores (<0.5 per cent). The majority of seed crops were also held in refrigerated stores in 2016 and 2014 (61 and 69 per cent respectively).

Ware potatoes were mostly refrigerated in 2018 (80 per cent) with 18 per cent in ambient ventilated stores and two per cent in unventilated stores. Ware storage regimes in 2018 were similar to those encountered in the previous two surveys; with 77 and 66 per cent of ware tubers held in refrigerated stores in 2016 and 2014 respectively.

Figure 1 Estimated total potato storage in Scotland 2014-2018

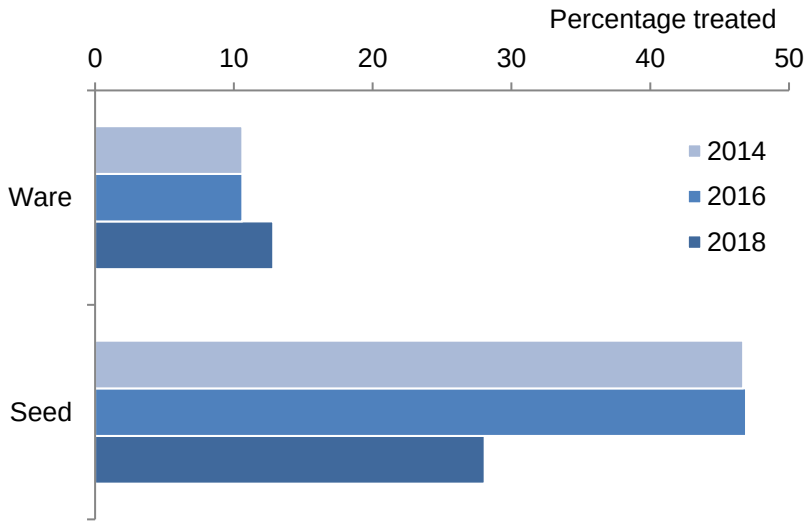


Pesticide usage

Seed potatoes

The proportion of seed potatoes treated with a pesticide in 2018 was 28 per cent. This was a decrease from 2016 and 2014 when 47 per cent of seed crops received a store treatment (Figure 2). Despite difficult growing conditions in 2018, the quality of seed potatoes harvested in Scotland was good which may have influenced the decline in pesticide use in store.

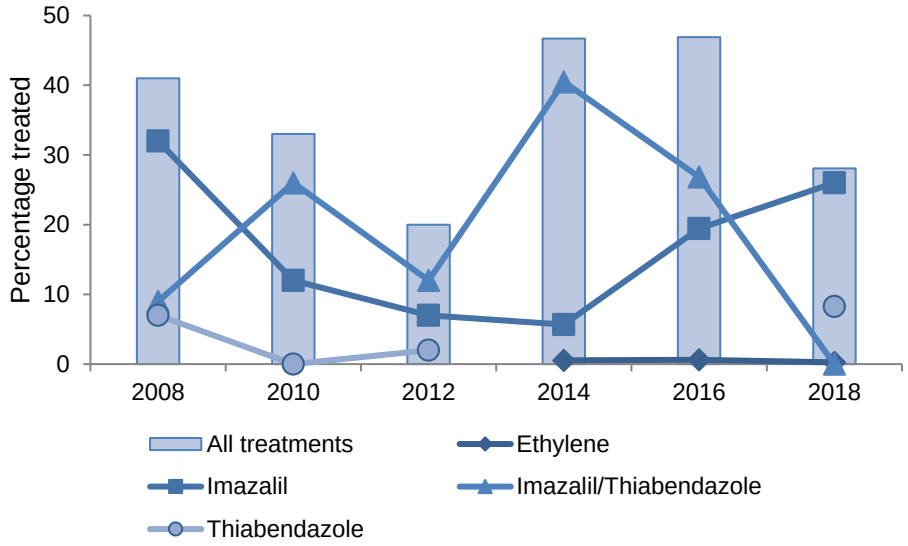
Figure 2 Percentage of stored potatoes treated with pesticides in Scotland 2014-2018



