Technical Note TN609

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Management of Grass Weeds in Winter Cereals

SUMMARY

- **Grass weeds are an increasing problem in Scottish winter cereal crops.**
- **Changes in rotation, cultivation, sowing dates and weather conditions are encouraging grass weeds.**
- **Husbandry and herbicidal techniques for managing grass weeds in cereals are described, with particular emphasis on husbandry and the major weeds: bromes, black-grass, rye-grass and wild-oats. Consideration is also given to control of meadow-grasses plus common couch-grass, black and creeping bent, onion couch, loose silky-bent, canary-grass and timothy.**

The Problem

Grass weeds are becoming an increasingly important feature in Scottish cereal farming. They are generally more difficult to manage in cereals than broad-leaved species and are relatively more competitive as a group.

There are a number of reasons why they are increasing as this Technical Note seeks to show, but perhaps the key factors are the increasing importance of winter cropping in the rotation in key arable areas, along with earlier sowing of crops in the autumn and reductions in tillage prior to sowing. It is also possible that changes in the climate, with milder winters and a longer growing season, may be having an effect on the germination and survival of grass weeds to set seed (see SAC Technical Note 604) This may mean that seeds of grasses, that are otherwise rare, brought into the country are more likely to establish, or that grasses which are already present, but are rare, are encouraged to spread. It also means that grasses already well-established may be encouraged further.

The last few years has seen the apparent 'appearance' of species such as meadow-brome and rye-brome in the Borders, with black-grass appearing more often in areas of north-east England and south-east Scotland where it was not considered as present a few years ago. Although still relatively rare, the spread of black-grass is considered of particular concern as it produces large numbers of seed so builds up populations rapidly to become very competitive. Furthermore, it is known to have developed resistance rapidly to key herbicides, which we discuss further below.

Italian rye-grass may also be spreading and can also develop herbicide resistance. Resistance development is not known in brome species in this country, but barren brome is now established as a difficult to control weed, and appears to be spreading, as does, more locally, soft brome and possibly giant brome. Wild-oats have always been a widespread and competitive species, and may be increasing again. Herbicide resistance is known in some English populations of wild-oats, but it has not been confirmed in SAC tests on Scottish populations.

Meadow-grasses have always been problem weeds, with annual meadow-grass (AMG) being present in most cereal fields. Although not particularly competitive, populations can increase to serious levels. Rough meadow-grass (RMG) is more local to moister soils, but can be a serious problem.

Common couch-grass (Couch) populations are generally kept under

control by the use of pre-harvest and stubble/ fallow glyphosate treatments. This treatment is not covered in this note; however, couch does produce seed and there are treatments available for control of couch in the growing crop.

Other weeds that propagate perennially and are treated similarly with glyphosate to couch are black and creeping bent, timothy and onion couch.

Herbicide treatments for the control of the rarer and occasional weeds, loose silky-bent and canary-grasses, are given, although these species do not appear to persist as problems in the northern UK at present.

This Technical Note reviews the grass weeds, their competitiveness and other features, biodiversity value, control by husbandry, use of herbicides and the potential and management of herbicide resistance development in key species.

Cereal pests and diseases hosted by grass weeds

Aphids	*Meadow-grasses, Couch-grass, Wild-oats*
Barley leaf blotch	*Couch-grass*
Eelworms	*Couch-grass*
Ergot	*Black-grass, Bromes (?), Meadow-grass, Rye-grasses, Timothy*
Gout-fly	*Couch-grass*
Powdery mildew	*Couch-grass*
Rusts	*Couch-grass*
Smuts	*Couch-grass*
Sooty moulds	*Rye-grasses*
Take-all	*Black-grass, Couch-grass, Wild-oats (?)*
Wheat bulb-fly	*Couch-grass*
Wireworms	*Couch-grass*

Effects of Grass Weeds

- Grass weeds compete with the crop for water, mineral nutrients, space and light. They are often very competitive as individual plants (eg wild-oats), or produce so much seed that their populations rapidly increase to competitive levels (eg barren brome, black-grass).
- Their presence within the crop affect the environmental conditions within the canopy, encouraging some diseases and pests. They can also act as hosts for pests and diseases (see inset).
- If present at harvest, some grass weeds can hinder the combine harvesting efficiency by making the drying of the straw and grain more uneven and they may also encourage lodging of the crop. In severe infestations, combining may become impossible. Where high levels of matter other than grain passes through the combine, grain losses will increase.
- Grass weed seeds can contaminate the grain sample affecting the value of the crop seed. Most grass weeds are difficult to remove from cereal grain, and some, notably wild-oats, cannot be removed.

Relative competitiveness of grass weeds in winter wheat: approximate numbers/ sq m required to give 5% reduction in yield

Black-grass	13	Rye-grasses	9
Barren brome	40	Wild-oats	5
Other bromes	20 - 40	Common couch-grass	15
Annual meadow-grass	> 50	Bents	15
Rough meadow-grass	15	Loose silky-bent	15

The threshold values for an economic return are much lower as failure to control these populations will lead to much greater problems in future seasons. With serious weeds where control is very difficult, such as black-grass, bromes, rye-grasses and wild-oats, a zero threshold is probably the best approach; especially if the weed has not been seen before in the field.

Biodiversity Value

Grass weeds in general but particularly black-grass, brome grasses and rye-grasses appear to have little biodiversity benefit, although a range of soil fauna and flora may utilise the seeds. However, some grasses do act as direct food sources.

