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Is black-grass a threat to Scotland?

An overview of the situation

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Black-grass recognition

Black-grass (*Alopecurus myosuroides*), also known as slender foxtail or slender meadow foxtail, is an annual grass with slender stems and hairless, elongated, flat leaves. It can exceed 1 m tall and bears dense, dark purple seed heads 2–12 cm long, tapering at both ends (Figures 1 and 2).

Figure 1. Single black-grass plant emerging above wheat canopy

Figure 2. Close up of black-grass seed head at flowering

Agroecology

Black-grass competes with the crop for light, nutrients, space and water and although individual plants are not highly competitive compared with cleavers, for example, large populations can cause significant yield losses (Table 1). Seed production is high, with 100 seeds per head common, meaning that populations can increase rapidly if control is not high, with more than 95% control required to maintain a stable population.

Table 1. Yield loss resulting from different black-grass infestations based on 16 trials on winter wheat in England between 1995 and 1997.

Black-grass plants/m^2	Average percentage yield loss	Range of yield losses
12	5	<5-15
25	10	<5-25
50	15	<5-35
100	20	5-50
250	35	10-65
500	50	20-70

From Blair, Cussans & Lutman, Proc. 1999 Brighton Conference – Weeds, 753–760

Seed shed begins in June in England, meaning most of the seed is shed before harvest (Figure 3). Innate seed dormancy is moderately high and is increased by cool damp weather during seed maturation. In ADAS tests between 2001 and 2014, funded by BASF, innate dormancy was 64% on average but varied from 38% in 2001 to 85% in 2008, with significant site-to-site variation.

Figure 3. Black-grass heads shedding seed on winter wheat crop. Taken on 2nd July in Cambridgeshire.

Seeds are small and will only emerge from the top 5 cm. Peak germination is in September and October in England and, although there is some seed germination through winter and in spring, around 80% of germination occurs in the peak autumn period. Plants that emerge in spring are smaller and do not produce as much seed. Seed that does not germinate is relatively short-lived in the seed bank, with approximately 75% mortality per year, but numbers of viable seeds in the seedbank can easily exceed 20,000/m^2.

The issue in England

Black-grass is now the most prevalent arable weed in England and is causing significant problems to growers across much of the arable area of the south and east, particularly on heavy textured soils. Ideal conditions for black-grass in the 2013/2014 cropping season resulted in severe infestations, with populations of several hundred plants per m^2 being a common sight (Figure 4). Some growers adopted desperate measures to prevent massive seed return, such as taking the crop for silage or spraying off with glyphosate before seed shed (Figure 5).

Figure 4. Severe black-grass infestation in winter wheat, Cambridgeshire, July 2014.

Figure 5. Winter wheat sprayed off with glyphosate to prevent seed return from black-grass, Northamptonshire 2014. Note significant infestation in part of the unsprayed area.

The serious situation in England has resulted from a number of factors all favouring black-grass.

Autumn cropping

There has been a decline in the area of all the major spring crops (spring barley, peas, sugar beet and potatoes) in England since the mid-1980s. These have been replaced by autumn-sown crops, providing ideal conditions for black-grass germination in autumn.

Simplified rotations

Simple rotations of winter wheat and winter rape dominate much of the arable area of England, reducing diversity in herbicide programmes.

Earlier drilling

There has been a trend towards earlier drilling of winter wheat (5% of English winter wheat was sown in September in 1970, by 2012 this had increased to 50%). This has pushed sowing into the peak black-grass germination period.

Reduced cultivations

In an attempt to reduce costs and increase work rates, there has been a large increase in the area of wheat established by minimal cultivation in preference to the plough: from 10% in the 1990s to 40% by 2012. This retains more of the black-grass seed near the surface where it can germinate.

All these factors have contributed to the black-grass problem in England but the factor that has really driven the increase in black-grass populations and widespread failure to control them adequately is ***resistance to herbicides***.

