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Pesticide Usage in Scotland

A National Statistics Publication for Scotland

Grassland and Fodder Crops 2017

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Executive summary

This report presents information from a survey of pesticide use on grassland and fodder crops in Scotland in 2017. The crops surveyed included direct sown grass, undersown grass, grass one to four years old, grass over five years old, rough grazing, arable silage, fodder beet, fodder rape, kale and cabbage, maize, stubble turnips, turnips and swedes and other fodder crops.

The estimated area of grassland and rough grazing grown in Scotland in 2017 was approximately 4,364,000 hectares, similar to that grown in 2013. Rough grazing accounted for 70 per cent of the total area grown, grass over five years 25 per cent and grass under 5 years, five per cent.

The fodder crop area was approximately 16,300 hectares, a 16 per cent decrease from the previous survey in 2013. Other stock-feeding crops accounted for 42 per cent of fodder crops grown, of which 85 per cent was arable silage. Turnips and swedes accounted for 23 per cent, fodder rape 12 per cent, kale and cabbage 12 per cent, maize five per cent, fodder beet four per cent and stubble turnips two per cent.

Data were collected from 183 holdings with both fodder crops and grassland, and an additional 511 holdings with grassland only. This sample represented 14 per cent of total fodder crops grown in Scotland, seven per cent of grassland area and three per cent of rough grazing. Ratio raising was used to produce estimates of national pesticide use from the sampled data.

The estimated total area of grassland and rough grazing treated with a pesticide formulation was ca. 87,900 ha (± nine per cent Relative Standard Error, RSE), with a combined weight of 84 tonnes (± ten per cent RSE). Overall these pesticides, almost exclusively herbicides, were applied to four per cent of grassland and less than 0.5 per cent of the rough grazing area. There was little difference in the total area treated, or weight of pesticide applied, to grassland and rough grazing from the previous survey in 2013, but there was a substantial reduction compared to 2009 (ca. one third). The area treated with insecticides, fungicides, seed treatments and growth regulators decreased (99, 41, 37 and 15 per cent respectively), whilst the area treated with herbicides increased (20 per cent).

The estimated total area of fodder crops treated with a pesticide formulation was ca. 24,200 ha (± eight per cent RSE), with a combined weight of eight tonnes (± 15 per cent RSE). Pesticides, primarily herbicides, were applied to 63 per cent of fodder crops. There was 31 per cent decrease in total area treated and a 34 per cent decrease in total weight applied from 2013 to 2017. The application of fungicides, insecticides, herbicides and seed treatments decreased (82, 40, 25 and 14 per cent respectively), whilst the application of molluscicides increased (33 per cent).

Data collected from farmers about their Integrated Pest Management (IPM) activities showed that farmers were using a variety of IPM methods in relation to risk management and the monitoring and control of insect pests, weeds and diseases.

Introduction

The Scottish Government (SG) is required by legislation[1][2] to carry out post-approval surveillance of pesticide use. This is conducted by the Pesticide Survey Unit at Science and Advice for Scottish Agriculture (SASA), a division of the Scottish Government's Agriculture and Rural Economy.

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

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

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

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

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

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

Structure of report and how to use these statistics

This report is intended to provide data in a useful format to a wide variety of data users. The general trends section provides commentary on recent changes in survey data and longer term trends. The 2017 pesticide usage section summarises usage on all grassland and fodder crops in 2017. Appendix 1 presents all estimated pesticide usage in three formats, area and weight of formulations by crop and area and weight of active substances grouped by their mode of action. The area and weight of active substances by crop data, which were previously published in this report are now published as supplementary data in Excel format. These different measures are provided to satisfy the needs of different data users (see Appendix 3 for examples). Appendix 2 summarises survey statistics including census and holding information, raising factors and survey response rates. Appendix 3 defines many of the terms used throughout the report. Appendix 4 describes the methods used during sampling, data collection and analysis as well as measures undertaken to avoid bias and reduce uncertainty. Any changes in method from previous survey years are also explained.

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

General trends

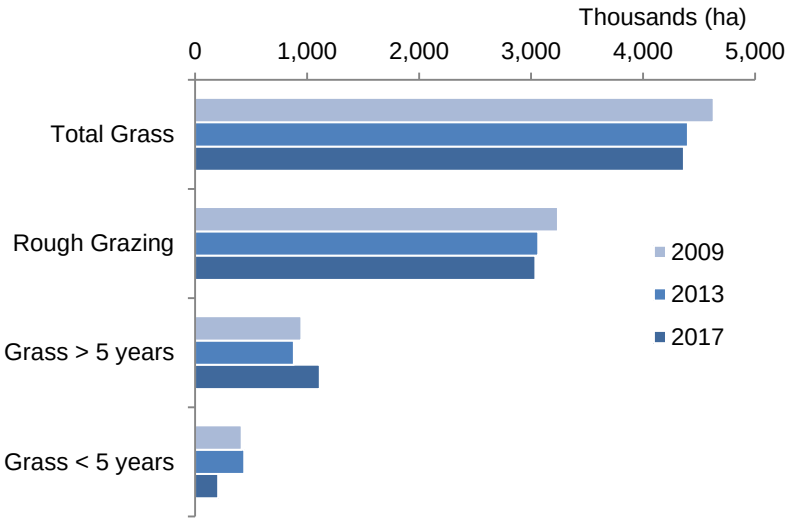
Crop area – grassland and rough grazing

The estimated area of grassland and rough grazing in 2017 was 4,363,985 hectares (Table 16). This is very similar to the area recorded in 2013[(3)] and a six per cent decrease from 2009[(4)]. Since the last survey, the area of rough grazing has remained almost the same, grass over five years old has increased by 26 per cent and grass under five years old and undersown grass have decreased by 53 per cent and 51 per cent respectively (Figure 1). However, it should be noted that these changes in reported crop areas, and the subsequent estimates of pesticide use made using these census areas, may have been influenced by changes in the census definitions of temporary and permanent grass implemented since the last survey rather than wholly reflecting changes in land use (refer to Appendix 4).

In 2017, rough grazing accounted for 70 per cent of Scottish grassland area, grass over five years old 25 per cent and grass under 5 years old five per cent. Undersown grass accounted for less than 0.5 per cent of the crop

(Figure 2). Over half of all grassland and rough grazing in Scotland is in the Highlands and Islands region (Figure 3).

Figure 1 Area of grassland and rough grazing in Scotland 2009-2017



Note: Undersown grass has been excluded as the area grown is <30,000 hectares.
There was a change in census definition of temporary and permanent grass between 2013 and 2017. Therefore reported crop changes may not wholly reflect changes in land use (Appendix 4)

Figure 2 Grassland and rough grazing census areas in Scotland 2017 (percentage of total area)

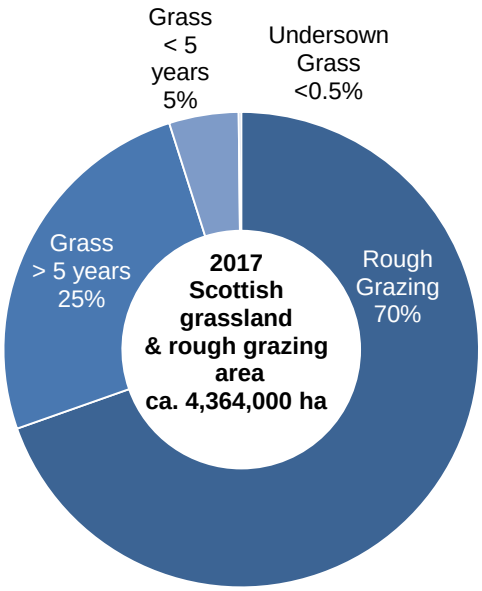
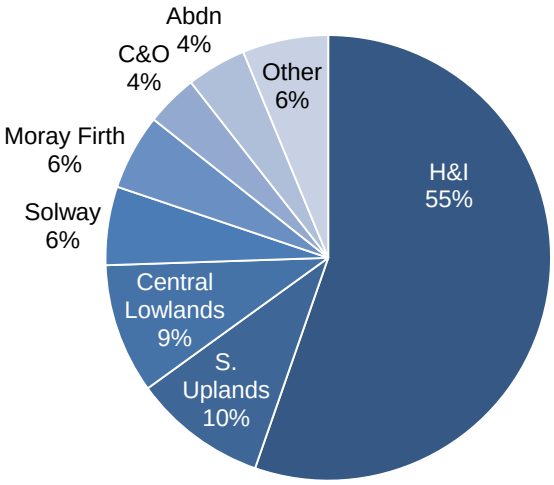


Figure 3 Regional distribution of grassland and rough grazing in Scotland 2017 (percentage of total area)



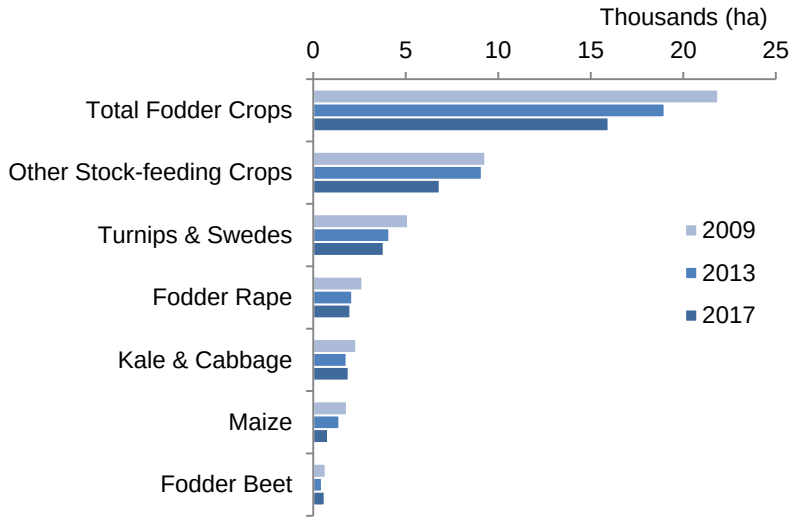
Note: H&I = Highlands and Islands, S. Uplands = Southern Uplands, C&O = Caithness and Orkney, Abdn = Aberdeen, Other = Angus, East Fife, Lothian and Tweed Valley

Crop area – fodder crops

The estimated area of fodder crops grown in 2017 was 16,304 hectares (Table 17). This represents a 16 per cent decrease from 2013 and a 29 per cent decrease from 2009. Since the previous survey, the areas of maize, other stock-feeding crops, turnips & swedes and fodder rape have decreased in area (44, 25, 7, 5 per cent respectively). In contrast, areas of fodder beet and kale & cabbage have increased (32 and six per cent respectively, Figure 4).

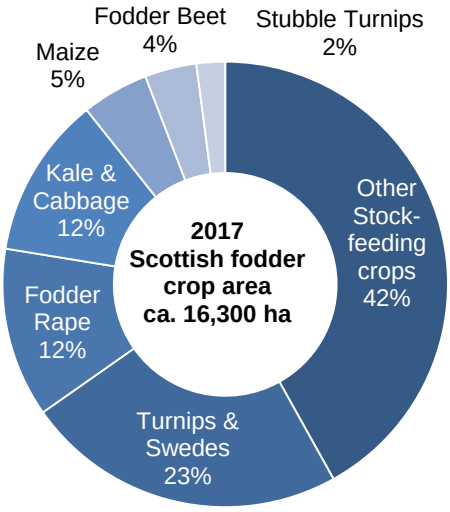
In 2017, almost half of the fodder crops were found in the 'other stock-feeding' category of the census (Figure 5). Within this category, 85 per cent of the crops were arable silage. Turnips & swedes, fodder rape and kale & cabbage were also widely grown (23, 12 and 12 per cent of the total fodder crop area respectively). Fodder crops are fairly evenly distributed within Scotland, with the largest proportion, 21 per cent, grown in the Aberdeen region (Figure 6).

Figure 4 Area of fodder crops in Scotland 2009-2017



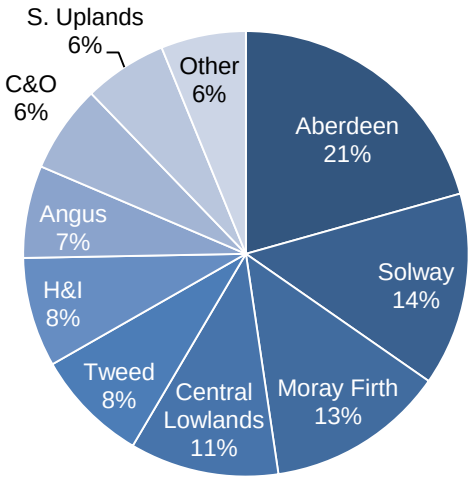
Note: 'other stock-feeding crops' include arable silage, red clover, swedes, kale, stubble turnips and fodder crop mixes

Figure 5 Fodder crop census areas Scotland 2017 (percentage of total area)



Note: 'other stock-feeding crops' include arable silage, red clover, swedes, kale, stubble turnips and fodder crop mixes

Figure 6 Regional distribution of fodder crops in Scotland 2017 (percentage of total area)



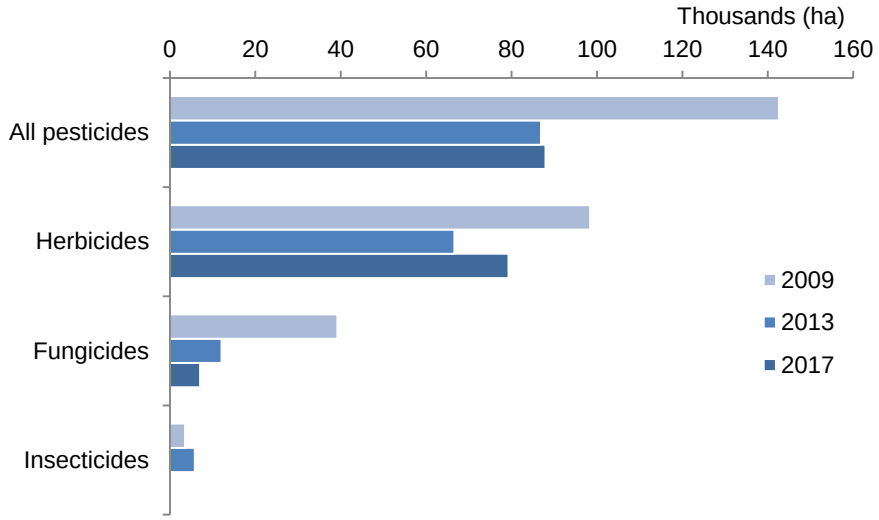
Note: H&I = Highlands and Islands, C&O = Caithness and Orkney, S. Uplands = Southern Uplands, Other = Lothian and East Fife

Pesticide usage – grassland and rough grazing

As in previous surveys, the proportion of grassland and rough grazing treated with a pesticide was very low. Only four per cent of grassland and less than 0.5 per cent of rough grazing was treated with a pesticide and these areas received, on average, a single spray during 2017 (Table 1).

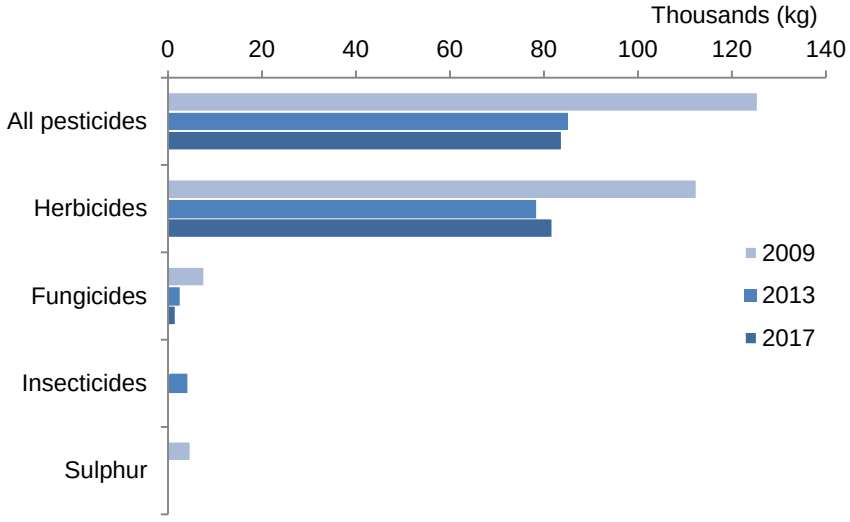
It is estimated that the area of grassland and rough grazing treated with a pesticide formulation in 2017 was ca. 87,900 hectares (Table 16 & Figure 7). This represents an increase of one per cent since 2013 but a decrease of 38 per cent from 2009. A similar pattern is shown in relation to the weight of pesticide applied; 84 tonnes was applied in 2017, a decrease of two per cent from 2013 and a decrease of 33 per cent from 2009 (Figure 8).

Figure 7 Area of grassland and rough grazing treated with the major pesticide groups in Scotland in 2009-2017



Note: Seed treatments, growth regulators, sulphur and molluscicides have been excluded as they represent <1,000 hectares

Figure 8 Weight of major pesticide groups applied to grass crops in Scotland 2009-2017



Note: Seed treatments, growth regulators and molluscicides have been excluded as they represent <1,000 kg

In order to make accurate comparisons between surveys, temporal differences in crop area must be taken into account. Therefore, the number of pesticide treated hectares and total weight of pesticide used per hectare of crop grown have been calculated. Once pesticide use has been adjusted for crop area, there is little difference in pesticide treated area or weight on grassland and rough grazing between 2013 and 2017 (Figures 9 and 10).

However, there is a substantial reduction in pesticide use in comparison to 2009 (34 per cent decrease in treated area and 28 per cent decrease in weight).

As noted in the trends in crop area section of the report, the census grass area and, as a result, subsequent estimates of pesticide use, may have been influenced by changes in census definitions of temporary and permanent grass implemented since the last survey rather than wholly reflecting changes in land use (refer to Appendix 4).

Figure 9 Number of pesticide treated hectares (formulations) per hectare of grass crop grown - 2017

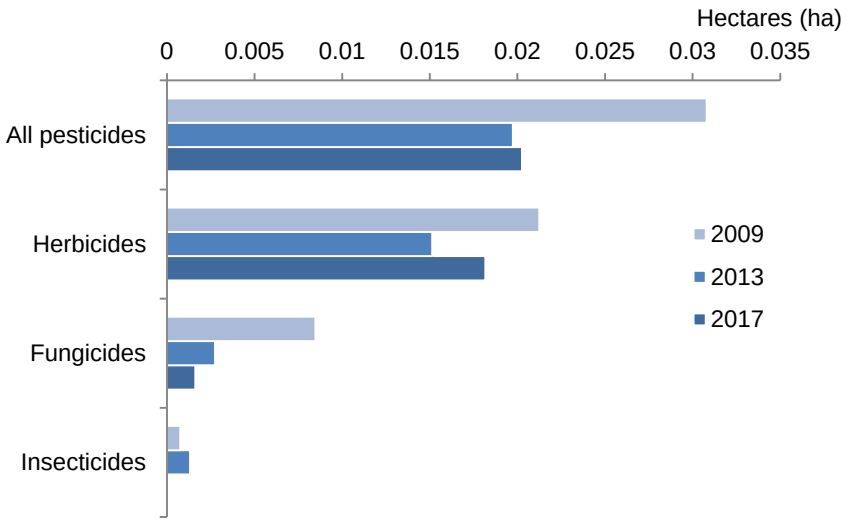
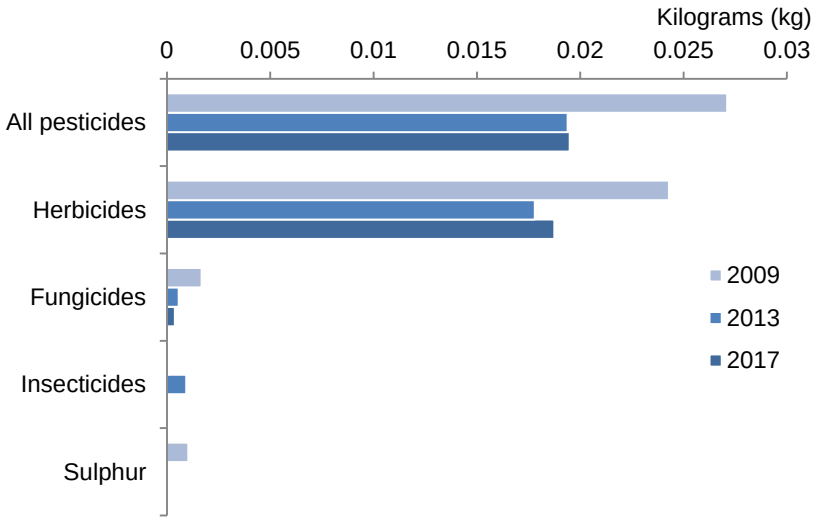


Figure 10 Weight of pesticides applied per hectare of grass crop grown – 2017



Note: Seed treatments, growth regulators and molluscicides have been excluded as they represent <0.001 kg per hectare

Despite overall pesticide use being very similar to that reported in the last survey, there were some differences in the types of pesticides encountered. As in previous surveys, herbicides were the most commonly used pesticides on grassland and rough grazing in 2017, accounting for 90 per cent of the treated area and 98 per cent of total pesticide use by weight (Figures 11 & 12). The majority of herbicide use was on undersown and direct sown grass (60 per cent and 20 per cent of crop area treated respectively). Herbicides were the only type of pesticide applied to one to four year old grass, grass over five years old and rough grazing (Table 1). When changes in crop area are taken into account, there was there was a 20 per cent increase in the area treated with herbicides from 2013 to 2017 (Figure 9) and a five per cent increase in herbicide weight (Figure 10). Mean Scottish winter and spring temperatures in 2017 were 78 and 57 per cent higher respectively than in 2013. These warmer conditions may have increased weed pressure and could have contributed to this increase in reported herbicide use[5].

