SESSION 8A

SPECIFIC GRAMINICIDES— THEIR INTEGRATION INTO ARABLE AND HORTICULTURAL BROAD-LEAVED CROPS

Proceedings 1982 British Crop Protection Conference - Weeds

THE CONTROL OF GRASS WEEDS IN ANNUAL AND PERENNIAL BROAD-LEAVED CROPS IN THE UNITED KINGDOM

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Summary. Over the last few years a new generation of herbicides which control annual and perennial grasses in broad-leaved crops has been introduced. Their place in husbandry systems are discussed. The conclusions drawn may have to be modified in the light of more specific information on the time of removal of grass weeds from annual broad-leaved crops. It would appear that in annual crops the major potential use is for annual grass weed control. Based on current herbicide use, autumn sown oil seed rape offers the largest market. In perennial crops, they provide the opportunity of safely controlling grass weeds in strawberries and ornamental crops. Herbicide usage, competition, annual grass weeds, perennial grass weeds, Avena fatua, Agropyron repens, Alopecurus myosuroides.

INTRODUCTION

Over the last few years a new generation of herbicides has emerged which control annual and perennial grass weeds in broad-leaved crops. These, for the sake of brevity, will be called 'graminicides' in this paper. The first to be introduced was alloxydim-sodium (Ingram *et al*, 1978) with sethoxydim (Ingram *et al*, 1980) and fluazifop-butyl (Plowman *et al*, 1980) being introduced at the last British Crop Protection Conference - Weeds. There are other herbicides with a similar action under development.

As members of the Agricultural Development and Advisory Service, we are frequently asked how these 'graminicides' fit into the modern husbandry systems of annual and perennial broad-leaved crops. This paper attempts to investigate this aspect. Broad-leaved crops include, in this context, non-graminaceous monocotyledonous crops.

Since 1977, the broad-leaved crops listed in Table 1 have been slowly declining as a percentage of total area of tillage. The dramatic increase in the area of oil seed rape has been countered by a decline in the area of vegetables grown in the open and fodder beet, mangels and brassicas for stockfeeding. Seed sales for the 1982 autumn sowing of oil seed rape indicates another significant increase in area. Though the area of peas declined by 18 percent over the period 1977-1981, at 80,000 hectares they still account for nearly half the total vegetable area.

GRASS WEEDS OF BROAD-LEAVED CROPS

Annual grass weeds that are commonly found in autumn sown annual broad-leaved crops include *Avena fatua*, *Alopecurus myosuroides*, *Poa annua*, *Poa trivialis* and volunteer cereals, the species and severity of infestation depending on sowing date and crop rotation. All these grass weeds may be found in early spring sown crops but the occurance of *A. myosuroides*, *P. trivialis* and volunteer cereals is often of minor importance. Summer crops sown or planted after the end of April rarely suffer from a significant infestation of annual grass weeds except *P. annua* in forage crops in wetter areas.

Perennial crops may suffer from annual grass weeds in the year of establishment, these being controlled by cultivation or herbicide. In subsequent years perennial grass weeds may potentially present problems.

Table 1

Area of broad-leaved crops in the United Kingdom (in '000s' hectares)
(U.K. Ministry of Agriculture Fisheries and Food)

	1970-72	1977	1979	1980	1981	1982*
Potatoes	246	233	204	205	191	191
Sugar beet	190	203	214	213	210	204
Oil seed rape	5	55	74	92	125	174
Hops	7	6	6	6	6	6
Vegetables grown in the open **	190	223	203	190	178	a
Orchards	63	51	49	46	44	a
Soft fruit	18	16	19	19	18	a
Ornamentals	15	13	12	12	12	a
Beans (*Vicia faba*) for stock feeding	64	37	42	48	45	39
Fodder beet, mangels and brassicas for stock feeding	b	182	154	144	133	117
Total tillage	4890	4863	4986	5031	5071	5118

* Provisional

** Includes a very small area of sweet corn (*Zea mays*)

a Not available

b Surveyed on a different basis to years 1977 onwards.

Agropyron repens is the major perennial grass weed in both annual and perennial crops. *Agrostis stolonifera* and *Agrositis gigantea* also commonly occur.

AREA OF BROAD-LEAVED CROPS INFESTED WITH ANNUAL AND PERENNIAL GRASSES

There has been no published survey data on the area of broad-leaved crops infested with annual and perennial grasses. A survey of grass weeds in cereals was made in nine areas of central southern England in summer 1981 (Froud-Williams and Chancellor, 1982). In winter cereals the most frequent species were *Avena* spp. in 32 percent of fields, *A. repens* in 24 percent, *P.trivialis* in 22 percent and *A. myosuroides* in 19 percent. In spring barley the two most frequent species were *A. repens* in 53 percent of fields and *Avena* spp. in 52 percent.

A rather imprecise guide to the area of broad-leaved crops where grasses present a problem can be obtained from surveys of herbicide use. The shortcomings of such an approach are numerous. For instances, in some crops, herbicides used primarily for annual broad-leaved weeds may also control grass weeds, whilst in others there may not be a suitable herbicide for the control of certain grass weeds. Some farmers and growers may spray unnecessarily, others insufficiently.

Potatoes

A survey by the Potato Marketing Board in 1980 indicated that 7.5 percent of the potato area of England and 2.3 percent of Scotland were sprayed pre-planting with glyphosate (Taylor, 1980). It may be assumed that the majority of this area was sprayed in autumn before planting for the control of *A. repens* and other perennial grasses. A further 5.1 percent of the potato area in England and Scotland was treated with EPTC. Although this herbicide does control *A. fatua*, it is used primarily to control *A. repens*. The area treated with a specific herbicide to control *A. fatua* was minimal. This may have been due to the use of cultivations or non-selective herbicides after the main period of germination of the weed. Most herbicides used in this crop to control annual broad-leaved weeds will control *P. annua*.

Sugar beet

Statistics of herbicide use issued by British Sugar, do not include the use of herbicides for the control of A. repens and other perennial grasses in the autumn prior to drilling. The task of estimating the scale of the grass weed problem is further complicated by some herbicides used for the control of annual broad-leaved weeds also offering some control of A. fatua and P. annua.

The statistics for the 1981 crop show that 4 percent of the area was treated with TCA pre-planting. In some instances at least, this would be for the control of A. repens. Tri-allate, primarily for the control of A. fatua, was used on 18 percent of the area and herbicide mixtures that control A. fatua on approximately a further 10 percent of the area (British Sugar, 1981).

Oil seed rape

Virtually all the oil seed rape area is autumn sown. A survey by the Ministry of Agriculture's Pesticide Survey Group has just been completed for the 1982 harvest crop. So far, only provisional figures based on unraised data are available (Umpelby, 1982). This suggests that approximately 70 percent of the area of the autumn sown crop in England was treated prior to drilling or emergence with TCA, primarily for the control of volunteer cereals and annual grasses. Approximately, a further 10 percent of the area was treated with dalapon for the control of volunteer cereals and annual grass weeds. Propyzamide and carbetamide were used on a significant area of the crop. These herbicides give good activity on annual grass weeds, but often follow sequentially after the use of TCA or dalapon.

