Survey of Scottish Winter Oilseed Rape Cultivation in 2014/15: Impact of Neonicotinoid Seed Treatment Restrictions
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Executive summary

This survey was conducted to inform the Scottish Government about the impact of the first year of the neonicotinoid restrictions on Scottish oilseed rape cultivation. Data were collected from a sample of Scottish farmers collectively growing 16 per cent of the 2015 winter oilseed rape (WOSR) crop.

Some of the farmers surveyed stated that the restricted use of neonicotinoid seed treatments influenced their decision not to grow WOSR in 2015, or to reduce the area sown. The total area of oilseed rape grown in Scotland decreased by 3.4 per cent between 2014 and 2015 to 35,198 ha. However, total Scottish oilseed rape production increased by one per cent due to a four per cent increase in yield. Average yield also increased in the surveyed crop in 2015.

A quarter of the growers surveyed made pre-emptive changes in crop cultivation to attempt to mitigate for the absence of insecticidal seed treatments. These integrated pest management strategies were implemented on more than a third of the crop area and were primarily aimed at reducing the impact of cabbage stem flea beetle (CSFB) damage.

According to grower perception, insect pest pressure at crop establishment was generally low to moderate. One third of crops were not treated with foliar insecticides and a majority of growers who did spray applied a single insecticide application. Almost 50 per cent more sprays per grower were made in autumn 2014 than in 2013, when neonicotinoid seed treatments were available. It was acknowledged that some of these sprays were precautionary.

The main target of insecticide use was CSFB and the sprays applied were almost exclusively pyrethroid insecticides. Despite concerns about the resistance status of pests to pyrethroids, the majority of growers did not report problems with the efficacy of their pest control measures.

Autumn insect damage to the crop, which was primarily from CSFB, was reported as low or moderate by most growers. Sixty ha of crop (one per cent of the sample) was redrilled due to CSFB damage.

Based on their experience in the first year of the seed treatment restrictions, more than 80 per cent of growers said that they would continue to grow WOSR in future. The remainder stated that they were less likely or unsure with the majority stating that they would base their decision on economic return.

The absence of neonicotinoid seed treatments made the control of autumn insects more challenging for some growers. However, the impact of the restrictions appears to be less severe in Scotland than has been encountered in England, particularly in the most affected areas in Eastern and South Eastern regions. This may be influenced by lower pest pressure due to cooler climatic conditions and also potentially by lower resistance rates. A further survey is being conducted during the second year of the restrictions.
Introduction

In 2013, the European Commission implemented restrictions on the use of three neonicotinoid insecticides; clothianidin, imidacloprid and thiamethoxam. This action was taken following a series of scientific reviews by the European Food Safety Authority (EFSA) that concluded that there was insufficient information available to fully describe the risk to pollinators from exposure to these active substances\(^1,2,3\).

EU legislation prohibits the use of these three neonicotinoids as seed, soil and foliar treatments on crops considered to be attractive to bees and on spring-grown cereals\(^4\). Exceptions are made for crops grown in greenhouses and for foliar applications made after flowering. Non-professional use of these compounds is also prohibited. The regulation stipulates that, within two years of its enforcement, the European Commission will initiate a review of new scientific information. EFSA is undertaking this review and their findings will be published in January 2017\(^5\). The European Commission will then consider EFSA’s conclusions.

In Scotland, the main effect of the restrictions is the loss of all insecticidal seed treatments for oilseed rape. Due to the uncertainty about the potential effects on Scottish oilseed rape cultivation, a survey was conducted to inform the Scottish Government of the impact on a representative sample of oilseed rape growers.

The Scottish Government (SG) is required by legislation\(^6,7\) 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, Food and Rural Communities Directorate. As an addition to these mandatory surveys, a supplementary survey of growers of winter oilseed rape (WOSR) was conducted alongside the 2014 Pesticide use on arable crops survey\(^8\). The WOSR crops surveyed were sown in 2014 and harvested in 2015. As the restrictions of neonicotinoid seed treatments were imposed in December 2013, the survey coincides with the first WOSR crops sown without insecticidal seed treatments.

Approximately 35,000 hectares (ha) of oilseed rape are grown in Scotland each year, of which around 98 per cent are winter-sown varieties\(^9\). Scottish oilseed rape has a market value of between £30 and £40 million per annum (£35.5 in 2014)\(^10\) and is mainly exported for use as biofuel, with a small amount processed for edible oil\(^11\).

Oilseed rape is an important break crop in arable rotations, providing an alternative cropping system to help suppress the build-up of weeds, disease and insect pests associated with cereals and potatoes. Over the last decade, oilseed rape has been the third most commonly grown combinable crop in Scotland after wheat and barley, accounting for seven to eight per cent of the total crop area\(^9\). During the same period, alternative combinable break crops such as peas and beans collectively accounted for one per cent of the combinable crop\(^9\).
Oilseed rape is host to a wide range of insect pests and crops are at risk of damage throughout the growing season; from seedling emergence through to flowering and seed pod development. The pest pressure oilseed crops are subject to is reflected in their insecticide input in relation to other combinable crops. For crops harvested in 2014, it was estimated that 79 per cent of Scottish WOSR received a foliar insecticide spray, compared with 43 per cent of winter cereal crops and 36 per cent of combinable legumes.

In addition to sprays, use of insecticidal seed treatments to protect crops from insect damage during crop emergence and establishment has historically been an integral part of oilseed rape production. Prior to its withdrawal in 2001, lindane, an organochlorine insecticide, was used as a seed treatment on 60 to 80 per cent of Scottish oilseed crops (Figure 1). The neonicotinoid, imidacloprid was approved for use as a seed treatment in oilseed rape in 2000 and first encountered in Scottish pesticide usage surveys in 2002, when it was estimated to have been applied to 14 per cent of the crop, increasing to 47 and 71 per cent of the crop in 2004 and 2006 respectively. Other neonicotinoids, thiamethoxam and clothianidin were approved for use on oilseed rape crops in 2007 and 2008 respectively and over time have largely replaced the use of imidacloprid. Between 2008 and the implementation of the restrictions, it is estimated that over 80 per cent of Scottish WOSR crops were sown with neonicotinoid treated seed.