Figure 11 Use of pesticides on grassland and rough grazing (percentage of total area treated with formulations) - 2017

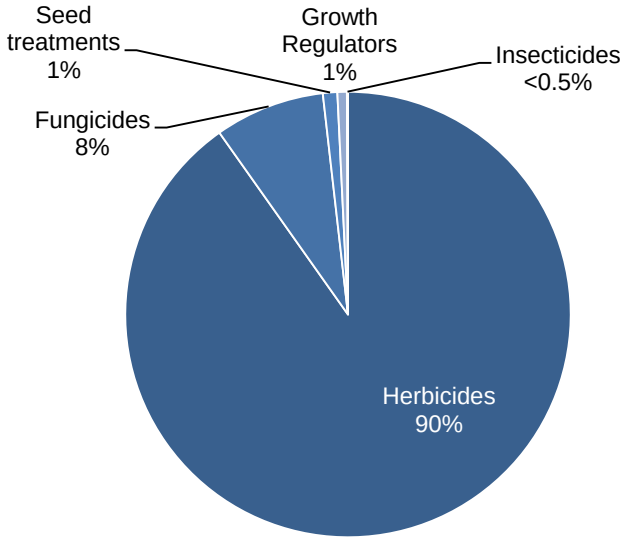
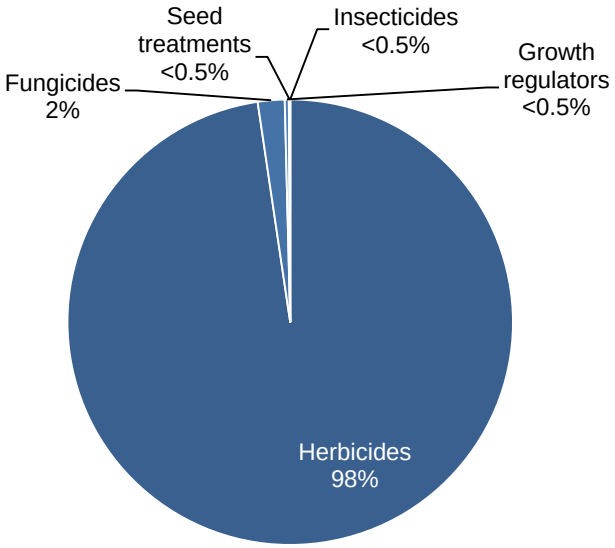


Figure 12 Use of pesticides on grassland and rough grazing (percentage of total weight of pesticides applied) – 2017



In 2017, fungicides accounted for eight per cent of the total pesticide treated area and less than two per cent of the total weight applied (Figures 11 & 12). Fungicides were only applied to undersown grass for the control or prevention of disease on the nurse crop. Forty eight per cent of undersown grass was treated, with an average of 1.3 fungicide applications. When changes in crop area are taken into account, the fungicide treated area decreased by 41 per cent from 2013 to 2017 (Figure 9) and the weight applied decreased by 33 per cent (Figure 10). Again, this may have been influenced by differences in the weather in the two crop seasons. Winter and spring 2017 had 12 and 15 per cent less rainfall respectively than in 2013 as well as fewer rain days. This may have reduced disease pressure and the requirement for fungicide sprays[(5)].

Growth regulators accounted for only one per cent of the total pesticide treated area and less than 0.5 per cent of the total weight of pesticides applied (Figures 11 & 12). Growth regulators were only applied to undersown grass, of which eight per cent of the crop area was treated. When changes in crop area are taken into account, there was a 15 per cent decrease in area treated between 2013 and 2017 (Figure 9) and a seven per cent decrease in weight applied (Figure 10).

Seed treatments also accounted for only one per cent of the total pesticide treated area and less than 0.5 per cent of the total weight of pesticides applied. (Figures 11 & 12). Seed treatments were only applied to direct sown grass, of which five per cent of the crop area received a treatment. When changes in crop area are taken into account, there was a 37 per cent decrease in area treated between 2013 and 2017 (Figure 9). However, the weight of seed treatments applied increased by 58 per cent (Figure 10). This reduction in treated area but increased pesticide weight in 2017 is a result of

recording seed treatments applied at different dose rates in the two surveys. In 2013 both *Bacillus subtilis*, a biological seed treatment applied at very low dose rates, and thiram were encountered, in 2017 thiram was the only seed treatment recorded.

There was a substantial decrease in the use of insecticides on grass crops in 2017 (Figures 7 & 8). Insecticides accounted for less than 0.5 per cent of the total pesticide treated area and weight applied (Figures 11 & 12). Insecticide use was only recorded, on one per cent of undersown grass, for insect control on the nurse crop. When changes in crop area are taken into account, treated area decreased by 99 per cent between 2013 and 2017 (Figure 9) and weight of insecticides decreased by >99 per cent (Figure 10). In 2016, the active substance chloropyrifos, which was used as a treatment for leatherjackets on grass in the previous survey, was withdrawn. As there are no alternative pesticides approved for leatherjacket control, insecticide use on grass crops was not encountered in this survey. However, some farmers reported that they used non-chemical methods for control of leatherjackets (see Appendix 6).

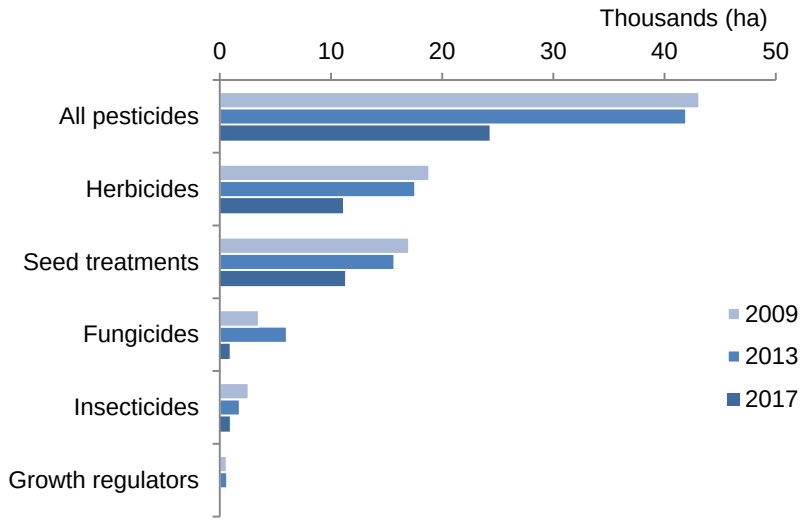
No molluscicides or sulphur were applied to grassland or rough grazing crops in 2017. In the 2013 survey, molluscicides accounted for less than one per cent of the total pesticide treated area and use of sulphur was not encountered (last recorded in 2009).

Pesticide usage – fodder crops

In contrast to pesticide use on grassland, an estimated 63 per cent of the total fodder crop was treated with a pesticide (Table 1). The area of fodder crops treated with a pesticide formulation in 2017 was estimated to be ca. 24,300 hectares (Table 17 & Figure 13) and the total weight of pesticide applied ca. eight tonnes (Figure 14). When crop area is taken into account, there was a decrease of 31 per cent in total area treated with pesticide formulations from 2013 to 2017 and a 21 per cent decrease from 2009 to 2017 (Figure 15). In terms of weight of pesticide applied, there was a 34 per cent decrease from 2013 to 2017 and a 38 per cent decrease from 2009 to 2017 (Figure 16).

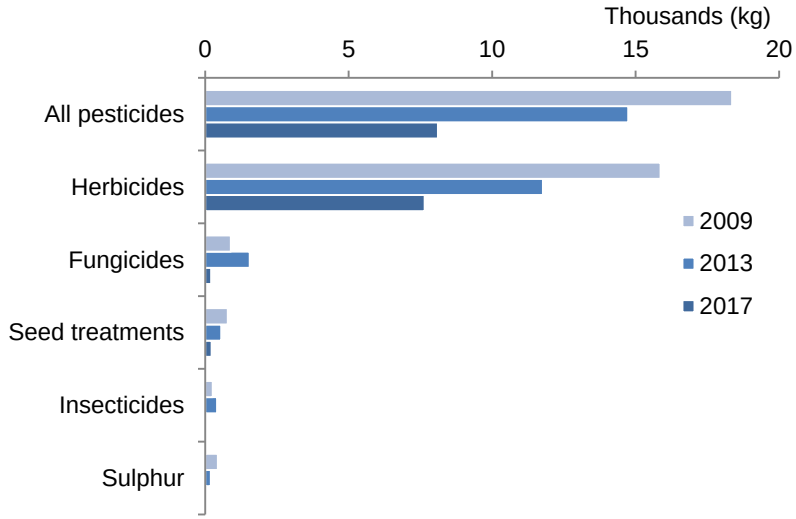
Maize and fodder beet crops had the highest proportion of area treated, with all crops encountered receiving at least one pesticide treatment (Table 1). Other fodder crops received a range of pesticide input, with 29 to 58 per cent of their crop area treated with pesticide, primarily herbicide. In contrast, no pesticide treatments were recorded on stubble turnips.

Figure 13 Area of fodder crops treated with the major pesticide groups in Scotland in 2009–2017



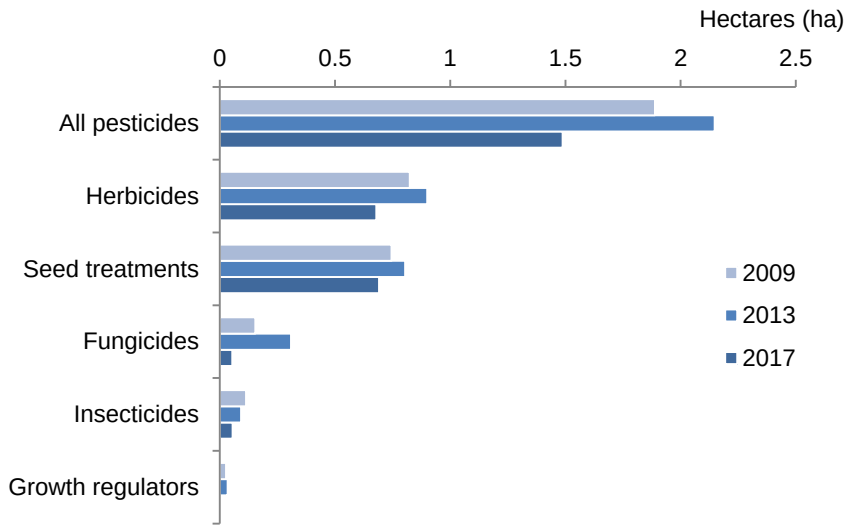
Note: molluscicides and sulphur have been excluded as they represent less than 500 hectares

Figure 14 Weight of major pesticide groups applied to fodder crops in Scotland 2009-2017



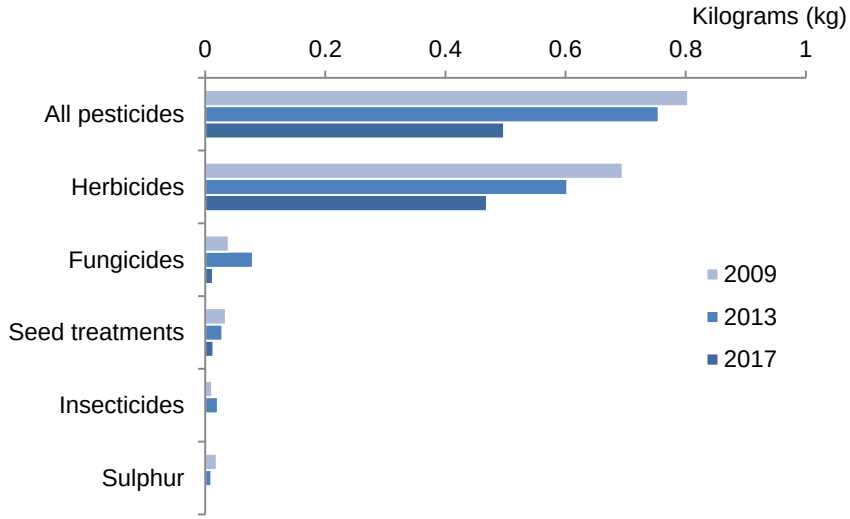
Note: growth regulators and molluscicides have been excluded as they represent <400kg

Figure 15 Number of pesticide treated hectares (formulations) per hectare of fodder crop grown - 2017



Note: molluscicides and sulphur have been excluded as they represent less than 0.02 treated hectares per hectare grown

Figure 16 Weight of pesticides applied per hectare of fodder crop grown - 2017



Note: growth regulators and molluscicides have been excluded as they represent <1,000kg

Herbicides were the most commonly used pesticide, accounting for 46 per cent of the area treated (Figure 17) and 94 per cent of the total weight of pesticides applied (Figure 18). When changes in crop area were taken into account, there was a 25 per cent decrease in area treated with herbicides from 2013 to 2017 (Figure 15) and a 22 per cent decrease in weight (Figure 16). This reduction is in contrast to the increase in herbicide use encountered

in grass crops and may have been influenced by the limited number of post emergence herbicide options currently available for use on fodder brassicas[6] The dry spring may also have reduced the likelihood of secondary weed germination flushes (F. Burnett, SRUC, pers. comm. Aug 2018). In addition, changes in crop specific cultivation methods, such as increased use of plastic film on maize crops at establishment, may also have influenced changes in herbicide use.

Figure 17 Use of pesticides on fodder crops (percentage of total area treated with formulations) - 2017

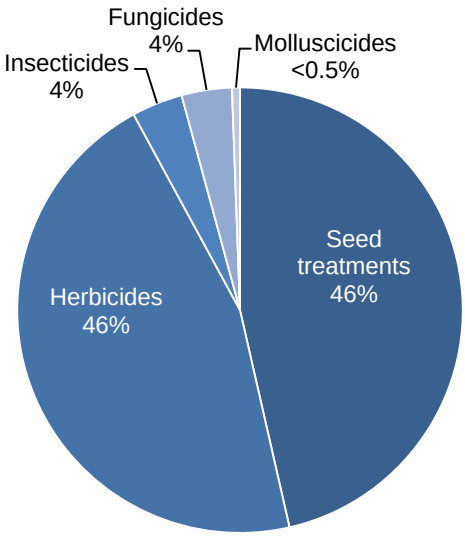
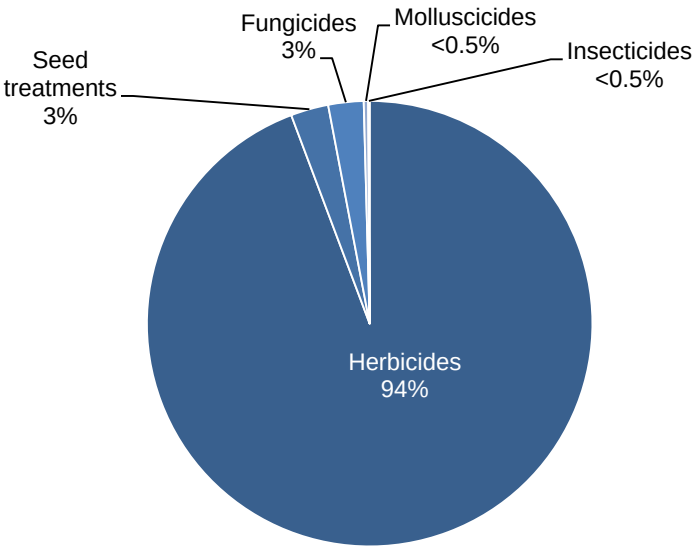


Figure 18 Use of pesticides on fodder crops (percentage of total weight applied) – 2017



Seed treatments accounted for 46 per cent of the total area treated and three per cent of the total weight of pesticide applied (Figures 17 & 18). When changes in crop area were taken into account, the area treated decreased by 14 per cent from 2013 to 2017 (Figure 15) and weight decreased by 52 per cent (Figure 16). There are no clear reasons for this reduction in seed treatments, influencing factors may be the smaller range of approved seed treatments available in comparison with the last survey and differences in the areas of the types of fodder crops grown.

Fungicide use was low in fodder crops, accounting for four per cent of the total treated area and three per cent of the total weight of pesticides applied (Figures 17 & 18). When changes in crop area are taken into account, there was an 82 per cent decrease in area treated from 2013 to 2017 (Figure 15) and an 84 per cent decrease in weight (Figure 16). As discussed in the grassland pesticide use section, this large decrease in the use of fungicides may have been partly influenced by the weather in the 2017 crop season, which was drier than in 2013 and resulted in reduced disease pressure.

Insecticide use was also low, accounting for four per cent of the total treated area and under 0.5 per cent of the total weight of pesticides applied (Figures 17 & 18). When changes in crop area are taken into account, there was a 40 per cent decrease in area treated between 2013 and 2017 (Figure 15) and a 98 per cent decrease in weight (Figure 16). The withdrawal of chlorpyrifos has limited the options available for the treatment of pests such as cabbage root fly in forage brassicas[6]. In addition, pirimicarb lost approval in July 2017, half way through the field season, limiting its use on turnips & swede crops. These organophosphate and carbamate insecticides used in the previous survey are applied at higher dose rates than the pyrethroid insecticides encountered in the current survey.

Molluscicides accounted for less than 0.5 per cent of both pesticide treated area and weight (Figures 17 & 18). When changes in crop area are taken into account, there was a 33 per cent increase in area treated from 2013 to 2017 (Figure 15) and a 23 per cent increase in weight (Figure 16). There was 77 per cent more rainfall in Scotland in the summer of 2017 compared to 2013[5], which led to an increased risk of slug damage in crops[7] and may have influenced molluscicide use patterns.

No growth regulators or sulphur were applied to fodder crops in 2017. In the 2013 survey, molluscicides accounted for less than one per cent of the total pesticide treated area and growth regulators less than two per cent.

General trends in active substances encountered – grass and fodder crops

The majority of pesticides used in grass and fodder crops are herbicides. In terms of area treated, the most commonly used herbicide active substances were fluroxypyr, MCPA and triclopyr (Table 14). These three active substances were also in the top five most commonly used herbicides in the 2013 survey, although comparative use has increased (by 88, 23 and 126 per cent respectively). In relation to weight, the most used herbicides were MCPA, asulam (applied under emergency authorisation to grassland for bracken control) and glyphosate (Table 15). Glyphosate use has decreased since the previous survey (reduction of 11 and 23 per cent in relation to area treated and weight applied respectively).

Other notable changes in herbicide active substance use include: clopyralid (136 per cent increase in area, 151 per cent in weight), chloridazon (141 per cent increase in area, 170 per cent in weight), dicamba (63 per cent decrease in area, 53 per cent in weight), metazachlor (37 per cent decrease in area, 54 per cent in weight) and 2,4-DB (44 per cent decrease in area, 47 per cent in weight).

As in the 2013 survey, the most used foliar fungicide active substance by area was prothioconazole and the most used seed treatment active substance was thiram. The most commonly used insecticide in the 2017 was lambda-cyhalothrin, in 2013 the most commonly used was chlorpyrifos.

The herbicides dimethenamid-P and s-metolachlor and the fungicides bixafen and fluxapyroxad were recorded for the first time in grass and fodder crops in 2017 (Table 10).

For the first time in this series of reports, insecticides, fungicides and herbicides have been classified into groups according to their mode of action (Tables 11-13).

Integrated pest management

For the first time in this series of surveys, additional data collection was conducted in relation to grower adoption of Integrated Pest Management (IPM) measures. This is a summary of the data; please refer to Appendix 6 for the full dataset. Growers were asked a series of questions about the IPM activities that they implemented for their grass and fodder crop production. Unlike the other statistics in this report, the figures relating to IPM are not raised to produce national estimates but represent only the responses of those surveyed.

In total, IPM data was collected from 119 growers, collectively representing eight per cent of the Scottish fodder crop area and 0.4 per cent of the grass area. Of these, 95 per cent did not have an IPM plan, three per cent of farmers completed their own plan and two per cent had a plan completed by their agronomist (Figure 38). Despite the majority of farmers not completing a plan, uptake of a wide range of IPM methods was encountered. Growers were asked about their IPM activities in relation to three categories; risk management, pest monitoring and pest control.

Ninety seven per cent of growers conducted at least one IPM risk management measure (Table 32). The majority of farmers tested their soils in order to tailor inputs to improve crop performance (84 per cent), managed their seed bed production to minimise pest risk (82 per cent) and used crop rotation to manage their risk of pest damage (65 per cent). Around half of growers adopted techniques to protect or enhance populations of beneficial organisms (57 per cent), considered risk management when selecting seeds and varieties (51 per cent) and amended cultivation methods at sowing to increase crop success (48 per cent). Nine per cent sowed cover crops as part of their crop production cycle.

Ninety four per cent of growers conducted at least one IPM pest monitoring activity (Table 33). The majority of growers monitored crop growth stages (81 per cent) and also monitored and identified pests on their crops (93 per cent). Eighteen per cent of growers used action thresholds when monitoring pest populations and 17 per cent used specialist diagnostics when dealing with pests that were more problematic to identify or monitor. The low use of thresholds in this crop sector is influenced by its low pesticide input.

Ninety seven per cent of growers conducted at least one IPM pest control activity (Table 34). Eighty seven per cent of growers used non-chemical control in partnership or instead of chemical control. Fifty one per cent of growers targeted their pesticide applications to reduce pesticide use and 39 per cent followed anti-resistance strategies. Finally, 82 per cent of respondents stated that they regularly monitored the success of their crop protection measures.