Almost all (99 per cent) of the pesticides used in seed potato stores were fungicides (Figure 3, Table 2). In 2018 the most commonly used fungicide was imazalil applied to 26 per cent of the seed crops and thiabendazole applied to eight per cent. In 2016, the most commonly used fungicide was a formulation of imazalil/thiabendazole which was applied to 27 per cent of seed crops, and imazalil alone was applied to 19 per cent of the crop. This difference in use is due to changes in pesticide approval. The imazalil/thiabendazole formulation lost approval in 2015 and had a final use date of 30th June 2017. Prior to 2018, the use of imazalil and thiabendazole as single active substances products in seed stores had been declining over time (Figure 3). Thiabendazole on its own was not encountered in the previous two surveys (2016 & 2014). As reported in the Potato Store 2014 report(4), resistance to thiabendazole in some storage diseases has been noted since 2010 and it is not recommended for use as a stand-alone treatment. In this survey, most of the thiabendazole products were applied along with an imazalil product.

As in the previous two surveys, a small proportion (<0.5 per cent) of stored seed potatoes were treated with ethylene. Ethylene, which is generated from ethanol, is not approved as a plant protection product for stored seed potatoes. However, it is approved as a commodity substance for plant growth regulation for post-harvest crops under COPR(6).

Figure 3 Percentage of stored seed potatoes treated with a pesticide in Scotland 2008-2018



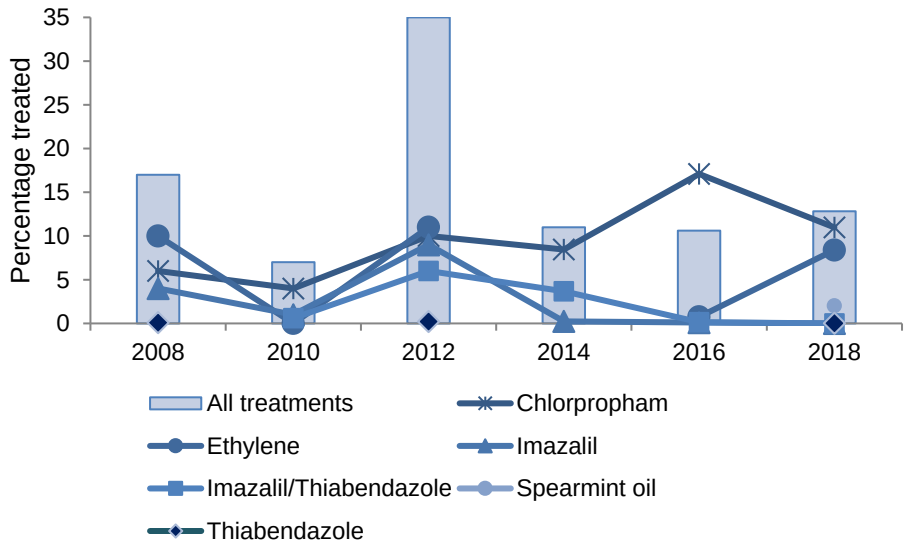
Ware potatoes

The proportion of stored ware potatoes treated with a pesticide was 13 per cent, very similar to the 11 per cent in 2016 and 2014 (Figure 2). Less than one per cent of the stored crop was treated with a fungicide, the lowest level since 2012.

Almost all of the pesticides used in ware stores were growth regulators (>99 per cent, Figure 4). There was a decrease in the use of chlorpropham which was the principal active substance in 2016 (applied to 17 and 11 per cent of the stored ware crop in 2016 and 2018 respectively). Chlorpropham has being going through the EU reapproval process and the EU commission announced in June 2019 that authorisations for products containing chlorpropham will not be renewed. A stewardship scheme has been in place for several years to promote best practice and reduce exceedances of maximum residue levels in potato tubers. The combination of stewardship and the risk of the potential loss of chlorpropham may have influenced growers to use other growth regulating active substances.

Ethylene was applied to eight per cent of the stored ware potato crop in 2018, compared with only one per cent in 2016. Ethylene was not encountered during the 2014 survey but had been applied to 10 per cent of the stored ware crop in 2012. In addition, spearmint oil was encountered in Scotland for the first time in this series of reports (applied to two per cent of the stored ware crop)[7]. Spearmint oil is a sprout suppressant applied as a fog in store. It should be noted that the use of growth regulators has shown variation over time, as have the compounds encountered (Figure 4) and it is difficult to interpret trends within this data series.