Field beans (Vicia faba)

The Ministry of Agriculture's Pesticide Survey Group indicate that in 1977, 18 percent of the autumn sown crop and 18 percent of the spring sown crop in Great Britain were treated with herbicides used primarily for the control of A.fatua (Steed et al, 1979). Seventy three percent of the total area of crop was treated with simazine which controls A. myosuroides and other annual grass weeds including P.annua with some control of A. fatua and volunteer cereals.

Peas

In 1977, 28 percent of the pea crop in England, Wales and Scotland was treated with tri-allate used primarily to control A. fatua (Umpelby et al 1982). A further 6 percent of the area was treated with diclofop-methyl or barban, again primarily used to control A. fatua. The dried pea crop is drilled in the early spring and usually grown in a cereal rotation. For this reason a grass weed herbicide is applied to a higher proportion of the crop that to the processed pea crop. Annual grasses such as P. annua and A. myosuroides are controlled or suppressed by some herbicides used for the control of annual broad-leaved weeds in peas.

Forage crops

A survey in 1979 indicated that 7 percent of the area of swedes and turnips and 13 percent of fodder beet and mangels in England and Wales were treated with TCA (Hicks and Sly, 1982). The average rate of active ingredient used suggests that the prime objective for the application was A. repens and perennial grass control. In Wales and the South West of England these crops are grown typically where A. fatua is not a problem. P. annua is one of the major weeds of some of these crops but is usually controlled by herbicides such as propachlor and trifluralin. Trifluralin also controls some A. fatua

Other horticultural crops

Data on horticultural crops is less extensive. However a survey of vegetables in England, Wales and Scotland by the Ministry of Agricultures Pesticide Survey Group in 1977 indicates that 4 percent of broad beans (Vicia faba) and 5 percent of Brussels sprouts were sprayed with TCA for the control of A. repens; 31 percent of early carrots with tri-allate for A. fatua; 5 percent of red beet and 15 percent of narcissus with glyphosate presumably pre-drilling/planting for A. repens (Umpelby et al, 1982). According to the 1979 study of orchards by the Ministry of Agricultures Pesticide Survey Group, 77 percent of all top fruit in England and Wales received one or more applications of aminotriazole alone or in mixtures with other herbicides. (Umpelby et al, 1980). This would not have been solely for the control of A. repens but also for the suppression of some broad-leaved perennial weeds notably Equisetum sp.

In summary, based on surveys of herbicide use with all its imperfections, some guide to area of crop which are in the opinion of the farmer or grower worth treating against grass weeds can be estimated. However, it should be borne in mind that in many cases the herbicides used are those applied pre-emergence of the weed, before the level of infestation can be reliably assessed.

The hectarage of annual crops with infestation of perennial grasses that may be worth treating is the area with the least information. This is due to the fact that most surveys do not include the use of glyphosate in the autumn prior to drilling the crop. The 1980 survey data on potatoes included the use of glyphosate and suggests that approximately 10 percent of the area had infestations which growers took some measures to control. Approximately the same percentage of some forage crops were treated against perennial grasses. This figure of 10 percent, perhaps represents the maximum area of an annual crop that may be treated against perennial grass weeds. This is because potatoes are historically a cleaning crop and in addition are often grown on rented land infested with perennial grasses. In perennial horticultural crops, a very high proportion of the area is treated against perennial grasses.

A more reliable guide can be gained on A. fatua infestations. In years the survey was carried out, of the early spring drilled crops in the main arable areas, approximately 25-35 percent of the area appears to have been treated against this weed. The exceptions were potatoes where cultivations and the use of non-selective herbicides control many annual grass weeds and field beans where simazine may offer some control of A. fatua.

However, based on current herbicide use, the major market for annual grass weed and volunteer cereal control in broad-leaved crops appears to be autumn sown oil seed rape, where a minimum of 80 percent of the area was treated with TCA or dalapon for the 1982 harvest crop.

HERBICIDES FOR THE CONTROL OF ANNUAL AND PERENNIAL GRASS WEEDS IN BROAD-LEAVED CROPS

None of the 'graminicides' are included in the 1982 list of Approved Products and their uses for Farmers and Growers (UK Ministry of Agriculture Fisheries and Food, 1982).

Agricultural crops Not discussed in this section are those herbicides primarily used both for annual broad-leaved and annual grass weed control. This exclusion particularly refers to simazine in field beans, some pre- and post-emergence herbicides in sugar beet and propyzamide and carbetamide in autumn sown oil seed rape. These herbicides although giving good control of target grass weeds are often supplemented by specific herbicides for grass weed control or a specific annual grass weed herbicide is used along with a specific annual broad-leaved weed herbicide. In either case the following must be viewed as the main alternative to the 'graminicides'.

There are currently both pre-drilling or pre-emergence and post-emergence herbicides Approved specifically for the control of some annual grass weeds in all crops. However, the post-emergence herbicides barban and benzoylprop-ethyl applied in the spring exclusively control A. fatua in a narrow range of broad-leaved crops. Diclofop-methyl may be applied post-emergence of a more comprehensive range of broad-leaved crops and when applied in late spring controls A.fatua, Lolium spp. and offers some control of A. myosuroides and P. trivalis but not P. annua. Therefore, at the time of writing, there is no Approved herbicide for post-emergence application, that controls a very wide range of annual grasses and volunteer cereals. Tri-allate is commonly used prior to sowing of a range of crops, primarily for the control of A. fatua. However, this herbicide does give some control of a range of annual grasses. It requires incorporation. This results in extra wheeling of the seedbed and, under some conditions, a delay in drilling. In addition, a depth of drilling the seed may be specified. In some crops, the granular formulation of tri-allate may be used, which preferably should be incorporated in dry seasons.

In autumn sown oil seed rape, TCA is very commonly used for annual grass weed control. Preferably it should be lightly incorporated into the soil immediately before drilling. There are reports that this herbicide may on occasions reduce the yield of the crop (ARC Weed Research Organization, 1982). TCA de-waxes oil seed rape making it more susceptible to diseases (Gladders, 1982). The post-emergence use of dalapon, primarily for the control of cereal volunteers, may significantly damage the crop when applied prior to a frost.

Glyphosate is the standard herbicide for the control of A. repens and other perennial grasses. It is very effective and the pre-harvest recommendation in specified crops of wheat and barley has removed the problem of inadequate growth in cereal stubbles, frequently encountered in northern England and Scotland with a post-harvest treatment. In addition, with the pre-harvest treatment, control of perennial grasses can be achieved before autumn sown oil seed rape. Compared with the other Approved herbicides for perennial grass weed control, glyphosate is expensive. Lower rates than that recommended by the manufacturer can be contemplated in some situations (Orson, 1982). The other Approved herbicides are capable of effective control but in practise appear to be less reliable than glyphosate. However, glyphosate cannot be used in the spring before the period of rapid A. repens growth, usually mid-June. EPTC is Approved for application prior to planting potatoes. It can give very effective control of A. repens but requires good seedbed conditions and a high standard of incorporation and following cultivations. TCA may also be used prior to planting of some spring sown crops for the control of A. repens. Again, incorporation is required and in addition a significant interval between application and drilling the crop is necessary for the control of the weed. Where only weed suppression is required, a lower dose may be used in some crops, allowing for a smaller or negligible interval. Aminotriazole and dalapon may also be used in the spring prior to some crops but a subsequent ploughing and an interval of 3-6 weeks is necessary before a recommended crop may be drilled.