2017 Pesticide usage

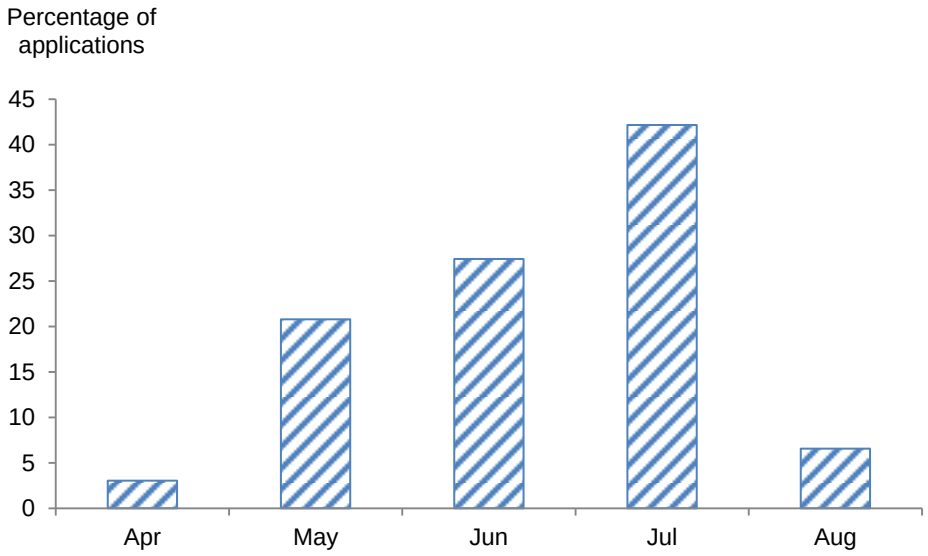
Direct sown grass

- An estimated 19,587 hectares of direct sown grass was grown in Scotland in 2017, a decrease of 29 per cent since 2013
- 25 per cent of the crop was treated with a pesticide
- Pesticides were applied to 6,321 treated hectares and 4,917 kilograms of pesticide were applied in total (see summary table below)
- 85 per cent of pesticides applied, by area, were herbicides and 15 per cent were seed treatments
- Direct sown grass received on average one herbicide spray applied to 20 per cent of the crop area (Table 1)
- Timings of herbicide applications are shown in Figure 19
- 45 per cent of herbicide use was for grass weed control, 24 per cent for crop destruction/pasture kill, nine per cent for chickweed, seven per cent for docks, six per cent for daynettle and the remaining 11 per cent for control of other weeds including redshank, thistle, fat hen, rushes and broad-leaved weeds

Summary of pesticide use on direct sown grass

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Herbicides	5,396	4,834	20	Glyphosate (1,517), 2,4-DB (1,132)
Seed treatments	925	83	5	Thiram (925)
All pesticides	**6,321**	**4,917**	**25**	

Figure 19 Timing of herbicide applications on direct sown grass - 2017



Undersown grass

- An estimated 7,563 hectares of undersown grass was grown in Scotland in 2017, a decrease of 51 per cent from 2013
- 60 per cent of undersown grass was treated with a pesticide (see Figure 20 for types of pesticides used
- 16,092 hectares of pesticide formulations were applied and 6,389 kilograms of pesticide were used in total on the crop (see summary table below)
- All fungicide and insecticide use on undersown grass was for controlling disease or insect pests in the nurse crop.
- Undersown grass received on average 1.4 pesticide sprays on 60 per cent of the crop (Table 1). These included 1.3 fungicide applications on 48 per cent of the crop and one herbicide application on 60 per cent of the crop
- The timing of pesticide applications are shown in Figure 21
- Reasons for fungicide applications were supplied for 65 per cent of total use; 47 per cent was for general disease control, eight per cent for mildew, five per cent for *Rhynchosporium* and five per cent for *Ramularia*
- Reasons for herbicide applications were supplied for 82 per cent of all use; 52 per cent for general weed control, 10 per cent for annual broad-leaved weeds, six per cent for nettles, five per cent for chickweed, four per cent for thistles, two per cent for annual grass weeds and one per cent for rushes.
- All use of insecticides on undersown grass was for aphid control

Summary of pesticide use on undersown grass

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Herbicides	8,352	4,482	60	2,4-DB (2,746), Tribenuron-methyl (2,735)
Fungicides	7,065	1,656	48	Chlorothalonil (1,511), Prothioconazole/ trifloxystrobin (1,142)
Insecticides	69	<0.5	1	Lambda-cyhalothrin (69)
Growth regulators	606	250	8	Chlormequat (258)
All pesticides	**16,092**	**6,389**	**60**	

Figure 20 Use of pesticides on undersown grass (percentage of total area treated with formulations) – 2017

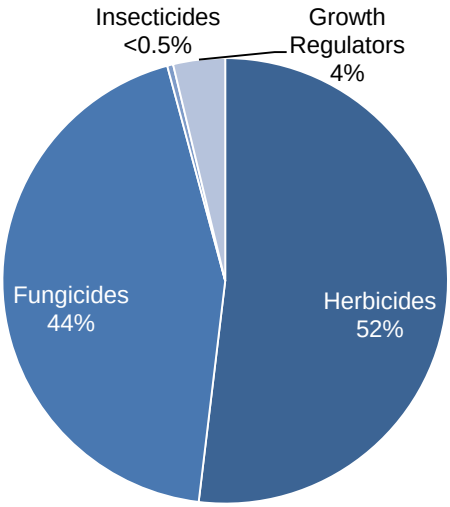
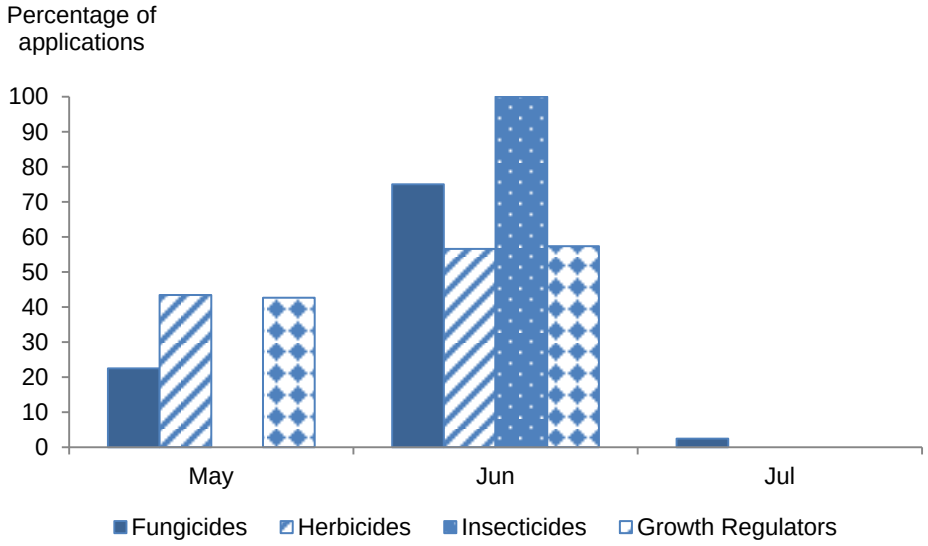


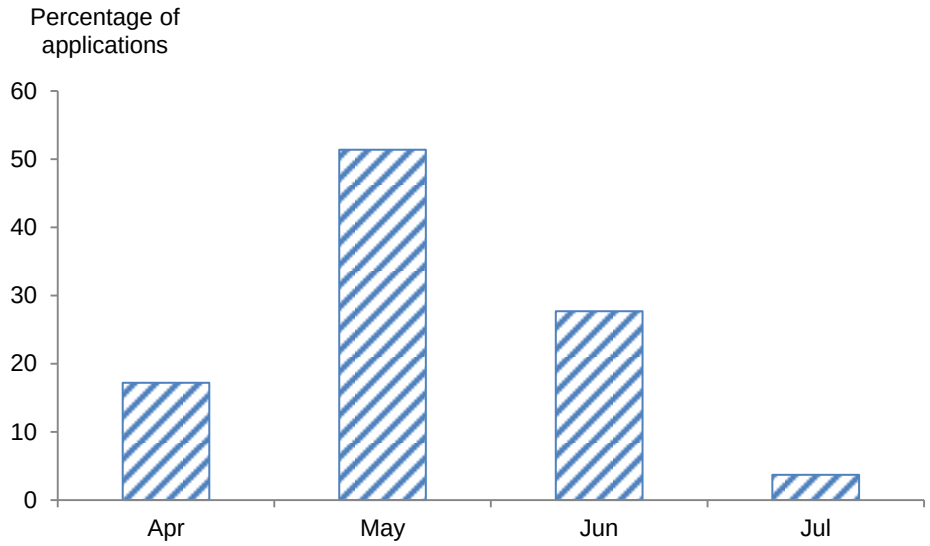
Figure 21 Timing of pesticide applications on undersown grass - 2017



Grass one to four years old

- An estimated 186,667 hectares of grass between one and four years old was grown in Scotland in 2017. This represents a decrease of 55 per cent from 2013
- Only herbicides were applied to grass between one and four years old
- Three per cent of the crop was treated with a herbicide (Table 1)
- 5,098 hectares of herbicide formulations were applied and 2,729 kilograms of herbicide were used in total
- Fluroxypyr (1,043 hectares) and fluroxypyr/triclopyr (931 hectares) were the most used herbicide formulations
- The timing of herbicide applications are shown in Figure 22
- Reasons were given for 99 per cent of total herbicide use; 66 per cent for control of docks,12 per cent for thistles, seven per cent for grass weeds, six per cent for ragwort, four per cent for other weeds (including nettles, daisies and rushes) and three per cent for grass kill

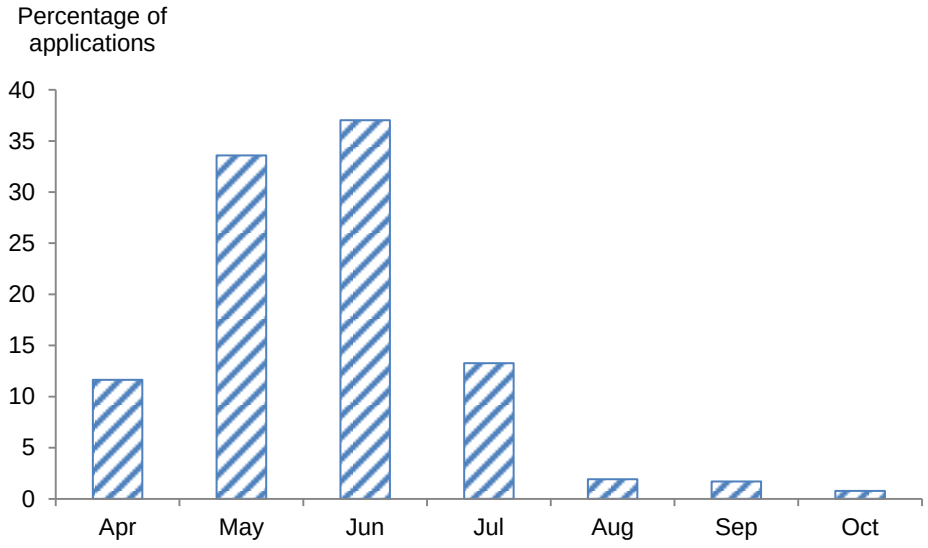
Figure 22 Timing of herbicide applications on grass one to four years old - 2017



Grass over five years old

- 1,112,553 hectares of grass over five years old was grown in Scotland in 2017. This was a 26 per cent increase from 2013
- Only herbicides were applied to grass over five years old
- Three per cent of the crop was treated with a herbicide (Table 1)
- Herbicides were applied to 46,050 hectares and 34,217 kilograms of herbicides in total were applied to the crop
- The most used herbicide formulations were MCPA, applied to 10,489 hectares, fluroxypyr applied to 8,804 hectares and fluroxypyr/triclopyr applied to 8,061 hectares
- Timings of herbicide applications are shown in Figure 23
- Reasons were given for 98 per cent of herbicide use; docks accounted for 44 per cent of herbicide applications, thistles 21 per cent, rushes 15 per cent, nettles five per cent, ragwort five per cent, other weeds (including buttercup and general weed control) five per cent and one per cent grass/crop destruction

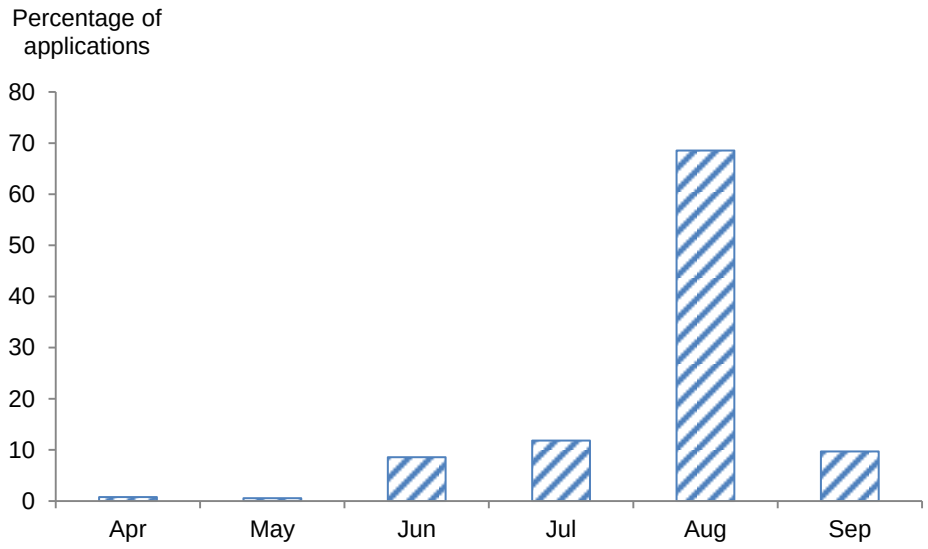
Figure 23 Timing of herbicide applications on grass over five years old - 2017



Rough grazing

- 3,037,615 hectares of rough grazing was grown in Scotland in 2017, a one per cent decrease from the 2013 survey
- Only herbicides were applied to rough grazing
- 0.5 per cent of rough grazing was treated with a herbicide, with an average of one application (Table 1)
- An area of 14,378 hectares of herbicide formulations and 35,553 kilograms were applied in total
- The most commonly encountered herbicide formulations were asulam (5,886 hectares) and MCPA (5,762 hectares)
- Timings of the herbicide applications are shown in Figure 24
- Reasons were supplied for all herbicide use on rough grazing; 45 per cent of applications were for bracken, 44 per cent for rushes, six per cent for docks and five per cent for thistles

Figure 24 Timing of herbicide applications on rough grazing - 2017



Arable silage

- An estimated 5,801 hectares of arable silage was grown in Scotland in 2017, a decrease of 32 per cent from 2013
- Arable silage is recorded in the 'other crops for stock-feeding' category of the Agricultural Census
- Crops grown for arable silage included spring barley, spring oats, spring wheat, peas, lupin, triticale, rye, clover and vetches, some of which were undersown
- 58 per cent of the crop was treated with a pesticide (see Figure 25 for types of pesticides used)
- 5,928 hectares of pesticide formulations and 1,669 kilograms of pesticides were used in total on arable silage (see summary table below)
- The arable silage crop received on average one application of fungicides and herbicides on 10 per cent and 21 per cent of the crop respectively (Table 1)
- Timings of the pesticide applications are shown in Figure 26
- Reasons were supplied for 62 per cent of applications of fungicides; 51 per cent was for general disease control and 11 per cent for mildew
- Reasons were supplied for 79 per cent of herbicide applications; 75 per cent was for general weed control and four per cent for docks

Summary of pesticide use on arable silage

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Herbicides	1,948	1,420	21	Tribenuron-methyl (319), Pendimethalin (290)
Fungicides	806	193	10	Chlorothalonil (220)
Seed treatments	3,174	56	48	Imazalil/ipconazole (759), Fluopyram/ prothioconazole/ tebuconazole (751)
All pesticides	**5,928**	**1,669**	**58**	

Figure 25 Use of pesticides on arable silage (percentage of total area treated with formulations) – 2017

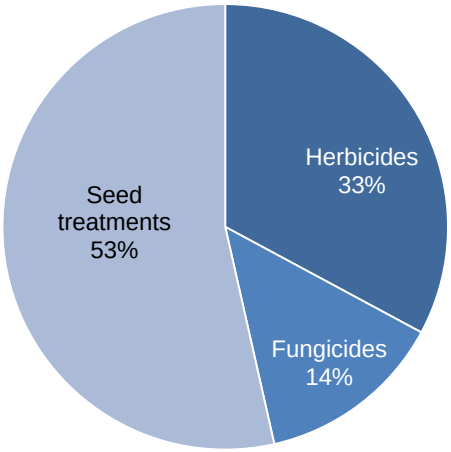
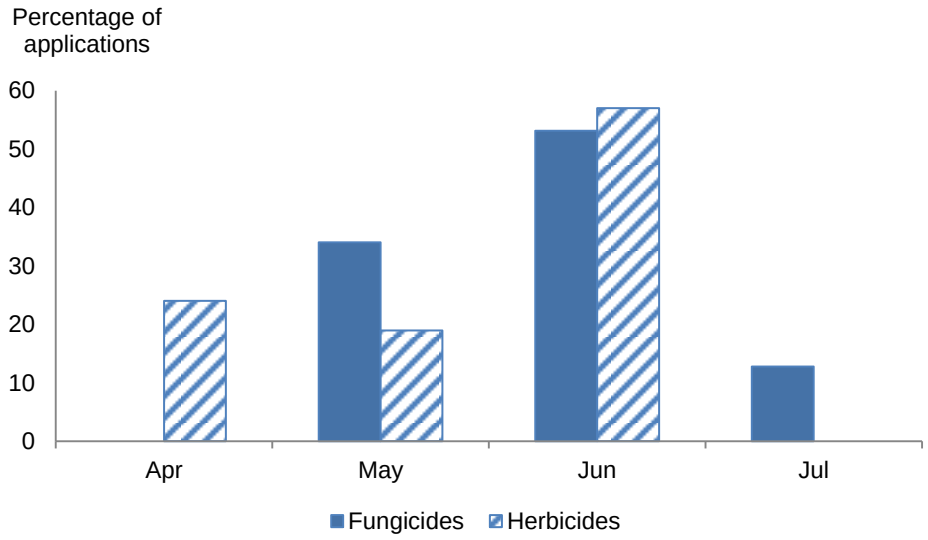


Figure 26 Timing of pesticide applications on arable silage - 2017



Fodder beet

- An estimated 611 hectares of fodder beet was grown in Scotland in 2017, a 31 per cent increase from 2013
- All of the crop surveyed was treated with a pesticide (see Figure 27 for types of pesticides applied)
- Pesticides were applied to 3,760 treated hectares and 2,115 kilograms were applied in total (see summary table below)
- The fodder beet crop received on average 3.6 pesticide applications (Table 1). These sprays included 3.2 herbicides and one insecticide application on 100 per cent and 34 per cent of the crop respectively
- The timings of pesticide applications are shown in Figure 28
- Reasons were provided for 91 per cent of herbicide use; 84 per cent was for general weed control, four per cent for crop destruction/ grass kill and three per cent for broad-leaved weeds
- The most common varieties encountered were Robbos, Tarine and Kyros, accounting for 40, 24 and 17 per cent respectively

Summary of pesticide use on fodder beet

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Herbicides	3,194	2,106	100	Metamitron (919), Desmedipham/ ethofumesate/lenacil/ phenmedipham (878)
Insecticides	210	1	34	Lambda-cyhalothrin (210)
Seed treatments	356	8	58	Tefluthrin (356)
All pesticides	**3,760**	**2,115**	**100**	

Figure 27 Use of pesticides on fodder beet (percentage of total area treated with formulations) – 2017

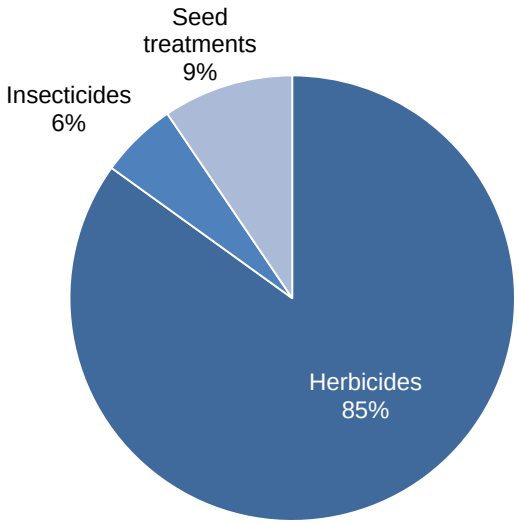
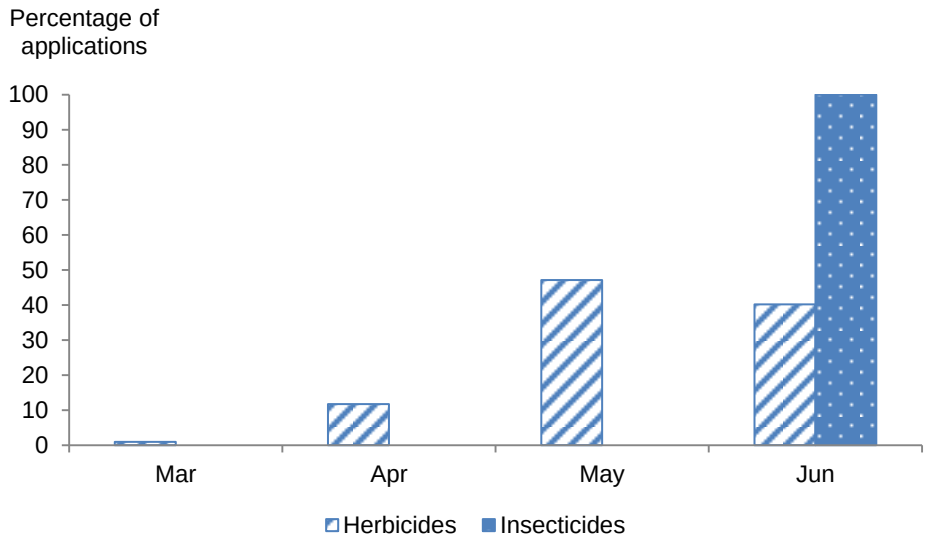


