# THE FUTURE FOR GRASS WEED MANAGEMENT IN THE UK

James Clarke from ADAS Boxworth, Stephen Moss from IACR-Rothamsted and Jim Orson from Morley Research Centre discuss grass weed control strategies in the UK at the start of a new century

## Introduction

Optimised weed management is a complex combination of weed biology (including cultural factors) and herbicide use. This has been highlighted in the recent MAFF-sponsored review 'Future Priorities for UK Weed Research' (Clarke, 1999). Recent projects (TALISMAN, IFS, LIFE) have all demonstrated the importance of weeds as a constraint to more integrated and cost-effective farming methods (Anon., 1997; Anon., 1999). Table 1 lists the major problem grass weeds in the UK. One key aspect of weeds, which make them different from most pests and diseases, is that the consequences of control practices in one year impact on subsequent crops in the rotation. Because of these complexities and other issues, such as pride in a clean crop, farmers and advisers are very reluctant, based on existing information, to reduce inputs. However, there is real scope to do so.

Weed management on farms needs to be improved for three major reasons:

- Herbicides are the major crop protection input in UK agriculture (Table 2) – whether viewed by value [£205M herbicides used in 1997 (source BAA, 1998)] or active ingredient use. Reductions in profitability of wheat cropping are increasing the need to review input costs. More carefully targeted weed control would offer financial benefits to farmers.
- Herbicides have a significant environmental impact because they appear more frequently in water than other pesticides, often a direct result of the large quantities of active ingredient used.
- The decline in weed numbers in fields is thought to be an important contributing factor in the decline in farmland birds (Campbell *et al.*, 1997).

This article outlines some of the recent weed research and identifies the important issues for future improvements in weed management.

## Stubble management

The period between harvest of one crop and establishment of the next is increasingly being recognised as a major opportunity to influence weed numbers. The changes in management to reduce numbers in the next crop(s) may be small and in many instances may result in reduced costs. Understanding the interactions of weed biology and husbandry operations in this window is essential. HGCA-funded work on brome has been one major area of increased knowledge in recent years (Orson, Peters and Blair, 1998).

### Acronyms

TALISMAN = Towards a Lower Input System for Managing Agro-chemicals and Nitrogen
IFS = Integrated Farming Systems
LIFE = Less Intensive Farming and Environment
AOPP = Aryloxypenoxypropionate
CHD = Cyclohexanedione

**Table 1. Major problem grass weeds in UK**

| Scientific name | Common name | Comments |
|---|---|---|
| *Alopecurus myosuroides* | Black-grass | Major problem and common in major winter cropping dominated arable areas. Many populations now resistant to herbicides. |
| *Anisantha sterilis* | Barren brome | Common, especially on field margins. Very limited herbicide options. |
| *Avena* spp, | Wild oats | Common in all areas, locally very important. Germinates in both autumn and spring. Some populations now resistant to herbicides. |
| *Bromus commutatus* | Meadow brome | Increasingly common in major arable areas. Locally severe. Herbicide options very restricted. |
| *Lolium multiflorum* | Italian rye-grass | Locally very severe, but problem restricted to areas where grown for seed or as grass short-term ley. Some populations now resistant to herbicides. |
| *Poa annua* | Annual meadow-grass | Widespread. Normally only a severe problem in wet areas. Well controlled by a wide range of herbicides. |

**Table 2. Principal herbicides used against grass weeds in wheat (1,967,270 ha in 1996, 2,035,686 in 1998) in Great Britain.**