TCA, aminotriazole and dalapon-sodium may be used to control or suppress A. repens prior to drilling autumn sown oil seed rape. Again incorporation and a time interval is necessary between application and drilling the crop. The only recommendation for A. repens control within a growing crop is dalapon in mangels, sugar beet and carrots. Unreliable control and crop damage has been reported as a result of this treatment.

Therefore, if perennial grasses are not controlled with glyphosate in the autumn prior to sowing a crop in the spring, a range of alternative pre-drilling herbicides may be used. However, they require cultivation or ploughing and usually a time interval between application and drilling the crop. For autumn sown crops the application of glyphosate prior to the harvest of the previous wheat or barley crop is the preferred method. Using alternative methods may result in a delay in drilling.

Annual horticultural crops (mainly vegetables). In the intensive market garden rotation, annual grass weeds are not usually a problem. There is an adequate range of pre-emergence herbicides available. The two exceptions are celery, where prometryne is the main herbicide used and overwintered salad and bulb onions. In none of these crops is there an adequate Approved post-emergence herbicide treatment. A. repens has been a problem in the past, particularly affecting the harvesting of root and bulb vegetables. The advent of glyphosate used post-harvest between crops has reduced this problem. Horticultural crops, notably leaf brassicas and carrots have been grown in rented land as 'break crops' in a cereal rotation. These crops have often been infested with A. repens and also volunteer cereals and cereal associated annual grass weeds such as A. fatua. Cultivation in brassicas and dalapon in carrots have been standard means of control.

Perennial horticultural crops. Due to the inability to cultivate within the row, *A. repens* has been a major problem in perennial horticultural crops, notably fruit. However, a range of suitable herbicides is available for use in all fruit crops, except strawberries. These herbicides include aminotriazole, bromacil, chlorthiamid, dalapon, dichlobenil, glyphosate, propyzamide and terbacil. If the residual treatment in the dormant season fails, only in apple and pears is there any possibility of achieving safe post-emergence control using aminotriazole.

In strawberries, there is no safe Approved herbicide capable of controlling the weed. Terbacil may be used as a spot or patch application, accepting crop damage in the sprayed areas. Propyzamide, though widely used at 'own risk' is not recommended for use on 'matted rows' which constitute the major portion of the commercial crop.

In nursery stock production, control depends almost entirely on cleaning the land prior to planting. Although there are recommendations for the dormant season use of dichlobenil, chlorthiamid and propyzamide on established crops, no Approved post-emergence treatment exists.

GRASS WEED CONTROL - PRE- OR POST-EMERGENCE OF ANNUAL CROPS ?

The new group of 'graminicides' are mainly foliar acting and are applied post-emergence of the crop and weed. Those currently on the market are applied to annual grass weeds from the two to three true leaf stage to the fully tillered stage, and to perennial grass weeds when they have all emerged and have four to six leaves.

Advantages of pre-emergence or pre-drilling herbicides

1. Weeds are controlled before they emerge and before they can compete with the crop.

2. Residual herbicides are usually of a sufficient persistence in the soil to control a prolonged germination of a grass or a range of grass species.

Disadvantages of pre-emergence or pre-drilling herbicides

3. Incorporation may delay drilling, seedbeds may be overcultivated in wet conditions and the extra tractor wheelings may create soil structural problems.

4. There may be a time interval specified between application of the herbicide and drilling of the crop.

5. If there is a crop failure, subsequent choice of cropping may be limited or delayed.

6. Seed may have to be drilled at a specified depth.

7. Dry soil may limit herbicidal action.

8. Organic matter absorbs residual herbicides, limiting their use to soils below a specified level.

Advantages of post-emergence herbicides

9. Weed populations can be assessed before spraying.

10. Spot spraying or band spraying may be employed under certain circumstances.

Disadvantages of post-emergence herbicides

11. Crop may shade target weeds.

12. Timing in relation to the use of other crop protection inputs may be a problem in some circumstances.

Many of 1-12 do not apply to all crops in all circumstances, but do pose theoretical or real problems in some instances. Most are self-explanatory but one or two aspects need further explanation. A subsequent germination of *A. myosuroides* following the application of fluazifop-butyl to control volunteer cereals in autumn sown oil seed rape caused a potential problem in one of the six trials carried out by the Agricultural Development and Advisory Service in 1981/82. However, a sequential application of propyzamide controlled the *A. myosuroides* and no penaltly yield occurred.

It would appear that crops shading target weeds has not been a major problem with 'graminicides' in commercial use but it may be a marginal problem in some extreme circumstances.

The major area of contention is whether the 'graminicides' are capable of removing grass weeds early enough in the crops's growth to prevent yield loss.

Time of grass weed removal and yield response

Grass weeds obviously can compete with broad-leaved crops. Annual grass weeds may be effectively controlled by hand cultivation but control of perennial grass weeds by such a practise is almost impossible. Grass weeds affect the yield of a crop and also its quality and ease of harvest. It is unlikely that the crop quality will be affected by post-emergence spraying, provided that a loss in marketable yield is prevented. Additionally, provided the post-emergence application is made when the weeds are small, their physical presence, dead or alive, should not hinder harvesting.

There is no published information on the precise time when grass weeds should be removed from annual broad-leaved crops in the United Kingdom, in order to prevent yield loss. The introduction of 'graminicides' has created a demand for such experimental work. In the absence of such information provisional conclusions have to be drawn from published information on the time of removal of annual broad-leaved weeds from annual broad-leaved crops.

A major review of weed - crop competition concluded that all the crops surveyed can withstand weed competition for some duration after planting (Zimdahl, 1980). It would appear that no effect of any magnitude occurs until competition begins at the point when environmental resources cease meeting the needs of two or more plants in an area.

After crop and weed emergence there is a period of establishment before rapid growth begins. During this crop and weed establishment stage no great demand on environmental resources (principally water, nutrients and light) occurs. However, when the period of rapid dry matter accumulation starts a greater demand on resources is made and competition that is likely to reflect in yield loss is more probable. It has been reported that annual broad-leaved weeds should be removed from sugar beet (Scott and Wilcockson, 1976) and onions (Roberts, 1976) before the period of exponential growth of the crop. Sugar beet can recover from an initial reduction in crop dry matter due to weed competition but onions cannot.

However, no generalisation can be reliably made on when yield reducing competition starts. It depends on many factors such as crop and weed density, crop and weed species, environmental conditions, crop arrangement, nutrient status and time of weed emergence in relation to the crop.

Early spring sown crops and autumn sown crops suffer most from annual grass weeds. United Kingdom evidence on time of removal of annual broad-leaved weeds from March sown crops suggests that yield reducing competition can be prevented provided that weeds are removed four weeks after crop emergence for sugar beet (Scott and Wilcockson, 1976) 3-4 weeks after 50 percent emergence of field beans (Glasgow et al, 1976), 5 weeks after 50 percent emergence of bulb onions and 4 weeks after 50 percent emergence of red beet (Roberts, 1976). Therefore it would appear for some March sown broad-leaved crops at least, that a single weeding or a weed free period from approximately mid-May will prevent yield reducing competition from annual broad-leaved weeds.