- Meadow-grasses provide seed for a range of birds, and grazing for game birds. They are also food plants for a range of butterfly caterpillars and support a range of other insects.
- Bents and common couch-grass are food source for certain butterfly caterpillars
- Timothy supports a range of insects.
- Awned canary-grass is seed source for a range of birds, and is used in bird seed mixtures.

Key Biological Features of the Species

This section examines some key features of the biology and behaviour of the grass weeds which have to be considered in their management. For further information and a range of pictures, we suggest using the Weed Manager encyclopaedia or the Bayer Cropscience web site (www.bayercropscience.co.uk) which has a very helpful identification site.

Black-grass (*Alopecurus myosuroides):* This is an annual fox-tail grass, emerging mostly in early autumn, but also in early spring (see Fig. 1), so is encouraged by early autumn sowing of the crop and tends to be discouraged by spring cropping. It produces large amounts of seed, which readily germinates, so is encouraged by reduced tillage after seed shed, although some dormancy may occur after a cold, wet seed production period. The seed may persist in the seed bank for up to 5 years (see inset), but most die within 2-3 years. It can germinate from up to 5cm depth in the soil. It is suppressed by ploughing cultivation which buries seed below this depth and dilutes numbers near the surface.

Marsh fox-tail (*Alopecurus myosuroides*) is often mistaken for black-grass, but is restricted to very wet pockets in arable soils and does not spread further. Meadow-fox-tail (*Alopecurus pratensis*) is sometimes mistaken for black-grass but is generally only found at field margins and is a more robust and upright plant with a larger seed head.

Brome species : The bromes are divided into two type : Anisantha types have large drooping flowering heads, whist the Bromus types have upright heads. The Anisantha bromes can cause severe combining problems as their wiry stems can entangle the combine equipment. The most important brome species is **barren** or **sterile brome** (*Anisantha sterilis)*. This is widespread weed, coping with a range of fertile soils throughout the country. It is an annual which only emerges in the early autumn, so is encouraged by early sowing. It produces large quantities of seed. It has little or no dormancy, with most of the seed only lasting for 1 year in the seed bank, although a few may persist for longer. So it is encouraged by reduced tillage which does not bury the seed below 10-13cm, but suppressed by ploughing the seed down below that depth. It is often a particular problem in headlands because ploughing is less efficient alongside field margins, and, in many fields, the brome has spread from the field boundary. **Giant brome** *(Anisantha diandrus)* is like a very large barren brome in appearance. It is found very locally throughout Scotland and probably behaves in a similar manner to barren brome, so is probably encouraged by early autumn sowing and reduced rotation and tillage.

More locally a problem, preferring lighter, but damper soils, is **soft brome** *(Bromus hordaceus)*, which is relic of grassland. It is an annual, mostly emerging in the autumn, but also in early spring. It probably otherwise behaves in a similar manner to barren brome. Its ability to emerge in the spring, however, means that rotational control is reduced. **Meadow brome** *(Bromus commutatus)* has appeared in the Borders in the last few years, and is particularly found on damper, heavier soils. It is similar to soft brome, but more robust and less hairy. However, it only emerges in the autumn, so is encouraged by early sowing of winter crops. Its seed lasts for 1-2 years in the soil, and is encouraged by reduced tillage. **Rye-brome** *(Bromus secalinus)* has been seen on a few farms in the Borders and can be mistaken for meadow brome. It has similar pattern of emergence, with seed surviving for up to 1 year, so is encouraged by autumn sowing and reduced tillage.

Common couch-grass *(Elytrigia repens) :* This is the most widespread large grass weed, spreading by rhizomes, but in some populations, also by seed; other populations are sterile. The perennial nature means that rotation has little effect, however, where seed is produced, it emerges readily in the autumn. Ploughing and other cultivations can spread the rhizome, and has little impact on control. Pulling rhizomes to the surface to dry out or overwinter will help control. The difficulty of physical control has meant that when glyphosate became available, particularly as a pre-harvest treatment, it was widely taken up. It has become so successful a treatment, along with control in stubbles and fallows, that the populations of this weed in fields has declined dramatically since the 1980s. This approach has also been successful for other grasses which reproduce vegetatively as well as by seed; notably **black bent** *(Agrostis gigantea)* and **creeping bent** *(Agrostis stolinifera)*. However, if left alone for a few years, the couch often re-establishes.

Annual meadow-grass (AMG) *(Poa annua):* This is found in most arable fields, emerging throughout the year when conditions allow. Rotation, therefore, has a relatively smaller effect, although populations tend to be higher in winter crops, and that increases the population in the weed seed bank. Although individually it is not a competitive annual, populations can be so high that it can effect yield. In wet seasons it can persist up to harvest, often with new plants appearing through the season, and can affect the drying of the crop, as well as encouraging a range of pests and diseases. The seed can persist for up to 5 years in the soil, but can also germinate soon after shedding. It is, therefore, encouraged initially by reduced tillage, but ploughing does bring up a fresh seed bank. **Rough meadow-grass (RMG)** *(Poa trivialis)* is much more competitive, but is more restricted to moisture retentive soils. However, it probably behaves similarly to AMG in persistence in the seed bank and in its ability to emerge throughout the year, but particularly in damp, mild conditions.