Herbicide resistance

Despite cropping practices that favour black-grass becoming increasingly common, effective control is possible on susceptible populations through use of post-emergence herbicides in the ALS and ACCase inhibitor groups. Even as late as 2010, AHDB Cereals & Oilseeds-funded research (Project Report 509) showed that control levels as high as 99% could still be achieved on some populations where products containing iodosulfuron-methyl-sodium + mesosulfuron-methyl (e.g. Atlantis) were included in the programme. However, resistance to these groups of herbicides was detected as long ago as 1982 and is now widespread in England (Figure 6).

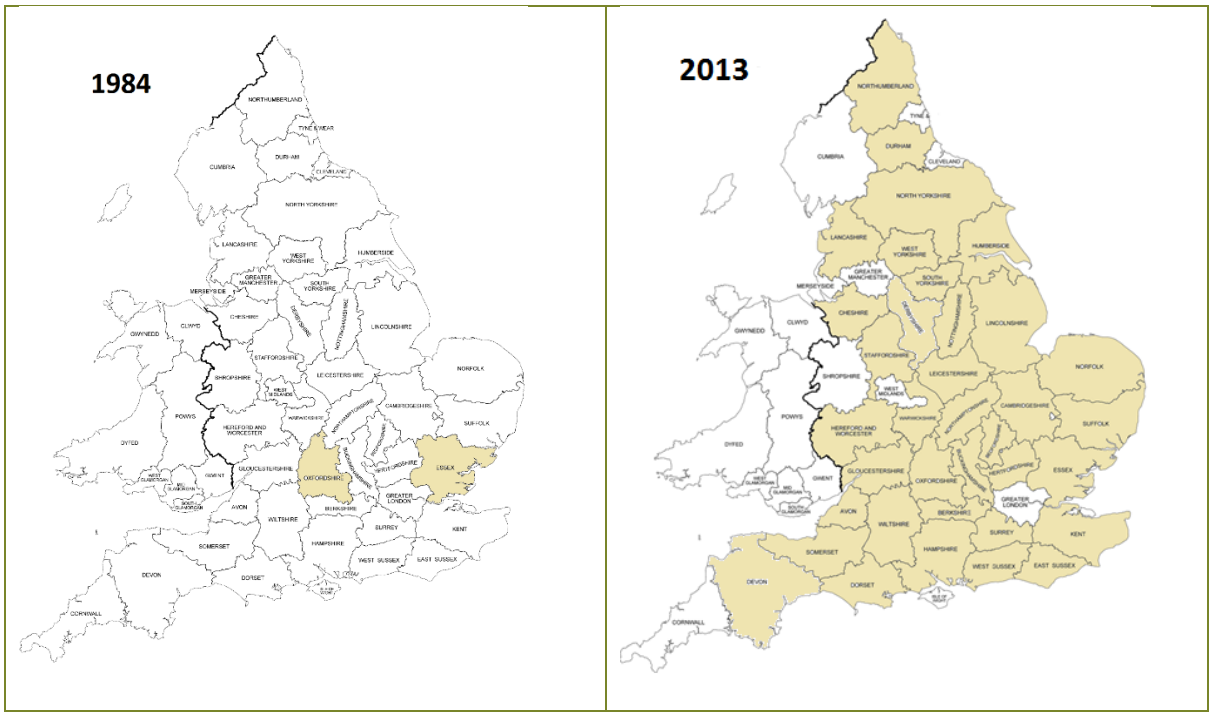

Figure 6. Counties of England and Wales with laboratory confirmed cases of black-grass resistance to herbicides in 1984 and 2013 (adapted from Hull *et al.* 2014)

In a survey of 19 randomly selected fields in southern and eastern England between 2009 and 2011, virtually all black-grass populations had resistance to one or more of the herbicides tested. Of 122 samples tested in 2013 by ADAS on behalf of BASF, 75% were either resistant (RR) or highly resistant (RRR) to sulphonylurea type herbicides, and 84% were RR or RRR to ACCase inhibitors.