In trials and commercial practise the 'graminicides' have been applied to early spring sown crops in the middle of May for annual grass weeds and the end of May to early June for perennial grass weeds. From these dates it can be theorised that the use of such herbicides to control annual grass weeds may prevent yield reducing competition. Many of the A. fatua populations in the United Kingdom are at a very low and often uncompetitive level and in this instance the use of 'graminicides' to control annual grass weeds may be considered, particularly if there is difficulty in deciding if it is necessary to adopt weed control measures. However, if very high infestations of annual grass weeds are expected and if seedbed conditions are ideal the application of a pre-emergence herbicide may be the preferred choice. This may be particularly so on a light soil where moisture stress may bring forward the period when weeds are competitive.

For perennial grass weed control, application of these 'graminicides' often would appear too late to maintain optimum yield in early spring drilled annual crops. In summer sown or planted crops the perennial grasses may emerge and establish closer to the emergence of the crop and 'graminicides' applied to control them may possibly prevent yield reducing competition. However, until more accurate information is forthcoming, in all but mild infestations the preferred treatment should be the application of glyphosate in the previous autumn or after mid-June for late summer drilled crops. If this cannot be applied for any reason, a pre-drilling herbicide may be used provided that the delay in drilling is not critical, seedbed conditions are satisfactory and the crop is tolerant to the herbicides. In annual crops, the post-emergence control of perennial grasses with 'graminicides' would be best confined to 'spot' treatment of low infestations. An exception to this may be in potatoes, where A. repens grows rapidly in stone windrows. If the perennial grasses have not been controlled in the previous autumn with glyphosate, they may be most effectively controlled post-emergence with a 'graminicide' as pre-planting residual herbicides are often ineffective in such a situation. Vining peas and potatoes are often grown on rented land infested with A. repens. In this situation the application of glyphosate in the previous autumn may be impossible and 'graminicides' may have to be used in some cases.

The time of annual grass weed control in the autumn sown oil seed rape crop has not been studied in detail. In one trial at High Mowthorpe Experimental Husbandry Farm, the early post-emergence use of fluazifop-butyl followed by propyzamide outyielded a TCA, propyzamide sequence and propyzamide alone, in a late sown uncompetitive crop in 1981/1982. This is very limited evidence to suggest that the extensive use of TCA may be replaced by a 'graminicide'. The Agricultural Development and Advisory Service has trials at three centres investigating this aspect and work is in progress at the ARC Weed Research Organization. Perennial grasses often emerge very late in the autumn in winter crops of oil seed rape and field beans and may be shielded by the crop by the time the relevant growth stage and conditions for their control arrives. Therefore, it is preferable that these weeds should be treated with glyphosate. In order to achieve the optimum drilling date for autumn sown oil seed rape, this would have to be a pre-harvest treatment to the preceding cereal crop.

CONCLUSIONS

1. The area of most broad-leaved crops in the United Kingdom has remained static or there has been only minor changes over the last 5 years. Horticultural crops have fallen significantly in area and oil seed rape crops increased dramatically.

2. It is impossible to obtain precise data on the area of broad-leaved crops infested with grass weeds. From usage surveys it would appear that the major potential use is the early removal of volunteer cereals and annual grass weeds in autumn sown oil seed rape.

3. The currently Approved pre-emergence or pre-drilling specific annual grass weed killers do not control all species and/or may require incorporation. The post-emergence annual grass weed herbicides in the spring sown crops have a limited spectrum.

The currently Approved perennial grass-weed killers have to be applied in the autumn previous to a spring sown crop. When used in the spring delay between application and sowing is necessary in most cases and in addition incorporation or ploughing may be necessary. The only Approved post-emergence use is dalapon-sodium in mangels, sugar beet and carrots. The control from this recommendation is variable and crop damage has been reported.

4. The introduction of 'graminicides' has created a demand for information on the effect on marketable yield and quality of the time of removal of annual and perennial grass weeds from broad-leaved crops. The conclusions on time of grass weed removal in this paper have been based on information on annual broad-leaved weeds in annual broad-leaved crops. Such conclusions may have to be modified in the light of more relevant information.

5. There are several advantages to the use of post-emergence herbicides. However with the current timing recommendations for 'graminicides' it would appear that in spring sown annual crops, yield reducing competition from perennial grasses will have occurred before their application. Therefore, the use of glyphosate in the previous autumn is the preferred treatment except in very low infestations of perennial grasses when spot treatment with a 'graminicide' may be an economic proposition. For annual grass weeds in spring sown annual crops, the application of 'graminicides' will in many cases retain optimal yield but in a severely competitive situation a pre-emergence residual herbicide may be preferred if it controls the weeds expected, seedbed conditions are suitable and the crop tolerance is satisfactory.

6. In most perennial crops adequate dormant season residuals and/or foliar acting herbicides exist for the control of perennial grasses. The notable exceptions are strawberries and nursery stock. Another notable exception in horticulture is the post-emergence control of annual grass weeds in autumn sown onions.

7. If it is proven that these 'graminicides' remove annual grass weeds early enough to prevent losses in marketable yields of annual broad-leaved crops, the need for pre-drilling or pre-emergence 'insurance' treatments will be eliminated.

These conclusions are based on the understanding that:-

a. Competition from the grass weeds cease almost immediately after application of the 'graminicide'.

b. The crops are tolerant to 'graminicides'. This cannot be assumed for all crops with some of the currently available products (Lawson and Wiseman, 1982).

c. That the 'graminicides' work effectively in the range of environmental conditions that may be met at the time of application.

d. That all grass weeds are susceptible to 'graminicides'. The currently available members of this group do not control P. annua. In many crops the broad-leaved herbicides do control this weed but its susceptibility to a 'graminicide' will add to flexibility of herbicide choice.

e. That tank-mixtures with a range of other crop protection chemicals are possible.

f. That the price of 'graminicides' is equivalent to the currently Approved alternatives. Some savings may be made post-emergence in row crops by band-spraying and in all crops by spot treatment.

g. That their efficacy is equivalent to currently Approved herbicides.

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POST-EMERGENCE CONTROL OF GRASS WEEDS IN PEAS WITH FLUAZIFOP-BUTYL

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Summary Four replicated experiments were carried out in 1980 and 1981 in commercial crops of vining peas for processing, to evaluate the control of *Avena fatua* with fluazifop-butyl (marketed under the name "Fusilade" which is a trade mark of Imperial Chemical Industries PLC.) plus wetter at several rates, compared with the Ministry Approved material diclofop-methyl, and with alloxydim-sodium at recommended rates. Fluazifop-butyl achieved excellent control of *Avena fatua* and performed as well as the other two materials. In 1982, the effectiveness of fluazifop-butyl plus wetter was compared with alloxydim-sodium in suppression of *Agropyron repens* in two experiments. *Agrostis gigantea* was also present at one site. Fluazifop-butyl gave significantly better control of these grass weeds than alloxydim-sodium. The peas showed visible damage after application of high rates at some sites, and at one site yields from peas treated with the highest rate of 1.5 kg ai/ha were significantly lower than from the 0.5 kg a.i./ha rate, although similar to those from untreated plots.