Figure 4 Percentage of stored ware potatoes treated with a pesticide in Scotland 2008-2018



2018 Potato storage and pesticide usage

Seed potatoes

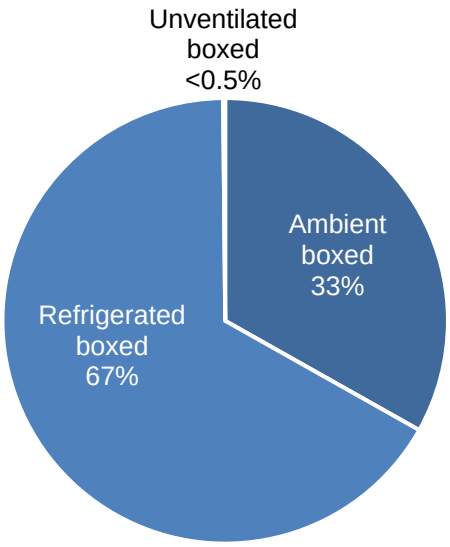
- An estimated 408,870 tonnes of seed potatoes were stored in Scotland in 2018, compared with an estimated 415,023 tonnes stored in 2016
- 67 per cent of seed potatoes were stored in refrigerated stores, 33 per cent in ambient ventilated stores and less than one per cent in unventilated stores (Figure 5)
- All seed potatoes sampled in 2018 were stored in boxes
- Overall, 28 per cent of seed potatoes received a pesticide treatment in store
- The percentage of seed potatoes receiving an in-store pesticide treatment was 33 per cent in refrigerated stores and 18 per cent in ambient ventilated stores. No treatments were recorded on unventilated stores (Table 1)
- Two fungicides (imazalil and thiabendazole) and one growth regulator (ethylene) were encountered in seed potatoes (summary below)
- Imazalil and thiabendazole are applied as sprays to tubers. Ethylene is applied as a gas in the store
- Reasons for use were supplied for 62 per cent of the crop which was treated with fungicides. 27 per cent for dry rot, gangrene and skin spot, and 20 per cent for silver scurf
- The only specified reason for ethylene use was sprout suppression. It is used, in conjunction with modified temperatures, to increase the number of sprouts and stems, resulting in increased tuber numbers

Summary of estimated pesticide use on seed potatoes in store:

Pesticide formulation	Total tonnes treated	% Treated
Ethylene[1]	**1,031**	<0.5
Imazalil	**106,348**	26
Thiabendazole	**33,805**	8

(1) Ethylene is not approved as a pesticide for use in seed potato stores under PPP regulations. However, it is approved as a commodity substance for plant growth regulation in post-harvest crops under COPR[6]

Figure 5 Seed potato storage by type – 2018



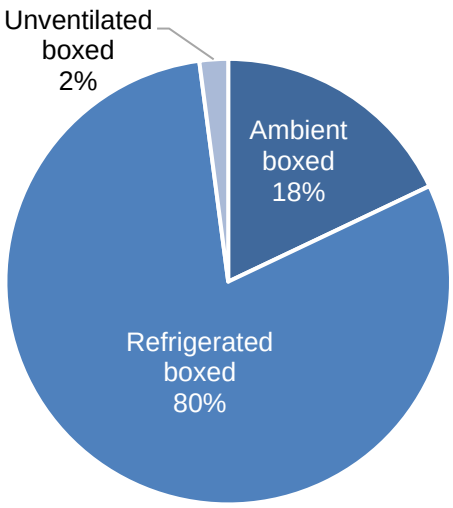
Ware potatoes

- An estimated 697,021 tonnes of ware potatoes were stored in Scotland in 2016. This is a four per cent decrease compared with the estimated 725,263 tonnes stored in 2016
- 80 per cent of ware potatoes were stored in refrigerated stores, 18 per cent were stored in ambient ventilated stores and two per cent in unventilated stores (Figure 6)
- All ware potatoes sampled were stored in boxes
- 13 per cent of ware potatoes received a pesticide treatment in store
- The percentage of ware potatoes receiving an in-store pesticide treatment was 13 and 14 per cent in refrigerated stores and ambient ventilated stores respectively. No treatments were recorded on unventilated stores (Table 1)
- One fungicide (thiabendazole) and three growth regulators (chlorpropham, ethylene & spearmint oil) were encountered in ware potato stores (summary below)
- Thiabendazole is applied as a spray to tubers. Ethylene is applied as a gas, and both chlorpropham and spearmint oil are applied as a fog to stores
- No reasons were supplied for the use of fungicides on ware potatoes
- The only specified reason for use of growth regulators was sprout suppression