Figure 28 Timing of pesticide applications on fodder beet - 2017



Fodder rape

- 2,007 hectares of fodder rape were grown in 2017, a five per cent decrease from 2013
- It is estimated that 68 per cent of the fodder rape encountered was mixed with another crop such as kale or stubble turnips
- A further 55 hectares of fodder rape were recorded in fodder crop mixes in the 'other crops for stock-feeding' category (see the other fodder section for details)
- 29 per cent of the crop was treated with a pesticide (see Figure 29 for types of pesticides used)
- 790 hectares of pesticide formulations were applied and 687 kilograms of pesticides were used in total (see summary table below)
- 27 per cent of the fodder rape crop was treated with a herbicide, receiving on average one application (Table 1)
- The timing of pesticide applications are shown in Figure 30
- 53 per cent of herbicide use was for grass/pasture kill and 47 per cent was for general weed control. All insecticide use was for flea beetle
- The most common varieties encountered were Hobson accounting for 18 per cent of the sampled area and Swift, a rape/kale hybrid accounting for 17 per cent

Summary of pesticide use on fodder rape

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Herbicides	585	663	27	Glyphosate (383)
Insecticides	36	<0.5	2	Cypermethrin (36)
Molluscicides	107	22	5	Metaldehyde (107)
Seed treatments	63	2	3	Thiram (63)
All pesticides	**790**	**687**	**29**	

Figure 29 Use of pesticides on fodder rape (percentage of total area treated with formulations) – 2017

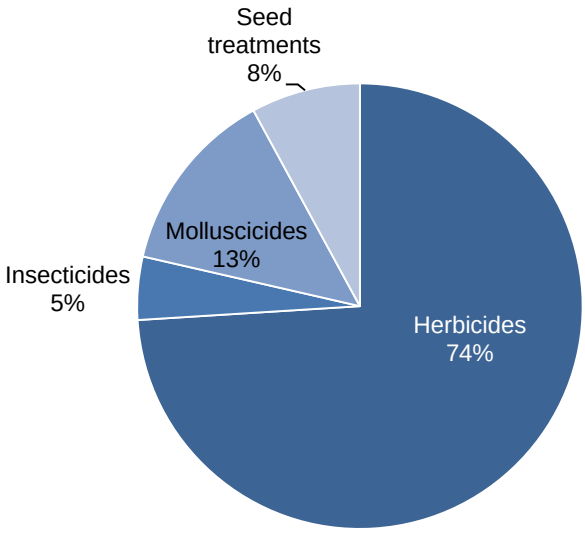
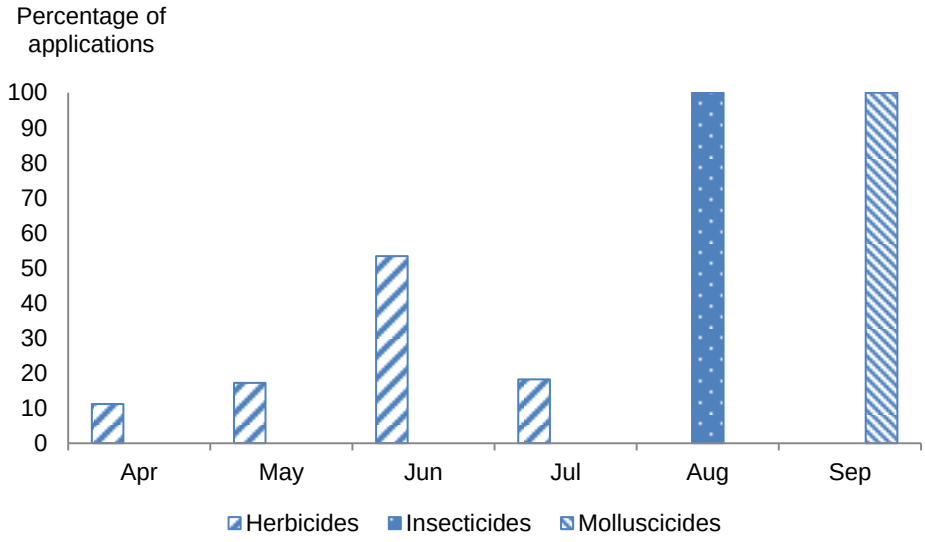


Figure 30 Timing of pesticide applications on fodder rape - 2017



Kale and cabbage

- 1,915 hectares of kale and cabbage were grown in 2017, a six per cent increase from 2013
- 99 per cent of the crop was kale and one per cent was cabbage
- The cabbage crop was grown from transplants
- It is estimated that 45 per cent of the kale and cabbage encountered was mixed with another crop such as fodder rape or turnips
- A further 190 hectares of kale, kale hybrid and kale mixes were recorded in the 'other crops for stock-feeding' category (see the other fodder section for details)
- 49 per cent of the crop was treated with a pesticide (see Figure 31 for types of pesticides applied)
- 1,830 hectares of pesticide formulations were applied and 489 kilograms of pesticide used in total (see summary table below)
- The kale and cabbage crop received on average 1.2 herbicide and 1.1 insecticide sprays on 19 and 14 per cent of the crop area respectively (Table 1)
- The timings of pesticide applications are shown in Figure 32
- Reasons were provided for 39 per cent of herbicide use on kale and cabbage; 18 per cent was for grass/pasture kill, 11 per cent for general weed control, seven per cent for annual broad-leaved weeds and three per cent for annual meadow grass. Reasons were supplied for 69 per cent of insecticide use; 56 per cent was for flea beetle and 13 per cent for diamond-back moth
- The most common variety encountered was Maris Kestrel, accounting for 29 per cent of the sample area surveyed

Summary of pesticide use on kale and cabbage

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Herbicides	503	460	19	Glyphosate (231), Metazachlor (132)
Insecticides	293	4	14	Deltamethrin (81), Lambda-cyhalothrin (48)
Molluscicides	33	4	2	Metaldehyde (33)
Seed treatments	1,001	21	35	Thiamethoxam (622), Thiram (379)
All pesticides	**1,830**	**489**	**49**	

Figure 31 Use of pesticides on kale and cabbage (percentage of total area treated with formulations) – 2017

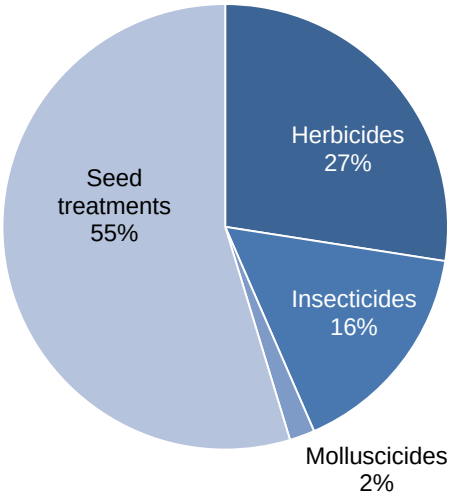
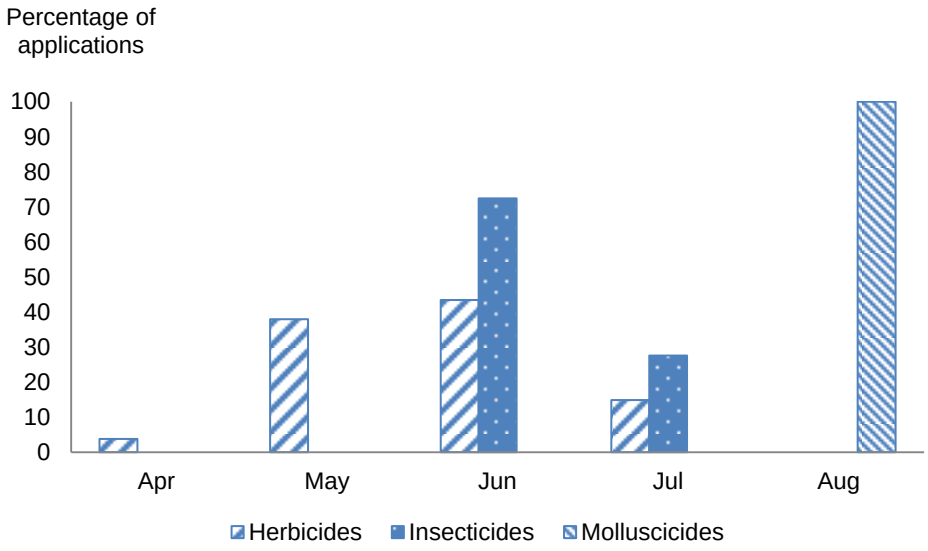


Figure 32 Timing of pesticide applications on kale and cabbage - 2017



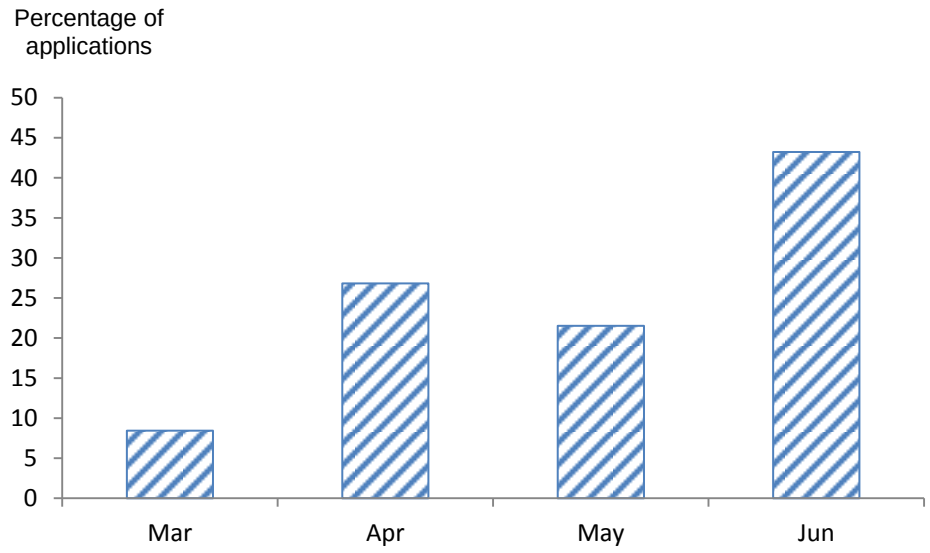
Maize

- An estimated 792 hectares of maize was grown in Scotland in 2017, a 44 per cent decrease since 2013
- All of the maize crop was treated with a pesticide
- 52 per cent of pesticides, by area applied, were seed treatments and 48 per cent were herbicides
- The maize crop received on average 1.1 applications of herbicides (Table 1)
- 2,392 hectares of pesticide formulations were applied and a total of 1,017 kilograms of pesticides were used (see summary table below)
- The timings of pesticide applications are shown in Figure 33
- 89 per cent of herbicide use was for general weed control, eight per cent for grass kill and three per cent for couch grass
- The most common variety encountered was Kaspian, accounting for 62 per cent of the sampled area
- 19 per cent of the sampled area was covered by plastic film at crop establishment

Summary of pesticide use on maize

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Herbicides	1,149	896	100	Pendimethalin (649), Dimethenamid-P/ pendimethalin (240)
Seed treatments	1,243	122	100	Methiocarb (792), Thiram (409)
All pesticides	**2,392**	**1,017**	**100**	

Figure 33 Timing of herbicide applications on maize - 2017



Stubble turnips

- An estimated 339 hectares of stubble turnips were grown in Scotland in 2017
- A further 398 hectares of stubble turnips and stubble turnips fodder crop mixes were recorded in the 'other crops for stock-feeding' category (see the other fodder section for details)
- Stubble turnips are often a constituent of other fodder mixes and therefore it is likely that the estimated area grown is under-estimated
- No pesticides were applied to the stubble turnips crop
- The most common variety encountered was Tyfon, accounting for 23 per cent of the sampled area

Turnips and swedes

- 3,806 hectares of turnips and swedes were grown in Scotland in 2017, representing a seven per cent decrease from 2013
- A further 207 hectares of turnips and swedes and turnips and swedes fodder crop mixes were recorded in the 'other crops for stock-feeding' category (see the other fodder section for details)
- 92 per cent of the crop was treated with a pesticide (see Figure 34 for types of pesticides applied)
- 8,544 hectares of pesticide formulations were applied and 1,773 kilograms of pesticides were used in total (see summary table below)
- On average turnips and swedes received 1.1 herbicide applications on 67 per cent of the crop (Table 1)
- The timing of pesticide applications is shown in Figure 35
- Half of fungicide use on turnips and swedes was for mildew and half was for phoma leaf spot. Reasons were given for 92 per cent of herbicide use; 83 per cent was for general weed control, five per cent for broad-leaved weeds, three per cent for annual meadow grass and one per cent for couch grass. Reasons were provided for 67 per cent of insecticide use; 46 per cent was for diamond-back moth and 21 per cent for flea beetle
- The most common varieties encountered were Lomond and Ruta Otofte accounting for 20 and 19 per cent of the sample area respectively

Summary of pesticide use on turnips and swedes

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Herbicides	3,277	1,747	67	Metazachlor (1,115), Dimethenamid-P/ metazachlor (812)
Fungicides	79	15	2	Prothioconazole (79)
Insecticides	283	2	7	Deltamethrin (283)
Seed treatments	4,906	9	80	Thiamethoxam (2,606), Thiram (2,227)
All pesticides	**8,544**	**1,773**	**92**	

Figure 34 Use of pesticides on turnips and swedes (percentage of total area treated with formulations) – 2017

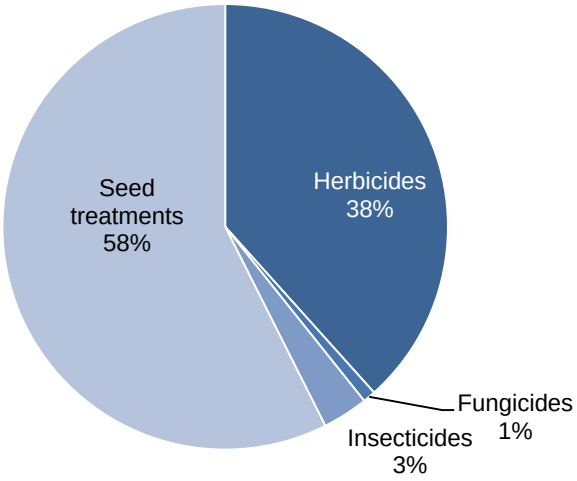
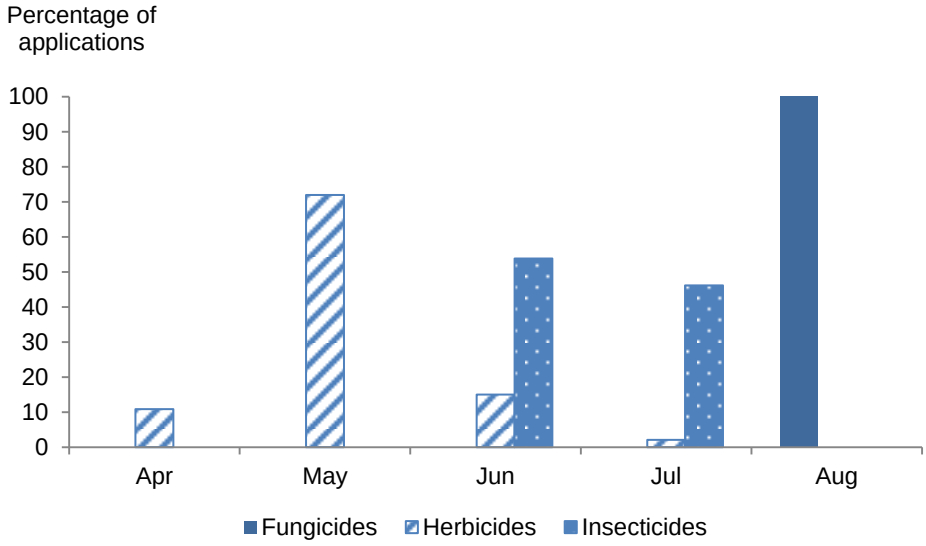


Figure 35 Timing of herbicide applications on turnips & swedes - 2017



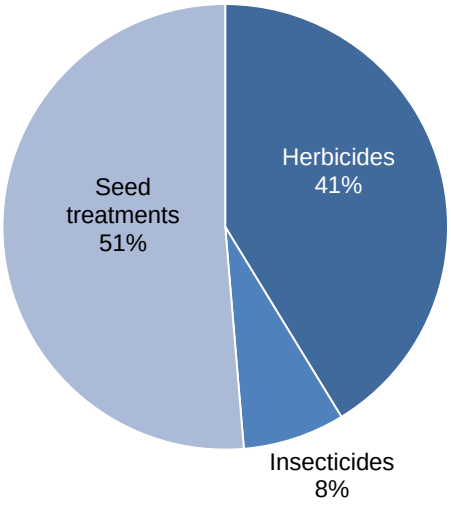
Other fodder crops

- 1,033 hectares of other fodder crops were grown in Scotland in 2017
- Other fodder consists of any crops other than arable silage reported in the 'other crops for stock-feeding' category
- In 2017 this consisted of red clover, swedes, kale, stubble turnips and fodder crop mixes
- 48 per cent of the crop was treated with a pesticide (see Figure 36 for types of pesticides applied)
- 1,017 hectares of pesticide formulations and 361 kilograms of pesticides were applied (see summary table below)
- The other fodder crop received on average one application of herbicides on 38 per cent of the crop (Table 1)
- All herbicides were applied in May and all insecticides were applied in June
- All insecticide use was for flea beetle. Eighty per cent of herbicide use was for general weed control and 20 per cent for destroying the previous crop

Summary of estimated pesticide use on other fodder crops

Pesticide group	Formulation area treated	Weight of pesticides applied	Percentage of crop treated	Most used formulations
	ha	kg	%	ha
Herbicides	420	356	38	Dimethenamid-P/ Metazachlor (152)
Insecticides	75	1	7	Lambda-cyhalothrin (75)
Seed treatments	522	5	30	Thiram (312), Thiamethoxam (210)
All pesticides	**1,017**	**361**	**48**	

Figure 36 Use of pesticides on other fodder (percentage of total area treated with formulations) – 2017



Appendix 1 – Estimated application tables

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

Crop	Fungicides		Herbicides		Insecticides		Molluscicide		Growth Regulators		Any pesticide exc. STs		Seed treatments	Any pesticide inc. STs
	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	%
Direct sown grass	0	0.0	20	1.0	0	0.0	0	0.0	0	0.0	20	1.0	5	25
Undersown grass	48	1.3	60	1.0	1	1.0	0	0.0	8	1.0	60	1.4	0	60
Grass 1 - 4 years	0	0.0	3	1.0	0	0.0	0	0.0	0	0.0	3	1.0	0	3
Grass over 5 years	0	0.0	3	1.0	0	0.0	0	0.0	0	0.0	3	1.0	0	3
Total Grass	**<0.5**	**1.3**	**4**	**1.0**	**<0.5**	**1.0**	**0**	**0.0**	**<0.5**	**1.0**	**4**	**1.0**	**<0.5**	**4**
Rough grazing	0	0.0	<0.5	1.0	0	0.0	0	0.0	0	0.0	<0.5	1.0	0	<0.5

Cont…

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

Crop	Fungicides		Herbicides		Insecticides		Molluscicide		Growth Regulators		Any pesticide exc. STs		Seed-treatments	Any pesticide inc. STs
	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	spray apps	%	%
Arable Silage	10	1.0	21	1.0	0	0.0	0	0.0	0	0.0	23	1.0	48	58
Fodder Beet	0	0.0	100	3.2	34	1.0	0	0.0	0	0.0	100	3.6	58	100
Fodder rape	0	0.0	27	1.0	2	1.0	5	1.0	0	0.0	29	1.2	3	29
Kale & Cabbage	0	0.0	19	1.2	14	1.1	2	1.0	0	0.0	28	1.5	35	49
Maize	0	0.0	100	1.1	0	0.0	0	0.0	0	0.0	100	1.1	100	100
Stubble Turnips	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0.0	0	0
Turnips & Swedes	2	1.0	67	1.1	7	1.0	0	0.0	0	0.0	67	1.2	80	92
Other Fodder Crops	0	0.0	38	1.0	7	1.0	0	0.0	0	0.0	38	1.2	30	48
Total Fodder Crops	**4**	**1.0**	**40**	**1.3**	**5**	**1.0**	**1**	**1.0**	**0**	**0.0**	**42**	**1.4**	**49**	**63**

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 Grassland seed treatment formulations - 2017

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

Seed treatment	Direct sown grass		Undersown grass		Total 2017	2017	2013[1]	2013[1]
	ha	%	ha	%	**ha**	**kg**	ha	kg
Thiram	925	5	0	0	**925**	**83**	489	53
All seed treatments	**925**	**5**	**0**	**0**	**925**	**83**	**1,490**	**53**
No information seed treatment[2]	0	0	74	1	**74**	**N/A**	0	N/A
No seed treatment	18,632	95	7,488	99	**26,120**	**N/A**	41,931	N/A
Area grown	19,587		7,563		**27,150**		43,421	

(1) For a full list of formulations recorded in 2013 please refer to the 2013 report[3]
(2) Refer to Appendix 3 for definitions
N/A = not applicable