Rye-grasses *(Lolium spp):* The most weedy form is **Italian rye-grass (IRG)** *(Lolium multiflorum),* which can be annual or biennial. It can emerge in early autumn or in spring, so rotation does not help greatly, although autumn-emergers tend to produce larger plants, producing more seed. It is encouraged by earlier autumn sowing, and as it produces a lot of seed with low dormancy, it is encouraged by reduced tillage. However, it can persist in the seed bank for over 5 years, so a viable seed bank can be readily ploughed back to the surface. **Perennial rye-grass (PRG)** *(Lolium perenne)* spreads by rhizomes as well as seed, but appears not to persist as successfully as a weed as IRG; otherwise it behaves in a similar manner. However, there are hybrid forms which are more or less weedy, and their potential to be weedy is poorly understood. It is probably best to assume that they all behave generally as IRG.

Spring wild-oats *(Avena fatua):* As far as is known, this is the only wild-oat species normally found in Scotland, although the occasional **winter wild-oat** *(Avena ludoviciana)* may be seen. However, distinguishing between the two species is very difficult. Spring wild-oat, nevertheless, emerges in early autumn as well as in spring, and ESCA surveys in the 1980's suggest that 50% of autumn emerging plants survived until spring. Winter weather has become much milder since then, so survival rates may be higher now.

Wild-oat is a large annual, producing large amounts of seed that can persist in the seed bank for many years, with records of over 20 years. It can emerge from 10cm in the soil. It can also become relatively dormant at or soon after shedding. In practice this means that the type of cultivation used in the short or medium term tends to have relatively little effect on wild-oat populations, although in the very long-term zero till may reduce the upper seed bank in time if there is sufficient control to prevent any seed return from emerging plants. Traditionally, hand-pulling of low populations has prevented an increase in this weed, but the cost of labour often prevents this approach, and populations may be subsequently increasing.

Other grasses: A range of other grasses are found less commonly in cereal crops, and seldom at numbers to cause major problems. However, some control may be required to prevent a build-up. **Loose silky-bent** *(Apera spica-venti)* and **canary-grass**es *(Phalaris spp)* are typical of these species, and are important weeds in parts of mainland Europe, but have not established in the UK except very locally in Eastern England, although canary-grasses have been sown as a bird seed crop. They are autumn emergers and are thus encouraged by winter cropping, and may also be encouraged by reduced tillage, but not to the extent of bromes or black-grass.

A native species, **Onion couch** *(Arrenatherum elatius var. bulbosum),* is found as a persistent weed in a few fields. It is a variant of false oat-grass which reproduces by propagating stem basal bulbils, as well as by

seed. It is the bulbils which maintains the populations in the field. False oat-grass, which only produces seed, is seldom found much beyond the field edge. Another native species found locally where there are grassy rotations which propagates by basal stem bulbils and seed is **timothy** *(Phleum pratense),* but it does not appear to persist for long into an arable rotation.

Persistence of weed seeds in seed bank and probable max. germination depth

	Years in seed bank	*Decline/ year*	*Max. germination depth (cm)*
Black-grass	1-3 (- 5)	80%	5-6
Barren brome	1 (-2)	90%	13
Great, rye and soft bromes	<1	100%	13
Meadow brome	1-2	90%	13
Meadow-grasses	1- 3 (- 5)	-	5
Italian rye-grass	5	-	5-6
Perennial rye-grass	1-5	-	5-6
Spring wild-oats	>5 (> 20)	50	13
Bents	>5	-	-
Loose silky-bent	>5	-	5-6
Common couch-grass	1-5	-	5

These are estimates derived from literature and experience. Where (-) this indicates that there evidence of some seed lasting much longer in the seed bank.

MANAGEMENT OF GRASS WEEDS THROUGH HUSBANDRY

The use of husbandry techniques is of prime importance in the management of grass weeds, and this is particularly important with weeds that are difficult to contain because of an inadequate herbicide armoury, such as bromes, and with species that are liable to develop resistance to herbicides, such black-grass.

From when new grass weed infestations are seen, growers are encouraged to develop husbandry strategies that assist in the control of the weed, as well as adopting appropriate herbicide strategies.

Impact of crop rotation

- As shown in Fig. 1, most black-grass seeds and all the barren and meadow brome seeds emerge in the autumn, so growing spring crops in the rotation dilute the impact of these weeds. Wild-oats, soft brome, rye-grass and rough meadow-grass emerge in both seasons, so spring crop rotation has less effect.
- Use of grass ley breaks for 2 or more years greatly reduces the seed bank of annual weeds, although some perennials and meadow-grasses may be less affected.
- Use of fallow breaks allows the use of the total herbicide, glyphosate, to reduce the near surface seed bank by killing shallow emerging plants before they set seed.
- Using winter oilseed rape, and spring broad-leaved weed crops, allows the use of effective graminicides that can not be used in cereals. Some of these have no known resistance, eg propyzamide.

Impact of cultivation

- Over 90% of grass weed seeds germinate from the top 2-3cm of the soil. Deep inversion ploughing removes the seed to a depth from which it cannot emerge**.**
- Ploughing can bring up grass seed, but if it has been buried for a while, it may not be viable. Most grass weeds do not persist for many years in the seed bank (see inset), and even after one year, the seed fecundity has usually been greatly reduced. Wild-oat seed may be a particular exception to this pattern.
- With some weeds with very short persistence in the seed bank, eg barren brome (c 1 year), ploughing seed down and leaving it there for at least 1 year, will greatly reduce the seed bank. Some seeds do escape being ploughed down because they smear up the plough profile, but this approach greatly assists in the control of brome and many other grass weeds.
- Where reduced tillage winter cereal systems are preferred, consider rotational ploughing, say one year in 3 or 4, where the seed bank developing near the soil surface is buried rotationally, to reduce the grass weed build-up which tends to occur in these systems. Herbicide control of weeds would have to exceed 99% to prevent such a build-up, and that seldom occurs.
- Rotational ploughing also helps dilute the build-up of herbicide resistance in seed banks of weeds such as black-grass and rye-grass.

