Br. Crop Prot. Counc. Monogr. No. 9 (1974)

REGIONAL WEED PROBLEMS - DICOTYLEDONOUS WEEDS IN TILLAGE CROPS

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Summary The northern regions of the United Kingdom are shown to have a characteristic weed flora with an affinity to that of Finland and N Sweden in which Galeopsis spp. and Spergula arvensis are more important and Galium aparine, Papaver spp., Polygonum convolvulus and Veronica spp. are less important than in the remainder of the country.

The possible effects on regional weed problems and their control of the following are discussed:-

differences in weed biology related to environment

differences in the proportions of arable crops, root crops and grassland

special northern crops and systems of husbandry

economic and social factors

INTRODUCTION

The objective of this review is to assess if there are differences, which might affect the selection and effectiveness of control measures, between weed problems in the northern regions of the United Kingdom and the remainder of the country. An attempt will be made to explain any such differences and to relate the problems of the northern United Kingdom to those of other north temperate countries.

There is very little published information available on regional weed problems and it will be necessary to consider evidence based on common knowledge and personal experience if a systematic account is to be presented.

For the purposes of this paper the title has been interpreted broadly and northern weed problems will be considered under the following headings.

1. weed floras - species frequency and density, weed associations, sub-species and ecotypes.
2. biology of weeds and crops - regional characteristics of germination, growth, reproduction and spread.
3. agronomic factors - regional crops or systems of husbandry.
4. economic and social factors.

These topics cannot all be dealt with to an equal depth and certainly any discussion of the last item must largely be a matter of speculation, nevertheless all these factors contribute towards characteristic regional weed problems or may influence the adoption of control measures.

WEED FLORAS

It would appear difficult at first sight to establish that there is a characteristic northern weed flora within the United Kingdom. According to Salisbury (1961) "None of our weeds of arable land are definitely northern in character." Perusal of the "Atlas of The British Flora" Perring and Walters (1962) and "Flora Europaea" Tutin et al (1964) also gives little encouragement, although it is doubtful if the methods of surveying and levels of recording used in the compilation of these publications are relevant to agricultural conditions. There are however indications that Papaver dubium tends to replace Papaver rhoeas in northern Britain and that whereas Galeopsis tetrahit is uniformly distributed throughout the arable farming regions of the country Galeopsis speciosa is more northerly in its distribution. In Finland Mukula et al (1969) record Galeopsis bifida and speciosa as being generally distributed and G. tetrahit as being more common in the south. Identification of Galeopsis species at the seedling stage is impossible and is not attempted in weed surveys. There is no evidence that they differ in their susceptibility to selective herbicides although this possibility must always be borne in mind.

Sub-species, ecotypes and clones of perennials are known to occur in many dicotyledonous arable land weeds including Raphanus raphanistrum, Polygonum aviculare, P. persicaria, Chenopodium album, Tripleurospermum maritimum, Capsella bursa-pastoris, Viola spp., Veronica spp., and Fumaria officinalis. There do not appear to have been any studies of their regional geographical distribution nor of the possibility of measurable differences in their sensitivity to selective herbicides, although Salisbury (1961) states that the yellow flowered northern Raphanus raphanistrum appears to be more resistant to MCPA and MCPB than the southern white flowered variety. If such differences were substantiated careful study would be needed to ascertain whether they are true genetic differences or a consequence of the effect of local environment on the growth characteristics of the weed.

In the surveying of weed floras, which is necessary before regional differences can be demonstrated, the potential problem can be determined by assessing the number of viable weed seeds and the weight of vegetative propagating material of perennial weeds in the soil. Such methods are difficult and time consuming and most surveys have used the number of emerged seedlings or shoots in cereal crops to characterise the weed flora of an area. As pointed out by Lawson (1974) assessing the weed flora in a crop sown at a different time might well produce an apparently different weed flora. Similarly recent unpublished work by Carnegie in Aberdeen has shown that the proportions of emerged weed seedlings of different species can be radically altered by the nature of the preceding soil cultivations. The time at which the assessment of weeds is carried out may also alter the picture although in cereals the period available for surveying is short and is limited to the time interval between the presence of recognisable seedlings and the onset of herbicide spraying. Most arable land weeds are widely distributed and if differences between regions are to be demonstrated it is necessary to have detailed information on presence or absence of particular species, frequency of occurrence, ie percentage of fields or acres infested, density of infestation and characteristic associations of species. This information can only be obtained by deliberate surveying of individual fields.

There has been very limited weed surveying in the United Kingdom and certainly nothing comparable to the surveys of the Scandinavian countries and Canada. Most British information is based on surveys in which the opinions of farmers, advisers or technical representatives as to which weeds are troublesome in particular fields are recorded and analysed. Whilst such information is very valuable in deciding the major weed problems of an area or a particular crop it is of a much lower degree of accuracy than that obtained from an objective survey based on identification and counting of seedlings or shoots of perennials in randomly scattered quadrats in randomly selected fields. Such a method of surveying was used by Carnegie (1974) when 20 one foot square quadrats equals total 2 m^2 per field (115 fields) were used and Mukula et al (1969) who used four quadrats each of 0.25 m^2 equals total 1 m^2 per field (2,088 fields). There would appear to be a reasonable basis for comparison of the results of these surveys.