Table 3 Grassland insecticide formulations - 2017

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

Insecticides	Direct sown grass		Undersown grass		Grass 1 to 4 years		Grass over 5 years		Rough grazing		Total 2017	Total 2017	2013[1]	2013[1]
	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Lambda-cyhalothrin	0	0	69	1	0	0	0	0	0	0	**69**	**<0.5**	256	1
All insecticides	**0**	**0**	**69**	**1**	**0**	**0**	**0**	**0**	**0**	**0**	**69**	**<0.5**	**5,811**	**4113**
Area grown	19,587		7,563		186,667		1,112,553		3,037,615		**4,363,985**		4,400,870	

(1) For a full list of formulations recorded in 2013 please refer to the 2013 report[3]

Table 4 Grassland fungicide formulations - 2017

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

Fungicides	Direct sown grass		Undersown grass		Grass 1 to 4 years		Grass over 5 years		Rough grazing		Total 2017	Total 2017	2013[(1)]	2013[(1)]
	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Azoxystrobin/ chlorothalonil	0	0	120	2	0	0	0	0	0	0	**120**	**34**	0	0
Bixafen/prothioconazole	0	0	83	1	0	0	0	0	0	0	**83**	**11**	0	0
Boscalid/epoxiconazole	0	0	92	1	0	0	0	0	0	0	**92**	**19**	409	72
Chlorothalonil	0	0	1,511	20	0	0	0	0	0	0	**1,511**	**738**	1,083	463
Cyprodinil	0	0	299	4	0	0	0	0	0	0	**299**	**83**	472	127
Epoxiconazole/ fenpropimorph	0	0	91	1	0	0	0	0	0	0	**91**	**18**	0	0
Epoxiconazole/ fenpropimorph/ metrafenone	0	0	551	7	0	0	0	0	0	0	**551**	**172**	472	68
Epoxiconazole/ isopyrazam	0	0	96	1	0	0	0	0	0	0	**96**	**11**	0	0
Fenpropimorph	0	0	91	1	0	0	0	0	0	0	**91**	**21**	327	49
Fenpropimorph/ pyraclostrobin	0	0	118	2	0	0	0	0	0	0	**118**	**31**	152	36
Fluoxastrobin/ prothioconazole/ trifloxystrobin	0	0	842	9	0	0	0	0	0	0	**842**	**121**	1,251	196
Fluxapyroxad	0	0	120	2	0	0	0	0	0	0	**120**	**3**	0	0
Folpet	0	0	87	1	0	0	0	0	0	0	**87**	**37**	672	244

Cont…

Table 4 Grassland fungicide formulations – 2017 continued

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

Fungicides	Direct sown grass		Undersown grass		Grass 1 to 4 years		Grass over 5 years		Rough grazing		Total 2017	Total 2017	2013[1]	2013[1]
	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Penthiopyrad	0	0	259	3	0	0	0	0	0	0	**259**	**27**	0	0
Prothioconazole	0	0	282	4	0	0	0	0	0	0	**282**	**21**	473	45
Prothioconazole/ spiroxamine	0	0	349	5	0	0	0	0	0	0	**349**	**55**	1,070	249
Prothioconazole/ tebuconazole	0	0	932	12	0	0	0	0	0	0	**932**	**121**	1,621	177
Prothioconazole/ trifloxystrobin	0	0	1,142	11	0	0	0	0	0	0	**1,142**	**133**	858	75
All fungicides	**0**	**0**	**7,065**	**48**	**0**	**0**	**0**	**0**	**0**	**0**	**7,065**	**1,656**	**12,081**	**2,508**
Area grown	19,587		7,563		186,667		1,112,553		3,037,615		**4,363,985**		4,400,870	

(1) For a full list of formulations recorded in 2013 please refer to the 2013 report[3]

Table 5 Grassland herbicide and growth regulator formulations – 2017

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

Herbicides	Direct sown grass		Undersown grass		Grass 1 to 4 years		Grass over 5 years		Rough grazing		Total 2017	Total 2017	2013[1]	2013[1]
	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
2,4-D	0	0	0	0	183	<0.5	1,558	<0.5	379	<0.5	**2,120**	**2,518**	5,043	6,584
2,4-D/dicamba	0	0	0	0	0	0	917	<0.5	0	0	**917**	**447**	152	211
2,4-D/dicamba/triclopyr	0	0	0	0	0	0	17	<0.5	0	0	**17**	**9**	0	0
2,4-D/glyphosate	207	1	0	0	0	0	0	0	0	0	**207**	**331**	0	0
2,4-D/MCPA	207	1	709	9	146	<0.5	1,527	<0.5	298	<0.5	**2,888**	**5,307**	2,154	4,754
2,4-DB	1,132	6	2,746	36	192	<0.5	507	<0.5	0	0	**4,577**	**5,033**	8,112	9,540
2,4-DB/MCPA	113	1	0	0	0	0	0	0	0	0	**113**	**190**	257	385
Amidosulfuron	132	1	0	0	697	<0.5	220	<0.5	0	0	**1,049**	**42**	468	17
Aminopyralid/triclopyr	73	<0.5	0	0	424	<0.5	3,938	<0.5	0	0	**4,436**	**2,185**	652	343
Asulam	0	0	0	0	0	0	142	<0.5	5,886	<0.5	**6,028**	**24,817**	5,758	24,885
Clopyralid/florasulam/ fluroxypyr	177	1	0	0	0	0	0	0	0	0	**177**	**32**	0	0
Clopyralid/fluroxypyr/ triclopyr	0	0	0	0	145	<0.5	461	<0.5	0	0	**606**	**441**	1,435	781
Clopyralid/triclopyr	64	<0.5	0	0	743	<0.5	6,591	1	0	0	**7,398**	**2,649**	1,988	845
Dicamba/MCPA/ mecoprop-P	0	0	87	1	0	0	0	0	0	0	**87**	**121**	836	1,057

Cont…

Table 5 Grassland herbicide and growth regulator formulations – 2017 continued

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

Herbicides	Direct sown grass		Undersown grass		Grass 1 to 4 years		Grass over 5 years		Rough grazing		Total 2017	Total 2017	2013[1]	2013[1]
	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
Dicamba/mecoprop-P	0	0	69	1	0	0	0	0	0	0	**69**	**40**	1,450	993
Florasulam/fluroxypyr	0	0	522	7	0	0	0	0	0	0	**522**	**60**	0	0
Fluroxypyr	413	2	867	11	1,043	1	8,804	1	298	<0.5	**11,426**	**3,191**	1,766	456
Fluroxypyr/triclopyr	50	0	0	0	931	<0.5	8,061	1	828	<0.5	**9,871**	**4,413**	4,701	2,062
Glyphosate	1,517	8	0	0	240	<0.5	2,037	<0.5	927	<0.5	**4,721**	**6,200**	4,941	8,333
MCPA	313	2	430	6	146	<0.5	10,489	1	5,762	<0.5	**17,140**	**23,761**	13,193	16,009
Metsulfuron-methyl	0	0	0	0	0	0	228	<0.5	0	0	**228**	**<0.5**	777	1
Thifensulfuron-methyl	48	<0.5	0	0	0	0	285	<0.5	0	0	**332**	**3**	725	8
Thifensulfuron-methyl/ tribenuron-methyl	0	0	188	2	0	0	0	0	0	0	**188**	**4**	0	0
Tribenuron-methyl	652	3	2,735	36	192	<0.5	223	<0.5	0	0	**3,802**	**21**	7,769	36
Unspecified herbicide[2]	297	2	0	0	13	<0.5	45	<0.5	0	0	**355**	**N/A**	0	N/A
All herbicides	**5,396**	**20**	**8,352**	**60**	**5,098**	**3**	**46,050**	**3**	**14,378**	**<0.5**	**79,274**	**81,815**	**66,602**	**78,377**

Cont…

Table 5 Grassland herbicide and growth regulator formulations – 2017 continued

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

Growth regulators	Direct sown grass		Undersown grass		Grass 1 to 4 years		Grass over 5 years		Rough grazing		Total 2017	Total 2017	2013[1]	2013[1]
	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	**kg**	ha	kg
2-Chloroethylphosphonic acid	0	0	189	2	0	0	0	0	0	0	**189**	**31**	0	0
Chlormequat	0	0	258	3	0	0	0	0	0	0	**258**	**194**	159	57
Mepiquat chloride/prohexadione-calcium	0	0	159	2	0	0	0	0	0	0	**159**	**26**	0	0
All growth regulators	**0**	**0**	**606**	**8**	**0**	**0**	**0**	**0**	**0**	**0**	**606**	**250**	**721**	**270**
	19,587		7,563		186,667		1,112,553		3,037,615		**4,363,985**		4,400,870	

(1) For a full list of formulations recorded in 2013 please refer to the 2013 report[3]
(2) Refer to Appendix 3 for definitions

Table 6 Fodder crop seed treatment formulations - 2017

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

Seed treatments	Arable silage		Fodder beet		Fodder rape		Kale & cabbage		Maize		Stubble turnips		Turnips & swedes		Other fodder[1]		Total 2017	Total 2017	2013 [2]	2013 [2]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	kg	ha	kg
Fludioxonil	618	11	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**618**	**3**	308	4
Fludioxonil/ metalaxyl-M	0	0	0	0	0	0	0	0	43	5	0	0	0	0	0	0	**43**	**<0.5**	204	<0.5
Fluopyram/ prothioconazole/ tebuconazole	751	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**751**	**11**	181	3
Imazalil/ipconazole	759	13	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**759**	**8**	544	8
Methiocarb	0	0	0	0	0	0	0	0	792	100	0	0	0	0	0	0	**792**	**108**	1,497	180
Prochloraz/ triticonazole	417	7	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**417**	**10**	2,295	66
Prothioconazole/ tebuconazole	34	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**34**	**0.5**	0	0
Tefluthrin	0	0	356	58	0	0	0	0	0	0	0	0	0	0	0	0	**356**	**8**	273	9
Thiamethoxam	0	0	0	0	0	0	622	32	0	0	0	0	2,606	68	210	20	**3,438**	**25**	3,589	79
Thiram	271	5	0	0	63	3	379	20	409	52	0	0	2,227	59	312	30	**3,661**	**48**	4,640	57
Unspecified seed treatment[1]	324	6	0	0	0	0	0	0	0	0	0	0	73	2	0	0	**397**	**N/A**	185	N/A
All seed treatments	**3,174**	**48**	**356**	**58**	**63**	**3**	**1,001**	**35**	**1,243**	**100**	**0**	**0**	**4,906**	**80**	**522**	**30**	**11,265**	**222**	**15,887**	**557**

Cont…

Table 6 Fodder crop seed treatment formulations – 2017 continued

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

Seed treatments	Arable silage		Fodder beet		Fodder rape		Kale & cabbage		Maize		Stubble turnips		Turnips & swedes		Other fodder[1]		Total 2017	Total 2017	2013 [2]	2013 [2]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	kg	ha	kg
No information seed treatment[1]	123	2	0	0	5	<0.5	196	10	0	0	0	0	207	5	0	0	**531**	**N/A**	0	N/A
No seed treatment	2,853	49	255	42	1,905	95	1,039	54	0	0	339	100	568	15	721	70	**7,679**	**N/A**	8,170	N/A
Crop grown from transplant	0	0	0	0	0	0	12	1	0	0	0	0	0	0	0	0	**12**	**N/A**	0	N/A
Area grown	5,801		611		2,007		1,915		792		339		3,806		1,033		**16,304**		19,524	

(1) Refer to Appendix 3 for definitions
(2) For a full list of formulations recorded in 2013 please refer to the 2013 report[3]
N/A = not applicable

Table 7 Fodder crop insecticide and mollusicide formulations – 2017

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

Insecticides	Arable silage		Fodder beet		Fodder rape		Kale & cabbage		Maize		Stubble turnips		Turnips & swedes		Other fodder[1]		Total 2017	Total 2017	2013 [2]	2013 [2]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	kg	ha	kg
Cypermethrin	0	0	0	0	36	2	0	0	0	0	0	0	0	0	0	0	**36**	**0**	0	0
Deltamethrin	0	0	0	0	0	0	81	3	0	0	0	0	283	7	0	0	**364**	**3**	784	5
Lambda-cyhalothrin	0	0	210	34	0	0	48	2	0	0	0	0	0	0	75	7	**333**	**6**	93	<0.5
Unspecified insecticide[1]	0	0	0	0	0	0	165	9	0	0	0	0	0	0	0	0	**165**	**N/A**	0	N/A
All insecticides	**0**	**0**	**210**	**34**	**36**	**2**	**293**	**14**	**0**	**0**	**0**	**0**	**283**	**7**	**75**	**7**	**897**	**9**	**1,796**	**413**
Molluscicides																				
Metaldehyde	0	0	0	0	107	5	33	2	0	0	0	0	0	0	0	0	**140**	**26**	126	25
All molluscicides	**0**	**0**	**0**	**0**	**107**	**5**	**33**	**2**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**140**	**26**	**126**	**25**
Area grown	5,801		611		2,007		1,915		792		339		3,806		1,033		**16,304**		19,524	

(1) Refer to Appendix 3 for definitions
(2) For a full list of formulations recorded in 2013 please refer to the 2013 report[3]
N/A = not applicable

Table 8 Fodder crop fungicide formulations – 2017

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

Fungicides	Arable silage		Fodder beet		Fodder rape		Kale & cabbage		Maize		Stubble turnips		Turnips & swedes		Other fodder[1]		Total 2017	Total 2017	2013 [1]	2013 [1]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	kg	ha	kg
Bixafen/ fluoxastrobin/ prothioconazole	181	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**181**	38	0	0
Chlorothalonil	220	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**220**	100	762	449
Epoxiconazole/ fenpropimorph	52	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**52**	9	0	0
Fluoxastrobin/ prothioconazole/ trifloxystrobin	148	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**148**	24	768	126
Prothioconazole	0	0	0	0	0	0	0	0	0	0	0	0	79	2	0	0	**79**	15	0	0
Prothioconazole/ tebuconazole	88	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**88**	5	832	103
Prothioconazole/ trifloxystrobin	116	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**116**	17	381	38
All fungicides	**806**	**10**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**0**	**79**	**2**	**0**	**0**	**885**	**208**	**6,079**	**1,539**
Area grown	5,801		611		2,007		1,915		792		339		3,806		1,033		**16,304**		19,524	

(1) For a full list of formulations recorded in 2013 please refer to the 2013 report[3]

Table 9 Fodder crop herbicide formulations – 2017

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

Herbicides	Arable silage		Fodder beet		Fodder rape		Kale & cabbage		Maize		Stubble turnips		Turnips & swedes		Other fodder[1]		Total 2017	Total 2017	2013 [2]	2013 [2]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	kg	ha	kg
2,4-D/glyphosate	0	0	0	0	37	2	0	0	0	0	0	0	0	0	0	0	**37**	**73**	0	0
2,4-D/MCPA	97	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**97**	**164**	99	133
2,4-DB	241	4	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**241**	**233**	766	824
2,4-DB/MCPA	174	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**174**	**290**	0	0
Bromoxynil/ terbuthylazine	0	0	0	0	0	0	0	0	29	4	0	0	0	0	0	0	**29**	**3**	1,083	1,168
Chloridazon	0	0	280	46	0	0	0	0	0	0	0	0	0	0	0	0	**280**	**372**	0	0
Chloridazon/ metamitron	0	0	123	20	0	0	0	0	0	0	0	0	0	0	0	0	**123**	**187**	103	154
Clomazone	0	0	0	0	0	0	49	3	0	0	0	0	711	19	24	2	**784**	**49**	1,151	78
Desmedipham/ ethofumesate/ lenacil/ phenmedipham	0	0	878	61	0	0	0	0	0	0	0	0	0	0	0	0	**878**	**260**	305	90
Desmedipham/ ethofumesate/ phenmedipham	0	0	28	5	0	0	0	0	0	0	0	0	0	0	0	0	**28**	**12**	290	80
Dicamba/MCPA/ mecoprop-P	14	<0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**14**	**8**	275	433
Dicamba/ mecoprop-P	110	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**110**	**58**	611	277

Cont…

Table 9 Fodder crop herbicide formulations – 2017 continued

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

Herbicides	Arable silage		Fodder beet		Fodder rape		Kale & cabbage		Maize		Stubble turnips		Turnips & swedes		Other fodder[1]		Total 2017	Total 2017	2013 [2]	2013 [2]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	kg	ha	kg
Diflufenican	72	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**72**	**12**	0	0
Dimethenamid-P/metazachlor	0	0	0	0	35	2	65	3	0	0	0	0	812	21	152	15	**1,064**	**803**	0	0
Dimethenamid-P/pendimethalin	0	0	0	0	0	0	0	0	240	30	0	0	0	0	0	0	**240**	**431**	0	0
Ethofumesate/ metamitron	0	0	48	8	0	0	0	0	0	0	0	0	0	0	0	0	**48**	**48**	0	0
Florasulam/ fluroxypyr	45	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**45**	**5**	0	0
Fluroxypyr	145	3	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**145**	**21**	184	22
Glyphosate	106	2	77	13	383	19	231	12	97	12	0	0	383	10	84	8	**1,362**	**1,877**	1,916	2,452
Lenacil/ triflusulfuron-methyl	0	0	459	53	0	0	0	0	0	0	0	0	0	0	0	0	**459**	**99**	6	<0.5
MCPA	48	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**48**	**50**	336	255
Mesotrione/ terbuthylazine	0	0	0	0	0	0	0	0	102	13	0	0	0	0	0	0	**102**	**56**	628	289
Metamitron	0	0	919	92	0	0	0	0	0	0	0	0	0	0	0	0	**919**	**1,010**	531	425
Metazachlor	0	0	0	0	0	0	132	7	0	0	0	0	1,115	29	81	8	**1,329**	**699**	3,816	2,385
Metsulfuron-methyl	48	1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**48**	**0**	0	0

Cont..

Table 9 Fodder crop herbicide formulations – 2017 continued

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

Herbicides	Arable silage		Fodder beet		Fodder rape		Kale & cabbage		Maize		Stubble turnips		Turnips & swedes		Other fodder[1]		Total 2017	Total 2017	2013 [2]	2013 [2]
	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	ha	%	**ha**	kg	ha	kg
Metsulfuron-methyl/ thifensulfuron-methyl	110	2	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**110**	**3**	391	9
Metsulfuron-methyl/tribenuron-methyl	14	<0.5	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**14**	**<0.5**	489	7
Nicosulfuron	0	0	0	0	0	0	0	0	31	4	0	0	0	0	0	0	**31**	**1**	101	3
Pendimethalin	290	5	0	0	0	0	0	0	649	82	0	0	0	0	0	0	**939**	**721**	1,321	1,676
Propaquizafop	0	0	69	11	0	0	0	0	0	0	0	0	0	0	0	0	**69**	**10**	89	10
S-metolachlor	0	0	0	0	0	0	0	0	0	0	0	0	63	2	0	0	**63**	**84**	0	0
Tribenuron-methyl	319	6	0	0	0	0	0	0	0	0	0	0	0	0	0	0	**319**	**2**	772	4
Triflusulfuron-methyl	0	0	312	29	0	0	0	0	0	0	0	0	0	0	0	0	**312**	**5**	53	1
Unspecified herbicide[1]	116	2	0	0	130	6	25	1	0	0	0	0	193	5	78	8	**542**	**N/A**	0	0
All herbicides	**1,948**	**21**	**3,194**	**100**	**585**	**27**	**503**	**19**	**1,149**	**100**	**0**	**0**	**3,277**	**67**	**420**	**38**	**11,074**	**7,647**	**17,574**	**11,776**
Area grown	5,801		611		2,007		1,915		792		339		3,806		1,033		**16,304**		19,524	

(1) Refer to Appendix 3 for definitions
(2) For a full list of formulations recorded in 2013 please refer to the 2013 report[3]
N/A = not applicable

Table 10 Compounds encountered in the grassland and fodder survey for the first time in 2017

Active substance	Type[(1)]	Area treated (ha)	Amount used (kg)
Dimethenamid-P	H	1,304	599
Bixafen	F	265	11
Fluxapyroxad	F	120	3
S-metolachlor	H	63	84

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

Table 11 Mode of action/chemical group of insecticide active substances on all grass and fodder crops - 2017

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

Mode of Action	Active Substance	Chemical Group	IRAC Group	Total Grass and Fodder 2017	Total Grass and Fodder 2017
				ha	kg
Sodium channel modulators	Cypermethrin	Pyrethroid	3A	36	<0.5
	Deltamethrin	Pyrethroid	3A	364	3
	Lambda-cyhalothrin	Pyrethroid	3A	402	6
All sodium channel modulators				**802**	**9**
All insecticides				**802**	**9**
Area grown				4,380,288	

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[8]

Table 12 Mode of action/chemical group of fungicide active substances on all grass and fodder crops - 2017

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

Mode of Action	Active Substance	Group Name	Chemical Group	FRAC Group	Total Grass and Fodder 2017	Total Grass and Fodder 2017
					ha	kg
C: Respiration	Bixafen	SDHI	Pyrazole-4-carboxamides	7	265	11
	Boscalid	SDHI	Pyridine-carboxamides	7	92	14
	Fluxapyroxad	SDHI	Pyrazole-4-carboxamides	7	120	3
	Isopyrazam	SDHI	Pyrazole-4-carboxamides	7	96	6
	Penthiopyrad	SDHI	Pyrazole-4-carboxamides	7	259	27
	Azoxystrobin	Qo inhibitors	Strobilurin	11	120	6
	Fluoxastrobin	Qo inhibitors	Strobilurin	11	1,171	46
	Pyraclostrobin	Qo inhibitors	Strobilurin	11	118	7
	Trifloxystrobin	Qo inhibitors	Strobilurin	11	2,247	91
All respiration					**4,487**	**211**
D: Amino acids and protein synthesis	Cyprodinil	Anilino - pyrimidine	Anilino - pyrimidine	9	299	83
All amino acids and protein synthesis					**299**	**83**
G: Sterol biosynthesis in membranes	Epoxiconazole	Demethylation inhibitor	Triazoles	3	883	49
	Prothioconazole	Demethylation inhibitor	Triazoles	3	4,241	325
	Tebuconazole	Demethylation inhibitor	Triazoles	3	1,020	53

