Changing weed species and management – then, now and tomorrow

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Summary

Weeds respond to changes in husbandry, rotation and climate. This is illustrated by a survey of weed management requests to SAC Consultancy Services over the past 20 years. The changes in northern Britain may be mimicking those previously seen in the south. Farmers need to be aware of the best management options to avoid the problems with grass weed management seen in the south. In the future, climate change may encourage new crops and weeds, particularly in the spring, and examples are given.

Introduction

Agricultural practices have had a profound effect on the flora of arable land. Cropping patterns, technologies and husbandry practices change continuously in response to economic demands. This paper examines the changes in importance of weed species in cereals over the past 20 years in Scotland as an indication of change in northern Britain, and analyses the relative importance of key factors in such changes. Data from SAC surveys on organic farms is also used to indicate how rotation can have a profound effect on weed management.

Some changes in the relative importance of weeds in northern Britain appear to mimic earlier changes in the south, so we can inform and forewarn northern farmers as to how to react to such changes.

Some changes in the north may be in response to climate change. Table 1 shows the growth stages by date of winter cereals and spring barley in 1986 and 2006 from Scottish surveys (Davies *et al.,* 2007a). Clearly there are annual differences, and changes in sowing date have an effect, but this data is a good reflection of the trend seen in Scottish crops over the period. It should also apply to all plant growth, including weeds, and the trend is ongoing. We, therefore, also look briefly at a few potential weed scenarios which climate models indicate could become a problem in the next 20 years and more.

Key husbandry changes since 1985

The north of Britain followed behind the south in converting a significant proportion of its arable acreage to winter cropping. The key period of change occurred in the mid 1980's (Table 2, from Davies *et al.,* 2007) in Scotland. Currently winter cereals occupy about a third of the acreage, and winter oilseed rape about 10% (not included in table). These crops occur in most rotations, particularly in the SE although spring barley still dominates in the NE of Scotland.

Table 1. Comparison of growth stages of wheat and barley, 1986 and 2006

	April	*May*	*June*	*July*
W Wheat 1986	*Two main tillers*	*First node detectable*	*Booting*	*Flowering*
W Wheat 2006	*First node detectable*	*Third node detectable*	*Ear fully emerged*	*Late milk*
W Barley 1986	Six main tillers	Flag leaf emerged	Flowering	Early dough
W Barley 2006	First node detectable	Booting	Early milk	Hard dough
S Barley 1986	*Coleoptile emerged*	*Leaf emergence*	*Flag leaf emerged*	*Late flower*
S Barley 2006	*First leaf emerged*	*One main tiller*	*Booting*	*Early milk*

Table 2. Crop areas (K ha) in Scotland 1975-1985 and 2005

	76	*77*	*78*	*79*	*80*	*81*	*82*	*83*	*84*	*85*	*05**
WC	27	22	26	34	52	60	84	117	168	173	148
SC	442	458	467	450	466	449	444	375	367	355	261

WC: winter cereals; SC: spring cereals; * Differences in total largely due to winter oilseed rape acreage

Reduced tillage has become more important in the last ten years; particularly associated with winter cropping dominated rotations. Reduced tillage is now widely used on larger arable farms in eastern Scotland. It is suggested that this is a response to economic benefits on larger holdings, but possibly also an increasing desire to sow winter crops earlier and in drier conditions.

Early sowing of wheat has become increasingly popular in northern Britain. Traditionally it followed potato crops, so a mid-October sowing would be normal. Most crops are now sown in September to early October as previous harvest allows. This has meant a very short break between harvest and re-sowing, which has implications for attempts to produce a stale seedbed for management between crops.

The shift to winter cropping, particularly in the south of the area, has encouraged change in the weed population simply because of different life-cycles between weed species. This has been reported by a number of authors for the south of England (e.g. Firbank, 1999), with a notable shift towards grass weeds, and certain broad-leaved weeds such as cleavers and speedwells.

The advent of novel herbicides in the 1980s also had an effect on selection of weed populations. For example, diflufenican rapidly dominated the autumn broad-leaved weed market, and sulfonyl-urea herbicides had a major effect on the previously dominated spring hormone herbicide market. These had different spectra of control from the earlier herbicide treatments. They helped to control particular weeds of winter crops such as

speedwells and pansy which were poorly controlled by hormone herbicides, and were more flexible in timing of use.