Summary of estimated pesticide use on ware potatoes in store:

Pesticide formulation	Total tonnes treated	% Treated
Chlorpropham	76,539	11
Ethylene	58,497	8
Spearmint oil	14,004	2
Thiabendazole	156	<0.05

Figure 6 Ware potato storage by type – 2018



Appendix 1 – Estimated application tables

Table 1 Potatoes stored, and proportion treated, by storage type - 2018

	Unventilated	Ventilated	Refrigerated	Total
Seed				
Tonnes stored	618	135,590	272,662	408,870
% type	<0.5%	33%	67%	
Basic tonnes treated	0	24,690	90,078	114,768
% treated	N/A	18%	33%	28%
Ware				
Tonnes stored	14,490	125,090	557,441	697,021
% type	2%	18%	80%	
Basic tonnes treated	0	16,962	72,502	89,464
% treated	N/A	14%	13%	13%
All stored potatoes				
Tonnes stored	15,108	260,680	830,103	1,105,891
% type	1%	24%	75%	
Basic tonnes treated	0	41,652	162,580	204,232
% treated	N/A	16%	20%	18%

N/A = not applicable

Table 2 Potato storage treatment formulations by storage type – 2018

	Unventilated	Ventilated	Refrigerated	Total tonnes treated	% Treated
Seed					
Ethylene[1]	0	0	1,031	**1,031**	<0.5%
Imazalil	0	19,392	86,956	**106,348**	26%
Thiabendazole	0	5,297	28,508	**33,805**	8%
Basic tonnes treated[2]	**0**	**24,690**	**90,078**	**114,768**	**28%**
Ware					
Chlorpropham	0	33,611	42,928	**76,539**	11%
Ethylene	0	0	58,497	**58,497**	8%
Spearmint oil	0	0	14,004	**14,004**	2%
Thiabendazole	0	156	0	**156**	0.02%
Basic tonnes treated[2]	**0**	**16,962**	**72,502**	**89,464**	**13%**

(1) Ethylene is not approved as a pesticide for use in seed potato stores under PPP regulations. However, it is approved as a commodity substance for plant growth regulation in post-harvest crops under COPR[6]

(2) This represents the total tonnage treated, not the column sum, as more than one formulation may be applied to potatoes in store

Table 3 Potato storage treatment active substances – 2018

	Tonnes treated	Kg
Seed Potatoes		
Ethylene[1]	1,031	N/A[2]
Imazalil	106,349	1,451
Thiabendazole	33,805	1,352
Ware Potatoes		
Chlorpropham	76,540	735
Ethylene	58,497	N/A[2]
Spearmint oil	14,004	840
Thiabendazole	156	6

N/A = not applicable
(1) Ethylene is not approved as a pesticide for use in seed potato stores under PPP regulations. However, it is approved as a commodity substance for plant growth regulation in post-harvest crops under COPR[6]
(2) The mass of ethylene used cannot be estimated (refer to Appendix 3 – definitions and notes)

Table 4 Potato cultivation and storage, comparison with previous surveys – 2018

	Crop	2014	2016	2018
Area grown (ha)[1]	Seed	13,300	12,760	12,092
	Ware	15,211	14,766	15,268
Tonnes stored	Seed	398,780	415,023	408,870
	Ware	747,902	725,263	697,021

(1) This is the census area of the crops intended to be grown for seed and ware production. Some of the seed crop was reclassified as ware post-harvest

Table 5 Percentage of stored potatoes treated, comparison with previous surveys – 2018

	Crop	2014	2016	2018
Total tonnage treated (%)	Seed	47	47	28
	Ware	11	11	13

Appendix 2 – Survey statistics

Census and sample information

Table 6 Distribution of sampled potato stores - 2018

Number of potato growers sampled in each region

Region		Number of stores
North:	Highlands & Islands, Caithness & Orkney, Moray Firth and Aberdeen	13
Angus		25
Central:	East Fife, Central Lowlands, Lothian	13
South:	Tweed Valley, Southern Uplands and Solway	6
Scotland		**57**