The systemic action of neonicotinoid seed treatments, where the insecticide contained in seed treatment is transported throughout the plant’s tissues, protects crops for the first 6 to 8 weeks of emergence and seedling establishment. During this period WOSR crops are vulnerable to damage from cabbage stem flea beetle (CSFB, Psylliodes chrysocephala), whose grazing can cause significant leaf damage and potentially plant loss, particularly when combined with damage by slugs. During autumn, adult CSFB lay eggs near to emerging seedlings and their larvae bore into the stems. This weakens the stems and may cause stunting; in addition the larval feeding tunnels can allow water to enter the plant which may cause winter kill if it freezes. Generally, untreated CSFB causes around one per cent yield loss but this can be greater on backward crops or in warm autumns where populations are large. Other Phyllotreta spp. flea beetles (turnip flea beetle and striped flea beetle) also feed on the cotyledons and first true leaves during crop emergence and can be damaging in dry conditions.

In addition to providing protection against coleopteran pests, neonicotinoid seed treatments also control aphids. Whilst more than one aphid species may be present in the crop, the main threat is from the peach potato aphid (Myzus persicae) which can transmit Turnip Yellow Virus (TuYV) during autumn feeding. TuYV is a significant viral disease of oilseed rape which reduces crop yield. Average yield loss associated with infection is 15 per cent but up to 26 per cent loss has been reported. The symptoms of TuYV are variable; they can resemble drought or nutritional stress and are often inconspicuous. As a consequence, TuYV infection can remain undetected in the crop.
The other main autumn pest is rape winter stem weevil (*Ceutorhynchus picitarsis*). Adult weevils lay eggs on the crop in winter and the larvae overwinter in the plant, feeding in the stems and crown. This can cause production of lateral shoots, crop stunting and, in severe infestations crop death. However, the phenology of this pest results in crop infestation after the period in which neonicotinoid seed treatments provide protection. As a result, stem weevil is not an approved target for these compounds and Scottish growers have historically used a late autumn foliar spray to control this pest when necessary.

As no alternative insecticidal seed treatments are approved for oilseed rape, the remaining control measures for early season insect pests are foliar insecticide sprays. There are operational difficulties associated with sprays. Foliar applications are reliant on time and weather constraints and, if delayed, may be too late to prevent damage, particularly in relation to virus transmission. In addition, sprays also cannot be applied until crops have developed sufficient leaf area and may be of limited use if pest colonisation occurs at cotyledon or first leaf stage. Another major potential limitation of foliar applications is the insecticide resistance status of both CSFB and peach potato aphid to many of the approved insecticides. Resistance to pyrethroid insecticides and the carbamate insecticide pirimicarb is prevalent in the peach potato aphid, limiting control options. In addition, CSFB resistance to pyrethroid insecticides has also recently been confirmed in the UK. This issue has been recognised by the UK regulatory authority and a number of emergency and extension of use authorisations have been made in response to the restrictions, to allow alternative insecticides to be available for autumn use on oilseed rape.

![Figure 1](image)

**Figure 1** Estimated use of insecticidal seed treatment on Scottish oilseed rape crops 1992 to 2014.
Results

Survey sample
A total of 259 arable farmers were contacted in relation to this survey. The majority of those farmers (144, 56 per cent of those contacted) had not grown winter oilseed rape (WOSR) in the previous five years and the crop was not part of their current rotation. No data were collected from these farmers.

A further 19 farmers had grown WOSR in the previous five years but had not sown the crop in 2014. These farmers were asked why they had not included the crop in their 2014/15 rotation. A range of responses were provided, with some farmers giving more than one reason for the decision. The most common responses were that growers had experienced poor yields and/or insufficient profit in the past (53 per cent of respondents), or that they had not sown due to logistical or rotational issues and would sow again in future (37 per cent). Other reasons provided were experience of issues with pests such as slugs and pigeons (21 per cent) or club root (11 per cent). Two respondents (11 per cent) stated that the implementation of the restrictions on neonicotinoid seed treatments had influenced their decision not to sow WOSR in 2014. A variety of alternative break crops, including potatoes, grass, combine peas, oats and vegetable crops, were grown by these farmers.

The remaining 96 farmers had sown WOSR in 2014 and were recruited into the survey. These growers collectively sowed 5,465 hectares (ha) of WOSR, representing 16 per cent of the 2015 Scottish crop. Information was collected about all WOSR crops grown by these farmers, which in some cases were grown on multiple holdings. The areas sampled in each region reflected the geographic distribution of Scottish oilseed rape cultivation (Table 1).

Drilling date and seed rate
All WOSR surveyed was sown between August and September 2014 and harvested in 2015. The majority of crops were sown in August (81 per cent of growers and 77 per cent of the crop area) with most of the crop drilled in the last two weeks of the month (70 per cent of growers and 63 per cent of the crop area) (Table 2).

The seed rate used was dependent on variety, with hybrid varieties being drilled at lower rates than conventional varieties. The median seed rate used by the surveyed growers was 3 kg/ha (range 1.2 to 6 kg/ha).

Operational changes in crop cultivation in response to restrictions
Growers were asked if they had made any pre-emptive changes in crop cultivation techniques in response to the neonicotinoid restrictions, to attempt to mitigate for the absence of insecticidal seed treatments.

Twenty five growers (26 per cent of the sample), collectively growing 2,032 ha and representing 37 per cent of the crop surveyed, reported that they made one or more cultural changes to their 2014 crop (Table 3). The aim of the majority of the adaptations was to reduce the impact of potential CSFB
damage. Eleven per cent of the growers surveyed altered seed rates and seed spacing on 784 ha of crop (14 per cent of sample) to mitigate for potential plant loss from insect damage. Nine per cent of growers amended seed bed cultivations such as implementing minimum tillage, strip tillage or direct drilling in place of ploughing on 886 ha of crop (16 per cent). This was designed to allow a quicker turnaround from harvest of the previous crop and earlier oilseed rape establishment; allowing plants to be able to better withstand and grow away from damage and to reduce the potential for crop loss. A similar rationale was employed by five per cent of growers who amended drilling dates on 308 ha (six per cent) to avoid crops being at a vulnerable stage of development when the risk of flea beetle damage was at its greatest. As well as these precautions taken in relation to flea beetle attack, two growers chose to sow the WOSR variety Amalie on 106 ha (two per cent). Amalie is a variety with resistance to Turnip Yellow Virus (TuYV).