Carnegie compares her figures for species frequency with those resulting from a survey by Fisons, Edwards (1974), for the north of Scotland and points out that there is a reasonable measure of agreement for the larger more obvious components of the weed flora such as Galeopsis sp. but unreconcilable disagreement for the smaller weed seedlings such as Capsella bursa-pastoris, Spergula arvensis and Viola spp. Similar major inconsistencies can be found between various surveys of East Anglia as quoted by Fryer and Chancellor (1970a).

It is plainly advisable that in any future weed surveys a standardised objective method of assessment should be adopted and judging by the degree of agreement shown between Carnegie's 1973 figures with the author's results for 1967-68 (Scragg 1970) it would appear that the counting of seedlings in 20 random square foot quadrats per field has given reproducible results without being excessively arduous or time consuming.

A difficulty in surveying which will become increasingly troublesome in the future arises from the disappearance of field boundaries and perhaps a series of locations each of 100 x 100 m might be necessary as a future unit of assessment.

Most surveys which can be used to show regional differences in weed floras within the United Kingdom have been restricted to cereal crops and to relatively small parts of the country such as those of Brenchley (1920) - Norfolk to Somerset; Dadd (1962) and Elliott, Cox and Simonds (1968) - East Anglia; Scragg (1970) and Carnegie (1974) - the north east of Scotland. Phillipson, Cox and Elliott (1972) give information about the cereal weed floras of Northumberland, the Midlands and Dorset and show that certain difference exist between them. Elliott, Cox and McDonald (1965) report a survey of weeds in potato crops based on local agricultural advisers' opinions as to which were the most important weeds in this crop in their advisory area which revealed the importance of Galeopsis spp. in the north.

The only useful national survey available is that of Fisons Agrochemicals the results of which were published by O'Leary (1973). Additional hitherto unpublished data arising from Fisons survey has been supplied by Edwards (1973) and is used in this review. Fisons figures for percentage frequency of occurrence by acreage have a broad similarity to those of Mukula and Carnegie and are therefore used for regional comparison purposes in preference to those of other surveyors, eg Elliot et al (1968) where figures are much lower presumably due to differences in surveying technique.

In Table 1 the results of a x^2 test of significance applied to Edwards' data are given. It will be seen that two species Galeopsis spp. and Spergula arvensis occur at significantly higher frequencies in Scotland and northern Ireland and that four others Galium aparine, Papaver spp., Polygonum convolvulus and Veronica spp. have a significantly lower frequency.

Table 1

A comparison of the weed floras of Scotland and Northern Ireland with England and Wales

Species	Percentage frequency (Edwards 1973) Scotland and N Ireland	England and Wales	x^2	Significance
Capsella bursa-pastoris	5.5	13.6	4.10	*
Chenopodium album	30.0	48.0	3.02	NS
Chrysanthemum segetum	10.0	4.0	3.00	NS
Cirsium arvense	13.5	15.7	0.25	NS
Fumaria officinalis	30.0	21.6	2.00	NS
Galeopsis spp.	84.7	17.1	49.66	***
Galium aparine	5.5	23.7	10.14	**
Papaver spp.	0.8	16.6	13.09	***
Polygonum aviculare	56.7	64.1	0.09	NS
P. convolvulus	26.0	63.9	13.52	***
P. persicaria	66.2	48.9	3.92	*
Raphanus raphanistrum + Sinapis arvensis	63.0	51.6	2.05	NS
Rumex spp.	7.2	20.7	5.66	*
Spergula arvensis	33.2	11.6	11.95	***
Stellaria media	86.7	79.7	0.97	NS
Tripleurospermum spp.	16.0	27.4	2.27	NS
Urtica urens	4.5	15.7	5.48	*
Veronica spp.	8.7	33.4	12.87	***
Viola spp.	5.5	15.4	4.03	*
		Total x^2 = 148.07		***

Other regional differences revealed by the data supplied by Edwards are the high frequency of Polygonum persicaria in the west of Scotland confirmed by the survey of Waterson, Waddell and Anderson (1970), the relatively high frequency of Chrysanthemum segetum in northern Ireland and Lycopsis arvensis in the north of Scotland.

Before discussing the possible reasons for these peculiarities in regional weed floras it is useful to make a comparison of the data given by Carnegie (1974) for the north of Scotland with that of Mukula et al (1969) for Finland, Granstrom (1956) for northern Sweden (Norrland) and East Anglia, Edwards (1974), see Table 2. A comparison with the Finnish data is particularly rewarding for although the number of fields surveyed in Finland was very much greater the methods of surveying were similar.