Impact of time of sowing in autumn

- When autumn cereals are sown is influenced by work loads, soil type, weather conditions, and the further north or higher the farm, by any delay in the previous harvest. However, there is a general tendency to sow earlier to take advantage of better sowing conditions. Where grass weeds are becoming serious, a balance may have to be struck with the benefits, and perhaps rotational delayed sowing considered.
- Nevertheless, the later the drilling date in the autumn, the less germination of autumn grass weeds in the crop (Fig. 1). This is a particularly useful approach for control of most brome species and reducing black-grass in particular, but also the other grass weeds.
- Delaying sowing also allows the use of a stale seed bed, where the grass weeds emerge and are killed before the crop is sown, reducing the seed bank available to emerge in the crop. A light cultivation may encourage early weed emergence. The approach does require sufficient moisture in the seed bed for weed emergence.

Burning of stubbles

The burning of harvest stubbles is still allowed on a controlled basis in Scotland. This is a useful method of reducing grass weed seed populations before they are buried by cultivation, or re-emerge in a reduced tillage system.

Delayed winter ploughing

One of the prime reasons why grass weeds build up rapidly in reduced tillage systems is that most of these species have low inherent dormancy, so are ready to germinate soon after shedding. Many broad-leaved weeds have strong inherent dormancy and will not germinate until a period in the seed bank.

However, many grass weeds can develop a secondary dormancy, which delay germination and improve seed bank survival if ploughed down early. This occurs in wild-oat, and delaying ploughing can reduce the problem, and also allows birds and soil fauna to graze the seeds on the surface. Work by ADAS in England has shown big differences in black-grass dormancy between seasons, with greater dormancy in seed produced in cool/ wet conditions, and less in warm/ dry summers. So, we should expect more grass weed emergence in seed shed after a warm/ dry summer, and such years should be targeted for delayed drilling.

Crop competition

Crops differ in their ability to compete with weeds. A rapidly growing winter barley or oat crop are more able to shade out later emerging grasses compared with wheat. There is evidence for differences between varieties of cereals in competitiveness with broad-leaved weeds, but this is less clear for grass weeds. However, taller varieties with large leaves that tend to the horizontal, will tend to be more effective in reducing grass weed growth.

Increasing sowing rates can also be used to help increase crop competitiveness with weeds.

OPTIMAL USE OF HERBICIDES

Table 2 gives the relative activity of the herbicides available on the range of grass weeds commonly found in winter cereals. There are shades of activity which cannot be described in product labels. In the case of black-grass, rye-grasses and wild-oats, relative degrees of herbicide resistance in different populations confuses the issue. Where there is target-site resistance (TSR) there may be little or no activity, whereas the label indicates that there could be activity. Where there is metabolic resistance (EMR), then there will be partial control; perhaps only if the weed is small. So the table is just a guide, and particularly for the weeds above, you should assume that there may be some resistance. Even if there is still good control, you should assume that resistance could develop, and approach herbicide use in that manner. That is, you should not rely on a single herbicide treatment.

Herbicide Resistance

Resistance to grass weed herbicides is a major problem in the UK, although to date not extensive in Scotland. Resistance is found primarily in black-grass, but commonly in Italian rye-grass and hybrids; it is also found very locally in wild-oats populations.

Resistance development can be hard to pick up as many factors can lead to poor herbicide activity. Key signs after herbicide treatment include:

- The presence of live plants next to dead ones
- Other susceptible species are well controlled
- A decline in herbicide activity over a period of seasons
- Resistance is known in the area

If you have used the same herbicide treatment over a number of seasons, this favours the development of resistance. This is encouraged by crop monoculture. Continuous reduced tillage also prevents a mixing of resistant and non-resistant weed seed banks; alternatively mixing by ploughing dilutes and slows the development of resistance through the populations.

Mechanisms of resistance

• Enhanced metabolism (EMR) – resistant plants detoxify herbicides. Resistance is often partial, but once in the population, does not decline. Cross resistance may occur to many different herbicides. EMR tends to develop slowly.

• Target site (TSR) – blocks the site of herbicide activity in the plant. This usually results in complete resistance. This is often associated with live plants alongside dead plants. TSR can develop quickly

Implicated herbicides

Table 1 gives an indication of the resistance that can occur in the key grasses affected to the herbicide types that are used in cereals for grass weed control. Where herbicides are relatively new, such as pinoxaden, there is no information on resistance, but it is indicated in the table that resistance could occur to this type of herbicide in the future and care should be taken In particular, it is important not to rely on a single active ingredient for routine management of a grass weed, but either mix, or use in sequences, active ingredients from different chemical groups, as exemplified below. The table groups the herbicides into the chemical groups- designated by a code number and or letter. The two main groups which are implicated in resistance in grasses are the –fops and –dims, which are generally called ACCase inhibitors, and the sulfonyl-ureas and related chemicals, generally called ALS- inhibitors.

For a fuller explanation, the Weed Resistance Action Group have produced guidelines: 'Managing and preventing herbicide resistance in weeds', published by and available from the HGCA (*www.hgca.com*). It is also available from agrochemical distributors and CPA companies.