In addition to the operational changes employed in relation to crop cultivation, one grower also reported that they had chosen to reduce the area of WOSR sown by almost 30 per cent; from a planned 700 ha to 500 ha. This was a precaution to avoid potential yield and profit loss if problems related to the restrictions on use of neonicotinoid seed treatments were encountered.

**Grower perception of insect pest pressure in autumn 2014**

Growers rated their perception of aphid and flea beetle populations during crop emergence and establishment; the period when WOSR crops are usually protected by a systemic seed treatment.

Pest numbers were ranked on a scale of low, moderate or high. As this reflects each grower’s personal assessment of population levels, it is a subjective measure and will not be consistent among respondents. To help address this issue, growers were also asked to report what measures they used to assess pest pressure on their crops. A range of responses were provided, with most growers using more than one source of information for their assessment of pest numbers. The majority of growers (83 per cent) relied on advice from agronomists to inform them of pest presence. In addition, 58 per cent of growers based their perception of insect numbers on their own crop walking and inspection. Other sources of information used directly by growers were use of traps and thresholds (seven and nine per cent of the sample, respectively). Seven per cent of growers also reported that their perception of pest populations was informed by the farming media (five per cent) and by technical bulletins produced by advisory bodies such as Scotland’s Rural College (SRUC) and Home Grown Cereals Authority (HGCA).

The majority of growers (70 per cent) reported that aphid populations were either low or that aphids were not seen on the crops. A further 21 per cent reported aphid numbers to be moderate (low/moderate or moderate) and five per cent reported numbers to be high (moderate/high and high) (Figure 2). Information about the species of aphid present was not available; both peach
potato aphids (*Myzus persicae*) and cabbage aphids (*Brevicoryne brassicae*) overwinter in WOSR crops. 

**Figure 2** Grower perception of aphid numbers in autumn 2014

The majority of growers (62 per cent) also reported flea beetle populations to be low or not seen (Figure 3). A further 25 per cent ranked levels as moderate (low/moderate or moderate) and 10 per cent as high (moderate/high or high).

**Figure 3** Grower perception of flea beetle numbers in autumn 2014

Of those growers who reported seeing flea beetles or flea beetle damage on their crops, the majority (51 per cent) identified the species present as cabbage stem flea beetle (CSFB). Three per cent identified them as a mixture of CSFB and *Phyllotreta spp.* flea beetles and four per cent as...
Phyllotreta spp. only. The remaining 42 per cent did not know which species of flea beetle were present in their crops.

**Autumn 2014 insecticide sprays and comparison to 2013**

Data relating to insecticide sprays applied by the growers during autumn 2014 were collected (Figure 4, Table 4). More than a third of growers did not use a foliar insecticide. This equated to 1,887 ha of untreated crop, 35 per cent of the survey area. Another 61 per cent of the growers sprayed at least once on the remaining 3,523 ha.

The majority of growers sprayed only once (54 per cent). These farmers collectively grew 3,133 ha (57 per cent of the surveyed crop). Six per cent of growers sprayed twice and one grower sprayed three times. The total treated area, including these repeated applications to the crop, was 3,955 ha.

In total 67 insecticidal sprays were applied by the growers who provided information; an average of 0.71 sprays per grower (n=95, data not provided by one participant).

![Graph of sprays applied by growers and area receiving sprays](image)

**Figure 4  Autumn insecticide sprays applied in 2014**

Growers were also asked about the number of foliar insecticide applications they used in autumn 2013, the season before the neonicotinoid restrictions were implemented, to allow some comparison of changes in insecticide use.

In 2013, just over half of the growers (53 per cent) did not apply an autumn insecticide spray and 40 per cent sprayed once (Figure 5). The remainder of growers sprayed more than once, with a maximum of two sprays recorded. In total 44 insecticidal sprays were applied by the growers who provided information; an average of 0.48 sprays per grower (n=93, 2013 data not provided by three participants).
Despite the increased number of sprays overall, the majority of growers (59 per cent) applied the same number of sprays as they had in the previous year, eight per cent applied fewer sprays and 31 per cent applied more sprays.

![Autumn insecticide sprays 2013](image)

**Figure 5  Number of autumn insecticide sprays applied in 2013**

Overall, the average number of autumn insecticide sprays applied by the growers surveyed was 0.48 and 0.71 in 2013 and 2014 respectively, representing an increase of almost 50 per cent.

As information on comparative targets, pest pressure and other parameters of the growing season are not available for the two seasons; it is difficult to make a direct comparison of insecticide applications. It should also be noted that some of the sprays applied in autumn 2014 were identified by growers as precautionary (refer to next section). The magnitude of increase in sprays therefore may also be influenced to some extent by concern and uncertainty about crop protection due to the absence of an insecticidal seed treatment. The data presented should be interpreted as an indication of increased insecticide use between these seasons but not necessarily as a direct representation of insecticidal input requirements.

**Reasons for foliar applications and targets of insecticide use**

Growers were asked what information they used when making a decision to apply a foliar insecticide in autumn 2014. A range of responses were provided, with most farmers giving more than one reason for the decision. For those growers who applied sprays, the majority (77 per cent) relied on agronomist advice on whether a spray was required. In addition, 55 per cent of growers were informed by walking their crops, seven per cent used action thresholds and five per cent based the decision on detection of damage in the crop. A further three per cent of growers stated that their decision to spray was influenced by advice from technical bulletins produced by advisory bodies such as SRUC and HGCA and two per cent were influenced by the agricultural media. In addition, seven growers (12 per cent, all of which
applied single sprays) stated that their sprays were precautionary and not based on damage forecasts.

As data were not routinely collected from agronomists, we cannot present information as to the decision making process agronomists followed when providing advice to the farmers. However, it should be noted that as well as advising 77 per cent of those growers applying autumn insecticide sprays, 70 per cent of those farmers who did not spray also received advice from an agronomist.