Table 2

A comparison of the weed flora of spring cereals

	Percentage fields or acres infested			
	N Scotland Carnegie 1974	Finland Mukula et al 1969	N Sweden Granstrom 1956	SE England Edwards 1973
Capsella bursa-pastoris	57*	32	-	19*
Chenopodium album	48*	92	92	48*
Cirsium arvense	0	37	4	13*
Erisymum cheiranthoides	0	74	-	-
Fumaria spp.	51*	40	18	12
Galeopsis spp.	90*	94	90	10
Galium aparine	0*	0	4	21
Lapsana communis	0	49	-	-
Myosotis spp.	41*	60	2	-
Polygonum aviculare	97*	42	-	70*
P. convolvulus	77*	59	4	79*
P. persicaria/lapathifolium	90*	73	14	29*
Ranunculus repens	71*	74	-	-
Raphanus raphanistrum	17*	45	-	-
Rumex spp. (sorrels)	13	61	-	-
Sinapis arvensis	42	0	-	†60
Sonchus spp.	4	36	10	9
Spergula arvensis	94*	88	78	8
Stellaria media	99*	85	71	74*
Thlaspi arvense	0	26	22	-
Tripleurospermum spp.	78*	48	2	48*
Veronica spp.	32	1	4	44
Viola spp.	84*	80	4	25*

* species with similar frequency to that in Finland

\- no information available

† includes Raphanus

It will be seen that 15 species in the north of Scotland have a frequency similar to that in Finland whereas only nine species in East Anglia are reasonably comparable. Figures for weed density are given in Table 3. These show that the north of Scotland and Finland have three out of four of their most densely occurring weeds in common. Weed densities in northern Sweden appear to be particularly high but it should be emphasised that when Granstrom's data was collected the growth regulator selective herbicides had only been available for a few years.

Table 3

A comparison of mean weed densities in spring cereals (infested fields)

N Scotland Carnegie 1974		Finland Mukula et al 1969		N Sweden Granstrom 1956	
Species	Plants /m²	Species	Plants /m²	Species	Plants /m²
Stellaria media	94	Spergula arvensis	98	Stellaria media	201
Galeopsis spp.	37	Stellaria media	95	Thlaspi arvense	194
Spergula arvensis	30	Galeopsis spp.	70	Chenopodium album	169
Polygonum aviculare	30	Chenopodium album	64	Spergula arvensis	161
All species	259	All species	550	-	-

A direct comparison of north of Scotland weed densities with other regions of the United Kingdom is impossible owing to absence of data on this important subject. At an average of 259 seedlings per m² or approximately 1.25 millions per acre it seems likely that weed densities in the north are above average for the country and are certainly much higher than quoted by Fryer and Chancellor (1970b) for two fields at Begbroke.

There would appear to be evidence for the existence in the northern United Kingdom of a regional weed flora which has an affinity to that of other northern European countries. This flora is based on the frequent occurrence of a relatively small number of species at rather high densities with Galeopsis spp. and Spergula arvensis as characteristic components.

Reasons for regional weed floras

The present weed flora of any region, district or field is a reflection of the interaction of previous husbandry, including herbicidal control, climate and soil on the native and introduced weed species. Certain species, eg Stellaria media which are widely distributed must find conditions satisfactory for their growth and reproduction throughout the United Kingdom. Others such as Galeopsis spp. Spergula arvensis, Galium aparine which show distinct regional differences in their frequency plainly have fairly narrowly defined environmental requirements which are only satisfied in limited areas of the country.

Chance introduction of a species to a non-infested field, farm or district, followed by its establishment and spread plays a part in determining weed floras and its role in connection with the distribution of such recently introduced exotic species such as Galinsoga parviflora and Cardaria draba is well established by Salisbury (1961). How far existing localised infestations of more common weeds, eg Chrysanthemum segetum and Lycopsis arvensis are the results of recent

introduction followed by outward spread or the relics of a gradually diminishing generalised distribution is harder to determine. There is historical evidence that Chrysanthemum segetum was at one time widespread in north east Scotland and the indications are that it has gradually become confined to areas such as the Moray Firth where it finds favourable environmental conditions.

Climate

This factor must play an overriding part in determining which species achieve importance as arable land weeds either through its direct effects on weed growth and reproduction or perhaps more important through its indirect effects on soil conditions or the pattern of husbandry which it permits.

Examples of the direct effect of climate are difficult to find but it is possible that the high incidence of Galeopsis spp. in northern regions may be associated with the wetter soil conditions which Gloyne (1974) has demonstrated to be characteristic of those areas. On the other hand the absence from northern regions of such typical southern European species as Ranunculus arvensis, Myosurus minimus and Adonis annua is probably due to their intolerance of the harsh northern climatic conditions. The high incidence of Polygonum persicaria in the high rainfall western regions is surely associated with the wetter soil conditions known to be favourable to this weed.