Surveys of weeds

Information on trends in weed populations in arable fields in the last 20 years is limited. In 1989, Whitehead & Wright (1989) provided the most thorough survey of UK winter cereal crops prior to herbicide treatment to date. Earlier surveys tended to be geographically limited (e.g. Chancellor & Froud-Williams, 1984) or limited to individual species' distribution or behaviour in relation to crop management (e.g.Theaker *et al.,* 1995). More recently, Firbank (1999) compared the change in weed species between 1978 and 1990 within specific areas. Ranking of species had changed but a shift to grass weeds was noted, although the survey did not list black-grass as frequent. Firbank (1999) used a botanical survey of the UK to predict the occurrence of weed species within 2km squares, but this did not take into account the husbandry within the area. There are also weed seed bank surveys which give a snap shot of the potential weed problems which are a useful guide but are naturally weighted towards species which may produce a lot of seed, but may not be economically particularly important. However, a fuller review of such data sets than can be covered here may provide a useful guide to change.

Many authors report the impact of husbandry factors and rotations on weed populations and seedbanks on specific sites which provide support as to why weed changes have occurred. These may help explain best the obvious observations that certain weeds have become more or less important in the last 20 years.

SAC survey of weed management request

All the requests made to the SAC Crop Clinic Weed Vegetation Specialist have been recorded since 1985. This survey examines these requests, and whilst the Crop Clinic requests generally target issues that growers found difficult to manage for a variety of reasons rather than being a record of the relative populations of weed species, the changes over time do reflect changes in farming. The survey examined each request and listed the weed species recorded. In many cases only a general request was made as to herbicide programme, but it is assumed that when a weed was mentioned it was of significant importance to the customer. Such an emphasis could reflect a particular problem in terms of severity or difficulty in control or, possibly, a weed newly significant to that customer. Sometimes the number of weed requests for a specific species is greater than would be expected from anecdotal evidence as to its presence on farms. That appears to be most often because the weed is relatively new as a significant problem. As growers get used to the management of a 'novel' problem, the number of enquiries reduce. There are cases of weeds 'disappearing' as a major problem as new herbicide programmes appear, but others persisting as there are no easy control measures.

Winter cereals – broad-leaved weeds

Table 3 gives the trend in requests for specific broad-leaf weeds, as a percentage of all weed requests in which weed names are mentioned in winter cereals. In the early 1990's there was a clear increase in requests for speedwells (*Veronica spp*), field pansy (*Viola spp*), fumitories (*Fumaria spp*) and volunteer oilseed rape management. It is assumed that oilseed rape volunteers were residual from the increased acreages of both winter and spring varieties, with some anecdotal evidence that spring varieties dominated. The other

weeds, speedwells, pansy and fumitories appeared as common weeds as a response to the increase in acreage of winter cereals in 1980.

Cleavers (*Galium aparine)* did not appear as a frequent weed until the late 1980s. This weed is also particularly associated with winter cropping. Since then, as a proportion of requests, it has not changed greatly, although as with all winter weed species, the total number of requests has increased over the survey period.

Common chickweed (*Stellaria media*) was the only species that reduced as a proportion of the requests, but it is still the most frequently cited as the most common weed of winter crops in Scotland.

Table 3. Main weed requests in winter cereal crops, SAC 1985-2006, as percent of total number of requests

Year	S m	G a	V sp	F sp	B n	V a	P a	A f	B sp	A m	Other
85	16	0	9	0	0	0	14	2	10	0	5
86	23	0	0	0	0	0	10	0	17	0	10
87	23	0	0	0	0	0	10	8	5	0	4
88	29	7	5	7	0	0	13	4	12	0	1
90	23	6	0	0	0	0	6	4	8	0	1
91	21	11	9	4	8	0	5	13	4	0	3
92	18	12	15	5	6	0	4	7	2	1	4
93	16	10	8	5	8	0	7	9	5	0	3
94	17	7	7	7	12	4	8	9	4	0	3
95	22	7	10	5	0	0	10	8	2	0	1
96	20	9	6	3	9	0	9	8	3	6	2
97	16	10	11	8	12	4	6	8	6	0	0
98	14	7	8	11	3	3	5	7	3	1	2
99	15	4	11	9	10	4	10	7	4	2	1
00	10	8	11	7	8	3	8	12	5	3	6
01	17	5	11	8	6	4	11	8	1	2	1
02	17	5	7	10	5	2	13	7	2	2	5
03	18	6	4	5	6	4	14	7	4	3	3
04	13	9	3	10	7	0	5	7	11	6	3
05	16	12	5	11	7	3	9	10	6	9	49