Keywords: Peas, fluazifop-butyl, *A. fatua*, *A. repens*, yields, weed control.

INTRODUCTION

Populations of grass weeds cannot always be predicted, and some vining pea crops are on rented land, where the grower may be unaware of such a problem. Therefore, much work on development of post-emergence grass weed killers in peas has been carried out at the PGRO in the last few years, evaluating diclofop-methyl (King and Handley, 1976) for control of *Avena fatua*, and later alloxydim-sodium (Knott, 1978) and sethoxydim (Knott, 1980) for control of *A. fatua* and *Agropyron repens*. Alloxydim-sodium is the first selective post-emergence herbicide recommended for suppression of *A. repens* in the pea crop.

Screening tests at the Weed Research Organisation (Richardson, West, and Parker, 1980) demonstrated fluazifop-butyl to be highly active post-emergence against annual or perennial grass weeds, with the exception of *Poa annua*, and selective in peas. Field experiments carried out between 1978-80 by ICI Plant Protection Division (Plowman, Stonebridge and Hawtree, 1980) demonstrated consistent post-emergence control of annual and perennial grass weeds with fluazifop-butyl. Data from a number of sugar beet, potatoes and oil seed rape trials. (Finney and Sutton, 1980) also showed tolerance of these broad-leaved crops to fluazifop-butyl, and effective grass weed control. A 'logarithmic' field screening experiment at PGRO in 1980, also showed tolerance of peas. Replicated experiments were carried out between 1980 and 1982, evaluating control of *A. fatua* and of *A. repens*.

METHOD AND MATERIALS

In 1980 and 1981, experiments of randomised block layout with four replications were laid down in commercial crops of vining peas cvs. Galaxie, Puget, Tristar and Small Sieved Freezer at sites 1, 2, 3, and 4 respectively, to evaluate A. fatua control. Several rates of fluazifop-butyl (25% m/V e.c. formulation) plus wetter, were compared with diclofop-methyl (36% m/V e.c. formulation) Approved for use in peas and also the recommended material alloxydim-sodium (75% m/m s.p. formulation).

In 1982, two experiments with a 5 x 5 Latin Square layout were carried out at sites 5 and 6 in cvs. Sparkle and Scout, to evaluate control of A. repens with fluazifop-butyl plus wetter, and alloxydim-sodium. Agrostis gigantea was also present at site 5.

In the experiments reported, a non-ionic wetter "Agral" was always added to fluazifop-butyl at 0.1% of the final spray volume. The range of rates used, was different in each of the three years of experiments, and is shown in the results.

Growth stages for crop and grass weeds at the dates when sprays were applied are shown in table 1.

Table 1

Crop and weed growth stages at spray application

Site	Spray date	Peas Height cm.	Peas No. expanded leaves	Grass weed Height cm.	Grass weed Growth stage
					A. fatua
1	22/5/80	20	5	-	3 leaf, some tillering
2	3/6/80	5	3	-	3 leaf
3	30/5/81	12	5	-	2-3 leaf
4	10/6/81	5	4	-	2 leaf
					A. repens & A. gigantea
5	19/5/82	25	7 in bud	12	4-5 leaf, 3-4 tillers
6	29/5/82	12	5	15	4 leaf, tillering

At site 5, the proportion of A. gigantea was estimated to be about 35%, the remainder being A. repens.

The materials were applied with a van der Weij plot sprayer using Birchmeier cone nozzles delivering 220 l/ha water at 1.7 bar pressure. Plot size was 10m^2. Timing of treatments was based on the optimum target growth stage of the grass weed. Assessments were made for effects on the crop and for grass weed control. Broad-leaved weeds were controlled with either of the pre-emergence herbicides, trietazine/simazine, or terbutryne/terbuthylazine, or with dinoseb-amine or, a tank mix of cyanazine plus MCPB/MCPA applied post-emergence at least seven days after application of the experimental materials.

At harvest A. fatua was assessed by counting and weighing the plants and panicles per 10m^2 plot. A. repens and A. gigantea were assessed at harvest by counting the number of live shoots in 0.25m^2 quadrats placed in four random positions per plot. The peas were harvested at the green freezing or canning stage of maturity, and threshed using a plot viner. The pea yields were measured, and the maturity recorded using a tenderometer.

Samples of peas from plots treated with fluazifop-butyl at different sites were frozen and canned, and the produce tested for taints by the Campden Food Preservation Research Association.

RESULTS

Crop effects

Peas were healthy and had moderate to good leaf wax at the time of treatment, with the exception of site 1 where they had suffered damage from a severe frost two weeks earlier. Peas treated with 1.0 kg a.i./ha of fluazifop-butyl at site 1, and with the 1.5 kg a.i./ha rate at site 3 showed severe visual damage effects in the form of chlorotic patches on upper leaves. The chlorosis appeared to be temporary, and less apparent two weeks after spraying. At site 6 where application was made after a period of drought, plots treated with 1.5 kg a.i./ha fluazifop-butyl were stunted, and the upper part of the plant had a 'closed up', 'pinched' appearance. The stunting effect was severe and obvious even at harvest, although good growing conditions followed. Few visual effects were seen from the lower rates 0.25, 0.375 and 0.50 kg a.i./ha of fluazifop-butyl, only slight necrotic spots on lower leaves were observed.

Effects on *A. fatua*, *A. repens* and *A. gigantea*

Visual assessments made a week after application of the treatments showed that at all sites, action of fluazifop-butyl was faster than the other materials used. Symptoms of cessation of growth were apparent, the central shoot of the *A. fatua* and *A. gigantea* species became necrotic and the other leaves chlorotic. *A. repens* assumed a reddish tinge and later became necrotic and after four to five weeks the shoots of these grass weeds were dead. Control of *A. fatua* was rapid, and at some sites fluazifop-butyl at the highest rates achieved a complete kill after about 10 days, when applied at early growth stage of 2-3 leaves.

Control of *Avena fatua*

The results of counts of *A. fatua* plants and panicles made at sites 1 and 2 in 1980, and 3 and 4 in 1981 appear in table 2.

Table 2

Percentage reduction in number of *A. fatua* plants and panicles at harvest

Material	Rate kg a.i./ha	% reduction in *A. fatua* at harvest: No. plants, Site: 1	2	3	4	No. panicles 1	2	3	4
fluazifop-butyl	0.25	100	86	-	-	100	100	-	-
" "	0.38	100	80	83	100	100	100	94	100
" "	0.50	100	83	-	-	100	100	-	-
" "	0.75	100	87	94	100	100	100	100	100
" "	1.00	100	91	96	100	100	100	100	100
" "	1.50	-	-	96	97	-	-	100	96
diclofop-methyl	1.25	95	85	94	95	99	98	98	92
alloxydim-sodium	0.94	90	82	90	73	97	94	98	88
Significance @ P=0.05		SD	SD	SD	SD	SD	SD	SD	SD
LSD @ P=0.05		34.1	27.9	10.0	34.9	47.6	18.5	8.6	38.6
SE as % of general mean		27.1	25.6	8.5	29.2	37.3	14.5	6.8	31.6
No/m^2 plants or panicles on untreated		10.3	8.8	9	2	6.1	4.5	3	2
Spray/harvest days		56	65	55	53				

Fluazifop-butyl, diclofop-methyl and alloxydim-sodium were applied at all sites at the target growth stage i.e. at the 2-3 leaf stage for A. fatua and few plants were at advanced tillering stage.