For climatic reasons it is not possible to grow such a wide range of arable crops in northern regions and the proportion of winter sown cereals is much lower (estimated 8 per cent Scotland, 30 per cent England and Wales). This is probably the factor responsible for the relatively narrow range of arable land weed species and the lower incidence of annuals such as Galium aparine and Veronica spp. which are strongly associated with winter cereal growing. Those annuals which are troublesome are either capable of germinating at any time of the year when the soil temperature is high enough, eg Stellaria media and Capsella bursa-pastoris or have a germination peak in late spring, eg Galeopsis spp., Spergula arvensis and Polygonum persicaria (Lawson 1974) which matches their life cycle to that of relatively late spring sown arable crops.

Climate will be moderated by distance from the sea and altitude. Carnegie (1974) found the flora of Upper Banffshire to be noticeably different from the remainder of north east Scotland and to be composed of a relatively small number of species occurring at rather high densities.

Soil

Soil preferences appear to play a part in determining the species present in the northern weed flora. The areas under arable cultivation are generally on lighter soils of high organic matter with a tendency towards acidity unless liming is generous and frequent (Batey 1974). Clay soils are relatively uncommon and although successfully utilised for arable crops in favoured areas such as in parts of Fife and the Lothians of Scotland would be difficult to manage and probably utilised for grass production in the cooler wetter areas. It is interesting to note that in Carnegie's survey the Laurencekirk area with its heavier soil and more intensive arable cropping has different proportions of species than the neighbouring Aberdeenshire areas.

Galeopsis spp. appears to be a weed with a strong preference for soils of high organic matter. Both Mukula and Granstrom agree on this although Carnegie does not show a correlation with organic matter possibly due to the fact that the soils on almost all her sites were relatively high in organic matter. Within the northern regions it is frequently observed that Galeopsis spp. infestations are dense on

peaty fields. Outwith the northern regions of Britain Galeopsis spp. are only troublesome on the black peaty Fenland soils where high organic matter content and soil moisture may combine to produce conditions favourable to this species.

Spergula arvensis appears to be favoured by sandy soils of high organic matter such as are common in north east Scotland and is apparently tolerant of their inherent acidity (Mukula 1969 and Granstrom 1956). Chrysanthemum segetum and Lycopsis arvensis are characteristic of extremely sandy soils (Carnegie 1974).

Husbandry

Husbandry factors especially the rotation practiced and use of herbicides are unquestionably of importance in determining the weed flora. The northern regions are characterised by a higher grassland to arable land ratio than the south of the country and for this reason it would be expected that in the absence of control a build up of arable land weeds would be slower; on the other hand satisfactory herbicides are now available for most species and there is evidence, which will be dealt with in the next section, to suggest that the decline in weed seed populations will be more rapid under frequent arable cropping providing weed control is satisfactory than under a rotational system with less frequent arable crops. For these reasons comparative stability of the weed flora may be characteristic of northern regions.

BIOLOGY OF WEEDS AND CROPS

Roberts E H (1972) in his review of factors affecting seed survival in the soil shows that low temperature, high moisture and organic matter all tend to increase the duration of viability. Champness and Morris (1948) include soil acidity as a soil characteristic favourable to survival. Thurston (1966) and Roberts and Feast (1973) show that longer survival occurs when soil disturbance is less frequent. It seems likely that soil conditions and the husbandry systems prevailing in northern regions will favour longer persistence of weed seeds in the soil and this may partially explain the high weed densities and frequency of occurrence of species such as Galeopsis spp. in spite of successful weed control measures in arable crops.

Small differences in mean monthly air temperature, Gloyne (1974) and soil temperature, Hogg (1971) have been shown to exist in the spring between the north and south of the United Kingdom. These may critically affect the relative time of germination and emergence of crop and weeds which has been shown by Friesen (1972) to be an important factor in weed/crop competition. Data is not available on minimum temperatures for germination of annual dicotyledonous weeds but Chancellor and Peters (1972) give 6-7°C as the minimum for Avena fatua which is slightly higher than the 3-5°C usually quoted for barley. Field observations over many years show that the predominant annual weed in the north east of Scotland Galeopsis spp. does not emerge in large numbers until about one to two weeks after wild oats have reached the 1-2½ leaf stage which would suggest that this species has a relatively high minimum soil temperature requirement for germination. Studies of weed emergence at Mylnefield, Angus by Lawson et al (1974) show that year to year variation in date of peak weed emergence are greater than the differences between their station and Wellesbourne, Warwickshire. Mylnefield is however adjacent to the Tay estuary and climatically favoured compared with many arable areas of eastern Scotland. In general it is probable that annual dicotyledon weed emergence is late in comparison with cereal emergence in northern regions and that the weeds are still small and relatively easy to control when the cereal reaches the safe stage for application of growth regulator type herbicides. The favourable balance of competition towards the crop may also explain why MCPA with its limited weed spectrum usually provides

effective annual dicotyledonous weed control under Scottish conditions. The difference in time of emergence of wild oats and dicotyledonous weeds would be a barrier to effective action of a combined barban/broad leaved weed herbicide in the north.