| Active ingredient | Tonnes a.i. used 1996 | Area sprayed (ha)1996 | Tonnes a.i. used 1998 | Area sprayed (ha) 1998 |
|---|---|---|---|---|
| Chlorotoluron | 233.74 | 81,878 | | |
| Clodinafop | 3.45 | 83,873 | 6.65 | 231,721 |
| Clodinafop/trifluralin | | | 111.50 | 136,756 |
| Diflufenican/isoproturon | 459.37 | 754,163 | 514.88 | 862,111 |
| Fenoxaprop-P-ethyl | 15.23 | 288,560 | 14.62 | 312,603 |
| Fenoxaprop-ethyl | 7.29 | 95,663 | | |
| Glyphosate | 97.38 | 137,342 | 199.86 | 262,412 |
| Isoproturon | 1,875.68 | 1,176,469 | 1,862.14 | 1,312,274 |
| Isoproturon/pendimethalin | 286.00 | 170,255 | 245.41 | 153,220 |
| Pendimethalin | 125.02 | 160,264 | 86.75 | 95,193 |
| Tralkoxydim | 16.76 | 62,487 | 16.16 | 56,332 |
| Tri-allate | 293.61 | 157,029 | 457.90 | 216,174 |
| Trifluralin | 230.47 | 246,761 | 259.79 | 276,497 |
| All herbicides | 4,625.20 | 5,926,468 | 4,760.19 | 6,842,830 |

Source: Pesticide Usage Surveys: Arable Farm Crops in Great Britain 1996 and 1998, (Thomas, Garthwaite and Banham, 1997; Garthwaite and Thomas, 1999)

Barren, or sterile, brome (*Anisantha sterilis*) germinates most rapidly in the dark and HGCA-funded experiments have proved that both in wet and dry autumns it is worth cultivating as soon as possible after harvest to encourage germination when minimal tillage is to be used to establish a crop in the same autumn. This early cultivation may not be necessary where straw cover is providing shade on the soil surface. However, where the soil is ploughed well, to bury the brome seed at least 12.5 cm deep in consolidated soil, there is likely to be no advantage in early cultivation. This, and other, work has shown that the timing of the ploughing is less important than the quality of the ploughing. An extremely small proportion of the seed will retain viability after burial for one year (Orson, Peters and Blair, 1998).

On the other hand, soft brome (*Bromus hordeaceus* ssp. *hordeaceus*) and meadow brome (*Bromus commutatus*) should be left on the soil surface for around 28 days prior to any tillage (Orson, Peters and Blair, 1998). This exposes the seed to the elements, particularly warmer temperatures, minimising dormancy. Hence, where possible, it may be worth removing the straw. However, with meadow brome care in handling the straw is needed since there is likely to be substantial quantities of seed remaining in it. Subsequently, it is then best to bury the seed with good quality ploughing and only an extremely small proportion of the seed will retain viability after a years burial. The current information relating to stubble management, from many research projects is summarised in Table 3.

## Timing of control

Recent MAFF-funded work is confirming earlier work, that to maintain yield black-grass (*Alopecurus myosuroides*) control at low/moderate populations is not required in the UK until March (Blair, Cussans and Lutman, 1999). Black-grass at levels of up to 224 black-grass plants/m$^2$ did not need to be controlled for yield reasons alone until about 150 days after drilling. However, there are important issues on timing related to resistance, effectiveness of herbicides and ability to get onto land to spray which mean most control should be made much earlier than this, especially since the impact of surviving black-grass on the crop increases rapidly in late spring.

## Crop–weed competition

Intensive studies of the factors influencing the competitive effects of black-grass on winter wheat have confirmed the previously proposed economic threshold levels of around 20 plants/m$^2$. However, they have also shown that the

**Table 3. Optimum timing of stubble cultivations to reduce infestation of key weeds**

| | Cultivate early (within 4 weeks of harvest) | Do not cultivate early | Unknown/neutral |
|---|---|---|---|
| Barren brome | ✔ (especially if no straw) | | ✔ (if good straw cover) |
| Volunteer cereals | ✔ (unless cold and wet) | | |
| Meadow brome | | ✔ | |
| Freshly shed wild-oats | | ✔ | |
| Black-grass | | | ✔ |
| Volunteer oilseed rape | | ✔ | |