Cont…

Table 12 Mode of action/chemical group of fungicide active substances on all grass and fodder crops – 2017 continued

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

Mode of Action	Active Substance	Group Name	Chemical Group	FRAC Group	Total Grass and Fodder 2017	Total Grass and Fodder 2017
					ha	kg
	Fenpropimorph	Morpholine	Morpholines	5	904	167
	Spiroxamine	Morpholine	Spiroketal-amines	5	349	36
All sterol biosynthesis in membranes					**7,397**	**629**
M: Chemicals with multi-site activity	Folpet	Phthalimide	Phthalimide	M 04	87	37
	Chlorothalonil	Chloronitrile	Chloronitrile	M 05	1,851	867
All chemicals with multi-site activity					**1,938**	**904**
U: Unknown mode of action	Metrafenone	Aryl-phenyl-ketone	Benzophenone	U 08	551	38
All unknown mode of action					**551**	**38**
All fungicides					**14,673**	**1,864**
Area grown					4,380,288	

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

Table 13 Mode of action/chemical group of herbicide active substances on all grass and fodder crops – 2017

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

Mode of Action	Active substance	Chemical Group	HRAC Group	Total Grass and Fodder 2017	Total Grass and Fodder 2017
				ha	kg
Inhibition of acetyl CoA carboxylase	Propaquizafop	Aryloxyphenoxy-propionate 'FOPS'	A	69	10
All inhibition of acetyl CoA carboxylase				**69**	**10**
Inhibition of acetolactate synthase ALS	Amidosulfuron	Sulfonylurea	B	1,049	42
	Metsulfuron-methyl	Sulfonylurea	B	399	1
	Nicosulfuron	Sulfonylurea	B	31	1
	Thifensulfuron-methyl	Sulfonylurea	B	630	7
	Tribenuron-methyl	Sulfonylurea	B	4,322	25
	Triflusulfuron-methyl	Sulfonylurea	B	771	12
	Florasulam	Triazolopyrimidine	B	745	3
All inhibition of acetolactate synthase ALS				**7,947**	**91**
Inhibition of photosynthesis at photosystem II	Chloridazon	Pyridazinone	C1	403	468
	Desmedipham	Phenyl-carbamate	C1	906	59
	Lenacil	Uracil	C1	878	125
	Metamitron	Triazinone	C1	1,013	1,133
	Phenmedipham	Phenyl-carbamate	C1	906	79
	Terbuthylazine	Triazine	C1	131	48

Cont…

Table 13 Mode of action/chemical group of herbicide active substances – 2017 continued

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

Mode of Action	Active substance	Chemical Group	HRAC Group	Total Grass and Fodder 2017	Total Grass and Fodder 2017
				ha	kg
	Bromoxynil	Nitrile	C3	29	1
All inhibition of photosynthesis at photosystem II				**4,268**	**1,914**
Bleaching: Inhibition of carotenoid biosynthesis	Diflufenican	Pyridinecarboxamide	F1	72	12
All bleaching: Inhibition of carotenoid biosynthesis				**72**	**12**
Bleaching:Inhibition of 4-hydroxyphenyl-pyruvate-d	Mesotrione	Triketone	F2	102	10
All bleaching:Inhibition of 4-hydroxyphenyl-pyruvate-d				**102**	**10**
Bleaching: DOXP inhibitors	Clomazone	Isoxazolidinone	F4	784	49
All bleaching: DOXP inhibitors				**784**	**49**
Inhibition of EPSP synthase	Glyphosate	Glycine	G	6,083	8,319
All inhibition of EPSP synthase				**6,083**	**8,319**
Microtubule assembly inhibition	Pendimethalin	Dinitroaniline	K1	939	954
All microtubule assembly inhibition				**939**	**954**
Inhibition of DHP	Asulam	Carbamate	I	6,028	24,817
All inhibition of DHP				**6,028**	**24,817**
Inhibition of VLCFAs	Dimethenamid-P	Chloroacetamide	K3	1,304	599
	Metazachlor	Chloroacetamide	K3	2,392	1,100

Cont…

Table 13 Mode of action/chemical group of herbicide active substances– 2017 continued

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

Mode of Action	Active substance	Chemical Group	HRAC Group	Total Grass and Fodder 2017	Total Grass and Fodder 2017
				ha	kg
	S-metolachlor	Chloroacetamide	K3	63	84
All inhibition of VLCFAs				**3,759**	**1,784**
Inhibition of lipid synthesis	Ethofumesate	Benzofuran	N	954	114
All inhibition of lipid synthesis				**954**	**114**
Action like indole acetic acid	2,4-D	Phenoxy-carboxylic acid	O	6,150	5,934
	2,4-DB	Phenoxy-carboxylic acid	O	5,105	5,678
	MCPA	Phenoxy-carboxylic acid	O	20,560	26,536
	Mecoprop-P	Phenoxy-carboxylic acid	O	280	105
	Aminopyralid	Pyridine carboxylic acid	O	4,436	243
	Clopyralid	Pyridine carboxylic acid	O	8,181	1,236
	Fluroxypyr	Pyridine carboxylic acid	O	22,742	5,646
	Triclopyr	Pyridine carboxylic acid	O	19,831	5,872
	Dicamba	Benzoic acid	O	1,214	138
All action like indole acetic acid				**88,499**	**51,386**
All herbicides				**119,504**	**89,461**
Area grown				4,380,288	

Note: Active substances have been grouped by their mode of action. Full details on mode of action classification can be found on the Herbicide Resistance Action Committee (HRAC) webpage[10]

Table 14 Principal active substances by area treated

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

	Active substance	Type[(1)]	2017	2013	% change
1	Fluroxypyr	H	22,742	12,112	88
2	MCPA	H	20,560	16,765	23
3	Triclopyr	H	19,831	8,776	126
4	Clopyralid	H	8,181	3,469	136
5	Asulam	H	6,028	5,758	5
6	2,4-D	H	6,150	7,636	-19
7	Glyphosate	H	6,083	6,857	-11
8	2,4-DB	H	5,105	9,135	-44
9	Prothioconazole	F/S	5,026	7,547	-33
10	Thiram	S	4,585	5,583	-18
11	Aminopyralid	H	4,436	4,821	-8
12	Tribenuron-methyl	H	4,322	9,155	-53
13	Thiamethoxam	S	3,438	3,623	-5
14	Metazachlor	H	2,392	3,816	-37
15	Trifloxystrobin	F	2,247	3,257	-31
16	Chlorothalonil	F	1,851	2,754	-33
17	Tebuconazole	F/S	1,805	3,129	-42
18	Dimethenamid-P	H	1,304	0	
19	Dicamba	H	1,214	3,323	-63
20	Fluoxastrobin	F	1,171	2,036	-43

Table 15 Principal active substances by weight

Weight (kg) of the 20 most used active substances on all grass and fodder crops surveyed

	Active substance	Type[(1)]	2017	2013	% change
1	MCPA	H	26,536	19,764	34
2	Asulam	H	24,817	24,885	<0.5
3	Glyphosate	H	8,319	10,785	-23
4	2,4-D	H	5,934	9,517	-38
5	Triclopyr	H	5,872	2,219	165
6	2,4-DB	H	5,678	10,695	-47
7	Fluroxypyr	H	5,646	2,478	128
8	Clopyralid	H	1,236	492	151
9	Metamitron	H	1,133	499	127
10	Metazachlor	H	1,100	2,385	-54
11	Pendimethalin	H	954	1,800	-47
12	Chlorothalonil	F	867	1,154	-25
13	Dimethenamid-P	H	599	0	
14	Chloridazon	H	468	174	170
15	Prothioconazole	F/S	331	570	-42
16	Aminopyralid	H	243	251	-3
17	Chlormequat	G	194	403	-52
18	Fenpropimorph	F	167	311	-46
19	Dicamba	H	138	292	-53
20	Thiram	S	131	167	-21

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

Table 16 Grassland and rough grazing, comparison with previous years

Pesticide usage in 2009, 2013 and 2017, area treated with formulations, active substances (a.s.) and weight (kg) applied

	2009			2013			2017		
	Formulations	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**
	ha	**ha**	**kg**	**ha**	**ha**	**kg**	**ha**	**ha**	**kg**
Insecticides	3,537	3,537	259	5,811	5,811	4,113	69	69	<0.5
Molluscicides	191	191	54	179	179	27	0	0	0
Fungicides	39,203	56,471	7,754	12,081	22,127	2,508	7,065	12,873	1,656
Sulphur	669	669	4,793	0	0	0	0	0	0
Herbicides	98,378	168,807	112,478	66,602	86,020	78,348	79,274	104,770	81,815
Growth regulators	624	1,223	162	721	914	270	606	764	250
Seed treatments	488	488	48	1,490	1,490	53	925	925	83
All pesticides	**142,602**	**230,898**	**125,500**	**86,884**	**116,541**	**85,319**	**87,939**	**119,401**	**83,804**
Area grown		4,630,016			4,400,870			4,363,985	

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 weight applied

Table 17 Fodder crops, comparison with previous years

Pesticide usage in 2009, 2013 and 2017, area treated with formulations, active substances (a.s.) and weight (kg) applied

	2009			2013			2017		
	Formulations	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**	**Formulations**	**a.s.**	**Weight**
	ha	**ha**	**kg**	**ha**	**ha**	**kg**	**ha**	**ha**	**kg**
Insecticides	2,591	2,591	261	1,796	1,796	413	897	897	9
Molluscicides	373	373	42	126	126	25	140	140	26
Fungicides	3,512	5,819	894	6,030	10,312	1,553	885	1,800	208
Sulphur	183	183	440	49	49	197	0	0	0
Herbicides	18,835	26,550	15,871	17,574	23,658	11,769	11,074	15,631	7,647
Growth Regulators	608	832	71	658	658	228	0	0	0
Seed treatments	17,025	25,648	785	15,703	19,907	557	11,265	14,020	222
All pesticides	**43,127**	**61,996**	**18,364**	**41,935**	**56,505**	**14,740**	**24,262**	**32,488**	**8,111**
Area grown		22,838			19,524			16,304	

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 weight applied

Appendix 2 – Survey statistics

Census and sample information

Table 18 Regional distribution of grassland and rough grazing crop areas in 2017

Census area (ha) of grassland and rough grazing grown in Scotland

	Highlands & Islands	Caithness & Orkney	Moray Firth	Aberdeen	Angus	East Fife	Lothian
Grass under 5 years	12,957	13,593	18,995	43,037	16,698	5,453	6,546
Grass over 5 years	212,766	73,288	58,709	98,258	33,103	19,399	23,210
Rough grazing	2,181,114	76,911	161,429	47,374	39,743	2,735	19,169

	Central Lowlands	Tweed Valley	Southern Uplands	Solway	Scotland 2017	Scotland 2013	% change
Grass under 5 years	30,878	17,439	11,459	29,199	**206,254**	439,061	-53
Grass over 5 years	242,220	63,081	130,240	158,278	**1,112,553**	882,165	26
Rough grazing	137,301	30,507	280,799	60,532	**3,037,615**	3,064,184	-1

Table 19 Regional distribution of fodder crop areas in 2017

Census area (ha) of fodder crops grown in Scotland

	Highlands & Islands	Caithness & Orkney	Moray Firth	Aberdeen	Angus	East Fife	Lothian
Fodder beet	31	*	*	19	*	121	38
Fodder rape	258	113	324	245	76	29	61
Kale & cabbage	61	*	229	327	154	92	118
Turnips & swede	275	132	876	1,524	312	58	67
Maize	*	*	*	*	*	*	*
Other stock-feeding crops	633	756	601	1,180	411	88	303

	Central Lowlands	Tweed Valley	Southern Uplands	Solway	Scotland 2017	Scotland 2013	% change
Fodder beet	98	*	2	141	611	465	32
Fodder rape	255	234	292	121	2,007	2,102	-5
Kale & cabbage	230	266	220	200	1,915	1,802	6
Turnips & swede	221	127	153	63	3,806	4,106	-7
Maize	84	13	*	*	792	1,406	-44
Other stock-feeding crops	839	623	284	1,115	6,834	9,106	-25

*Regional data have not been provided in order to prevent disclosure of information relating to fewer than five holdings
Note: 'other stock-feeding crops' include arable silage, red clover, swedes, kale, stubble turnips and fodder crop mixes

Table 20 Distribution of grassland sample - 2017

Number of holdings surveyed in each region and size group

Size[1] (ha)	H&I[2]	C&O[2]	Moray Firth	Abdn[2]	Angus	East Fife	Lothian	Central Low-lands	Tweed Valley	S. Uplands[2]	Solway	Scotland
0.1 - 19.9	16	4	5	9	4	1	1	8	3	2	2	**55**
20.0 - 49.9	14	10	10	15	6	1	2	12	4	2	5	**81**
50.0 - 99.9	16	9	7	17	3	5	2	25	6	6	24	**120**
100.0 - 149.9	12	7	3	14	2	0	2	22	3	12	15	**92**
150.0 +	18	18	7	8	4	4	1	29	18	25	31	**163**
All sizes	**76**	**48**	**32**	**63**	**19**	**11**	**8**	**96**	**34**	**47**	**77**	**511**

Table 21 Distribution of fodder sample - 2017

Number of holdings surveyed in each region and size group

Size[1] (ha)	H&I[2]	C&O[2]	Moray Firth	Abdn[2]	Angus	East Fife	Lothian	Central Low-lands	Tweed Valley	S. Uplands[2]	Solway	Scotland
0.1 - 4.9	8	4	6	8	2	1	1	2	1	1	2	**36**
5.0 - 9.9	5	5	8	15	5	1	2	6	3	4	4	**58**
10.0 - 14.9	2	2	3	5	3	1	2	4	3	3	5	**33**
15.0 - 19.9	2	2	2	4	1	0	0	3	3	1	7	**25**
20.0 +	3	0	5	3	2	0	3	2	5	1	7	**31**
All sizes	**20**	**13**	**24**	**35**	**13**	**3**	**8**	**17**	**15**	**10**	**25**	**183**

(1) Size refers to the area of fodder crops grown on the holding
(2) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, S. Uplands = Southern Uplands

Table 22 Sampled area of grassland - 2017

Area (ha) of grassland and rough grazing in the sample

	H&I[1]	C&O[1]	Moray Firth	Abdn[1]	Angus	East Fife	Lothian	Central Low-lands	Tweed Valley	S. Uplands[1]	Solway	Total
Grassland	9,924	7,655	5,483	9,447	3,788	1,991	2,302	13,113	8,581	12,300	14,199	88,783
Rough grazing	51,155	5,430	2,535	4,914	2,633	61	853	9,512	2,388	11,634	5,488	96,602

Table 23 Census area of grassland - 2017

Area (ha) of grassland and rough grazing in Scotland

	H&I[1]	C&O[1]	Moray Firth	Abdn[1]	Angus	East Fife	Lothian	Central Low-lands	Tweed Valley	S. Uplands[1]	Solway	Scotland
Grassland[2]	225,723	86,881	77,704	141,295	49,801	24,852	29,756	273,098	80,520	141,699	187,477	1,318,807
Rough grazing	2,181,114	76,911	161,429	47,374	39,743	2,735	19,169	137,301	30,507	280,799	60,532	3,037,615

(1) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, S. Uplands = Southern Uplands
(2) These areas do not include the estimated 7,563 hectares of undersown grass as this is not recorded on the census (refer to Appendix 3)
Note: Data taken from the 2017 June Agricultural Census [11]

Table 24 Sampled area of fodder crops - 2017

Area (ha) of fodder crops grown in the sample

Size[1] (ha)	H&I[2]	C&O[2]	Moray Firth	Abdn[2]	Angus	East Fife	Lothian	Central Low-lands	Tweed Valley	S. Uplands[2]	Solway	Total
0.1 - 4.9	11	12	19	27	5	5	5	7	5	4	7	**107**
5.0 - 9.9	48	32	67	103	40	46	14	44	25	44	27	**491**
10.0 - 14.9	25	25	43	61	33	13	23	52	43	37	71	**425**
15.0 - 19.9	35	32	26	69	13	0	0	59	55	6	115	**411**
20.0 +	66	0	113	65	49	0	68	19	153	21	211	**766**
All sizes	**185**	**101**	**268**	**324**	**140**	**65**	**109**	**181**	**281**	**113**	**432**	**2,200**

(1) Size refers to the area of fodder crops grown on the holding
(2) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, S. Uplands = Southern Uplands

Table 25 Census area of fodder crops - 2017

Area (ha) of fodder crops grown in Scotland

Size[1] (ha)	H&I[2]	C&O[2]	Moray Firth	Abdn[2]	Angus	East Fife	Lothian	Central Low-lands	Tweed Valley	S. Uplands[2]	Solway	Scotland[3]
0.1 - 4.9	419	339	509	887	172	79	42	309	144	105	161	**3,165**
5.0 - 9.9	308	408	538	1,040	392	167	116	553	270	304	513	**4,611**
10.0 - 14.9	272	99	354	520	211	82	113	351	347	132	564	**3,047**
15.0 - 19.9	106	65	216	323	50	49	17	208	256	245	323	**1,856**
20.0 +	165	106	456	526	246	21	299	306	303	179	680	**3,286**
All sizes	**1,270**	**1,017**	**2,073**	**3,296**	**1,071**	**398**	**587**	**1,727**	**1,320**	**964**	**2,241**	**15,965**

(1) Size refers to the area of fodder crops grown on the holding
(2) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, S. Uplands = Southern Uplands
(3) These areas do not include the estimated 339 hectares of stubble turnips as this is not recorded on the census (refer to Appendix 3)
Note: Data taken from the 2017 June Agricultural Census [11]

Table 26 Raising factors for grassland - 2017

	H&I[1]	C&O[1]	Moray Firth	Abdn[1]	Angus	East Fife	Lothian	Central Low-lands	Tweed Valley	S. Uplands[1]	Solway
Grassland	23.08	11.67	14.83	15.56	13.69	12.72	13.50	21.09	9.67	11.65	13.44
Rough grazing	42.64	14.16	63.68	9.64	15.09	44.51	22.48	14.43	12.77	24.14	11.03

(1) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, S. Uplands = Southern Uplands
Note: Raising factors are calculated by comparing the sampled crop area to the census crop area. Please see Appendix 4 – survey methodology for a full explanation

Table 27 Raising factors for fodder crops- 2017

	H&I[1]	C&O[1]	Moray Firth	Abdn[1]	Angus	East Fife	Lothian	Central Low-lands	Tweed Valley	S. Uplands[1]	Solway
0.1 - 4.9	36.50	27.80	27.42	33.27	35.09	16.05	8.77	47.22	29.51	23.30	22.25
5.0 - 9.9	6.46	12.63	7.97	10.09	9.75	3.61	8.46	12.52	10.97	6.90	18.78
10.0 - 14.9	10.85	4.02	8.30	8.59	6.35	6.22	5.01	6.72	8.11	3.59	7.94
15.0 - 19.9	2.99	2.01	4.04	4.71	3.94	N/A	N/A	3.52	4.64	40.39	2.80
20.0 +	2.52	N/A	7.73	8.03	5.02	N/A	4.38	15.84	1.98	8.45	3.22

(1) H&I = Highlands & Islands, C&O = Caithness & Orkney, Abdn = Aberdeen, S. Uplands = Southern Uplands
N/A = not applicable
Note: Raising factors are calculated by comparing the sampled crop area to the census crop area. Please see Appendix 4 – survey methodology for a full explanation

Table 28 First and second adjustment factors - 2017

	H&I[1]	C&O[1]	Moray Firth	Abdn[1]	Angus	East Fife	Lothian	Central Low-lands	Tweed Valley	S. Uplands[1]	Solway	Adj 2
Grass under 5 years	0.60	0.80	0.97	0.92	1.28	0.78	0.59	1.16	0.96	0.66	0.98	1.00
Grass over 5 years	1.03	1.02	0.96	1.00	0.88	1.07	1.21	0.97	0.98	1.03	0.99	1.00
Rough grazing	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00	1.00
Fodder rape	0.57	1.72	0.77	0.43	0.92	N/A	1.45	1.10	0.73	2.57	2.99	1.01
Fodder beet	0.93	N/A	N/A	0.65	N/A	1.07	N/A	0.55	N/A	N/A	2.15	1.49
Kale and cabbage	0.34	0.29	0.98	1.49	1.13	N/A	0.56	0.62	1.00	0.92	2.06	1.05
Maize	N/A	N/A	N/A	N/A	N/A	N/A	N/A	3.61	N/A	N/A	0.86	1.16
Turnip and Swedes	2.67	0.94	0.66	1.07	0.84	0.73	1.56	0.45	1.00	2.68	0.51	1.00
Other Fodder	1.26	1.17	1.81	1.24	0.88	0.77	1.10	2.66	1.03	0.51	0.93	1.00

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

Response rates

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

Table 29 Response rate - Grassland postal survey

	2017	% total
Target sample (no. of forms sent out)	1,335	100
Total achieved (no. of returns)	**511**	**38**
Total number of non-returns	824	
Total number of farms approached	1,335	

Table 30 Response rate - Fodder

	2017	% total
Target sample	200	100
Total achieved	**183**	**92**
Total number of refusals/non-contact	100	
Total number of farms approached	283	

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.

The grassland survey was carried out by postal questionnaire, so required no visits and very few telephone calls. The fodder survey was carried out by telephone and email without any visits.

All respondents to the grassland postal survey were asked how long it had taken for them to fill out the survey form. Out of 511 respondents, 461 provided this information (90 per cent). The median time taken to provide the information for the grassland survey was 10 minutes.