S m: Common chickweed; G a: Cleavers; V sp: Speedwell spp.; F sp: Fumitory spp.; B n: Oilseed rape; V a: Pansy spp.; P a: Annual meadow-grass; A F: Wild-oats; B sp: Brome spp.; A m: Black-grass; Other: various other grasses.

Winter cereals – grass weeds

Table 3 also shows the trend in requests for grass weed management. Couch-grass (*Elymus/ Elytrigia repens*) was mentioned frequently in the early 1980's (also see Spring Cereals below) but disappeared as glyphosate used pre-harvest treatment had its full controlling effect. Brome (*Anisantha/ Bromus*) species have appeared in the record since then and continue to be a problem - largely sterile brome (*Anisantha sterilis).* More recently there have been a number of records of meadow brome (*Bromus commutatus*) in the Borders Region, which we has never previously been recorded, along with two records of rye brome (*Bromus tenuiflora*). The bromes are indicators of winter cropping and reduced tillage, and these factors, along with their notorious difficulty in control, are the

probable reasons for their increase. However, meadow and rye bromes are warmer climate species, with rye brome of Mediterranean origin, so their appearance may reflect changes in weather.

The appearance of apparently 'new species' of brome may also indicate seed ingress; this may apply to black-grass (*Alopecurus myosuroides)* in Scotland. The one or two cases each year in the 1990s has increased in the early 2000's to a significant proportion of queries. However, tests for herbicide resistance in five Scottish populations indicate low levels or no resistance to some standard black-grass herbicides, which may be present in imported populations. It is possible that they are local, rare populations responding to increased winter cropping and reduced tillage in much the same way as local populations in southern English grassland adapted in the 1970's. It may also be a response to climatic changes, reflected in the growth pattern of winter crops (Table 1).

Spring cereals

Table 4. Main weed requests in spring cereal crops, SAC 1985-2006, as percent of total number of requests

Year	S m	A f	E l	G sp	P av	P an	F sp
85	29	12	18	0	0	0	0
86	14	10	29	0	0	0	0
87	29	5	10	12	0	0	0
88	15	10	11	19	0	0	0
89	12	2	0	11	9	0	0
91	13	7	0	15	13	0	0
92	15	8	0	11	5	0	0
93	15	3	0	0	0	0	5
94	0	10	0	0	11	0	6
95	16	15	0	13	7	0	7
96	14	17	0	5	0	0	5
97	13	11	0	11	14	6	0
98	12	8	0	14	11	0	6
99	12	7	0	5	15	0	5
00	15	7	0	10	10	5	6
01	9	13	0	12	12	5	8
02	11	1	0	9	16	5	11
03	11	20	0	9	6	0	13
04	18	19	0	6	10	0	15
05	18	11	0	9	0	11	15

S m: Common chickweed; A f: Avena fatua; G sp: Hemp-nettle/ Day-nettle spp., P av: Knot-weed; Po a: Annual meadow-grass; F sp: Fumitory spp.

Spring cereal broad-leaved weed populations are more complex than those of winter cereals. Common chickweed, hemp-nettle/day nettle (*Galeopsis* spp.) and knot-grass (*Polygonum aviculare*) have been at consistently high level since the 1980's. In contract, the fumitories first appeared in the early 1990's, have increased in importance since then. This probably reflects the increase in winter crops, in which they appear to be encouraged (Table 1), and the widespread use of herbicides which are particularly ineffective against this group of species: diflufenican in winter cereals and sulfonyl-ureas (e.g. metsulfron-

methyl) in both spring and winter cereals. There is strong anecdotal evidence, plus evidence from the Royal Botanic Gardens of Edinburgh (McHaffie, 2007), that the fumitories in Scottish arable fields are now a complex of species including common fumitory (*Fumaria officinals*), but also wall fumitory or common ramping fumitory (*Fumaria muralia*), white ramping fumitory (*Fumaria capreolatea*) and purple ramping fumitory *(Fumaria purpureum*) –a BAPS red-list species. This may explain continuing difficulties in managing this group of species.