Table 2 shows that all treated plots had significantly fewer A. fatua plants and panicles than untreated plots at all sites. All materials gave good control of A. fatua panicles. Control of A. fatua plants was reduced at sites 2 and 3 where a few emerged after sprays were applied. All rates of fluazifop-butyl gave excellent control at sites 1 and 4. Alloxydim-sodium did not appear to perform as well as other treatments at site 4. The only significant difference between treatments, however, was at site 3, where fluazifop-butyl at 0.38 kg a.i./ha did not control A. fatua plants as well as higher rates, or as well as diclofop-methyl at 1.25 kg a.i./ha, but this effect was not reflected in the weight of plants or number and weight of panicles.

Yield of peas

Yield data from sites evaluating control of A. fatua, sites 1 and 2 in 1980 and 3 and 4 in 1981, appears in table 3.

Table 3

Yield of peas

Material	Rate kg a.i./ha	Site:	Yield (% of untreated) 1	2	3	4
fluazifop-butyl	0.25		116	99	-	-
" "	0.38		132	111	86	99
" "	0.50		122	97	-	-
" "	0.75		111	94	90	94
" "	1.00		112	94	90	94
" "	1.50		-	-	88	95
diclofop-methyl	1.25		131	83	98	91
alloxydim-sodium	0.94		113	85	90	95
untreated	-		100	100	100	100
Yield of untreated t/ha			4.6	4.4	6.0	5.3
Significance @ P=0.05			NSD	NSD	NSD	NSD
LSD @ P=0.05			-	-	-	-
SE as % of general mean			22.8	16.0	12.8	14.7

There were no significant differences between yield of peas from treated and untreated plots or between treatments at any of the sites. This may have been because the levels of infestation were not high. The severe damage in the form of chlorotic patches, visible after treatment with the higher rates of fluazifop-butyl at sites 1 and 3 was temporary, and did not appear to cause any yield reduction.

Control of A. repens and A. gigantea

Results of reduction in number of live shoots of A. repens and A. gigantea present at harvest from site 5, and A. repens at site 6 in 1982, are shown in table 4.

Table 4

Percentage reduction in number of live shoots of *A. repens* and *A. gigantea* at harvest

Material	Rate kg a.i./ha	Site: 5	SEM	Site: 6	SEM
fluazifop-butyl	0.50	98	0.58	99	0.37
" "	0.75	100	0.11	99	0.29
" "	1.50	100	0.00	100	0.00
alloxydim-sodium	1.50	88	1.91	90	2.71
untreated	-	0	11.83	0	16.95
No/m^2 live shoots on untreated		449		467	
Spray/harvest days		36		46	

Fluazifop-butyl, and alloxydim-sodium gave good suppression, as shown by reduction in number of shoots of grass weeds present. At both sites fluazifop-butyl, at all rates, applied, performed significantly better than alloxydim-sodium at the recommended rate. At site 5 rates of 0.75 and 1.50 kg a.i./ha gave significantly better control than the 0.50 kg a.i./ha rate. The live shoots found at harvest on plots treated with alloxydim-sodium appeared to be new growth.

Although the degree of infestation by harvest was similar at both sites, the peas offered more competition at site 5 and the *A. gigantea* has a less erect habit than *A. repens*, grass weed cover visible on untreated plots being about 40 per cent. The *A. repens* grew through the untreated plots of peas at site 6 to give about 75 per cent plot cover.

A few *Poa annua* plants were present on most plots, at site 5 and these were not controlled by either material.

Yield of peas

Yield data from sites 5 and 6 in 1982 evaluating suppression of *A. repens*, including *A. gigantea*, at site 5 is presented in table 5.

Table 5

Material	Rate kg a.i./ha	Yield (% of untreated) Site: 5	6
fluazifop-butyl	0.50	108	118
" "	0.75	102	109
" "	1.50	101	104
alloxydim-sodium	1.50	110	113
untreated	-	100	100
Significance @ P=0.05		NSD	SD
LSD @ P=0.05		-	12.1
SE as % of general mean		8.0	8.1
Yield of untreated t/ha		6.3	4.0

At site 5, all treatments yielded better than the untreated control but not significantly so, possibly because the treatments were applied at a later stage of pea growth. Trends suggested a slight decrease in yield as rate of fluazifop-butyl increased, but differences were not significant and little crop effect was seen at this site.

At site 6, plots treated with the lowest rate of fluazifop-butyl, or with alloxydim-sodium out-yielded untreated plots. These yield increases were statistically significant. Although the degree of grass weed infestation was similar at both sites, the "thinner" crop competed less well on untreated plots at site 6. Peas treated with the highest rate 1.50 kg a.i./ha of fluazifop-butyl gave significantly lower yields than the 0.50 kg a.i./ha rate, and this may have been a reflection of the visual damage effect of stunting.

Maturity

Maturity of peas as recorded by tenderometer readings, showed no significant differences between treated and untreated plots for the series of experiments. Thus the materials and rates used, appeared to have no effect on maturity of the peas.

Produce Quality

Canned and quick-frozen samples of peas from plots treated with fluazifop-butyl from the experimental sites were assessed for taints by the Campden Food Preservation Research Association, and none have been found so far.

DISCUSSION

Fluazifop-butyl applied post-emergence at rates of 0.25, to 1.50 kg a.i./ha effectively killed *Avena fatua*, and achieved 100 per cent control at two of the sites. Acceptable levels of control were achieved by recommended rates of alloxydim-sodium and diclofop-methyl where application was made at the 2-3 leaf stage of the weed. The rate of fluazifop-butyl recommended commercially for control of *A. fatua* is 0.375 kg a.i./ha, and the pea crop appears tolerant at rates of up to 0.75 kg a.i./ha.

Fluazifop-butyl at all rates tested (0.50, 0.75, 1.50 kg a.i./ha) performed significantly better than alloxydim-sodium at 1.5 kg a.i./ha when applied post-emergence to *A. repens* at 4-5 leaf stage, and achieved nearly 100 per cent reduction in numbers of live grass weed shoots at harvest.

Effects in the form of chlorotic patches on upper leaves were seen on peas treated with fluazifop-butyl at 1.0 and 1.50 kg a.i./ha at two sites, but these were only temporary and were outgrown two weeks after application. Where application of 1.50 kg a.i./ha fluazifop-butyl was made under conditions of drought stress, peas suffered damage in the form of severe stunting which was still obvious at harvest. Although the effect was reflected in a lower yield of peas than those for the 0.50 and 0.75 kg a.i./ha rates, yields were higher than the untreated plots. Visual assessments indicated that action of fluazifop-butyl on annual and perennial grasses was faster than alloxydim-sodium,or diclofop-methyl (annuals only) at all sites.