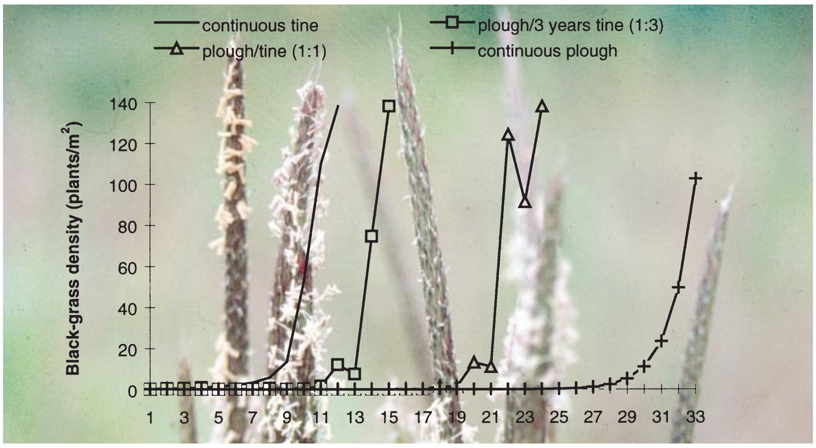


Figure 1. **Effect of different cultivation regimes on the build-up of black-grass (*A. myosuroides*), when AOPP/CHD ('fop' and 'dim') herbicides are applied each year achieving 90% kill of susceptible plants.**

competitive impact of the weed can vary considerably from field to field and year to year (Blair, Cussans & Lutman, 1999). Some of this variation can be attributed to 'site' factors such as soil type and nitrogen level and some to 'weather' factors, particularly rainfall. Low soil nitrogen levels have been correlated with more competitive black-grass. Wet summers tend to increase the competitive effects of the weed. The response to soil moisture seems to be associated with the shallower rooting characteristic of the weed compared to wheat. This variability has implications for the development of less intensive management systems for this weed and leads to the conclusion that it is very risky to reduce herbicide inputs for its control. This is confirmed by the recent modelling work reported by Cavan, Cussans & Moss (1999), where less than 80% control speedily resulted in rapidly increasing grass-weed populations.

## Herbicide resistance

Herbicide resistance is an increasing risk. In black-grass very many populations are now showing some degree of resistance. In 1999, 79% of samples received by ADAS for herbicide resistance testing were showing some resistance, with a worrying 30% of all samples showing target site resistance. Other organisations also report similar results with over 25% of samples showing target site resistance – a much higher frequency than found previously. The following numbers of herbicide-resistant populations have been recorded: black-grass – 746 farms in 30 counties; wild oats (*Avena* spp.) – 65 farms in 19 counties; and Italian rye-grass (*Lolium multiflorum*) – 25 farms in 11 counties (Moss *et al.*, 1999). These results are not based on random surveys and far fewer samples of wild oats and Italian rye-grass have been tested compared with black-grass. Thus, the full extent of resistance is unknown, but these results demonstrate that resistance occurs over a very wide geographical area in all three grass-weeds. There was a noticeable increase in the number of reports of poor control of both black-grass and Italian rye-grass in 1999. Many of these have subsequently been shown to be due to resistance.

The results of recent research have been well publicised and are summarised in the Weed Resistance Action Group 'Revised Guidelines for Preventing and Managing Herbicide-Resistant Grass-Weeds' (available from http://www.farmline.com/hgca/grassweedsguideline/) and HGCA Topic Sheet No. 22 'Preventing and controlling herbicide-resistant grass weeds', both published by HGCA.

Recently an attempt to quantify the evolutionary process of herbicide resistance has been made at IACR-Rothamsted using modelling techniques (Cavan, Cussans and Moss, 1999). Figure 1 shows results for black-grass where resistance evolves much more quickly under a non-inversion tillage system than under continuous ploughing. Work with wild-oats has also been initiated.

This modelling has been confirmed by field experiments at ADAS Boxworth on a clay soil, and under continuous minimal cultivation. MAFF and The Chadacre Agricultural Trust have funded work to compare a wide range of herbicide treatments for the development of resistance. After only three years, the first resistance test results are showing that target site resistance has developed (RR – resistance confirmed, probably reducing herbicide performance) where a 'fop' was used annually as the main means of control, and especially if this was applied late (GS22/23).

The majority of new herbicide resistance work is on wild oats. A project funded jointly by MAFF, HGCA, AgrEvo, Monsanto, Novartis and Zeneca is now producing some valuable information on herbicide resistance in wild oats. An important finding is that the levels of resistance in wild oat populations are variable (Figure 2). This reinforces the need to investigate all possible causes for poor control, not just resistance. Figure 2 demonstrates the continuum of response from highly resistant (left) to susceptible (right) and that many populations are only partially resistant. A key objective of the current project is to determine how rapidly partially resistant populations become highly resistant.