Table 7 Distribution of stored potatoes in sample - 2018

Quantity (tonnes) of potatoes sampled in each region

Crop	North	Angus	Central	South	Scotland
Seed Potatoes	19,779	95,297	22,427	9,700	**147,203**
Ware Potatoes	15,792	116,699	46,048	32,700	**211,239**
Total	**35,571**	**211,996**	**68,475**	**42,400**	**358,442**

Table 8 Distribution of sampled areas – 2018

Areas (ha) of potatoes sampled in each region

Crop	North	Angus	Central	South	Scotland
Seed Potatoes	541	2,753	649	252	**4,195**
Ware Potatoes	356	1,942	812	591	**3,701**
Total	**897**	**4,695**	**1,461**	**843**	**7,896**

Table 9 Distribution of census areas – 2018

Areas (ha) of potato crops grown in Scotland

Crop	North	Angus	Central	South	Scotland
Seed Potatoes	3,948	5,947	1,637	560	**12,092**
Ware Potatoes	1,592	7,109	4,761	1,806	**15,268**
Total	**5,540**	**13,056**	**6,398**	**2,366**	**27,360**

Table 10 Raising factors – 2018

Region	Seed	Ware
North	7.3025	4.4694
Angus	2.1603	3.6600
Central	2.5220	5.8654
South	2.2170	3.0561

Table 11 First adjustment factors for ware potatoes – 2018

Region	Ware
North	1.0454
Angus	0.9450
Central	0.9511
South	0.9874

Table 12 Second adjustment factors – 2018

Crop	Adjustment Factor
Seed	0.9545
Ware	0.8368

Financial burden to farmers

To minimise the burden on farmers, the survey team used non-visit methods of collection such as email, post or telephone call, where possible.

To determine the total burden that the 2018 Potato Storage survey placed on those providing the information, the surveyors recorded the time that 28 respondents spent providing the data during the surveys. This sample represents 49 per cent of growers surveyed. The median time taken to provide the information was 5 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 £14.38)[8]

The total financial burden to all growers resulting from participation in the 2018 Potato Storage survey was calculated to be £68.31.

Appendix 3 - Definitions and notes

1) Pesticide information recorded in this survey relates to **any pesticide usage during potato storage** and to **post-harvest applications**, carried out in the field at lifting, prior to entry to the store. Pre-planting treatments with a fungicide intended to control disease post-planting e.g. black scurf, are not included, even if the fungicide had been applied in store. Use of pesticides in this situation is recorded in the seed treatment section of the preceding arable crop report.

2) '**Pesticide**' is used throughout this report to include commercial formulations containing active substances (a.s.) used as herbicides, fungicides, insecticides, molluscicides, biological control agents, growth regulators, seed treatments and physical control. A pesticide product consists of one or more active substances co-formulated with other materials. In this survey, only fungicides and sprout suppressants (growth regulators) were encountered.

3) 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.

4) 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.

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

6) A **growth regulator** is a pesticide used to regulate the growth of the plant, for example to suppress the growth of sprouts by potato tubers in store.

7) A **seed treatment** is a pesticide applied to seed or potato tuber before planting to protect that plant against disease and pests from the earliest stage of development.

8) **Basic tonnage** is the quantity of potatoes treated with a pesticide, irrespective of the number of times they were treated or the number of pesticides used. This figure is used to calculate the percentage of potatoes treated with a given pesticide or pesticide group.

9) **Seed potatoes** are crops grown for marketing or planting as seed for next season's crop. A fraction of the crop intended for seed production may not meet the necessary requirements and may be reclassified as ware potatoes post-harvest.

10) **Ware potatoes** are those grown for the ware (consumption) market, including those processed by a manufacturer. Ware potatoes may include a proportion of potatoes originally planned for seed production but later classified as ware.

11) **Unventilated stores** are defined as simple stores without fans that are naturally ventilated.

12) **Ventilated stores** can either be **adapted ambient** or **purpose built ambient ventilated stores**. These stores use forced air ventilation; they are not refrigerated.

13) **Adapted ambient ventilated stores** are basic stores with forced air ventilation. These stores commonly contain temporary fans and raised vents (normally wire hoops) on the floor of the store.

14) **Purpose built ambient ventilated stores** are purpose-built stores with forced air ventilation including open walled letterbox systems or suction wall systems. The potatoes are often stored to a depth of 3-5 metres; the floor is concrete and contains ventilation ducts. Pesticides can be applied by means of fogs and gases dispersed through the ventilation system.