Avoiding herbicide resistance development in grass weeds

Rotate spring/ autumn crops
Include break crops with different herbicides
Plough routinely
Delay autumn sowing
Use stale seed bed and fallows to reduce the seed bank
Use herbicides from different chemical families in mixtures and sequences.

Types of herbicide

Table 2 gives the herbicides available for grass weed control. The first group ('early treatments') can be used pre- or early post-emergence on the crop and pre-emergence and, in most cases, very early post-emergence on the weed. The table indicates the weed growth stages for each treatment. These herbicides have varying degrees of residual activity, which may persist to control spring emerging weeds; e.g. pendimethalin. However, this cannot be relied upon and there is evidence that residual herbicides do not persist as long as the winters become warmer with climate change. The 'post-emergence only' treatments may be used in autumn and/ or spring. Table 4 gives the crop growth stage timings. Some of these have some residual activity, but this is generally limited, and many treatments only have foliar activity. Some indication of residuality of effect is given in Table 2, but this will vary with conditions.

Sequences and mixtures

For many grass weeds, the inadequacy of herbicides available, the large populations involved, and often a prolonged emergence period, demands a programmed approach. This may be the use of mixtures of herbicides from the different chemical groups, or their use in sequence through the season, and between seasons. This may initially appear to

be an extra cost, but there are clear cost-benefits over time. This also applies to the husbandry approaches listed above.

The list below indicates examples of typical herbicidal approaches for the control of the most serious of the grass weeds. These are not the only, or always the best options. In addition you should consider the husbandry approaches outlined elsewhere.

- *Black-grass in wheat*: pre-emergence/ early post-emergence herbicide based on flufenacet or tri-allate, followed by autumn or spring iodosulfuron-methyl-sodium + mesosulfuron-methyl with pendimethalin. A –fop or –dim herbicide may also be used in part of the programme. In barley, options are more limited. In oats, only Lexus Class can be used to give some suppression.

- *Barren brome*: pre-emergence triallate or flufenacet. In wheat, follow up with chlorotoluron in suitable varieties then iodosulfuron-methyl-sodium + mesosulfuron-methyl or propoxycarbazone-methyl or sulfosulfuron in wheat in spring. In barley there is no appropriate spring follow-up, so avoid growing barley in infested fields. There is no useful treatment for oats.

- *Italian rye-grass*: pre-emergence use of flufenacet product plus chlorotoluron in suitable varieties, followed up by iodosulfuron-methyl-sodium in spring in wheat, or pinoxaden in wheat or barley. There is some suppression in the autumn in oats with Lexus Class.

- *Wild-oats*: for this weed, use an autumn herbicide only if it emerges, populations are large or plants are more that 5 leaves. In general, otherwise leave until the spring emergers have appeared, then use a single wild-oat treatment (see Tables). This is more restricted in barley. There are no treatments for use in winter oats. If you are aware that there may be some resistance development, consider using tri-allate pre-emergence or up 2 leaves of the wild-oats, or chlorotoluron up to 3 leaves of the wild-oats in the autumn, followed by another wild-oat herbicide in the spring, such as pinoxaden or, in wheat, a mesosulfuron-based product.

Where herbicides are used, read the label carefully regarding suitability of treatment (crop and variety), timing of treatment, miscibility with other treatments, use of adjuvants to improve activity (check crop) and their use in sequences. The latter is particularly important where sulfonyl-ureas are used.

Control of other weeds

In most situations the grower will also wish to control key broad-leaved weeds. This is not covered in detail in this note, but Table 3 gives the effect of the grass herbicides on important broad-leaved weeds, to help in the treatment selection process.

Optimal conditions for activity

The product label details the maximum and recommended dose and optimum conditions of use. Optimal conditions can often allow some flexibility in dose of herbicides, but with grass weeds that may have some resistance this may mean a failure of treatment. Residual treatments are most active on finer seedbeds, lighter soils and reasonable soil moisture levels near the surface. Foliar acting treatments are most active in general in mild conditions where the crops and weeds are growing well.

Table 1: Potential resistance to the herbicide types that are used in cereals for grass weed control.

Herbicide (chemical group)	*EMR*			*TSR*		
	Black-grass	*Wild-oats*	*Italian Rye-grass*	*Black-grass*	*Wild-oats*	*Italian Rye-grass*
Ureas (C2)						
Chlorotoluron	(✓)	?	✓	x	x	x
- fops (A fop)						
Diclofop-methyl	✓	✓	✓	✓	✓	✓
Fenoxaprop-P-ethyl	✓	✓	?	✓	✓	?
Clodinafop-propargyl	(✓)	(✓)	(✓)	✓	✓	✓
-dims/ -dens (A dim/ den)						
Pinoxaden	?	?	?	?	?	?
Tralkoxydim	✓	✓	✓	✓	✓	✓
ALS (B)						
Flupyrsulfuron-methyl	✓	?	?	?	x	x
Iodosulfuron-methyl	✓	?	?	?	x	x
Mesosulfuron-methyl	✓	?	?	?	x	x
Propxycarbazone	?	?	?	?	x	x
Sulfosulfuron	?	?	?	?	x	x
Others						
Flufenacet (K3)	(✓)	?	?	x	x	x
Pendimethalin (K1)	(✓)	?	?	x	x	x
Prosulfocarb (K2)	?	?	?	x	x	x
Tri-allate (N)	(✓)	x	?	x	x	x

✓: Frequent high-level resistance; (✓) : partial resistance occurs; x : no evidence of resistance; ? : No information indicating resistance, but believed it could develop.