There are differences in the pattern and extent of vegetative growth of crops and weeds in northern regions which will influence the severity of weed problems. In spring cereals vegetative growth is more profuse and continues for longer in the north in response to cooler conditions and higher soil moisture content. Potatoes produce taller and more vigorous haulm and the foliage of fodder brassicas is less severely damaged by powdery mildew. Hammerton (1965) has shown differences in the character of growth of Polygonum persicaria according to its origin and the same author (Hammerton 1969) records intra specific variation in spray retention in Polygonum spp. in samples obtained from different regions.

There is evidence to suggest the likelihood of differences in crop and weed cuticle thickness in different regions. The experimental work of Skoss (1955) and Juniper (1959) shows that cuticle is thicker under conditions of high light intensity, high temperature and water stress. Kirkwood (1972) has reviewed this subject and also discusses the effects which environment have on retention, penetration and absorption of foliar applied materials. Differences in the performance of herbicides, especially contact materials, are observed in northern regions which may result from interaction of environmental factors with crop and weed growth.

Vegetative growth, flowering and seed set in annual weed species with an indefinite end to their seasonal growth such as Chrysanthemum segetum and Stellaria media continues for longer in the autumn under northern conditions than in regions where summer soil dryness prematurely cuts short their growth. Such weeds are likely to cause more serious hindrance to combine harvesting in northern regions than in the south.

Later harvest and earlier onset of winter in the north have limiting effects on the treatment of dicotyledonous perennial weeds such as Tussilago farfara and Sonchus arvensis with foliar absorbed translocated herbicides. Poor results indicate that although foliage of these weeds may be present in cereal stubbles it is not physiologically active and fails to absorb or translocate herbicides satisfactorily. It is also possible that low autumn soil temperature influences the germination of winter annuals such as Galium aparine and Veronica spp. which infest winter cereals in the south, although another possible explanation for their comparative absence in the north would be seedling death due to the severity and duration of the winter season.

AGRONOMIC FACTORS

The character of agriculture in the northern regions of the United Kingdom can be judged from Table 4 where the acreages of arable land, grassland and root crops are given. The ratio of arable/grassland shows that in Scotland and particularly in northern Ireland grassland predominates. Root crops form a higher percentage of the Scottish arable acreage although the figures given for Norfolk, Fife and Aberdeenshire show that there are major differences within regions. Winter cereals are relatively unimportant in the north and sugar beet is no longer grown.

The consequences of this pattern of agriculture have already been considered in so far as it leads to a simpler and more stable weed flora with a low incidence of species associated with winter cereals. In the absence of sugar beet Chenopodium album becomes a weed of relatively low importance. The relatively high proportion of root crops should assist control of grass weeds.

Table 4

A comparison of the proportion of arable crops to grassland in various regions of the United Kingdom 1971 data

	Arable Crops 1000's acres	*Grassland 1000's acres	Ratio arable/ grass	Root Crops 1000's acres	Root Crops per cent of arable crops
England and Wales	10,417	13,383	1/1.3	1,294	12.4
Scotland	1,475	2,690	1/1.8	290	19.7
Northern Ireland	247	1,817	1/7.4	45	18.2
Norfolk	616	177	3.5/1	†164	26.6
Fife	123	92	1.3/1	††29	23.6
Aberdeenshire	256	355	1/1.4	46	18.0

* excluding rough grazing

† excluding beans, oil seed rape and mustard

†† before closure of Cupar sugar beet factory

Regional crops

Seed potatoes are a crop almost entirely restricted to northern regions (53,000 ac in Scotland 1971). The problem of weed control in this crop is different and probably easier than in the ware crops of the south. In seed crops high stem numbers are achieved through the planting of a greater weight of setts (30 cwt/ac against 20 cwt/ac in ware crops). Weed emergence is earlier than crop emergence due to the widespread use of unsprouted seed and contact herbicides alone generally give satisfactory results. Slight crop scorch arising from early post emergence spraying is not important in seed crops which in any event are not allowed to grow on to maximum yield. Once emerged crop haulm is vigorous and late emerging weeds are less troublesome than in the more open canopied ware crops in the south.

Turnips and swedes (Scotland 137,000 ac, England and Wales 100,000 ac 1971) can also be regarded as important northern crops. In these crops the brassica weeds Sinapis arvensis, Raphanus raphanistrum and Capsella bursa-pastoris present a problem as they are resistant to currently available brassica herbicides. Fortunately the use of selective herbicides in cereals over the past 25 years has reduced their incidence to a comparatively low level. The main herbicides used in fodder brassicas are soil applied and the undoubted differences which exist between north and south in soil moisture and organic matter make it important that their performance be adequately tested under northern conditions.

Another crop characteristic of the north is raspberries (Scotland 8,000 ac, England and Wales 1,400 ac). Here the main difference between north and south lies in the climatic and soil conditions which permit the safe use of certain residual soil applied herbicide treatments. Other crops in which there is a possibility of differences between north and south in their weed problems are carrots, peas and beans, horticultural brassicas, strawberries and bulbs.