The target pests of the autumn insecticide sprays are presented in Table 5. Some sprays had more than one target. When the targets are collated together the main focus of the sprays was to control flea beetle, primarily CSFB. Sprays to combat flea beetle accounted for 67 per cent of total sprays, applied to 2,677 ha. Aphids were one of the targets of four per cent of sprays applied to 123 ha. Rape winter stem weevil, which is not an approved target of neonicotinoid seed treatments, was one of the targets for 22 per cent of applications applied to 585 ha. The target was not recorded for 12 per cent of sprays (499 ha).

**Insecticide active substances applied and reported efficacy**

All but one of the specified sprays applied were pyrethroid insecticides (Figure 6 and Table 6). Six pyrethroid active substances were recorded; alpha cypermethrin, cypermethrin, deltamethrin, lambda cyhalothrin, tau-fluvalinate and zeta cypermethrin. Cypermethrin, lambda cyhalothrin and zeta cypermethrin were the most frequently used compounds, together accounting for 79 per cent of sprays applied by growers and 84 per cent of the total spray area. The only non-pyrethroid spray encountered was a single use of acetamiprid, applied to 26 ha. Acetamiprid is a neonicotinoid insecticide not included in the current restrictions, which was given an emergency authorisation for use in autumn 2014 for control of CSFB.

![Spray area of active substances](image)
Growers were consulted as to the effectiveness of the sprays applied and, despite concerns over the pyrethroid resistance status of both peach potato aphid and CSFB, the majority of growers who applied a spray did not report any problems with the efficacy of their pest control measures (84 per cent). Of the nine growers that did encounter problems, the reasons cited included; operational issues with foliar control such as poor weather conditions (two growers), and the time lag between pest and damage detection and spraying (one grower). Two growers cited an inability to achieve direct contact with adult CSFB when they were under stones and soil, making foliar control difficult. Two additional growers reported that they had not achieved sufficient efficacy with the single pyrethroid spray that they applied and one grower stated that problems were encountered due to the limited control options available. The single grower applying acetamiprid reported no problems with control of CSFB using this compound.

**Grower perception of autumn insect damage and crop loss**

Growers rated the overall level of autumn insect damage to their crops as low, moderate or high along with an indication of the species responsible for the damage. As these are subjective assessments, there will be inconsistencies of reporting amongst respondents.

Insect damage during the crop emergence and establishment period of 2014 was rated as low by 63 per cent of growers on 2,798 ha (51 per cent of the sample area). Damage was ranked as low/moderate or moderate by 28 per cent of growers on 2,141 ha (39 per cent of sample area) and high by six per cent of growers on 358 ha (seven per cent of the crop area). Damage incidence was recorded as unknown for the remainder of the sample (three per cent of growers and area).

Those growers reporting high levels of damage all identified flea beetles (CSFB and *Phyllotreta spp.*.) as the species causing the damage. For those reporting moderate damage the majority (63 per cent) also cited flea beetles as the main damage causing species, with 11 per cent citing rape winter stem weevil and a single grower assigning damage to aphids. The remaining growers did not provide data on the species causing damage.

Growers were also asked whether they thought that the lack of seed treatment in 2014 resulted in greater autumn insect damage to their crops than in previous years, when seed treatments were available. Forty six per cent of growers with 3,135 ha (57 per cent of sample) responded yes. Forty nine per cent of growers with 2,119 ha (39 per cent of sample) responded no and the remainder of the growers (5 per cent) with 210 ha of crop responded that they were not sure.

For some growers in the sample, failure of the crop during emergence and establishment resulted in re-drilling of a proportion of the sample area. Of the 96 growers and 5,465 ha surveyed, eight growers collectively re-drilled 131 ha (2.4 per cent) of failed crop. Of that area, 60 ha (1.1 per cent of the sample), grown by two farmers, were re-drilled due to damage from CSFB. These two
crops were located in south-east Scotland and both of these growers had applied pyrethroid insecticides. The remaining 71 ha (1.3 per cent of sample) was lost to a variety of non-insect related issues, including weather at drilling, poor seed vigour and pests such as slugs, rabbits and pigeons. These crops were distributed throughout the sample area.

**Incidence of TuYV**

Growers were contacted after harvest in 2015 and asked about incidence of TuYV in their crops during the preceding season. Eighty seven of the original sample provided information. Of these growers, 79 per cent checked their crops for TuYV and four per cent reported seeing viral symptoms. However, as infected plants can exhibit a variety of indicators and may also be symptomless the reporting of visible symptoms is unlikely to be a good indication of the presence of TuYV in Scottish crops. TuYV can only be definitively detected by serological testing and only one grower, based in the south-east of Scotland, had their crops tested for TuYV. Virus presence was confirmed in this crop.

**Crop yield**

Data relating to crop yield was obtained from 83 of the growers from the original sample, collectively growing 4,506 ha of winter oilseed rape (13 per cent of the Scottish crop area). These growers provided average crop yield data for both 2014 and 2015. Information on other parameters of the two growing seasons, such as insect and disease pressure and weather conditions, were not collected. Yield comparisons therefore cannot be directly related to seed treatment availability. However, growers were invited to state their perceived reasons for changes in yield between the two seasons.

Overall, there was little difference in crop yield on the farms surveyed between 2015 and 2014, with growers reporting average yields of 4.28 and 4.21 t/ha, respectively (Table 7). These yield estimates correspond fairly closely with total Scottish Government yield estimates of 4.15 t/ha and 3.98 t/ha in 2015 and 2014 respectively. When yield data was analysed regionally, average yields decreased in those holdings in the Aberdeen region where poor weather conditions, including very wet weather at drilling and frosts at flowering, were reported by a number of growers. A small decrease was also reported in crops grown in Moray, where poor weather conditions were also reported by growers.

At the individual grower level, there was variation in yield between the two seasons. Forty seven per cent of respondents, growing 2,167 ha (48 per cent of sample area) reported a yield increase of more than five per cent. Twenty two per cent of respondents, growing 1,170 ha (26 per cent of sample area) reported a yield similar to the previous season (within 5 per cent of the year before). A further 31 per cent of respondents, growing 1,169 ha (26 per cent of sample area) reported a yield decrease of more than five per cent.