Table 2: Activity of cereal herbicides on grass weeds (Growth stages of weeds and * > * estimated levels of activity)**

	Black-grass	*Barren/ sterile brome*	*Giant brome*	*Soft brome* and *Meadow brome*	*Canary-grass*	*Loose silky- bent*	*Common couch-grass*	*Onion couch*	*Rye-grass seedlings*	*Wild-oats*	*Annual meadow-grass*	*Rough meadow-grass*	Residual Activity
Early treatments													
Chlorotoluron	** 00-15	-	-	-	-	-	-	-	** 00-13	** 00-12	*** 00-15	*** 00-15	Weeks
DFF + flufenacet	** 00-20	* (00)	-	-	-	-	-	-	** (00)	-	** 00-22	-	Few Weeks
DFF + flurtamone	* 00-21	-	-	-	-	*** 00-21	-	-	-	-	** 00-21	-	Few Weeks
Flufenacet+ PDM	** 00-13	** (00)	-	-	-	*** 00-12	-	-	** 00-13	* (00)	*** 00-21	*** 000-12	Months
***Flupyrsulfuron-methyl*⁺**	** 00-22	-	-	-	-	*** 00-13	-	-	** 00-13	-	** 00-12	** 00-12	Few Weeks
PDM	** 00	-	-	-	** 00	-	-	-	-	* 00	*** 00	** 00	Months
PDM + picolinafen	-	* (0)	-	-	-	-	-	-	-	-	*** 00-12	** 00-12	Months
Prosulfocarb	* (00)	* (00)	-	* (00)	-	*** 00	-	-	** 00-12	-	*** 00	** 00	Months
Tri-allate	** 00	* (00)	-	-	-	-	-	-	-	** 00-12	*** 00	*** 00	Months
Post-em only treatments													
Clodinafop-propargyl	** 11->	-	-	-	-	-	-	-	* (11 ->)	*** 11->	-	** 11->	None
Diclofop-methyl+ fenoxaprop-p-ethyl	** 12-30	-	-	-	-	-	-		** 12-23	*** 12-30	-	-	None
DFF+ flupyrsulfuron-methyl	** 12->	-	-	-	-	-	-	-	-	-	* -	* -	Few Weeks
Fenoxaprop-P-ethyl	** 12-40	-	-	-	*** 12-23	-	-	-	* (11 ->)	*** 12-39	-	-	None
Flupyrsulfuron-methyl+ thifensulfuron-methyl	** 11-31	-	-	-	-	-	-	-	-	-	-	-	Few Weeks
Fumioxazin	* 11-12	-	-	-	-	*** 11-12	-	-	* 11-12	-	** 10-13	-	Weeks
Iodosulfuron-methyl-sodium	-	-	-	-	-	-	-	-	*** 11-31	-	** (11-30)	-	Few Weeks
Iodosulfuron-methyl-sodium+ mesosulfuron-methyl	*** 11-39	** 11-31⁺	** 11-33⁺	-	?	?	-	-	*** 11-32	*** 11-39	*** 11-31	*** 11-31	Few Weeks
Pinoxaden	** 11-13	-	-	-	*** (11-39)	*** (11-39)	-	** (11-39)	*** 11-39	*** 11-39	-	** (11-39)	None
Propoxycarbazone-ethyl	-	** (11-31)	* (11-31)	*** (11-31)	-	*** (11-31)	** (11-31)	*** (11-31)	-	-	-	-	None
Sulfosulfuron	-	** 29-32	* (21-30)	*** (30-32)	*** (30-32)	*** 12-32	-	** 12-39	-	-	-	-	None
Tralkoxydim	** 11-23	-	-	-	** (11-23)	-	-	-	** 13-33	*** 12-31	-	-	None

(-) Not on label - estimated effect and growth stage. ? Activity known, but no details; ⁺ Varies between products.

NB Strains of some annual grasses, notably black-grass, rye-grasses (mainly Italian-type) and wild-oats, have developed resistance to herbicides which may lead to poorer control than indicated in the Table. Read section on Herbicide Resistance in this note and the Weed Resistance Action Group guidelines 'Managing and preventing herbicide resistance in weeds', published by and available from HGCA (*www.hgca.com*). Read the product label before use as there may be further assistance regarding the level of control achieved in resistant and non-resistant forms and for different growth stages of the weeds.

NB There are no specific recommendations known for black and creeping bent, or timothy. These have, therefore been omitted from the table.

Table 3: Effect of grass weed herbicides on some important autumn-emerging broad-leaved weeds at most active timing for grass weeds