Regional methods of husbandry

An aspect of cultural methods peculiar to the north which must be mentioned is the technique of growing fodder roots on ridges. Several reasons have been advanced for this traditional practice such as to produce a drier and warmer seed bed, to assist singling and inter-row cultivation and make harvesting easier. Inter-row cultivation is certainly made easier especially on sloping land and most farmers being equipped with tools for sowing and cultivating ridge grown crops would be unwilling to change to cultivation on the flat unless some very persuasive reasons were given. So far as weed problems are concerned it seems likely that weed emergence is less complete and spread over a longer period of time on a lumpy ridge than on a fine textured flat seed bed. Certain weed species such as Fumaria officinalis, Veronica spp. and Avena fatua have been observed to germinate from a greater depth and therefore to emerge later on ridges than on the flat. Soil incorporated herbicides must be incorporated to a greater depth on land that is to be ridged and if the same dose is used may be less effective than on the flat because of their lower concentration in the treated soil.

ECONOMIC AND SOCIAL FACTORS

Size of farms in the northern regions is generally lower and a high percentage of holdings are family farms where the owner or occupier has a strong personal interest in maintaining a high standard of husbandry on his farm. Under these conditions social pressure to grow crops and grass visibly free from weeds is high and weed control measures which are mainly cosmetic in their effect may be undertaken.

On the other hand the market for agricultural chemicals offered by smaller units may be too restricted to interest major herbicide manufacturers. The unavailability or high local cost of materials and application equipment may limit the exploitation of modern herbicide technology and reliance be placed on relatively ineffective cultural and mechanical methods of weed control. There may also be a certain lack of knowledge and expertise on the part of farmers on small farms in certain remote areas, due partly to the restricted educational facilities available and partly to their limited interest in tillage crops. Such problems are particularly evident in upland regions and the Highlands and Islands of Scotland where they are further intensified by the crofting system of land tenure. Here the restricted areas of arable crops are often little more than a mass of weeds.

In the more typical arable areas of the east of Scotland we find a high standard of arable crop husbandry coupled with the availability of a skilled labour force. Standards of weed control achieved by traditional methods were high and herbicides must perform equally well if they are to be acceptable. The diminishing supply of agricultural labour has tended to enforce a departure from these high standards and encouraged a rapid acceptance of chemical methods of control.

Rising land value has an influence on weed problems especially perennial species whose presence leads to lower productivity and a tendency to improve land in hand rather than seek extra acres outwith the existing unit is clearly detectable. The current profitability of cereals has already had a marked influence on weed problems and farmers are now less willing to accept even small yield losses caused by weeds. The threshold for acceptability of herbicide costs has recently moved markedly upwards.

Acknowledgements

The author gratefully acknowledges the assistance of Fisons Agrochemicals Limited in the provision of regional weed survey data, Mr A.D. McKelvie of The North of Scotland College of Agriculture for statistical analysis and editorial assistance, and Miss H. Carnegie of the University of Aberdeen for data on the weed flora of north east Scotland.

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SOME EFFECTS OF THE NORTHERN ENVIRONMENT ON THE OCCURRENCE AND CONTROL OF GRASS WEEDS IN TILLAGE CROPS

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Summary The most important gramineous weeds of Scottish tillage crops are Agropyron repens and Avena fatua. This review suggests that while certain features of the northern environment (such as the generally strong growth of crops) favour control of these weeds the majority of its aspects are unhelpful to available control methods by chemicals and cultivation.

INTRODUCTION

The main grass weeds of Scottish agriculture - wild oats and couchgrass - may be few in number but they are of great significance to any farmer whose land they infest. The wild oat is normally Avena fatua, although A. strigosa persists in some districts and has a nuisance value; A. ludoviciana is not a problem. Couchgrass is generally Agropyron repens, but Arrhenatherum elatius, Agrostis gigantea and A. stolonifera are also found. In more detail the list of grass weed species reads:

ANNUAL/BIENNIAL	PERENNIAL
Alopecurus myosuroides	Agropyron repens
Avena fatua	Arrhenatherum elatius
Avena strigosa	Agrostis spp
Bromus mollis	Holcus mollis
Poa annua	Poa trivialis

The additional species shown are of sporadic and ill-documented occurrence and this paper uses as examples the annual Avena fatua and the perennial Agropyron repens.

GENERAL CONTROL METHODS

Relevant methods of weed control are classed:

a) "Selective" cultivations or herbicides within a crop.
b) "Non-selective" cultivations or herbicides used before, after, or in place of a crop.
c) Rotational practices, crop competition, etc.

For selective weed control by cultivation the machinery used must either be fairly sophisticated (as for hand roguing wild oats!) or the crop has to be grown in a geometrical arrangement to permit inter-row work or cross-blocking. The facility with which a selective herbicide can be developed depends to some extent

upon the nature of the task which it has to perform, but in general the more alike are weed and crop the more difficult is the search for a suitable material.