The time taken to provide the data requested was recorded for 176 respondents to the fodder survey (96 per cent). The median time taken to provide information for the fodder survey was 10 minutes.

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

Burden (£) = No. surveyed x median time taken (hours) x typical hourly rate* (* using median “Full Time Gross” hourly pay for Scotland of £13.98) [12]

The total financial burden, accounting for all farmers’ participation in the 2017 grassland survey was £1074 and for the fodder survey was £410. Therefore, the overall financial burden to growers for 2017 survey participation was £1484

Appendix 3 - Definitions and notes

1) '**Pesticide**' is used throughout this report to include commercial formulations containing active substances (a.s.) used as herbicides, fungicides, insecticides, molluscicides, biological control agents, biopesticides, 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).

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.

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) **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.

11) **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.

12) 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.

13) 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 (Tables 2 to 9). 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.

14) 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.

15) The **June Agricultural Census**[11] is conducted annually by the Scottish Government's Rural and Environmental Science Analytical Services (RESAS). The June Agricultural Census collects data on land use, crop areas, livestock and the number of people working on agricultural holdings. For this report the June Agricultural Census was used to draw a sample of famers growing the relevant crops to participate in the survey

16) 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.

17) The census category '**grass under five years old**' includes the survey categories '**direct sown grass**' and '**grass one to four years old**'. For this survey, direct sown grass is grass that has been sown either in autumn 2016 or spring 2017 without a nurse crop. **Undersown grass** is grass that has been sown with a nurse crop, to aid establishment of the grass. As undersown grass is not included in the 'grass under five years old' census category, the area grown is estimated by multiplying the area encountered in the sample by the grassland raising factors. **Rough grazing** is uncultivated grazing land, such as mountain, hill or moor. Where '**grassland**' is stated in the text, this refers to all grass under five years and grass over five years. It does not include rough grazing.

18) **Stubble turnips** are not included in the fodder crop census category; the area grown is estimated by multiplying the area encountered in the sample by the fodder crop raising factors.

19) '**Other fodder**' consists of any crops other than arable silage, reported in the 'other stock crops for stock-feeding' category. In 2017 this includes red clover, swedes, kale, stubble turnips and fodder crop mixes.

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 2009[4] and 2013[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 to take into account that there may be 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 chemical group on at least ten per cent of the area grown. The average number of applications is calculated only on the areas using each pesticide group and therefore the minimum number of applications is always going to be one. Several pesticides may be applied as a tank mix as part of the same spray event; therefore the average number of pesticide sprays reported is less than the sum of sprays of each chemical group.

24) 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 farmer, 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.

25) 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.

26) **Integrated pest management** The sustainable use directive[13] defines IPM as; "'integrated pest management' means careful consideration of all available plant protection methods and subsequent integration of appropriate measures that discourage the development of populations of harmful organisms and keep the use of plant protection products and other forms of intervention to levels that are economically and ecologically justified and

reduce or minimise risks to human health and the environment. 'Integrated pest management' emphasises the growth of a healthy crop with the least possible disruption to agro-ecosystems and encourages natural pest control mechanisms."

Appendix 4 – Survey methodology

Sampling and data collection

Using the June 2017 Agricultural Census [(11)] (Tables 23 & 25), two samples were drawn. The first sample was taken from holdings with grassland (Table 20), the second from holdings growing fodder crops (Table 21). For the purpose of sampling, the country was divided into 11 land–use regions (Figure 37). The sample was stratified by these regions and also according to holding size. The holding size groups were different for grassland and fodder crops (Table 20 & 21) and were based on the total areas of crops grown on the holding. Holdings were chosen at random within each of these strata, with the numbers of holdings selected being proportional to the total area of crops grown. Sample sizes for each stratum were based on area rather than number of holdings, so that smaller holdings did not dominate the sample.

The survey period for pesticide applications to grassland was from August 2016 to August 2017. For fodder crops, the survey period covered pesticide applications during the 2017 growing season, including any post-harvest applications following the 2016 harvest through to the end of harvest in 2017. As well as recording treatments applied directly to the crop, land preparation treatments prior to sowing the crop were also collected.

For holdings in the fodder sample, an introductory letter was sent to farmers followed up by a telephone call. The majority of information was gathered during this telephone call, although some holdings required a subsequent telephone call or email. When necessary, data were also collected from consultant agronomists, contractors and seed merchants. In addition to information about fodder crops, pesticide use data were also collected for grassland crops grown on holdings selected in the fodder sample. In total, data were collected from 183 fodder holdings. These 183 holdings collectively grew 14 per cent of the census fodder area. Details of the distribution of the fodder sample can be found in Table 21.

Postal questionnaires were sent to holdings selected in the grassland sample. This postal survey supplemented the grassland data collected during the fodder survey. This combined dataset ensures that the proportionately large areas of grassland grown in Scotland are adequately represented in the survey. Of 1,335 questionnaires sent out there were 511 (38 per cent) useable responses (Table 29). Details of the distribution of the grassland sample can be found in Table 20. The grassland sample represented seven per cent of the total grassland grown in Scotland and three per cent of the total rough grazing.

For both samples, the data collected included the area of grassland and/or fodder crops grown, selected agronomic information and a record of the area and weight of all pesticide applications. Holdings that were not able or not

willing to provide data were replaced with alternative holdings from the same region and size group.

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 26 & 27). These factors were calculated by comparing the sampled area to the areas recorded in the 2017 Agricultural Census within each region and size group. Grassland is raised only by region, size groups are not taken into account. An adjustment (Table 28) 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.

Changes from previous years

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

In 2015 there was a change in the census definition of temporary and permanent grass on the Single Application Form (SAF). This change is explained in clause 4.8 of the 2017 Scottish agriculture census[(11)]. From 2015, temporary grass relates to whether it has been reseeded in the last five years, whereas previously it related to how long it had been used for grass. The new definition only includes land that is included in a holding's crop rotation. This means changes in grass one to four years and grass over five years between 2013 and subsequent surveys do not solely represent genuine changes in land use, but include differences in the way crop data has been recorded. As sampled areas are raised to census areas this will also influence our estimates of pesticides used. Whilst it is not possible to quantify the impact of these changes, data users should be aware of them when making comparisons of total pesticide use over time. To aid interpretation, the trends section presents pesticide usage information in relation to crop area grown as well as overall estimates of use.

The term 'active substance' is now used instead of 'active ingredient' which appeared in previous reports.

Data relating to the average number of applications for each crop and type of pesticide have been included in Table 1.

The areas 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 2-9 and summary active substance data are presented in Tables 11 to 15. 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.

Details relating to pesticide application timings for each crop have been included in the pesticide usage section. Fungicides, herbicides and insecticides have been classified into groups according to their mode of action and chemical group in Tables 11-13.

Data on Integrated Pest Management activities (e.g. non-chemical methods to control pests, weeds and diseases) have been collected from the farmers surveyed as part of the fodder survey and are reported in Appendix 6.

Data quality assurance

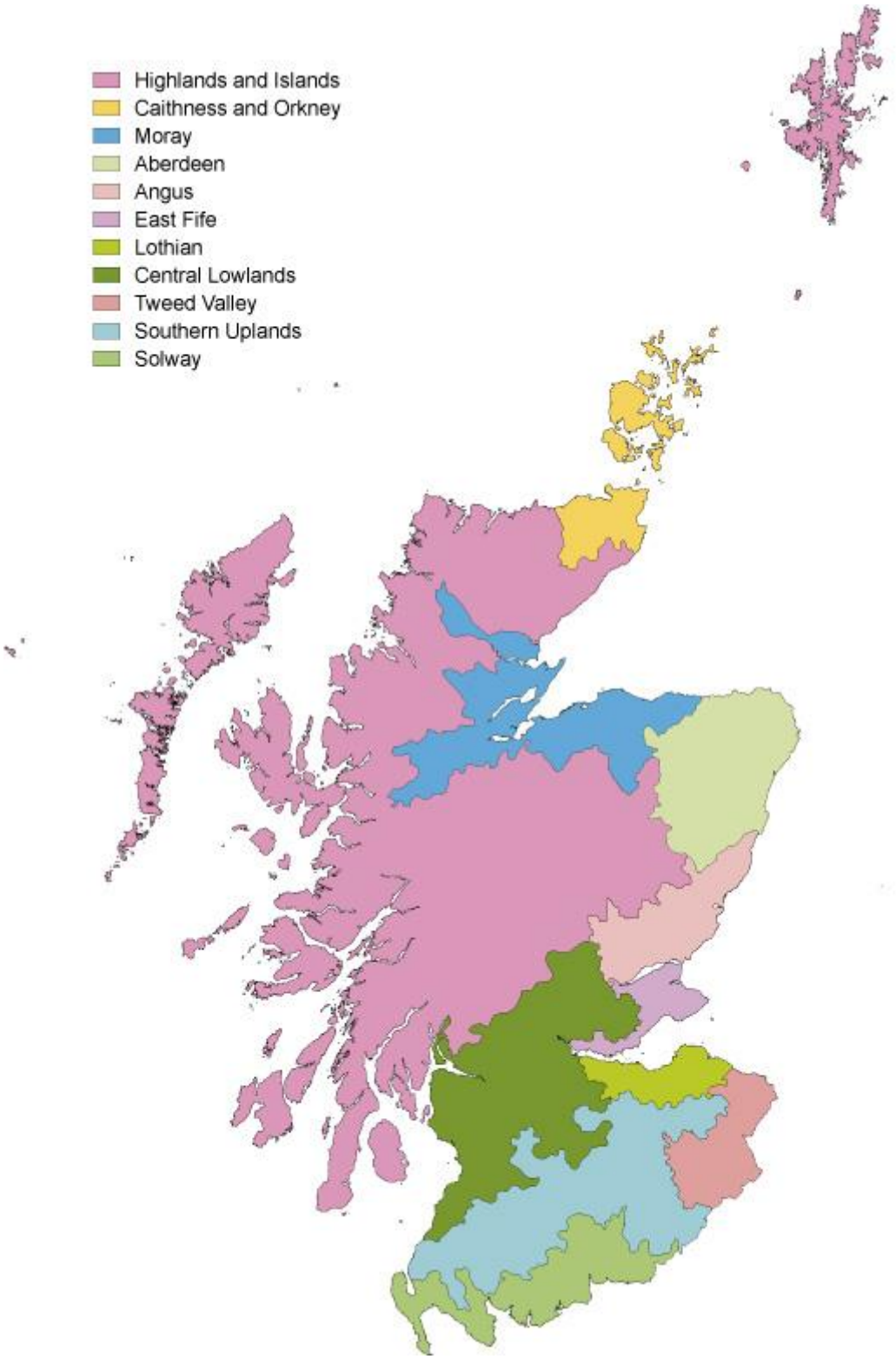
The dataset undergoes several validation processes as follows; (i) checking for any obvious errors upon data receipt (ii) checking and identifying inconsistencies with use and pesticide approval conditions once entered into the database (iii) 100 per cent checking of data held in the database against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

Main sources of bias

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

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

Figure 37 Land use regions of Scotland[14]



Appendix 5 – Standard errors

The figures presented in this report are produced from surveying a sample of holdings rather than a census of all the holdings in Scotland. Therefore the figures are estimates of the total pesticide use for Scotland and should not be interpreted as exact. To give an idea of the precision of estimates, the report includes relative standard errors (RSE) (Table 31). Standard errors are produced using the raising factors. An overall variance was calculated by summing the variance estimates for individual strata (region and size groups) multiplied by the square of their raising factors. These variance estimates include a finite population correction. The overall standard error is calculated from the overall variance by taking its square root. This method of standard estimation was implemented as it is both relatively straightforward and has advantages over ratio estimator methods when within-strata sample sizes are small.

Standard errors are expressed as percentage relative standard errors (Table 31) for both total pesticide use by area treated and for weight applied. Larger relative standard errors mean that the estimates are less precise. A relative standard error of 0 per cent would be achieved by a census. A relative standard error of 100 per cent indicates that the error in the survey is of the same order as the measurement. Relative standard errors may be reduced with larger sample sizes. However, larger relative standard errors can also result from greater variability in pesticides among holdings.

The RSE for estimates of total pesticide use on grassland crops (Table 31) was nine per cent for area and ten per cent for weight. The RSE for total pesticide use for fodder crops was eight per cent for area and 15 per cent for weight. Rough grazing estimates have a particularly high RSE (64 per cent for area and 67 per cent for weight) due to the very low pesticide use on this type of grassland. Total estimates of pesticide use for fodder and grassland have lower standard errors than those for their constituent crops as sample sizes are greater.

Table 31 Relative standard errors

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

	Area SE (%)	Weight SE (%)
Grass Over 5yrs Old	10	11
Grass Under 5yrs Old	14	17
All Grassland	**9**	**10**
Rough Grazing	64	67
Fodder Beet[1]	20	38
Fodder Rape	30	37
Kale and Cabbage[1]	16	12
Maize	24	36
Turnips and Swedes	12	16
Other Stock-feeding Crops[2]	14	37
All Fodder	**8**	**15**

(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 and the overall RSE values should be treated with caution

(2) Other stock-feeding crops include arable silage as well as other fodder crops (red clover, swedes, kale, stubble turnips and fodder crop mixes) all recorded under 'other stock-feeding crops' in the June 2017 Agricultural Census

Appendix 6 – Integrated pest management

It is a requirement of the EU Sustainable use of Pesticides Directive (2009/128/EC)[13] that member states should promote low pesticide input pest management, in particular Integrated Pest Management (IPM).

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

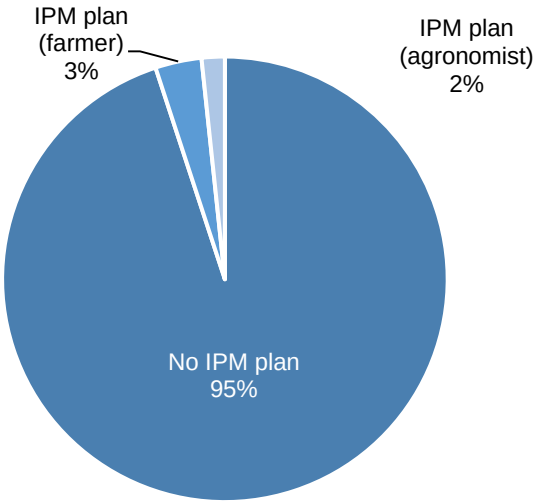
Information about the uptake of IPM measures by Scottish growers was collected alongside the 2017 grass and fodder crop pesticide usage survey. Similar data have been collected for other crop groups in previous years (vegetable crops 2015[15], protected edible crops 2015[16], arable crops 2016[17] and soft fruit crops 2016[18]). In future, we intend to survey IPM uptake in each crop sector every four years. This monitoring programme is designed to describe adoption of IPM techniques in the main crop sectors and inform the Scottish Government of trends in uptake over time. These data can be used as an indicator of the success of Scottish Government funded IPM research, knowledge transfer and promotion activities.

It should be noted that in the main pesticide usage survey two samples are drawn, one based on holdings cultivating fodder crops (from which data are collected by personal interview) and another of holdings cultivating grass (from which data are collected by postal form, Appendix 4). These dual samples ensure that both fodder crops and Scotland's large grass area are adequately represented in the sample. The IPM data presented here were collected only from the fodder proportion of the sample. This reflects that this data collection is more suited to personal interview than postal return and it ensures methodological consistency with previous IPM surveys. The fodder holdings surveyed also cultivated grass and the survey covers the IPM measures implemented on all grass and fodder production on those farms. Unlike the other statistics in this report, the figures reported in this section are not raised to produce national estimates, but represent only the responses of those surveyed. The IPM sample, whilst smaller than that sampled for the pesticide usage survey, represents all Scottish regions and farm size groups.

In total, IPM data was collected from 119 farmers, collectively growing 18,711 ha of crops (17,408 ha grass, 1,302 ha fodder). This sample represents eight per cent of Scotland's 2017 fodder crop area (15,965 ha) and 0.4 per cent of the grass area (4,453,540 ha). Of these growers, 95 per cent did not have an IPM plan, three per cent of farmers completed their own IPM plan and two per cent had a plan completed by an agronomist on their behalf (Figure 38). Using an IPM plan helps growers to make the best possible, and most sustainable, use of all available methods for pest control. Whilst

completion of a plan is voluntary, it also helps growers meet their legal obligation to take reasonable precautions to protect human health and the environment when using pesticides.

Figure 38 Percentage of respondents with an IPM plan – 2017



Farmers were asked about their IPM activities in relation to three categories; risk management, pest monitoring and pest control. Information was collected about all activities each grower conducted in relation to these categories and the responses are reported in the following sections. Despite the fact that the majority of growers did not complete an IPM plan, uptake of a wide range of IPM activities was encountered. The term 'pest' is used throughout to denote diseases, weeds and invertebrate pests.

Risk management

IPM programmes aim to prevent, or reduce, the risk of pests becoming a threat by minimising the likelihood of damage occurring that will require subsequent control. Table 32 presents an overview of the risk management measures adopted by those growers surveyed. Almost all of the growers sampled (97 per cent) reported that they implemented at least one risk management activity.

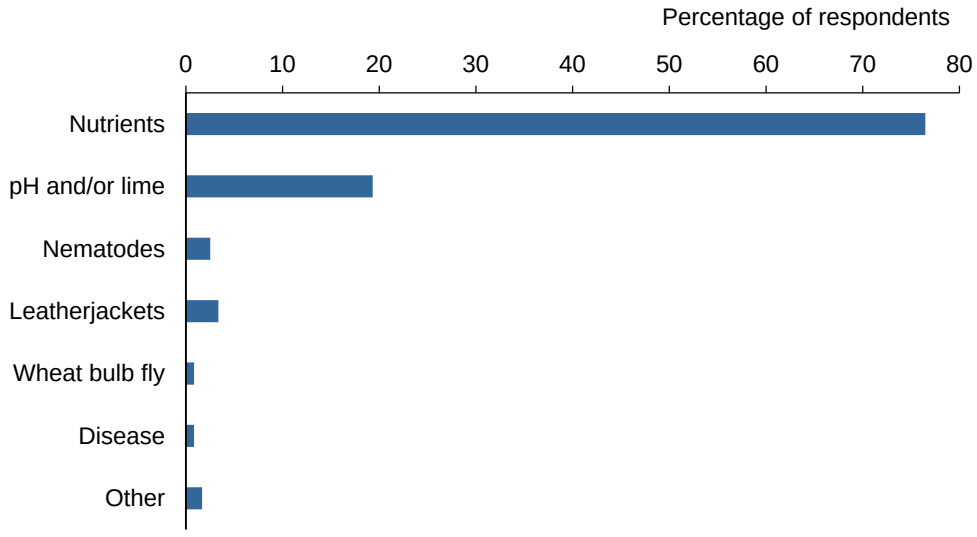
Sixty five per cent of growers used crop rotation to reduce the risk of pest damage. Rotation breaks the link between pest and host, reducing pest population build-up. It can also improve soil fertility and structure, and consequently crop vigour.

Table 32 Summary of responses to IPM risk management questions

Risk management activity	Percentage positive response
Crop rotation	65
Soil testing	84
Cultivation of seed bed	82
Cultivations at sowing	48
Varietal or seed choice	51
Catch and cover cropping	9
Protection or enhancement of beneficial organism populations	57
Any risk management activity	**97**

The majority of growers (84 per cent) tested their soil in order to tailor inputs to improve crop performance (Table 32, Figure 39). By testing for nutritional and pest status, farmers' can make informed decisions about the inputs required and optimal crop choice for their land. Most testing encountered was for soil nutrients (76 per cent) and soil pH and/or lime requirements (soil buffering capacity) (19 per cent). Lower proportions of growers tested for soil pests such as nematodes, leatherjackets and wheat bulb fly (three, three and one per cent respectively) or soil-borne disease (clubroot, one per cent). Soil mapping and testing for earthworm activity were also each reported by one per cent of growers.

Figure 39 IPM: Soil testing - 2017

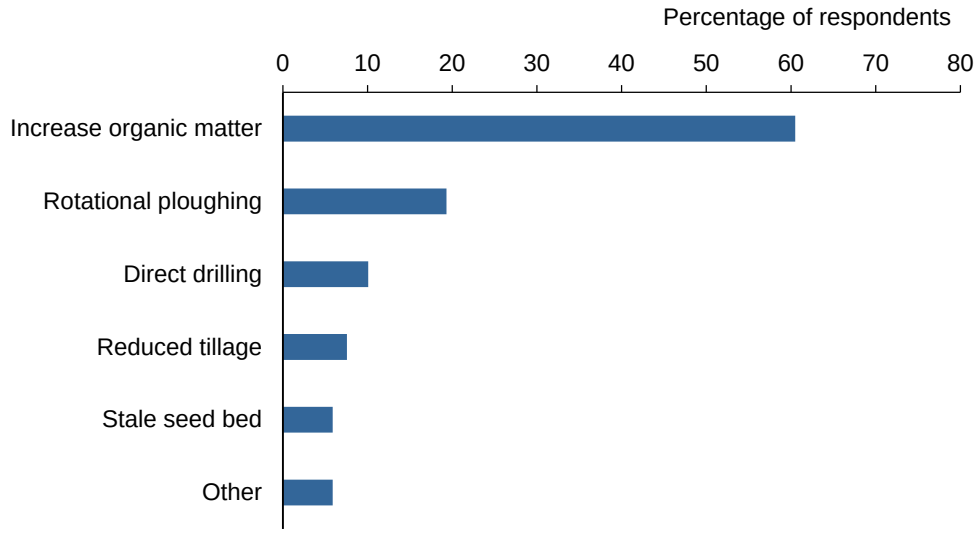


Note: 'other' includes soil mapping and testing for worm activity

The majority of growers (82 per cent) also reported that they managed their seed bed agronomy to improve crop performance and reduce pest risk (Table 32, Figure 40). Sixty one per cent increased soil organic matter. Eight per cent of growers used non-inversion tillage (primarily min till, with one report of strip tillage) and 10 per cent used direct drilling. Non-inversion techniques can preserve soil moisture and organic matter and reduce compaction and erosion. There is also evidence that it is beneficial for populations of earth worms and predatory ground beetles. Nineteen per cent employed rotational ploughing between periods of non-inversion cultivation; rotational ploughing can reduce weed burden and is also used to incorporate organic matter.