Preliminary results indicate that resistance in wild oats can often be restricted to patches within fields which are often initially misdiagnosed as "spray misses". This highlights the importance of monitoring and detecting resistance at an early stage, before it spreads across the whole farm – hence the need for good diagnostic tests. More rapid tests are being developed for all grass-weeds, such as the "Rothamsted Rapid Resistance Test", which aims to provide results before the end of September for seed samples collected in July.

Cross-resistance patterns in wild oats are complex and variable. Some populations are highly resistant to 'fops' only (and not 'dims'). Others show partial resistance to 'fops' and also show cross-resistance to the 'dim' tralkoxydim and to herbicides with different modes of action, such as imazamethabenz-methyl and flamprop-M-isopropyl, but not cycloxydim. So far we have not found resistance to difenzoquat or tri-allate in the UK, although it has been found in Canada and USA.

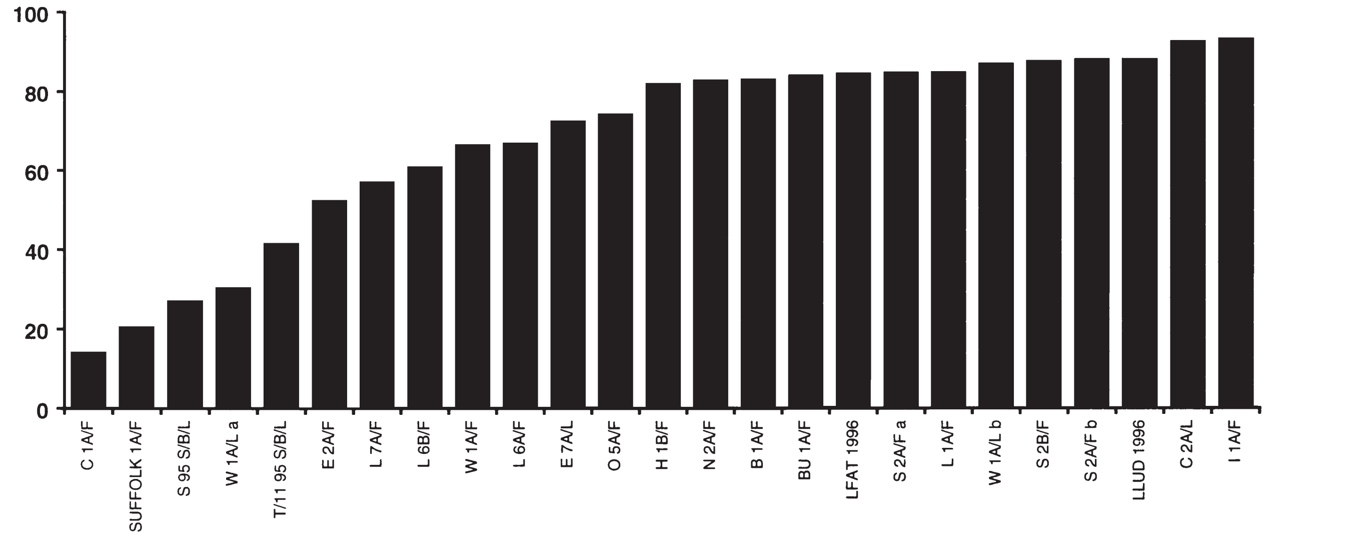


Figure 2. **Percentage reduction in fresh weight from fenoxaprop-P-ethyl (55 g a.i./ha) of wild oat populations in the glasshouse at IACR-Rothamsted.**

## Mechanical weeding

MAFF-funded work on mechanical weeding has shown that although integrating low rates of herbicide with tine weeding gave satisfactory results on broad-leaved weeds, it has so far not proven reliable for black-grass (Blair *et al.*, 1997). This project has evolved into looking at more vigorous hoe weeding between the rows (Tillett *et al.*, 1999). This relies on using video imaging to steer the weeder at high speeds, coupled with with weed control within a wide-spaced row using herbicides. Initial results suggest that this could contribute to grass weed control in organic rotations and provide a useful alternative where herbicide use might be restricted.