In general, resistance to pre-emergence herbicides is less common than resistance to post emergence herbicides; the level of resistance is much lower and it increases more slowly. However, of the 122 samples tested in 2013, 66% showed enhanced herbicide metabolism, which can and reduce efficacy of many pre-emergence herbicides (notable exceptions are propyzamide and carbetamide), most worryingly, 46% showed some degree of target site resistance resistance to sulphonylureas and ACCase inhibitors and evidence of enhanced metabolism.

It is now widely accepted that some degree of herbicide resistance occurs on all farms where black-grass active herbicides have been used routinely. In response, growers have had to resort to ‘stacking’ multiple pre and post emergence herbicides, with herbicide bills in excess of £100/ha being common and even then growers have lost control of black-grass populations in some cases.

There are no recorded instances of resistance to the oilseed post-emergence herbicides, carbetamide and propyzamide, nor to the non-selective herbicide, glyphosate. However, both carbetamide and propyzamide require specific environmental conditions to be effective and growers in England have become increasingly concerned that they are not achieving sufficient levels of black-grass control in oilseed rape crops. In addition, all three herbicides are threatened by EU legislation which may limit or prevent their use.

Given the widespread existence of herbicide resistance in black-grass populations in England, cultural control options including spring cropping, higher seed rates and competitive varieties are being increasingly adopted by growers (in addition to stacking multiple herbicides) to try and get control of their black-grass.

Black-grass in Scotland

The threat

There are populations of black-grass present naturally in Scotland, although their abundance is much lower than in southern England (Figure 7). Warmer winters favour black-grass and more autumn cropping combined with reduced tillage is likely to encourage these populations to grow and spread. Some of these populations may already carry some degree of herbicide resistance if they have been regularly treated with black-grass active herbicides, even though black-grass may not have been the target.

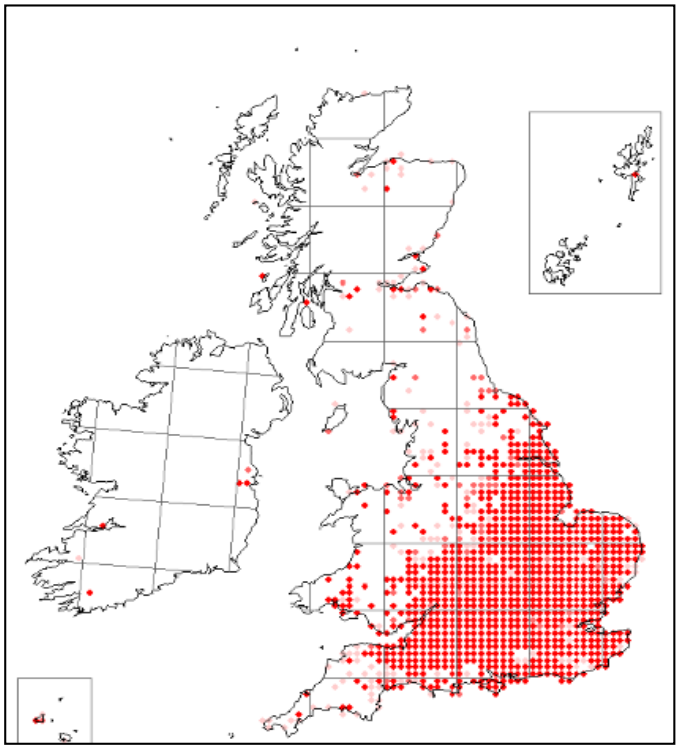

Figure 7. 10 x 10 km grid squares of the British Isles where black-grass is found (Source New Atlas of the British and Irish Flora).