	Cleavers	*Common chick-weed*	*Common field speed-well*	*Common fumitory*	*Common poppy*	*Crane's-bills*	*Field forget-me-not*	*Field pansy*	*Groundsel*	*Ivy-leaved speedwell*	*Mayweed*	*Shepherd's purse*	*Volunteer oilseed rape*	*Red dead-nettle*	*Fool's parsley*
Early treatments															
Chlorotoluron	-	S	-	-	-	-	-	S	-	-	S	-	-	-	-
DFF + flufenacet	M	S	-	S	-	-	S	S	S	M	S	-	-	S	-
DFF + flurtamone	M	S	S	-	M	-	S	S	-	S	S	S	M	S	-
Flufenacet+ PDM	M	S	S	-	S	-	M	M	-	S	M	M	-	S	-
Flupyrsulfuron-methyl	M	M	-	-	M	S	S	-	S	-	S	S	S	S	-
PDM	M	S	S	M	S	-	S	S	-	S	M	M	M	S	-
PDM + picolinafen	M	S	S	S	S	-	-	S	-	S	-	S	M	S	-
Prosulfocarb	S	S	S	-	-	S	S	M	-	S	-	-	-	S	-
Tri-allate	M	M	S	M	M	-	M	M	-	M	M	-	-	S	-
Post-em only treatments															
Clodinafop-propargyl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Diclofop-methyl+ fenoxaprop-p-ethyl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DFF+ flupyrsulfuron-methyl	-	S	S	-	S	S	S	S	S	M	S	S	S	S	-
Fenoxaprop-P-ethyl	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Flupyrsulfuron-methyl+ thifensulfuron-methyl	M	S	M	-	S	S	S	M	S	M	S	S	S	S	-
Fumioxazin	S	S	S	S	S	S	S	S	S	S	S	S	S	S	-
Iodosulfuron-methyl-sodium	M	S	S	-	-	-	-	M	-	-	S	-	S	S	-
Iodosulfuron-methyl-sodium+ mesosulfuron-methyl	-	S	-	-	-	-	-	-	-	-	S	-	S	-	-
Pinoxaden	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
Propoxycarbazone-ethyl	-	-	-	-	-	-	-	-	-	-	-	M	M	-	-
Sulfosulfuron	S	M	-	-	-	-	-	-	-	-	S	S	S	-	S
Tralkoxydim	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-

NB The levels of activity listed above reflect the best level available at the optimum timing. This may vary between weed growth stages. It is a guide only and the product label should be read carefully. S: Susceptible; M: Moderately Susceptible.

Table 4: Crop selectivity of herbicides for winter cereals (Zadoks Growth Stages of use)

	Winter wheat	*Winter barley*	*Winter oats*	*Autumn- sown Spring wheat*	*Durum wheat*	*Winter rye*	*Triticale*
Early treatments							
Chlorotoluron (NB Varietal selectivity)	00- 29 V	00- 29 V	x	x	00 V*	(00- 29 SOLA)	00- 29 V
DFF + flufenacet	00- 23	00- 24	x	x	x	x	x
DFF + flurtamone	00- 32	00- 32	x	x	x	x	x
Flufenacet+ PDM (31 DEC)	00- 23	00- 23	x	x	(00- 23 SOLA)	(00- 23 SOLA)	(00- 23 SOLA)
Flupyrsulfuron-methyl	00- 31	00*	31 DEC*	x	x	x	x
PDM	00- 30	00- 30	x	x	00- 30	00- 30	00- 30
PDM + picolinafen	00- 30	00- 30	x	x	(00- 30 SOLA)	(00- 30 SOLA)	(00- 30 SOLA)
Prosulfocarb	00- 21	00- 21	x	x	x	x	x
Tri-allate	00- 31	00- 31	x	x	00- 31	00- 31	00- 31
Post-em only treatments							
Clodinafop-propargyl	12- 41	x	x	x	x	x	x
Diclofop-methyl+ fenoxaprop-p-ethyl	11- 32	11- 32	x	x	x	x	x
DFF+ flupyrsulfuron-methyl	00- 31	x	x	x	x	x	x
Fenoxaprop-P-ethyl	11- 41	x	x	11- 41	x	x	x
Flupyrsulfuron-methyl+ thifensulfuron-methyl	12- 31	x	x	x	x	x	x
Fumioxazin	00- 15	x	x	x	x	x	x
Iodosulfuron-methyl-sodium	13- 33	x	x	x	x	13- 33	13- 33
Iodosulfuron-methyl-sodium+ mesosulfuron-methyl	12- 39	x	x	x	x	x	x
Pinoxaden	12- 41	12- 41	x	x	x	x	x
Propoxycarbazone-ethyl	Up to 33	x	x	x	x	x	x
Pyroxsulam (approval awaited)	12- 32						
Sulfosulfuron	Up to 39	x	x	x	x	x	x
Tralkoxydim	12- 41	12- 41	x	12- 41	12- 41	12- 41	12- 41

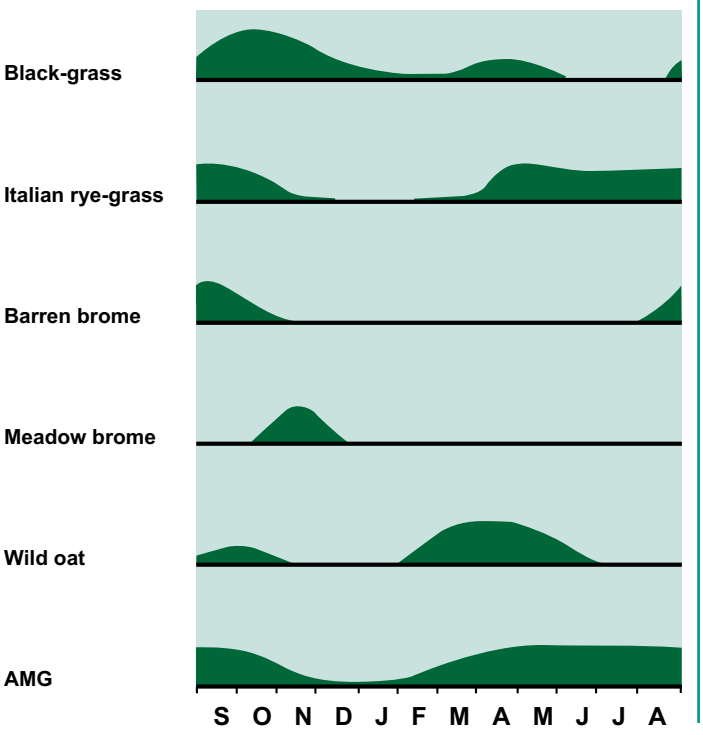
V: check label for varietal selectivity. (-- SOLA): Specific Off-label Approval – check *www.pesticides.gov.uk* for specific details and products. * Specific product amongst a range.
31 DEC = Up to 31st December only. DFF = diflufenican; PDM = pendimethalin.