The non-selective use of cultivations and or herbicides offers, in theory at least, a wide range of possibilities. These include:

a) spring or autumn use of herbicides, with or without cultivations (i.e. pre- or post-crop).
b) spring or autumn use of cultivations (i.e. pre- or post-crop).
c) fallowing or bastard fallowing by cultivations and/or herbicides.

In practice limits are set to the usefulness of these methods by the need for the weed to be in a reasonably active state of growth before it can be killed either by cultivation or herbicide; by economics, and by edaphic and climatic conditions.

General points are the importance of crop competition in controlling Agropyron repens (Cussans, 1970) and Avena fatua (Bate et al, 1970) and the necessity of avoiding any reinfestation by reproductive material of an area on which control is being attempted. Agropyron repens, for example, frequently reinvades a field from the hedgerow bottoms.

THE ENVIRONMENT

Earlier papers have dealt in detail with soil and climate, but in relation to weed control in the north attention must be drawn to:

a) The 'short summer - long winter' situation, where crop harvests tend to be late and there is little weed growth after harvest because of falling temperatures. Similarly growth is slow to start in spring so that pre-sowing work is limited. In both spring and autumn wet conditions can preclude cultivations, and high winds may rule out spraying.
b) Soil-acting herbicides may give unsatisfactory results when used on soils with high moisture and high organic matter contents.

AVENA FATUA - THE WILD OAT

National survey data for the distribution of A. fatua in Scotland are not available, but Perring and Walters (1962) in their Atlas of the British Flora show the weed as most common in the crop growing areas of the east and north. Phillipson (1974) reports a 1972 survey which included eastern Scotland and indicates that 52% of farms and 25% of the cereal acreage were infested in that year. The weed is less common in the west, where cropping is generally less intensive. A survey of west of Scotland barley growing farms in 1969 showed that only 16% had wild oats, and less than 1% of the barley acreage was infested (Waterson and Davies, 1973). These values have no doubt now increased. Wild oat distributions in the cereal growing districts of the north are presumably fairly comparable with those in the east.

Avena fatua is an annual plant which produces large numbers of seeds; 1000-6000 per square yard from moderate infestations (Wilson, 1970). Field survival of the seed varies according to soil conditions (Thurston, 1961, 1966) but Forbes (1963) indicated that for complete control of wild oats eight to nine years under a ley would be necessary. At the other extreme an association between frequent cereal cropping and wild oat infestation has been confirmed (Thurston, 1954; Dadd, 1957; Waterson and Davies, 1973). A few seeds of A. fatua germinate in autumn, most germinate in spring, and hardly any in summer or winter (Thurston, 1951).

CONTROL TECHNIQUES

It is thus possible to identify ways in which A. fatua might be controlled:

a) by attenuation of soil reserves of wild oat seed, as under a long ley.
b) by spring cultivations prior to crop sowing, first to induce germination and second to kill the wild oats.
c) by the use of a herbicide to prevent seeding.

Other possibilities such as soil sterilisation are impracticable, and whatever methods are used precautions are necessary against the re-introduction of wild oat seed from outside the area under consideration.

CONTROL IN THE NORTH

These control methods may now be considered in relation to our northern conditions. Use of the long ley is likely to be a greater possibility on many Scottish farms than, for example, in East Anglia, and avoidance of intensive cereal growing - generally confined to certain fields - should also be easier. In most districts of Scotland, and especially the west, crops make strong vegetative growth and so offer effective competition to the weeds. On the other hand the chances for effective spring cleaning operations are few, especially in advance of a cereal crop, and restricted swede and potato acreages mean that little can be done ahead of root crops.

Erskine (1973) has strongly advocated the inclusion of straw burning in any control programme for Avena fatua. Recent harvests have been reasonably favourable for this, but in the succession of wet harvests of the early sixties effective burning would have been impossible in many parts of Scotland.

Herbicides are available which can control A. fatua in root crops but the main chance to control the weed in this way is by selective herbicides in cereal crops. Triallate is sold in liquid form for soil incorporation to 1-1½" pre-sowing, the seed subsequently being drilled below the herbicide treated layer. Work to this degree of precision calls for a fine, firm tilth not always attainable under northern conditions; in any case an exact operation of this kind is unpopular in the usual rush to take advantage of "sowing weather". Triallate granules are not soil-incorporated but are applied to the surface after sowing and covering are complete. They are thus rather easier to use, but it is essential that a proper granule applicator is employed. The efficiency of triallate has been stated to decline with increasing soil organic matter content over five per cent, a fairly low figure by Scottish standards (Erskine, 1973).

Barban is applied when the wild oats have 1½-2 leaves and to this restriction must be added that imposed by weather unsuitable for spraying which is so common in the northern spring. Few northern farmers would in practice be able to apply barban to more than a small acreage at the correct growth stage of the wild oats. Benzoylpropethyl and chlorfenpropmethyl have the advantage of a slightly longer safe spraying period but the former - used only in wheat - may be rather late for crop safety where wild oat germination has been delayed by a cold spring. Use of the roguing glove should be as practicable in the northern environment as elsewhere, apart from any difficulty under windy conditions.