Six per cent of growers employed a stale seedbed technique for weed management. Stale seed beds allow weeds to germinate before sowing the next crop, these are treated with a herbicide, depleting the seed bank and resulting in lower weed pressure, and potentially pesticide use, in the succeeding crop. In addition, six per cent of growers reported other seed bed cultivations to improve crop performance, these included using mechanical methods such as disc harrowing, ploughing and rolling to attempt to reduce slug populations, rolling to combat leatherjacket larvae and application of lime to improve soil quality and crop health.

Figure 40 IPM: Seed bed cultivations - 2017

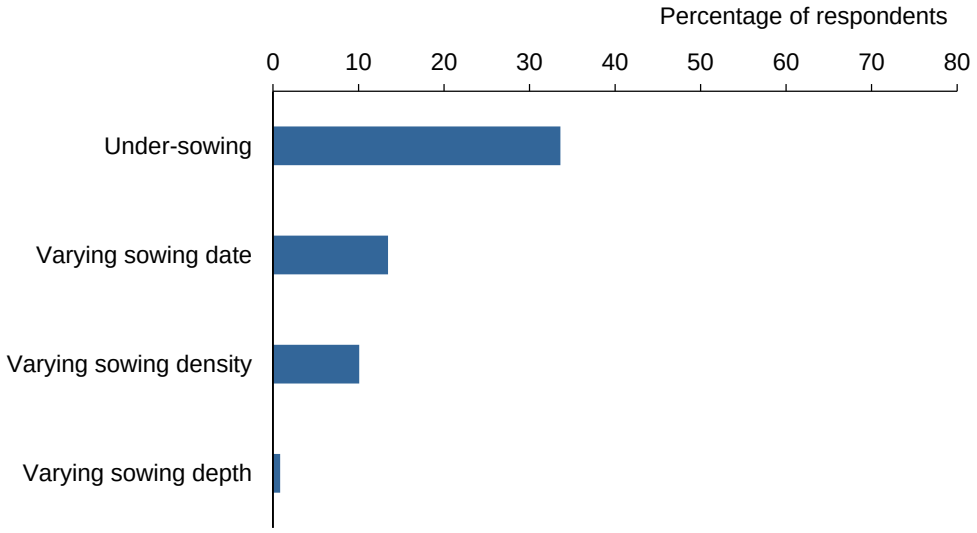


Note: 'other' includes using mechanical methods for slug (harrowing and rolling) and leatherjacket (rolling) control and liming soil

Forty eight per cent of growers amended cultivation methods at sowing with the aim of increasing crop success (Table 32, Figure 41). Thirty four per cent under sowed with a secondary crop. Under sowing can increase soil fertility (when under sown with a nitrogen fixing crop), suppress weeds and provide a host for wildlife. Thirteen per cent varied the timing of sowing to reduce the risk from a range of pests; flea beetles, leatherjackets, pigeons, geese and weeds were all cited as reasons for changes in sowing date.

Some growers (10%) also increased sowing density to mitigate for damage from insect pests (flea beetle and leatherjackets), decrease competition from weeds or in order to improve crop establishment generally. One grower (one per cent of sample) reported that they increased sowing depth to decrease seed loss to pigeons.

Figure 41 IPM: Cultivations at sowing - 2017



Just over half (51 per cent) of growers reported that they considered risk management when selecting seeds and/or varieties (Table 32, Figure 42). Twenty four per cent used certified seed and one per cent tested home saved seed. These actions ensure that seed meets the required quality standards and is pathogen free. Eighteen per cent of farmers selected pest resistant varieties, to reduce damage and the need for pesticide input, and three per cent implemented varietal diversification to increase overall crop resilience to pests and environmental stresses. Twenty two per cent of growers used pesticide seed treatments to protect seedlings at crop emergence.

Only nine per cent of those surveyed sowed cover crops as part of their crop production cycle (Table 32). The cover crops were reported to improve soil quality, by ploughing in as a green manure, and/or to control weeds (seven and five per cent of the sample respectively).

Finally, 57 per cent of growers stated that they adopted techniques to protect or enhance populations of beneficial organisms (Table 32, Figure 43). Thirty one per cent left uncultivated areas, including fallow and grass margins, and five per cent planted wild flower strips. Thirteen per cent took part in an agri-environment scheme; the main scheme reported was the Scottish Government agri-environment climate scheme (AECS) and actions primarily involved cultivation of wild bird seed mixes. A number of additional actions to support beneficial organism populations were also reported, some of which contributed to the Ecological Focus Area (EFA) element of the direct payment

scheme. These additional measures included; planting and maintaining hedges (six per cent) and woodland (three per cent), planting wild bird seed crops (three per cent) and maintaining species rich unimproved grassland (five per cent). Other minor categories included beetle banks, conservation grazing, protecting ground nesting birds and maintenance of ponds (five per cent in total).

Figure 42 IPM: Variety and seed choice – 2017

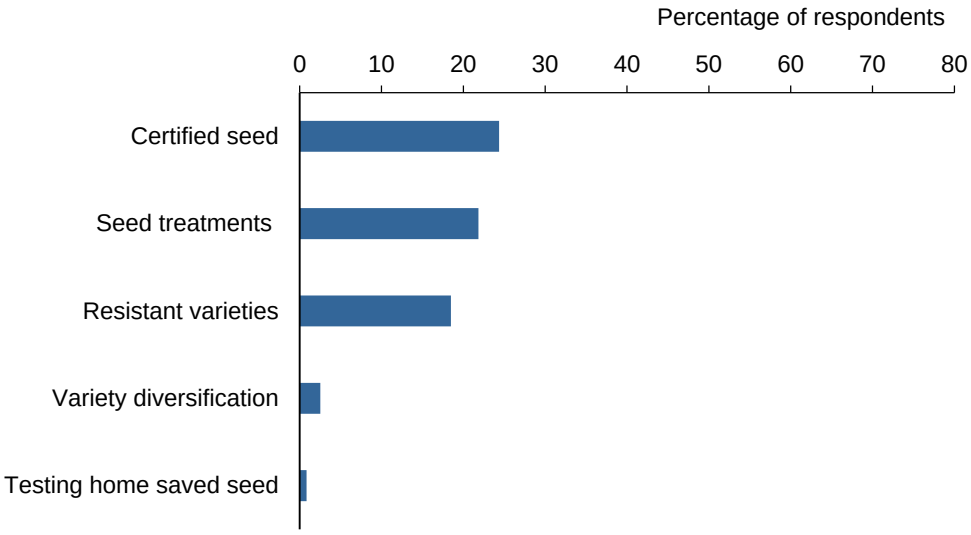
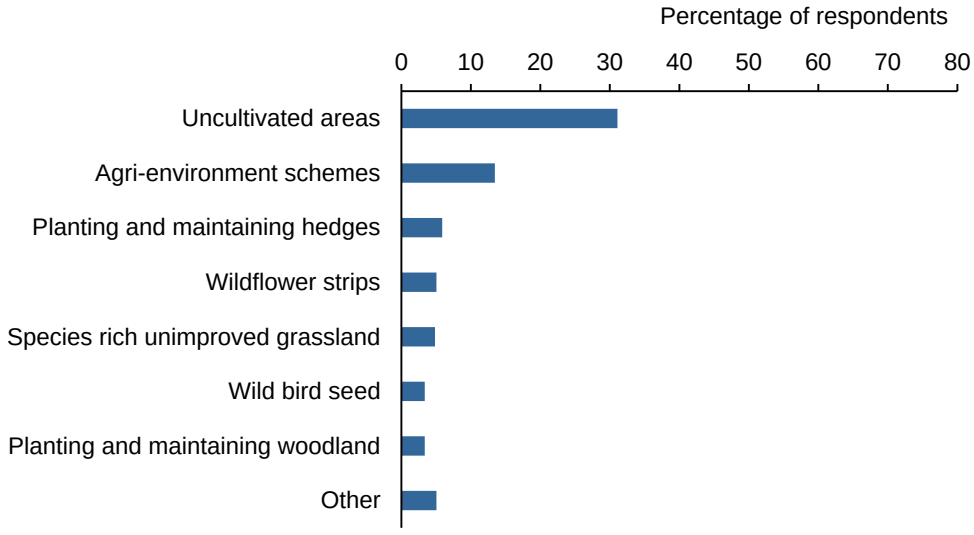


Figure 43 IPM: Protection and enhancement of beneficial organism populations – 2017



Note: 'other' includes established beetle banks, conservation grazing, protecting ground nesting birds and maintenance of ponds

Pest monitoring

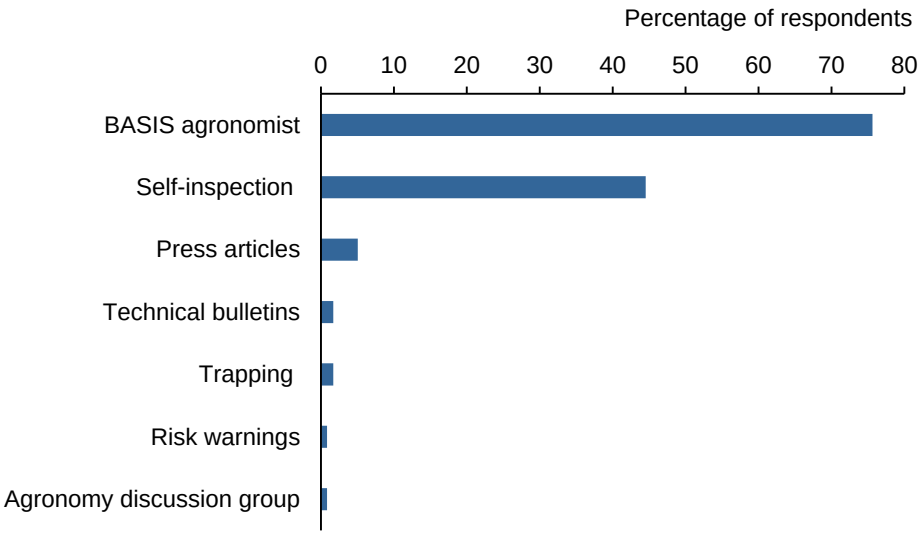
In IPM, pests are monitored both to determine whether control is economically justified and to effectively target control options. IPM programmes aim to monitor and identify pests, so that appropriate control decisions can be made in conjunction with action thresholds. Table 33 presents an overview of the pest monitoring measures adopted by the growers surveyed. The majority of the growers sampled (94 per cent) reported that they implemented at least one pest monitoring measure.

Table 33 Summary of responses to IPM pest monitoring questions

Pest monitoring activity	Percentage positive response
Monitor and identify pests	93
Regular monitoring of crop growth stage	81
Setting action thresholds for crops	18
Use of specialist diagnostics	17
Any pest monitoring activity	**94**

Ninety three per cent of growers reported that they regularly monitored and identified pests and 81 per cent regularly monitored crop growth stages (Table 33). Pest monitoring information was primarily gained by seeking advice from a BASIS qualified agronomist (76 per cent) and by self-inspection by the grower (crop walking, 45 per cent). Other methods of pest monitoring, adopted by less than five per cent of those surveyed, included; press articles, technical bulletins, trapping, using risk warnings and attending discussion groups (Figure 44).

Figure 44 IPM: Monitoring and identifying pests – 2017



Seventeen per cent of farmers also reported that they used specialist diagnostics when dealing with pests that were more problematic to identify or monitor (Table 33). Thirteen per cent used field or pest mapping (predominately field mapping) to aid crop monitoring. Six per cent of growers used tissue testing services to monitor crop nutritional deficiencies and one per cent used clinic services to identify unknown pests.

Despite reporting regular agronomist inspection and crop walking, uptake of setting action thresholds was lower than encountered in other crop systems (18 per cent), reflecting the lower pesticide input to grass and fodder crops.

Pest control

If monitoring, identification, and action thresholds indicate that pest control is required, and preventive methods are no longer effective or available, IPM programmes aim to evaluate the best control method in relation to effectiveness and risk. Control programmes incorporate non-chemical methods alongside, or instead of, chemical control. The premise of IPM is that chemical pest control should be as targeted as possible and the risk of resistance development should be minimised. The effectiveness of the control programme should be reviewed regularly to gauge success and improved as necessary. Table 34 presents an overview of the pest control measures reported by the farmers surveyed. Ninety seven per cent of the growers sampled adopted at least one IPM pest control activity.

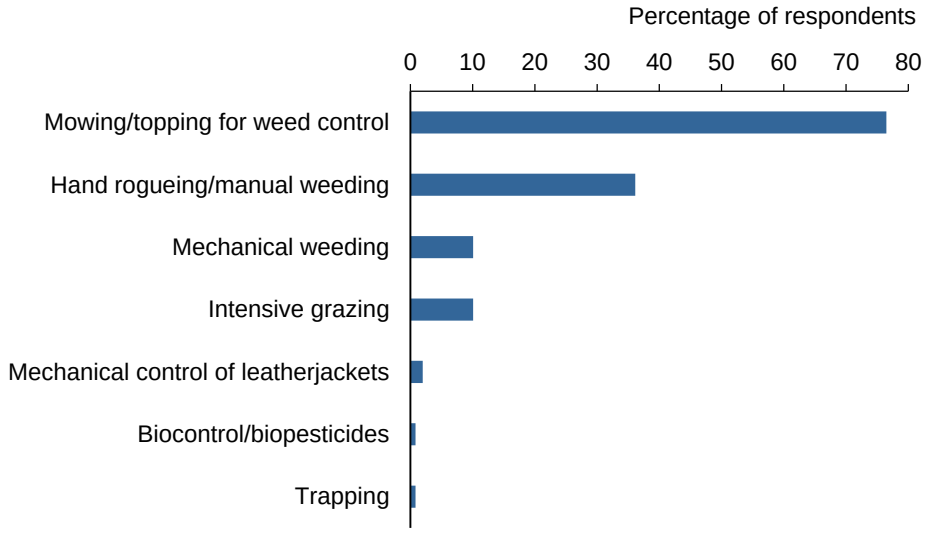
Table 34 Summary of responses to IPM pest control questions

Pest control activity	Percentage positive response
Non-chemical control used in partnership or instead of chemical control	87
Targeted pesticide application	51
Follow anti-resistance strategies	39
Monitor success of crop protection measures	82
Any pest control activity	**97**

Eighty seven per cent of farmers reported that they used non-chemical control in partnership or instead of chemical control (Table 34, Figure 45). The most common non-chemical method employed was mowing/topping grass to control a range of grass weeds (76 per cent). Thistles were the most common weed cited but mowing was also used to control rushes, ragwort, nettles and docks. Just over a third of farmers (36 per cent) used hand rogueing/manual weeding as part of their weed control measures. Hand weeding was primarily employed to control ragwort and wild oats. Some growers also used mechanical weed control (10 per cent). The mechanical control encountered was mostly for inter-row weed control in fodder swede and turnip crops, but was also employed to control rushes, thistles and bracken in grassland. A further 10 per cent of growers used intensive grazing to control weeds, with a single grower using grazing for disease control (removal of disease inoculum).

There was lower uptake of mechanical control of insects (rolling for leatherjacket larvae, two per cent of sample) and pest trapping and use of biocontrol/biopesticides (both one per cent). It should be noted that other mechanical cultivations aimed to control pests (slugs and leatherjackets) are reported in the seed bed cultivation risk management section.

Figure 45 IPM: Non-chemical control – 2017

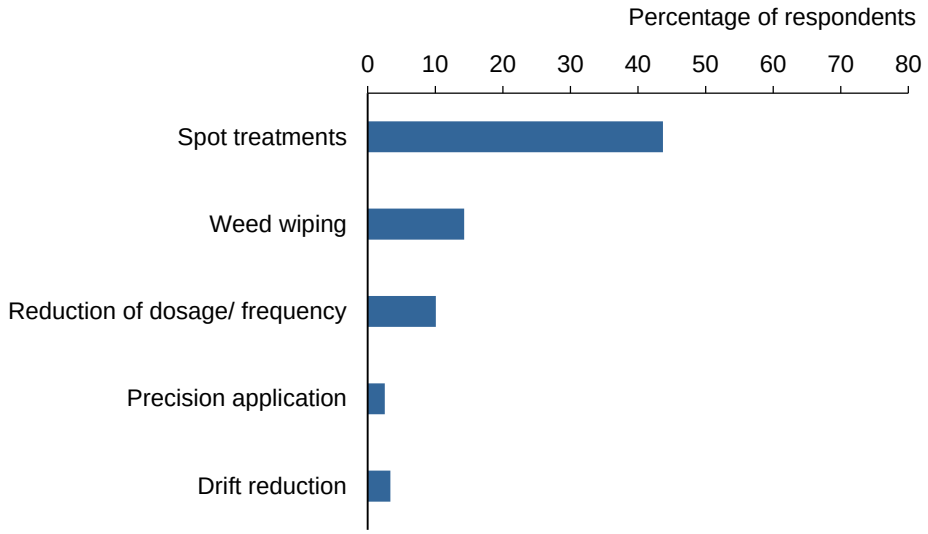


Of the 119 holdings sampled, five (four per cent) were organic. It should also be noted that, even where pesticides are used, pesticide input into grass and fodder crops are far lower, per hectare, than any other crop system. This should be taken into account when considering the responses below.

Fifty one per cent of the growers surveyed stated that they targeted their pesticide applications to reduce pesticide use (Table 34, Figure 46). The most common method reported was use of spot treatments (44 per cent). Spot treatments (applying only to the affected area) were used to combat a range of grassland weeds including thistles, docks, nettles and ragwort. Weed wiping (direct herbicide application to weeds taller than the host crop) was used by 14 per cent of growers, for control of thistles, bracken rushes, nettles and docks. Ten per cent of growers reported that they reduced their dosage or frequency of applications where possible. A further three per cent decreased pesticide application by using drift reduction apparatus and three per cent by precision application systems.

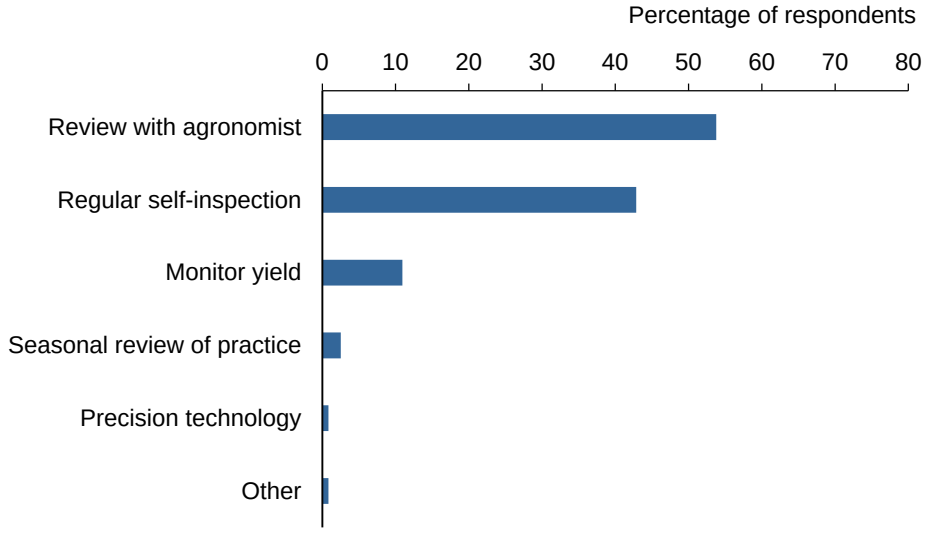
In addition, 39 per cent of farmers stated that they followed anti-resistance strategies when using pesticides, to attempt to minimise the risk of pest resistance development (Table 34). This included 34 per cent minimising the number of pesticide applications used, five per cent using pesticides with multi-site modes of action and three per cent using a range of pesticides with multiple modes of action. Other growers (three per cent) stated that their agronomist provided advice about anti-resistance strategies.

Figure 46 IPM: Targeted pesticide application – 2017



An important aspect of IPM is monitoring the success of risk management and crop protection practices to continually improve regimes. Eighty two per cent of the growers stated that they monitored the success of their crop protection measures (Table 34, Figure 47). This included 54 per cent conducting a regular review with their agronomist, 43 per cent conducting regular self-inspection and 11 per cent monitoring yields as a measure of crop protection success. In addition, lower proportions conducted a seasonal review of crop protection practice (three per cent), used precision technology (in field yield mapping, one per cent) or reviewed input costs (one per cent).

Figure 47 IPM: Monitoring success of crop protection measures – 2017



Note: 'other' is monitoring crop input costs

Acknowledgements

The authors would like to thank all the farmers, agronomists, contractors and seed merchants who agreed to provide information for this survey. The authors would also like to thank Fiona Burnett (SRUC), Sarah Cook, Faye Ritchie and Sacha White (ADAS) and Bashir Surfraz (Fera Science Ltd) for their very helpful comments on the manuscript. In addition, the authors are grateful for the support from Adam Hinchcliffe and his 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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The Scottish Government
St Andrew's House
Edinburgh
EH1 3DG

ISBN: 978-1-78781-232-1 (web only)

Published by The Scottish Government, September 2018

Produced for The Scottish Government by APS Group Scotland, 21 Tennant Street, Edinburgh EH6 5NA
PPDAS452266 (09/18)