Current research being funded by AHDB Cereals & Oilseeds and BBSRC is aiming to establish the main routes by which resistant black-grass spreads. Work conducted by Bayer in Germany suggests a limited role for spread from field to field, with spontaneous resistance development within fields being important. In Scotland, however, with a small scattered native population, introduction of black-grass from south of the border is likely to be a significant threat. Any black-grass seed brought in from England is likely to be already resistant to one or more of the main herbicide groups, particularly if it originates from the south or east, although as Figure 6 shows, resistance is now present across all of England.

Routes of spread

There is plenty of anecdotal evidence to suggest how black-grass seed is being spread, although very little research has been done to establish the importance of the different routes. Movement on machinery is often reported to have introduced black-grass into a field, particularly harvest machinery and bailers. Contract machinery that can move long distances across the country may be particularly at risk. There have also been some limited reports of seed travelling on second-hand machinery. Sprayers that are being used near harvest to desiccate crops may also spread seed.

Another route commonly reported to spread seed is straw. Large quantities of cereal straw are moved each year from the main arable areas in the east and south of England to the mixed farming areas of the west and north, including southern Scotland. Much of this straw is inevitably contaminated with black-grass seed, though the level of contamination and resistance status will vary significantly. Even with the widespread problems with black-grass in England, good management means that plenty of fields remain free of black-grass and the straw from these fields will be uncontaminated.

The other route by which black-grass seed is frequently reported as being spread is as a contaminant of crop seed. It ought to be easy to separate cereal seed from black-grass seed, which is much smaller. However, reports of this method of spread persist and, in some cases, are supported by multiple reports of the same variety being contaminated. It may be that at busy times when there is pressure to get new seed ready for planting, cleaning protocols are not always strictly adhered to.

Scotland is not England

Although there is undoubtedly a threat to Scotland from black-grass, particularly herbicide-resistant black-grass, being imported from England, there are important differences between the farming systems in the two countries which may go some way to mitigating the threat. However, there are also differences that may make control of populations that become established in Scotland more difficult.

Mixed farms

Mixed farms are more common in Scotland than in the key arable areas of England and they have the option of putting contaminated fields down to grass without loss of income. Farms in England have had to resort to this option, or even fallowing, in fields with severe infestations of highly resistant black-grass but, without animals, it is an option of last resort. The seed mortality rate of black-grass is approximately 75% per year and so after five years a small seedbank will be

exhausted, provided the black-grass is mown or grazed to prevent seed being returned. Farmers in south Wales who import straw from England report that this is a highly effective way of cleaning up fields, although if the seedbank is very large after severe infestations, it may take more than five years for all the seed to die.

Ploughing

Ploughing is more common in Scotland than England and can be very effective at burying shed seed, particularly when used rotationally, ploughing after dirty crops then employing minimum tillage after clean crops to avoid bringing up buried seed.

Spring cropping

Spring cropping remains more common in Scotland than England and can offer multiple opportunities to kill germinated seed prior to drilling, either through cultivation or non-selective herbicides. In addition, black-grass that germinates in spring will produce fewer seeds than autumn germinated plants.

Cooler wetter climate

Generally speaking, the climate of Scotland is cooler and wetter than the main arable areas of England where black-grass is a problem and where the research on control methods has been done. This may have implications both for the way black-grass grows and the control options being promoted in England.

As resistance to post-emergence herbicides has grown, there has been much more reliance on pre-emergence herbicides. Research in England shows that control from pre-ems is reduced in dry autumns. This may be less of an issue in Scotland but spray windows to apply pre-ems may be fewer, making appropriate timing more difficult.

Delayed drilling is promoted in England. It gives two benefits, firstly an opportunity to spray off black-grass flushes before sowing the crop and, secondly, it moves the crop sowing date out of the peak black-grass germination period (it has additional benefits in that soil moisture conditions are more likely to be ideal for pre-emergence herbicide activity). Current advice is that the majority of the benefit can be gained by delaying drilling wheat to mid-October. In Scotland this delay may be too risky but, perhaps more importantly, delayed drilling is less effective in seasons where black-grass seed dormancy is high. Dormancy is induced by cool wet conditions during seed maturation, so higher levels of dormancy might be expected in Scottish black-grass populations.