The appearance of annual meadow grass as a regular problem in the 1990's may reflect the general increase in grass weeds as winter cropping increased over the same period and damper spring weather. The pattern of requests may reflect wetter and drier spring periods.

Weeds in organic farms

Surveys of the impact of rotation on weed management in organic rotations, including those in conversion, have been undertaken by SAC (Davies *et al.*, 1997). These provide a good illustration of how husbandry affects weed populations. Table 5 shows the impact of the level of grass breaks. It is clear that the more grass cover in a rotation, the greater reduction in weeds in otherwise ploughed rotations. These results reflect those of other workers, and that many annual weeds, and notably grass weeds (data not presented), are much less of a problem in organic arable farming. The key factors that manage annual weed populations in organic cereals and legumes based rotations are reviewed by Davies & Welsh (2002). Apart from rotation, delaying sowing of winter crops, good establishment and crop competition, use of the plough and timing of weeding operations are highlighted.

Table 5. Impact of grass breaks in the rotation on mean number of weed seeds/m^2 to 20cm depth over four seasons on two farms (Woodside recently converted)

	Year 1	*Year 4*
Jamesfield		
Conventional rotation*	5,710	12,167
Rotations with grass	26.092	17,782
Rotations with no grass	25,276	42,141
Woodside		
Conventional rotation*	10,500	16,000
Rotations with grass for <2 years	22,140	45,857
Rotations with grass for >2 years	21,688	40,438
Rotations without grass	29,500	153,999

Changing management for changing weed problems

The weed problems that our records indicate are of increasing concern to Scottish growers include grass weeds other than couch-grass in winter cereals. We fortunately can look at the consequences of not undertaking an integrated control programme for these weeds in the north by examining what has happened in the south, such as the rapid spread of black-grass and bromes and the development of herbicide resistance in black-grass, rye-grass and wild-oats (WRAG, 2003), and take the advice prepared for southern growers (e.g. for

Italian rye-grass: HGCA, 2007; for autumn weed management, BASF 2006). Key factors include rotational breaks and ploughing breaks where there is reduced tillage, delayed autumn sowing, with stale seedbed approaches, rotation and mixing of herbicides from activity families and optimizing timing of herbicide treatments (eg Clarke, 2000). However, there are practicalities that limit the extent that individual northern farmers can follow southern recommendations. In particular, in many seasons there is little or no time for a stale seedbed before sowing the winter crop – which loses an important control option.

The loss of isoproturon and trifluralin and potentially increasing resistance problems will probably make the adoption of husbandry changes economically more attractive in the future, but at present the value of grain may prevent Scottish farmers following best practice. However, the loss of IPU already makes brome control in winter barley very difficult, and our recommendation is to avoid growing this crop in fields with brome grasses.

Amongst broad-leaved weeds, fumitories currently appear to be the most difficult to manage in the north. Herbicide recommendations may only be valid for common fumitory, and yet there is evidence (McHaffie, 2007) that at least four fumitory species are present which may have varying responses to herbicides. This may explain the number of requests concerning these weeds. There is little information on the behaviour of these species; they appear relatively resilient to rotational changes, and are poorly controlled in many crops, although ley breaks would probably help. We do not know their response to tillage. A return to hormonal herbicide programmes in cereals may help, but their timing limitations make them unpopular. Further work is required on these species.