Fluazifop-butyl did not appear to affect maturity when used in six cultivars of vining peas, and applied at a range of growth stages.

The material was also integrated successfully into programmes with pre-emergence herbicides trietazine/simazine, or terbutryne/terbuthylazine for broad-leaved weed control. When it was sprayed before post-emergence herbicides dinoseb-amine, or a tank-mix of cyanazine+MCPB/MCPA for broad-leaved weed control, no problems were encountered where an interval of 7 days was left to allow the pea leaf wax to recover. No evaluation of application of broad-leaved weed herbicides before fluazifop-butyl, or of tank mixes was carried out in the series of experiments in peas.

Fluazifop-butyl gave consistently good control of grass weeds in varying conditions in experiments from 1980-1982 and it is hoped there will be recommendations for usage in the pea crop when clearance under the Pesticides Safety Precautions Scheme has been given.

Acknowledgements

We are grateful to farmers for provision of experimental sites, and to the companies Imperial Chemical Industries PLC, May & Baker Ltd., and Hoechst UK Ltd. for supplying chemicals. Assistance from the Statistics Department at the National Vegetable Research Station is also acknowledged.

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Proceedings 1982 British Crop Protection Conference - Weeds

GRASS WEED CONTROL IN OILSEED RAPE, SUGAR BEET AND POTATOES WITH HOE 35609

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Summary. Hoe 35609 (ISO proposed common name fenthiaprop-ethyl) is a new post-emergence annual and perennial grass weed herbicide for broad-leaved crops. A summary of the results from over 200 field trials mainly in West Germany and the United Kingdom is presented for oilseed rape, sugar beet and potatoes. The compound has been tested for five years with a wide range of environmental conditions and crop stages and shown to be highly selective. Annual grasses are controlled with rates of 180 to 240 g a.i./ha and perennial grasses with 480 to 720 g a.i./ha.

The flexibility of timing for annual grass weed control, quick knock-down effect on *Agropyron repens*, high degree of rainfastness and the development of tank-mix recommendations will enable it to be integrated conveniently with crop management systems.
Post-emergence graminicide, annual, perennial, growth stage.

INTRODUCTION

Hoe 35609 (ISO proposed common name fenthiaprop-ethyl) is a new selective post-emergence herbicide for the control of annual and perennial grass weeds in broad-leaved crops. Structure and activity data have been published by Handte *et al.* (1982) showing that the compound controls temperate climate grass weeds such as *Avena fatua*, *Alopecurus myosuroides*, *Echinochloa crus-galli*, *Lolium* spp., and *Agropyron repens*. In this paper more detailed results are presented from trials carried out in different European countries between 1978 and 1982 in the major arable crops of oilseed rape, sugar beet and potatoes. The role of this compound in aiding weed management in these crops is discussed.

METHODS AND MATERIALS

The formulation of Hoe 35609 (also tested under the code Hoe 00583) used in all trials was a 240 g/l emulsifiable concentrate. Dosage rates for annual grasses were 180 to 240 g a.i./ha and for *Agropyron repens* 480 to 720 g a.i./ha. The most appropriate commercially available product alloxydim sodium (750 g/kg) was used as a standard in most trials, fluazifop-butyl (250 g/l) + Agral surfactant in some of the 1982 trials and propyzamide (500 g/kg) in oilseed rape. Metamitron (700 g/kg) and phenmedipham (114 g/l in England and 164 g/l in continental Europe) were used for tank mixture trials in sugar beet. Plot size varied from 10 to 20m^2 in a randomised block design with three or four replicates. Applications were made post crop and weed emergence with van der Weij precision plot sprayers at a pressure of 2.5 bar delivering 300 l/ha through Teejets. A total of 219 trials were carried out against annual grasses in oilseed rape (72), sugar beet (65)and potatoes (13) and against *A. repens* in sugar beet (40) and potatoes (29). Applications were made irrespective of crop growth stage and unless specified were applied when annual grasses were between the three to four leaf stage and tillering and *A. repens* had 25 to 30 cm of leaf growth. Treatments were evaluated using a scoring system of 0 to 100 for herbicidal efficacy and phytotoxicity.

RESULTS AND DISCUSSION

Crop Tolerance

Handte *et al*. (1982) have reported that Hoe 35609 is well tolerated by a wide range of broad-leaved crops irrespective of growth stage. This was confirmed in the trials discussed below in which good crop tolerance was recorded with dose rates of up to at least twice those required for effective perennial grass weed control. Only very slight crop effects were noticed one to two weeks after spraying but these completely disappeared after a further one to two weeks.

Oilseed Rape

Control of the most important graminaceous weeds in oilseed rape (volunteer cereals, *A. myosuroides* and *A. fatua*) with Hoe 35609 is shown in Table 1, weed stages ranging from three leaf to the end of tillering. The critical importance of such high levels of control and the maintenance of these through to the spring has been demonstrated by Proctor and Finch (1976). They showed that control in the autumn is important to avoid early weed competition but that post-emergence foliar treatments should not be too early in cases where later flushes of weeds occur unless the product is residual.

Table 1

Percentage control of annual grass weeds in oilseed rape with autumn applications of Hoe 35609 (Germany, U.K. 1980 - 82)

Weed species	Assessment (days after application)	Treatments (g a.i./ha) Hoe 35609 180	Hoe 35609 240	Alloxydim-sodium 937-1125	Untreated (% cover)	No. of trials
Hordeum sativum	35 - 60	93	94	86	16	27
A. myosuroides	35 - 60	94	96	98	14	21
A. fatua	35 - 60	97	98	98	16	4
Hordeum sativum	140 - 210	98	99	98	10	28
A. myosuroides	140 - 210	99	99	98	10	19
A. fatua	140 - 210	99	99	98	8	4

In other situations for example in Northern Germany when high autumn rainfall makes autumn treatment impossible, the ability of Hoe 35609 to control volunteer barley in the spring (Table 2) provides valuable flexibility in weed management. Normally the full effect of Hoe 35609 applied in the autumn is seen within three to four weeks after application.

The dosage response of volunteer barley to Hoe 35609 given in Figure 1 shows that although very low rates eventually give good control by the spring, higher rates of around 180 g a.i./ha are required for the more rapid kill in the autumn necessary to prevent weed competition.

Figure 2 gives an indication of the speed of action of Hoe 35609 compared with the standards albeit under the relatively cold late autumn temperatures of 1981.