15) **Refrigerated Stores** are purpose-built stores which may also have mechanically assisted ventilation. Potatoes are stored at low temperatures which can help reduce the use of pesticides. Pesticides can be applied through the ventilation system

16) Potatoes can be stored either in **bulk** (loose potatoes) or in **wooden boxes**. Potatoes stored in bags are excluded from this survey.

17) **Ethanol** is used as an **ethylene** generator to suppress tuber sprouting in stores. There is no standard recommended rate per tonne for the use of ethanol in potato stores and the quantity used varies according to store capacity, crop volume, type of store and duration of storage. In most cases the actual rate of application is not available and total quantity cannot be estimated. Therefore, estimated use of this pesticide is presented only as tonnes of potatoes treated.

18) In this report each estimated use of each pesticide is reported in three formats; tonnes treated with pesticide formulations (mixture of active substances in a product) and of individual active substances and quantities of active substance applied (Table 2 formulation data, Table 3 for active substance treated tonnes and quantity data). All three 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. Therefore, active substance data would be required. In addition, both quantity and tonnes treated with pesticides are important indicators of changes in use over time. Only single active substance formulations were encountered in 2018.

19) The **June Agricultural Census**[9] is conducted annually by the Scottish Government's Rural and Environmental Science Analytical Services (RESAS). The June Agricultural Census collects data on land use, crop areas, livestock

and the number of people working on agricultural holdings. For this report the June Agricultural Census was used to draw a sample of growers growing the relevant crops to participate in the survey

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[9]. These are the areas which the sampled areas are raised to. Please see Appendix 4 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) Where quoted in the text or within figures, reasons for application are the grower's stated reasons for use of that particular pesticide on that crop and may not always seem appropriate. It should be noted that growers do not always provide reasons; therefore, those presented in the figures only reflect those specified and may not reflect overall reasons for use.

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

23) Data from the 2016[3] and 2014[4] surveys are provided for comparison purposes in some of the tables and figures. It should be noted that there may be changes in areas of seed and ware potatoes grown between survey years. Also, when comparisons are made between surveys it is important to take into account that there may be changes in quantity of potatoes stored.

24) For notes on quality and sources of bias please refer to the notes and definitions section of the preceding arable report.

Appendix 4 – Survey methodology

Sampling and data collection

The sample of farms used for this survey was the same as that for the Arable Crops 2018 survey. Using the June 2018 Agricultural Census[9], a sample was drawn representing arable cultivation in Scotland. The country was divided into 11 land-use regions (Figure 8). 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 arable 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.

Data relating to pesticide use in potato stores were collected from all potato growers encountered in the arable sample, either during an on-farm or telephone interview, or via e-mail. In instances where the potato land was let, and storage was on a separate holding, the potato grower was contacted individually to obtain storage details. Data were collected for all potatoes stored by these growers, not just for those crops grown on the holdings sampled. Therefore, the sample of stored potatoes relates to a greater area of potato cultivation than that for which field pesticide treatments were collected in the 2018 arable pesticide survey report. In total, data were collected from 57 growers. The crops grown by these growers represent 29 per cent of the total 2018 potato crop census area.