Despite 31 per cent of growers reporting a yield decrease, only two stated that the neonicotinoid restrictions had contributed to the decline, citing CSFB
damage as a factor. The remainder of the growers cited a number of reasons for yield decrease, primarily local weather conditions, but also slug and pigeon damage, poor establishment of the crop, the influence of less productive land and changes in varietal choice between the seasons. The growers whose yield increased also cited weather conditions as the main factor for the change, along with changes in varietal choice and soil cultivations between the seasons. In relation to TuYV incidence, of the three growers who reported symptoms in their crops two reported a yield increase and one a yield decrease (+14, +5 and -18 per cent). The single grower whose crop tested positive for TuYV reported a yield increase (+11 per cent). However, the sample is too limited to draw any conclusions from these data.

**Grower attitudes to WOSR cultivation during the restrictions of neonicotinoid seed treatments**

Following harvest in 2015, growers were asked if they would grow oilseed rape in future if the neonicotinoid restrictions remained. The majority (82 per cent) said that they would grow again in future, 13 per cent were less likely, one per cent more likely and four per cent were unsure.

Farmers were invited to provide reasons and comments based on their response. Three respondents (four per cent) commented they would be less likely to grow the crop in future directly due to the lack of neonicotinoid seed treatments. However, most of those that were less likely or not sure based this response on the need to consider future market price and economic return, citing dropping economic returns and other reasons such as changes in rotations due to Common Agricultural Policy (CAP) reform and issues with slug control and molluscicide availability.

Many of those who stated that they would grow again in future were also cautious in their assessment. Common themes included the fact that most growers felt that it had been a good season with low pest pressure and good crop establishment but that this may change in subsequent seasons. These growers indicated that their view on oilseed rape cultivation might change if problems increased, so they are monitoring the situation carefully.
Discussion and future work

This survey provides data from a large representative sample of Scottish oilseed rape growers during the first year of the neonicotinoid restrictions.

A small number of the farmers surveyed stated that the restrictions had influenced their decision not to sow winter oilseed rape in 2014, or to reduce the area that they grew. At a national level, the June 2015 Scottish Agricultural census showed a decline in overall Scottish oilseed rape area of 3.4 per cent. The decrease recorded in Scotland is almost identical to the 3.3 per cent decrease in crop area for the same period in England. It is possible that these drops in area were influenced by the implementation of the neonicotinoid restrictions. However, the change in Scottish area is within normal limits of annual oilseed rape area fluctuation. Between 2005 and 2014 annual changes ranged between +27 and -15 per cent and the difference in area between 2014 and 2015 is the smallest change reported over the last decade. In addition, despite the decrease in area grown in Scotland in 2015, total oilseed rape production increased by one per cent, due to a four per cent increase in yield.

A number of Scottish growers in this survey proactively made operational changes to their crop cultivation in response to the neonicotinoid restrictions. Similar adaptations were reported to have been adopted by oilseed rape growers in England. The relative success of these changes can be used by growers to determine which actions should be adopted in future integrated pest management strategies for the crop.

It is clear that the absence of neonicotinoid seed treatments made the control of autumn insect pests more challenging for some growers. For some crops, it was necessary to apply additional insecticidal sprays to combat damage that has been controlled in the past by systemic seed treatments. The survey indicated that the average number of sprays applied by growers had increased by almost 50 per cent. It was acknowledged that some sprays were precautionary and that targets, pest pressure and weather conditions were not directly comparable. Therefore this represents indication of increased insecticide use between the seasons rather than a direct representation of insecticidal input requirements.

The increase in sprays detected in this survey is less than reported in a survey of English WOSR crops. The survey, of just under two per cent of English WOSR crops, estimated a 2.5 fold increase in use of autumn insecticides for CSFB control in the first year of the restrictions of neonicotinoid seed treatments. It should be noted that this 2.5 fold increase is based on the estimated weight of active ingredient applied in 2014 compared with 2012. This cannot be directly compared with the results of this survey which compares the average number of autumn sprays per grower for all targets between 2014 and 2013. However, fewer Scottish growers in this survey applied autumn insecticides for control of CSFB in 2014 than did in the English survey (42 and 82 per cent respectively).
The target of the majority of sprays applied in 2014 was CSFB. Despite concerns about CSFB resistance to pyrethroid insecticides, most growers who applied an insecticide did not report any problems with the efficacy of foliar sprays. Insect damage to crops in autumn was described as low by the majority of growers; although almost half of growers considered that damage was greater than when seed treatments were available. This might suggest that CSFB resistance is less prevalent in Scotland than in some areas of England. However, CSFB caused crop failure which necessitated redrilling on one per cent of the Scottish survey area. This area had been treated with pyrethroid insecticides. The one per cent crop loss encountered in this survey is less than the three to five per cent overall crop loss caused by CSFB reported in England and substantially less than the crop loss of up to 11 per cent reported in the most severely affected English counties\textsuperscript{20,21}.

Average Scottish oilseed rape yields were very similar between 2014 and 2015, both in this survey (4.2 and 4.3 t/ha respectively), and as reported in the June 2015 census (4.0 and 4.2 t/ha). Average English yields were lower but those crops that were not lost to flea beetle damage also showed an increase between the two seasons (3.6 and 3.9 t/ha in 2014 and 2015 respectively\textsuperscript{19}).

Despite the lack of impact on average Scottish yields there will be an effect on the financial return from the crop for some growers. The economic impact was not directly investigated in this survey and is difficult to estimate. However, for those farmers applying additional insecticide sprays there will be an associated cost related to the pesticide used and its application. Application costs will be higher in situations where insecticides are applied alone, rather than tank mixing with an autumn fungicide; this will particularly affect those growers who made more than one insecticide application. There will also be a financial impact for those growers who had to re-drill crops.

Overall, the impact of the restrictions appears to be less severe in Scotland than has been encountered in England, particularly in the most affected areas in the Eastern and South Eastern regions\textsuperscript{20,21}. There are several factors which may have influenced this; the most likely being lower pest pressure in Scotland due to cooler climatic conditions. Whilst comprehensive comparative reports of pest populations are not available, an indication can be inferred from relative use of foliar insecticides prior to the introduction of the restrictions of neonicotinoid seed treatments. Data from the UK 2014 Pesticide usage dataset indicates that both whole season and autumn foliar insecticide input into winter oilseed was greater in England than in Scotland, with around 10 per cent more of the English crop receiving sprays. In addition, multiple autumn insecticide sprays were more common on English crops than in Scotland (David Garthwaite, Fera Science, pers. comm.). Another reason for the lesser impact encountered in this study may be that there is lower incidence of pyrethroid resistance in Scottish CSFB populations.