The future

Grass weeds are likely to continue to become an increasing problem to northern growers in the next few years. Climate change may be a factor, and it assumed that its impact on northern British agriculture will become increasingly noticeable. Over the last half century temperatures have increased in every season in all parts of Scotland, and in northern and western areas, winter rainfall has increased by 60% (Davies *et al.,* 2007b). Winters will get warmer and wetter; summers warmer and drier; and there will be more extreme individual weather events, culminating in longer growing season. This, coupled with increased carbon dioxide levels, will affect crops and weeds. Much of the change is inevitable as it reflects past and current emissions of 'greenhouse gases' and any improvement will only affect us after 2050. We have used predictions and forecasts for the Scottish climate derived from scenarios produced by the UK Climate Impacts Programme and the Intergovernmental Panel on Climate Change. This indicates a warming of 1-2^{o}C, especially in summer, with fewer cold days in winter; winter rainfall is expected to increase by 15-20%, summer decrease by 15-30%, with a consequent reduction in summer soil moisture of 10-30% in lowlands.

Winter crops may be sown later to prevent too much autumn growth, but if autumn/ winters are much wetter, this may force earlier sowing, and more autumn weed growth. In the spring, conditions will become more suitable for spring hard wheat, maize and sunflowers, and in the south of Britain, other warm climate crops which may prove alternative options to autumn sown crops. This may give rotational weed management opportunities currently not available, but may introduce new weed species.

Future grass weeds

The climatic model used at SAC (Davies *et al.*, 2007) suggests a future of warmer, drier summers and wetter, warmer winters in Eastern Scotland. This appears to indicate a climate increasingly similar to that current in eastern England, although winter rainfall levels may be higher, and possibly more like that of western France. This would initially suggest an increasing trend in winter-based rotations towards grass weed problems such as sterile/ barren brome (*Anisantha sterilis),* black-grass *(Alopecurus myosuroides),* and meadow-brome *(Bromus hordaceous),* all of which are currently rare or very rare in Scotland. This would be particularly evident on heavier soils. It is noted by SAC that black-grass records have increased significantly in the last 5 seasons in heavier soils in south-east Scotland, whilst meadow-brome (4 recordings) has only appeared since 2002. These would be expected to increase in the short to medium term with conditions already suitable for an increase in black-grass (Fig. 1). Surprisingly, the model also suggests a reduction in spread of black-grass in England and little in Scotland by 2050 (Davies *et al.,* 2007b). This may be related to very dry summer predictions. Some of the brome species are warmer, drier climate species, and may be expected to increase: meadow brome, rye-brome *(Bromus secalinus)* and soft brome *(Bromus mollis)*. It has been suggested that loose silky-bent (*Apera spica - venti*), a major weed in central Europe, but rarely seen in UK, would increase, especially on lighter soils. However, although summers are warm in central Europe, winters are very cold and relatively dry.

There are suggestions that some grass weeds from warmer zones of Europe such as barnyard grass (*Echinochloa crus-galli*) and crab-grass (*Digitaria sanguinalis*) could become important in the UK as well as annual rye-grass (*Lolium annua*) in the longer term. As an example, the climate model indicates a 70% chance of barnyard-grass being present in parts of Scotland by 2050 (Fig.2).These weeds are more likely to cause problems in spring-sown crops such as maize and sunflowers, and certainly more extensive maize growing could be possible in Scotland by 2050. Other grass weeds that are problems in south-west France, which currently has a warm, moist climate, could also become problems. However, the attractiveness of these spring crops may improve the rotational possibilities for winter weed management.

Future broad-leaved weeds and meadow-grasses

Davies *et al. (*2007b) examines the effect of warm, moist winter climate and dry/warm summer climate on broad-leaved weeds in the future. Some weeds currently major problems in Scottish winter crops, such as annual meadow-grass *(Poa annua)*, common chickweed *(Stellaria media)* and ivy-leaved speedwell *(Veronica hederifolia),* may not survive long into warm dry springs. On the other hand, cleavers *(Galium aparine)* would still be a problem and poppies *(Papaver* spp*.)* and various umbellifers and weedy crucifers may become more serious, even in the medium term.

In spring crops, more field bind-weed *(Convulvulus arvensis)*, scarlet pimpernel *(Anagallis arvensis)* and various composite species *(Compositae)* would be expected to increase. Some species such as pigweeds *(Amaranthus* spp*.)*, already seen in south-east England as new species, may become important. Other species, common in parts of continental Europe, such as thornapple *(Datura stramomium*) and black nightshade *(Solanum nigrum),* serious and poisonous weeds in grain, vegetable and salad crops, may become important. They are seen now as temporary occasional in Scotland.