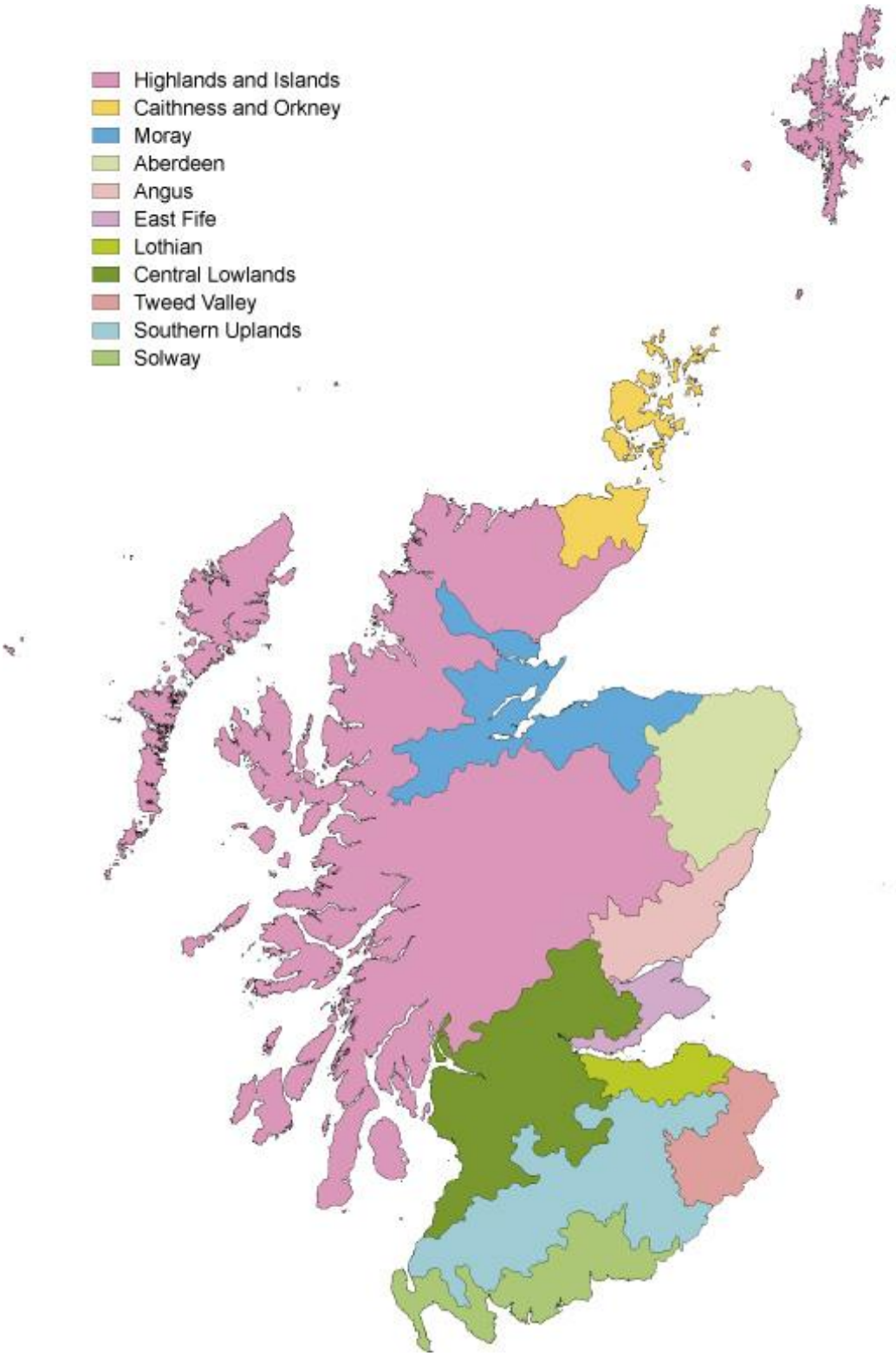
The data collected included the areas of seed and ware crops grown, quantities of potatoes sold and stored, storage type, storage method and post-harvest pesticide applications at crop lifting and during storage. Fungicidal seed treatments applied prior to planting are included in the arable crop report.

Raising factors

National pesticide use was estimated by ratio raising. This is a standard statistical technique for producing estimates from a sample. It is the same methodology used by the other UK survey teams and has been used for all historical datasets produced by the Pesticide Survey Unit, allowing comparability over time. The sample data were multiplied by raising factors (Table 10). These factors were calculated by comparing the sampled crop area to the areas recorded in the Agricultural Census within each region and size group. An adjustment (Table 11) was made to the ware fraction to correct for the potatoes grown as seed that were then designated as ware. A second adjustment (Table 12) was made to align the survey estimates of total tonnes stored with production estimates provided by AHDB Potatoes.

Due to the low numbers of potatoes grown and sampled in some geographic regions, stored data were amalgamated into four regions to allow more robust estimation of pesticide use: the North (Highlands & Islands, Caithness & Orkney, Moray Firth and Aberdeen), Angus (the main potato growing area in Scotland), Central (East Fife, Lothian and Central Lowlands) and the South (Tweed Valley, Southern Uplands and Solway).

Figure 7 Land use regions of Scotland[10]



Changes from previous years

There were no changes in methodology from the previous surveys presented as comparisons.

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