With exception of growers in the Aberdeen region, most participants reported that the 2014/15 season was favourable for oilseed rape cultivation with a dry autumn for both sowing and application of foliar sprays, a mild winter and a
cool extended growing season. This, coupled with low autumn pest pressure, resulted in a favourable cultivation season. It is possible that the impact of the restrictions could be greater in more agronomically challenging seasons. Whilst most farmers indicated that they would continue to grow oilseed rape they also stated that this was dependant on economic return.

A second survey is being conducted to allow the collection of comparable data during the second year of the restrictions. Approximately 70 per cent of farmers in this initial survey have agreed to take part to allow comparison across years and a supplementary sample will be recruited. This will allow the Scottish Government to continue to monitor the impact of the restrictions on Scottish oilseed rape growers. In addition to this survey, the 2016 pesticide use on Scottish arable crop survey, which will be reported in 2017, will provide comparative national estimates of insecticide use on oilseed rape between the crops harvested in 2014 and 2016.
## Appendix 1 - Results tables

### Table 1  Distribution of surveyed and census areas of winter oilseed rape in Scotland 2015

<table>
<thead>
<tr>
<th>Region</th>
<th>Census Area (ha)</th>
<th>Number of growers surveyed</th>
<th>Surveyed Area (ha)</th>
<th>Percentage of census area surveyed</th>
</tr>
</thead>
<tbody>
<tr>
<td>Highlands &amp; Islands</td>
<td>&lt;1</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Caithness &amp; Orkney</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>N/A</td>
</tr>
<tr>
<td>Moray Firth</td>
<td>2,673</td>
<td>6</td>
<td>286</td>
<td>11</td>
</tr>
<tr>
<td>Aberdeen</td>
<td>8,249</td>
<td>24</td>
<td>1,253</td>
<td>15</td>
</tr>
<tr>
<td>Angus</td>
<td>8,316</td>
<td>26</td>
<td>1,353</td>
<td>16</td>
</tr>
<tr>
<td>East Fife</td>
<td>2,368</td>
<td>7</td>
<td>368</td>
<td>16</td>
</tr>
<tr>
<td>Lothian</td>
<td>4,455</td>
<td>9</td>
<td>618</td>
<td>14</td>
</tr>
<tr>
<td>Central Lowlands</td>
<td>1,557</td>
<td>7</td>
<td>219</td>
<td>14</td>
</tr>
<tr>
<td>Tweed Valley</td>
<td>7,174</td>
<td>17</td>
<td>1,367</td>
<td>19</td>
</tr>
<tr>
<td>Southern Uplands</td>
<td>203</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>Solway</td>
<td>204</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td><strong>Total Scotland</strong></td>
<td><strong>35,198</strong></td>
<td><strong>96</strong></td>
<td><strong>5,465</strong></td>
<td><strong>16</strong></td>
</tr>
</tbody>
</table>

N/A = not applicable
### Table 2  Drilling date of winter oilseed rape crops

<table>
<thead>
<tr>
<th>Drilling Period (2014)</th>
<th>Number of growers</th>
<th>Percentage of growers</th>
<th>Crop area (ha)</th>
<th>Percentage of sample area</th>
</tr>
</thead>
<tbody>
<tr>
<td>August (last two weeks of August)</td>
<td>78 (67)</td>
<td>81 (70)</td>
<td>4,116 (3,331)</td>
<td>77 (63)</td>
</tr>
<tr>
<td>end August/early September</td>
<td>4</td>
<td>4</td>
<td>762</td>
<td>14</td>
</tr>
<tr>
<td>September</td>
<td>11</td>
<td>11</td>
<td>438</td>
<td>8</td>
</tr>
<tr>
<td>Not specified</td>
<td>3</td>
<td>3</td>
<td>148</td>
<td>3</td>
</tr>
</tbody>
</table>

### Table 3  Operational changes in crop cultivation in response to the restrictions

<table>
<thead>
<tr>
<th>Operational Change</th>
<th>Number of growers&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>Percentage of growers</th>
<th>Crop area (ha)&lt;sup&gt;(1)&lt;/sup&gt;</th>
<th>Percentage of sample area</th>
</tr>
</thead>
<tbody>
<tr>
<td>All operational changes</td>
<td>25</td>
<td>26</td>
<td>2,032</td>
<td>37</td>
</tr>
<tr>
<td>Seed rate and spacing</td>
<td>11</td>
<td>11</td>
<td>784</td>
<td>14</td>
</tr>
<tr>
<td>Soil cultivations&lt;sup&gt;(2)&lt;/sup&gt;</td>
<td>9</td>
<td>9</td>
<td>886</td>
<td>16</td>
</tr>
<tr>
<td>Drilling date</td>
<td>5</td>
<td>5</td>
<td>308</td>
<td>6</td>
</tr>
<tr>
<td>TuYV resistant varieties</td>
<td>2</td>
<td>2</td>
<td>106</td>
<td>2</td>
</tr>
<tr>
<td>No details of change</td>
<td>1</td>
<td>1</td>
<td>27</td>
<td>&lt;1</td>
</tr>
</tbody>
</table>

<sup>(1)</sup> Note that some growers made more than one operational change therefore the sums of individual actions are greater than for the all operational changes category

<sup>(2)</sup> Includes alterations to seed bed production and soil cultivation such as minimum tillage, strip tillage and direct drilling
Table 4  Insecticidal sprays applied in 2014

<table>
<thead>
<tr>
<th>No. of sprays(^{(1)})</th>
<th>Number of growers</th>
<th>Percentage of growers</th>
<th>Crop area (ha)</th>
<th>Percentage of sample area</th>
<th>Treated Area(^{(2)})</th>
</tr>
</thead>
<tbody>
<tr>
<td>None</td>
<td>36</td>
<td>38</td>
<td>1,887</td>
<td>35</td>
<td>N/A</td>
</tr>
<tr>
<td>One</td>
<td>52</td>
<td>54</td>
<td>3,133</td>
<td>57</td>
<td>3,133</td>
</tr>
<tr>
<td>Two</td>
<td>6</td>
<td>6</td>
<td>348</td>
<td>6</td>
<td>696</td>
</tr>
<tr>
<td>Three</td>
<td>1</td>
<td>1</td>
<td>42</td>
<td>1</td>
<td>126</td>
</tr>
<tr>
<td>Unknown</td>
<td>1</td>
<td>1</td>
<td>55</td>
<td>1</td>
<td>N/A</td>
</tr>
</tbody>
</table>

\(^{(1)}\) The total number of sprays applied by growers was 67 (52 x 1 spray, six x 2 sprays and one x 3 sprays).