Table 5: Products for Grass Weed Control in Winter Cereals

(See Table 4 for crop selectivity and timing details)

Active Ingredient (s)	*Products available in 2008 (Manufacturer)*	*Further information*
Early treatments		
Chlorotoluron : *500g/l products* *700g/l products* *90% w/w products*	eg Alpha Chlorotoluron (MA); Headland Tolerate (Headland); Lentipur CL%00 (Nufarm) eg Atol (Nufarm), tolugan 700 (MA) eg Tolurex 90WDG (MA)	Up to 7.0l/ha; pre- or post-em. Up to 5.0l/ha; pre- or post-em. Up to 3.9kg/ha; pre- or post-em.
DFF + flufenacet: *200+* *400g/l product* *100+ 400g/l products*	 Firebird (Bayer) Liberator/ Regatta (Bayer)	 Up to 0.3l/ha; pre- or early post-em. Up to 0.6l/ha; pre- or early post-em.
DFF + flurtamone *100+* *250g/l product*	Bacara (Bayer)	Up to 1.0l/ha; pre- or post-em.
Flufenacet+ PDM *60+* *300g/l products*	eg Crystal/ Ice/ Trooper (Bayer)	Up to 4.0l/ha; pre- or early post-em.
Flupyrsulfuron-methyl *50%* *w/w products*	eg Bullion, Lexus SX	Up to 20g/ha pre-emergence only in winter barley; up to 40g/ha in wheat post-em..
Pendimethalin (PDM) *300 or* *400g/l products*	Very many products available; eg Stomp 400SC (BASF)	Up to 5.0l/ha for 400g/l products and 6l/ha of 300g/l products; pre- or post-em.
PDM + picolinafen *330+* *7.5g/l products* *320+ 16g/l products*	Flight/ Orient (BASF) eg PicoPro, Stomp Pico etc (Bayer)	Up to 4.0l/ha. These products can be used pre-em. up to 30 November, plus post-em. Up to 3.0l/ha early post-em. only.
Prosulfocarb *800g/l product*	Defy (Syngenta)	Up to 3.0l/ha; pre- or early post-em.
Tri-allate *15%* *w/w product*	eg Avadex Excel 15G (Gowan)	Up to 15kg/ha granules; usually pre-em., although wild-oats controlled to 2 leaves.
Post-em only treatments		
Clodinafop-propargyl 240g/l product	Topik (Syngenta)	Up to 0.25l/ha in wheat only. Use mineral oil or methylated seed oil adjuvant.
Diclofop-methyl+ fenoxaprop-p-ethyl *250+20g/l product*	Corniche/ Tigress Ultra (Bayer)	Up to 2l/ha.
DFF+ flupyrsulfuron-methyl *41.7+8.3%w/w*	Absolute (DuPont)	Up to 120g/ha in wheat only
Fenoxaprop-P-ethyl *55g/l product* *120g/l product*	 Cheetah Super (Bayer) Triumph (Bayer)	Use adjuvant to help activity. Up to 1.5l/ha in wheat only, twice. Up to 0.65l/ha in wheat only, twice.
Flupyrsulfuron-methyl+ *thifensulfuron-methyl 10+40% w/w* *product*	eg Lancer (Headland); Lexus Millenium (DuPont)	Up to 100g/ha.
Flumioxazin 300g/l prod.	Digital/ Guillotine (Interfarm)	Up to 100ml/ha
Iodosulfuron-methyl-sodium 5% w/w *product*	Hussar (Bayer)	Up to 200g/ha in wheat, triticale, rye only. An adjuvant can help activity. Has separate spring barley recommendation.
Iodosulfuron-methyl-sodium+ *metsulfuron -methyl 0.6+ 3% w/w* *product* *1+ 3% w/w product*	Atlantis (Bayer) Pacifica (Bayer)	Add bioPower adjuvant. Up to 400g/ha in wheat only. Up to ----- g/ha in wheat only. ??
Pinoxaden 100g/l product	Axial (Syngenta)	Up to 0.6l/ha. Add Adigor adjuvant.
Propoxycarbazone-ethyl 70% w/w *product*	Attribut (Bayer)	Up to 100g/ha plus recommended adjuvant.
Pyroxsulam	GF-1274 (Dow)	Approval awaited for wheat only.
Sulfosulfuron 80% w/w product	eg Monitor (Monsanto); Safeguard (Agriguard)	Up to 25g/ha in wheat only, plus supported adjuvant.
Tralkoxydim 250g/l product	eg Grasp (Syngenta);Strimma (MA)	Up to 1.4l/ha plus a supported adjuvant.
	MA= Makhteshim Agan	

Fig 1: Germination patterns of some grass weed species



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