Of course, without the seed these species will not establish but experience shows that weed seeds do spread relatively readily if conditions allow. New weed challenges to farmers will arise and will be survived, but whether there will be weed scientists available to monitor and advise what to do with the new weed scenarios is questionable!

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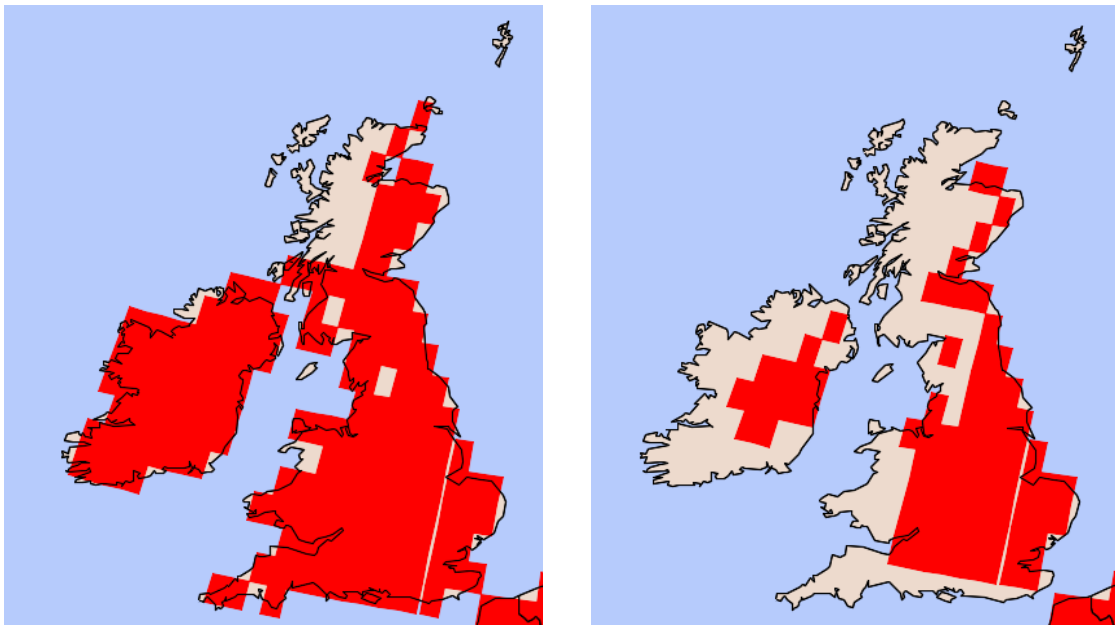

Fig. 1. The current potential areas of British Isles where black-grass could grow, and the potential areas in 2050, based on climatic change models.

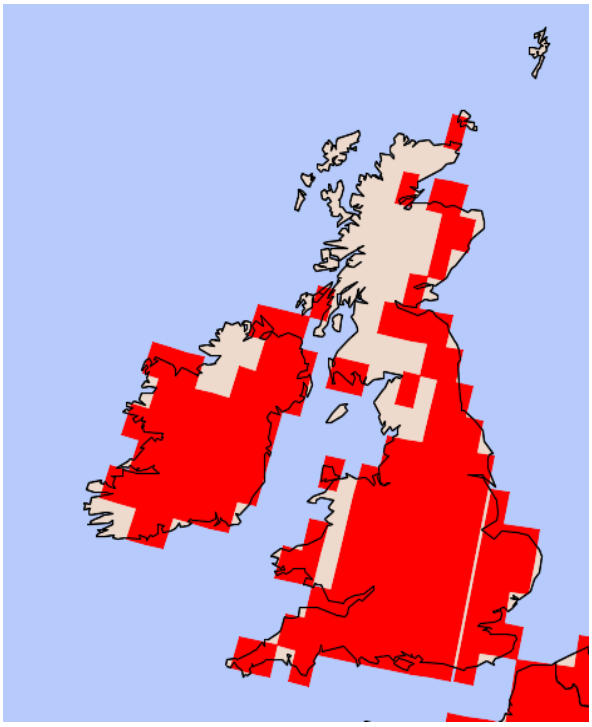

Fig. 2. Potential areas of British Isles where barnyard grass could grow in 2050, based on climatic change models.