\(^{(2)}\) Treated area is the basic area of a crop treated with an insecticide multiplied by the number of treatments that were applied. For example if a field of five hectares gets sprayed with the same insecticide twice, the basic area is five hectares, and the treated area is 10 hectares.
### Table 5: Target of autumn insecticide sprays in 2014

<table>
<thead>
<tr>
<th>Target pest(s)$^{(1)}$</th>
<th>Number of sprays (percentage of total sprays)$^{(2)}$</th>
<th>Basic Area (percentage of sample area)$^{(3)}$</th>
<th>Treated Area (percentage of total spray area)$^{(4)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>CSFB</td>
<td>28 (41%)</td>
<td>1,953 (36%)</td>
<td>2,092 (53%)</td>
</tr>
<tr>
<td>Flea beetle (unspecified species)</td>
<td>15 (22%)</td>
<td>590 (11%)</td>
<td>656 (17%)</td>
</tr>
<tr>
<td>Stem weevil</td>
<td>14 (20%)</td>
<td>556 (10%)</td>
<td>556 (14%)</td>
</tr>
<tr>
<td>CSFB and stem weevil</td>
<td>1 (1%)</td>
<td>28 (1%)</td>
<td>28 (1%)</td>
</tr>
<tr>
<td>Aphids</td>
<td>1 (1%)</td>
<td>18 (&lt;1%)</td>
<td>18 (&lt;1%)</td>
</tr>
<tr>
<td>CSFB and aphids</td>
<td>2 (3%)</td>
<td>105 (2%)</td>
<td>105 (3%)</td>
</tr>
<tr>
<td>Unknown</td>
<td>8 (12%)</td>
<td>499 (9%)</td>
<td>499 (13%)</td>
</tr>
</tbody>
</table>

| Total flea beetles (all species)$^{(5)}$ | 46 (67%) | 2,677 (49%) | 2,881 (73%) |
| Total stem weevil$^{(5)}$ | 15 (22%) | 585 (11%) | 585 (15%) |
| Total aphids$^{(7)}$ | 3 (4%) | 123 (2%) | 123 (3%) |

(1) Targets of sprays as identified by growers, grouped into common targets
(2) The sprays in this column add up to 69, not 67 as in Table 4, due to one grower spraying two different spray regimes (with different targets) on different areas of his crop i.e. the total number of sprays each composite area received was 2, but four different sprays were applied overall
(3) Basic area is the area of crop treated with an insecticide irrespective of the number of times that area is treated
(4) Treated area is the basic area of a crop treated with an insecticide multiplied by the number of treatments that were applied. For example if a field of five hectares gets sprayed with the same insecticide twice, the basic area is five hectares, and the treated area is 10 hectares
(5) Collating all sprays with at least one species of flea beetle as one of the targets (CSFB, Flea beetle (unspecified species), CSFB and stem weevil & CSFB and aphids)
(6) Collating all sprays with stem weevil as one of the targets (stem weevil & CSFB and stem weevil)
(7) Collating all sprays with aphids as one of the targets (Aphids & CSFB and aphids)
(8) Note that as some sprays had more than one target they have been counted more than once in the collated species data. Therefore when collated targets and unknown sprays are added together they exceed 100% of the total sprays.
Table 6  Insecticidal active substances applied in autumn 2014

<table>
<thead>
<tr>
<th>Active substance</th>
<th>Number of sprays (percentage of total sprays)</th>
<th>Basic Area treated (percentage of sample area)</th>
<th>Treated Area (percentage of total spray area)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All active substances</td>
<td>69 (43%)</td>
<td>3,523 (64%)</td>
<td>3,955</td>
</tr>
<tr>
<td>lambda cyhalothrin</td>
<td>30 (43%)</td>
<td>1,266 (23%)</td>
<td>1,284 (32%)</td>
</tr>
<tr>
<td>zeta cypermethrin</td>
<td>16 (23%)</td>
<td>773 (14%)</td>
<td>837 (21%)</td>
</tr>
<tr>
<td>cypermethrin</td>
<td>9 (13%)</td>
<td>1,100 (20%)</td>
<td>1,220 (31%)</td>
</tr>
<tr>
<td>alpha cypermethrin</td>
<td>5 (7%)</td>
<td>148 (3%)</td>
<td>148 (4%)</td>
</tr>
<tr>
<td>deltamethrin</td>
<td>3 (4%)</td>
<td>79 (1%)</td>
<td>98 (3%)</td>
</tr>
<tr>
<td>tau fluvalinate</td>
<td>3 (4%)</td>
<td>131 (2%)</td>
<td>131 (3%)</td>
</tr>
<tr>
<td>acetamiprid</td>
<td>1 (1%)</td>
<td>26 (&lt;1%)</td>
<td>26 (1%)</td>
</tr>
<tr>
<td>unknown</td>
<td>2 (3%)</td>
<td>211 (4%)</td>
<td>211 (5%)</td>
</tr>
<tr>
<td><strong>Total pyrethroids</strong></td>
<td><strong>67 (97%)</strong></td>
<td><strong>3,497 (64%)</strong></td>
<td><strong>3,718 (94%)</strong></td>
</tr>
<tr>
<td><strong>Total neonicotinoids</strong></td>
<td><strong>1 (1%)</strong></td>
<td><strong>26 (&lt;1%)</strong></td>
<td><strong>26 (1%)</strong></td>
</tr>
<tr>
<td><strong>Unknown</strong></td>
<td><strong>1 (1%)</strong></td>
<td><strong>211 (4%)</strong></td>
<td><strong>211 (5%)</strong></td>
</tr>
</tbody>
</table>