AGROPYRON REPENS - COUCHGRASS

Agropyron repens is widely distributed in low-ground districts of Scotland (cf Perring and Walters, 1962) and a survey in 1969 detected the weed on over 75 per cent

of barley growing farms in the west (Waterson and Davies, 1973). In some areas modern cultivation and cropping practices may have been responsible for spreading the weed, but on many farms it has been a problem to generations of farmers as evidenced by Sturrock (1867) who noted as a principal defect of the farm of Shields (near Auchincruive, of which his statement is still true today) that it was "ill to keep clear of couch and other creeping roots".

Waterson, Craig and Joice (1964) stressed the rhizome growth potential of Agropyron repens, 5.5 g of rhizome dry matter planted growing to 438 g during a summer. Grümmer (1963) found that budded rhizome pieces 1 cm long produced a high percentage of new plants, and that pieces 3 mm long with a normal bud gave 30 per cent normal plants. Thus cultivations which merely break up the rhizome with no follow-through to its destruction serve merely to encourage the growth of new plants.

Williams and Attwood (1971) drew attention to the conflicting information in the literature on seed production by A. repens. Their own work revealed large differences in the numbers of viable seeds produced, and they suggested that this variation might account for the earlier lack of agreement. As about 95 per cent of their spike samples contained viable seeds, and the average number of viable seeds per spike for all samples was 13, reproduction from seed is obviously of considerable potential importance. Glasshouse and laboratory studies on seed germination and seedling emergence by Williams (1971) suggested that part at least of this potential will be realised in the field.

In summary, Agropyron repens is a widely distributed perennial grass weed well able to survive and spread by seed or by rhizome pieces.

CONTROL

Farm experience with Agropyron repens as a weed in ley-farming rotations is that the ley is not an effective control measure. This has been confirmed experimentally by Courtney (1972) and Cussans (1973).

A method of controlling rhizomatous weeds by repeated rotary cultivations was described by Fail (1956) and this was compared with tined cultivations by Roebuck and Hughes (1968), who found the tines more effective. They noted the need for an early start with cultivations after harvest to take advantage of suitable weather conditions, and this was further emphasised by Barnes and Elliott (1970) for their grass-weed control system.

Recognition of the problems in attempting weed control by such methods in the northern situation of later harvests (and winters which often commence before harvesting is completed) led to the development of the combined rotary cultivator and sprayer for TCA application (Ramand et al, 1968). With this machine it has been possible to achieve commercially satisfactory control of A. repens from a single pass in winter, using doses of TCA as low as 17 kg per ha. There are, however, risks of residue damage to ensuing spring sown cereal crops. (Ashby, unpublished).

Fryer and Makepeace (1972) give official BCPC recommendations for the use of various herbicides in couch control, which if not universally adopted are at least representative. There may be problems in employing the standard procedure for use of TCA on heavy soils in the north. Two applications, each of 17 kg per ha are advised, each of which has to be preceded by shallow ploughing or cultivation and followed by light cultivations if possible. The northern autumn timetable and weather all too frequently prevent completion of such a schedule.

Comparable difficulties are experienced in attempting to follow the recommendations (loc. cit.) for use of the herbicide aminotriazole which has to be applied

to the foliage of actively growing couchgrass. By the time of cereal harvest most A. repens has headed, and after combining there is relatively little leaf growing in the stubbles. All too often by the time a reasonable amount of leaf has developed falling temperatures have slowed growth to a minimum level. Similarly the slow start to spring growth of A. repens in the north means waiting to spray the foliage, then waiting three weeks before ploughing, so that the chances of a full and competitive crop of oats or potatoes - not to mention wheat or maize, are poor.

It is of particular interest that the new herbicide glyphosate applied to Agropyron repens in cereal stubbles November-January has given effective control from 2 - 3 l per ha, against 4 l per ha in September and October (Hodkinson, 1973).

CONCLUSIONS

The two examples chosen show that the northern environment in its widest sense offers a few advantages but many disadvantages for the control of gramineous weeds. Cropping systems based on traditional rotations are still common, and are often considered to have great merit in controlling the build-up of weed populations. Against this the ley has been shown to be an ineffectual weapon against Agropyron repens and Avena fatua; any observer of Scottish swede crops not specially treated against these weeds must be aware that either species can flourish therein. On the credit side is a fairly low incidence of cereal monoculture, the problems of which are aggravated by our conditions.

Control of weeds outside the normal crop growing season is difficult, in that long periods of kindly weather in spring and autumn are rare. The development of early ripening cereal varieties, or varieties suitable for late sowing, and perhaps of herbicides for use in winter, could assist greatly in grass weed control. During the growing season most crops make vigorous growth and thus compete well with weeds, particularly if the weeds have been weakened by a herbicide. Unfortunately, conditions suitable for herbicide application may not occur within the appropriate weed growth stage period. Perhaps it is well that the northern environment offers solaces in other directions.

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