Unanswered questions

In addition to the uncertainties noted above, there are a number of unanswered questions regarding the spread and control of black-grass that growers often ask.

Farmyard manure and digestate

A question commonly asked by growers is whether black-grass seed is spread in FYM or other animal manures or digestate from anaerobic digesters. There has been no research in this area but anecdotal evidence suggests that FYM is not safe. This makes sense, as much of the straw will not have been through the animals and heating of muck heaps is uneven. There is more uncertainty around other manures but the same principle probably applies. Digestate should be less of a risk as the feedstock is less likely to be contaminated with black-grass seed and the processing is more controlled.

New chemistry

Although the agrochemical companies are understandably cautious about releasing information regarding new product development, all the indications are that there are no new black-grass active chemicals in development. The cost of developing a new active ingredient is high and black-grass is, globally, a small problem, being confined to parts of northwest Europe.

Burning

Straw and stubble burning is likely to have made a significant contribution to the control of black-grass in the past. A proportion of the seed on the surface is killed by burning, with greater kill at higher temperatures. However, the burning ban is based on environmental considerations and is unlikely to be rescinded. Some research is ongoing to examine the role that tractor-mounted gas burners could have in controlling black-grass but the cost is likely to be prohibitive except on a small scale.

Glyphosate

Because of reduced efficacy of in-crop herbicides against black-grass, growers in England have become increasingly reliant on control outside of the crop, based mainly on multiple applications of glyphosate. This has led to concerns that black-grass may become resistant to glyphosate. The threat is real but how significant it is and how best to mitigate the risk is uncertain. AHDB, in partnership with the Weed Resistance Action Group, has produced guidelines on best practice use of glyphosate but significant knowledge gaps remain.

Conclusions

Production systems that favour black-grass combined with widespread herbicide resistance have made black-grass a serious threat to arable systems in southern and eastern England. Some black-grass populations in Scotland are likely to already carry a degree of resistance and laboratory confirmed cases of resistance have been found in the Borders. Although black-grass is present in Scotland, it has not yet emerged as a significant problem. However, import of straw from England, particularly to southern Scotland, along with import of seed and movement of machinery all pose a risk of introducing populations with a high degree of resistance to multiple herbicides. Differences in cropping systems between England and Scotland should help to reduce the spread and vigour of any invading black-grass populations; however, growers should remain vigilant and seek to eliminate any new populations at an early stage. Where populations of resistant black-grass are suspected, seed should be tested so that appropriate control methods can be employed before a significant problem develops.

AHDB Cereals & Oilseeds-funded research

Because of the significant threat that black-grass poses to arable farming AHDB is continuing to fund research into its control via a number of projects.

BBSRC-AHDB Black-grass Resistance Initiative – Unravelling herbicide resistance in black-grass from gene to field (RD 2014-3807)
£280,000 (total £2,800,000, remainder funded by BBSRC). 2014–2018.
Examining the biology of herbicide resistance – how it spreads, how development might be slowed or reversed, field diagnostics.

Competitive crop cultivars: optimising yield and sustainable weed suppression (RD-2011-3757 – PhD)
£37,500. 2011-2015
Examining the traits that make some wheat varieties more competitive against black-grass than others.

Managing the resistance risk to retain long-term effectiveness of glyphosate for grass-weed control in UK crop rotations (RD 2140006131)
£250,000 (total £500,000, remainder funded by members of the Glyphosate Task Force) 2015–2020
Will fill knowledge gaps regarding the most appropriate ways to use glyphosate in order to minimise the possibility of resistance developing in grass weeds, particularly black-grass.

Further reading

AHDB Black-grass management pages

cereals.ahdb.org.uk/blackgrass

Glyphosate resistance management guidelines

tinyurl.com/weedrag

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