## Weeds and Integrated Farming

A MAFF-funded project is looking at the analysis of the seedbank samples taken from the Integrated Farming Systems (IFS) experiments. So far analysis has concentrated on the Boxworth site, where there were most grass weeds. In addition, seed bank data have been collected from a long-term cultivation experiment, which is being used to add to the interpretation and understanding of the results. Using an holistic approach to changes in seedbank communities can be useful in describing community composition and changes that have taken place, in relation to particular environmental variables. The analysis is still not complete, but it already shows the influence of ploughing at least once in five years on containing populations of grass weeds, but also of the integrated system on a more diverse seedbank.

## Conclusion

In summary, recent work has demonstrated that whilst there may be benefits from increased use of minimum cultivation, it is a strategy that involves increased risks from grass weeds. Where minimum cultivation is practiced there is a greater need to ensure that:

- grass weed numbers are minimised by good stubble management
- herbicides are selected and applied to maximise efficacy
- special attention is paid to monitoring, predicting and minimising herbicide resistance

## Future demands for weed management

Cropping systems will continue to be dominated by winter-sown rotations in most areas and there is no evidence that the implications of Agenda 2000 to reduce output prices to world market levels will lead to less intensive cropping. In fact, the reforms will result in continued pressure to reduce the fixed costs (cultivations, machinery, labour) and spread them over larger unit sizes. As a result managers will cover a larger area and that in turn will create a need for either a simple and robust approach to weed control which may reduce opportunities to fine-tune herbicide use in some fields, or the need for easy to use decision support systems. It will also become more important to have a greater spread of drilling dates in autumn (which will inevitably mean earlier drilling), to dilute fixed costs, which could result in a greater range of weed infestations and species present. This will result in decision making being more difficult in terms of current and future crops. In addition we are likely to see an increase in demand for reduced cultivations to keep costs down. Hence reductions in labour and machinery will mean that cultural control measures will have to be clearly justified.

More autumn-sown crops, reduced tillage and earlier drilling at reduced seed rates will all encourage grass-weeds. Herbicides are likely to remain the main method of control as reductions in labour and machinery will mean that cultural control measures will have to be clearly justified on both an efficacy and cost basis.

The anticipated changes in crop rotation and cultivation practice in the next decade are likely to increase the incidence of herbicide-resistant weeds. It will be particularly important to be able to predict more accurately where, why and how rapidly resistance will evolve. It will also be very important to know more about the long-term potential of cultural control methods for reducing reliance on herbicides, both for environmental reasons and for preventing resistance development.

The technology already exists to allow patches of weeds to be sprayed within fields. This is already leading to a demand for improved sensing of weed patch distribution and more robust information on weed thresholds. Thresholds cannot easily be adopted on a field scale because of variations in weed numbers. Spatial sensing and application offer the opportunity for weeds to be sprayed according to local need rather than the current practice of applying sufficient herbicide overall in order to control the highest local populations in the field.

Both cost pressures and environmental pressures will lead to increased demand for optimised weed management strategies. In particular recent attention has focused on farmland birds. There will be increased pressures to manage crops so that desirable plant species are retained, especially when they are needed to provide feed for birds. Better herbicides, herbicide tolerant crops and patch spraying may open up opportunities for better weed management through the rotation by the adoption of thresholds in individual crops without fear of the problems caused by shed seed. The use of an effective herbicide, such as glyphosate, also enable control of larger weeds, perhaps after they have been of benefit to wildlife, without affecting the crop. This will benefit farmland birds. The same technologies may also enable the return to minimum tillage with its environmental advantages, such as improved soil structure and reduced erosion.

Weed control strategies will have to continue to take into account herbicide resistance which will be a major challenge to the sustainability of current farming systems. Improved mechanical weeders may play an increased role in the future, both to reduce herbicide use but also to allow control of larger weeds.

Similar demands will result from organic farming, where weeds are one of the major constraints. Much of the requirements for improved knowledge of weed biology, and some of the technologies, such as hoe steerage, are equally, perhaps even more, applicable in this context.

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