(1) All products applied contained only one active substance; all of the compounds listed are pyrethroid insecticides with the exception of acetamiprid which is a neonicotinoid

(2) The total number of sprays is 69, not 67 as in Table 4, due to one grower spraying two different spray regimes (with different active substances) on different areas of his crop i.e. the total number of sprays each composite area received was two, but four different sprays were applied overall

(3) Basic area is the area of crop treated with an insecticide irrespective of the number of times that area is treated

(4) The percentage of sample area is the basic area of each active substance divided by the sample area

(5) Treated area is the basic area of a crop treated with an insecticide multiplied by the number of treatments that were applied. For example if a field of five hectares gets sprayed with the same insecticide twice, the basic area is five hectares, and the treated area is 10 hectares

(6) The percentage of total spray area treated is the spray area of each active substance divided by the total spray area
## Table 7  Comparison of average yield 2014 and 2015

<table>
<thead>
<tr>
<th></th>
<th>Average yield 2015 (t/ha)</th>
<th>Average yield 2014 (t/ha)</th>
<th>Percentage difference$^{(2)}$</th>
</tr>
</thead>
<tbody>
<tr>
<td>Aberdeen</td>
<td>3.57</td>
<td>3.99</td>
<td>-10.5</td>
</tr>
<tr>
<td>Angus</td>
<td>4.68</td>
<td>4.61</td>
<td>+1.5</td>
</tr>
<tr>
<td>Central Lowlands</td>
<td>4.28</td>
<td>4.06</td>
<td>+5.3</td>
</tr>
<tr>
<td>East Fife</td>
<td>3.96</td>
<td>3.82</td>
<td>+3.6</td>
</tr>
<tr>
<td>Lothian</td>
<td>4.31</td>
<td>3.91</td>
<td>+10.5</td>
</tr>
<tr>
<td>Moray Firth</td>
<td>4.52</td>
<td>4.63</td>
<td>-2.4</td>
</tr>
<tr>
<td>Tweed Valley</td>
<td>4.62</td>
<td>4.11</td>
<td>+12.2</td>
</tr>
<tr>
<td><strong>Total Sample$^{(1)}$</strong></td>
<td><strong>4.28</strong></td>
<td><strong>4.21</strong></td>
<td><strong>+1.6</strong></td>
</tr>
</tbody>
</table>

(1) Based on 83 growers growing 4,506 ha in 2015. Not all of the original survey respondents provided yield data

(2) Average yields are presented to two decimal places, percentage differences are calculated on unrounded data
Appendix 2 - Survey methodology

Sampling and data collection

In preparation for the 2014 Arable pesticide usage survey, a sample was drawn from the June 2014 Agricultural Census\textsuperscript{23} representing arable cultivation in Scotland. The country was divided into 11 land-use regions (Figure 7). Each sample was stratified by these land-use regions and according to holding size. The holding size groups were based on the total area of arable crops grown. The sampling fractions used within both regions and size groups were based on the areas of relevant crops grown rather than number of holdings, so that smaller holdings would not dominate the sample.

The WOSR survey was a supplementary survey conducted alongside the 2014 Arable crop survey. The crops surveyed were sown in 2014 and harvested in 2015, representing the WOSR first crops sown without insecticidal seed treatments. Following an introductory letter and telephone call, data were collected directly from growers by personal interview, telephone interview, email or post. In some cases growers referred the surveyors to their agronomists for collection of some or all of the data.

In total, WOSR cultivation data were collected from 96 farmers collectively growing 5,465 ha of WOSR, representing 16 per cent of the Scottish crop. Growers were contacted twice, once in winter 2014/15 and once in autumn 2015. At the first data collection point growers were asked for information about their winter oilseed rape cultivation (area, seed rate, drilling date) and about operational changes they had made to their cultivation to mitigate for the lack of insecticidal seed treatments. Growers were also asked for information about their perception of insect pest presence, their use of autumn insecticides, their perception of the efficacy of the insecticides applied and the insect related damage that the crop incurred. In addition, they were also asked about insecticide use in autumn 2013 and about what information sources they used for assessment and decision making. At the second data collection point growers were asked about monitoring and incidence of TuYV. They were also asked about yields in both 2015 and 2014 and the about likelihood of their continuing to grow oilseed rape in the future if the restrictions continued. At the end of both data collection points growers were invited to make any other comments about their experience of growing WOSR unrelated to the questions asked.
Figure 7  Land use regions of Scotland

- Highlands and Islands
- Caithness and Orkney
- Moray
- Aberdeen
- Angus
- East Fife
- Lothian
- Central Lowlands
- Tweed Valley
- Southern Uplands
- Solway
Data quality assurance

The dataset underwent several validation processes as follows; (i) checking for any obvious errors upon data receipt (ii) checking and identifying inconsistencies and omissions once entered into the database (iii) 100 per cent checking of data held in the database against the raw data. Where inconsistencies or errors were found these were checked against the records and with the farmer where necessary. Additional quality assurance is provided by sending reports for independent review before publication.

Main sources of bias

The data presented in this report were produced by surveying a representative sample of holdings rather than conducting a census of all the holdings in Scotland. The data, therefore, represents that sample of crop only and not all Scottish oilseed rape cultivation.

This survey may be subject to measurement bias as it is reliant on respondents recording and reporting data accurately. As this survey was not compulsory it may also be subject to non-response bias, as some farmers may be more likely to agree to participate than others. However, experience indicates that stratified random sampling coupled with collection of data by personal interview, delivers the highest quality data and minimises non-response bias.
Acknowledgements

The authors would like to thank the farmers who voluntarily provided the information presented in this report. The authors are also grateful to Prof Fiona Burnett and Dr Andy Evans (SRUC) for their helpful comments on the questionnaire design and Marie Coventry (Scottish Government), David Garthwaite (Fera Science), Dr Stephen Jess (Agri-Food & Biosciences Institute), Dr Kevin O'Donnell (SASA) and Dr Michael Taylor (SASA) for their valuable comments on the manuscript.

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