Table 2

The influence of weed growth stage at application on percentage annual grass weed control in oilseed rape (Germany, assessment Spring 1980/81)

Species/product	Rate (g a.i./ha)	Time of application: early Autumn (weeds 3 leaf to early tillering)	late Autumn (weeds early to full tillering)	Spring (weeds full to end tillering)
Hordeum sativum (untreated 14% cover)				
Hoe 35609	180	99	98	100
Alloxydim-sodium	1125	97	97	27
A. myosuroides (untreated 15% cover)				
Hoe 35609	180	99	99	100
Alloxydim-sodium	1125	97	99	96

Fig. 1

The dose response relationship for the control of volunteer barley with Hoe 35609 in oilseed rape (U.K., 5 trials, 1980)

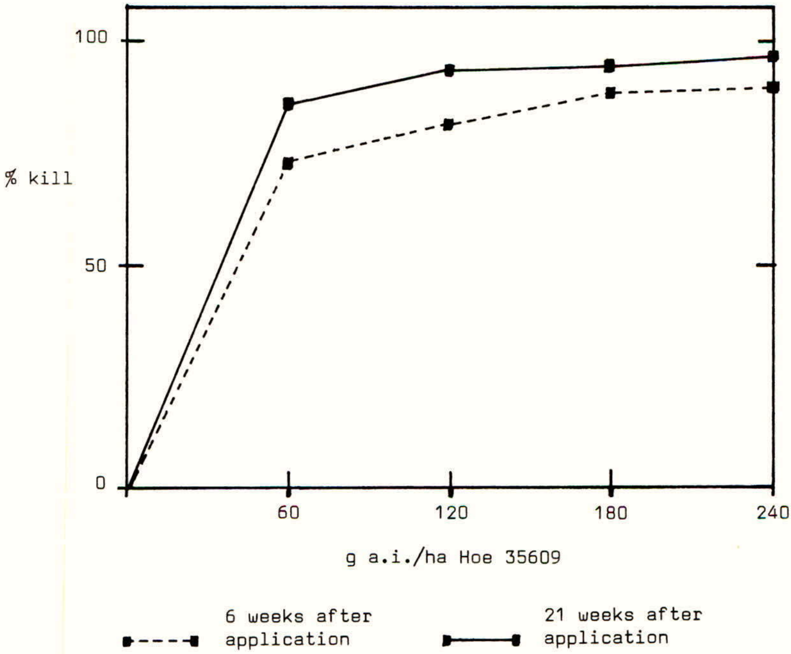
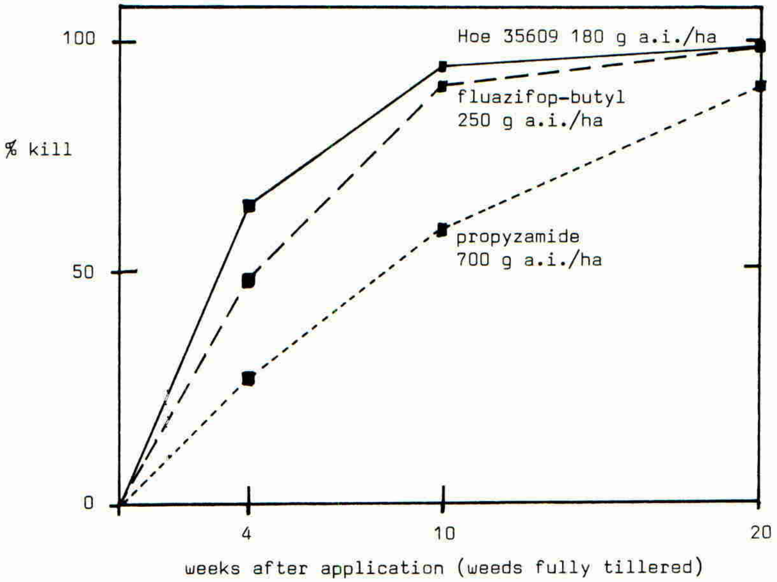


Fig. 2

The control of volunteer barley in oilseed rape with Hoe 35609 in early October 1981 (U.K., 5 trials)



Integration with broad-leaved weed herbicide programmes is possible as shown by trials in Germany and U.K. where Hoe 35609 was used after a pre-emergence application of the soil herbicide alachor (1920 g a.i./ha). This enabled the weed control spectrum to be extended to dicots. such as Matricaria spp. (98%), Veronica spp. (98%) and Lamium (98%). Possibilities for tank mixing with post-emergence broad-leaved weed herbicides such as benazolin + 3,6-dichloropicolinic acid are being investigated.

Sugar Beet

Until recently the control of annual and perennial grass weeds in sugar beet has been restricted mainly to pre-drilling incorporated treatments, which have involved the farmer in extra labour and expense and may be undesirable for producing optimum seed bed conditions (Baldwin 1972). Additionally the level of the grass weed problem is not always known pre-drilling. The results shown in Table 3 for the control of *Avena* spp., *A. myosuroides* and *A. repens* with Hoe 35609, show that it is an efficient post-emergence alternative. Applications should normally be made when grass weeds have fully emerged but before weed competition occurs. Good results have been obtained against *A. fatua* at the three leaf stage (Handte *et al*. 1982) but spraying can be delayed until the weeds are tillering. In 1982 a period of unsettled weather coincided with this time which illustrates the advantage of the extremely high rainfastness of Hoe 35609 (95% control of *A. fatua* with 8 mm rainfall one hour after spraying). Excellent control of cultivated oats (*A. sativum*) sown as a ground cover is shown in Table 3. Without this technique crops are so severely damaged by soil blowing on the light fens and sands that they need to be re-drilled. To complete the full integration of Hoe 35609 into sugar beet growing systems, the development of tank mix recommendations with products such as metamitron and phenmedipham is continuing.

Table 3

Percentage control of grass weeds in sugar beet and potatoes with Hoe 35609

Weed species (Country, year)	Average days after application	Treatments (g a.i./ha) Hoe 35609 180	Hoe 35609 240	Hoe 35609 480	Hoe 35609 720	Alloxydim-sodium 1312	Alloxydim-sodium 1875	Alloxydim-sodium 2250	Fluazifop-butyl 750	Untreated (% cover)	No. of trials
SUGAR BEET											
A. fatua (Germany, U.K. 1978-81)	40	94	96	-	-	96	-	-	-	35	28
Avena sativum (U.K. 1982)	28	94	97	-	-	-	-	-	-	50	2
A. myosuroides (Germany, 1978-81)	30	98	99	-	-	95	-	-	-	22	28
A. repens (Germany, U.K. 1980-82)	32	-	-	87	92	-	-	86	-	30	24
(U.K. 1982)	30	-	-	86	88	-	85	-	89	30	8
POTATOES											
A. fatua (Germany, U.K. 1978-81)	47	95	95	-	-	95	-	-	-	20	10
A. repens (Germany, U.K. 1979-80)	30	-	-	90	95	-	-	92	-	30	9
(U.K. 1982)	31	-	-	88	91	-	90	-	90	40	11

For the control of *A. repens*, the best results were achieved when the majority of shoots had emerged to an average of 25 to 30 cm in height. Tables 3 and 4 show the good control of this species equal or better than the standards fluazifop-butyl and alloxydim-sodium. In this situation the rapid knock-down effect of Hoe 35609 confirmed in Norfolk Agricultural Station trials in 1982 (Bray, W. E., 1982) may be a significant advantage in removing the weed competition quickly. However for some situations such as very dry weather and high infestations where the weed competition may adversely affect crop growth before the optimum stage for spraying is reached, sequential treatments are being developed as shown in Table 4.

Table 4

Percentage control of *Agropyron repens* in sugar beet with sequential applications of Hoe 35609 (Germany, U.K., 1981, 11 trials)

Chemical	Rate (g a.i./ha)	Days after first application			
		14	29	54	72
Hoe 35609	480	68	87	74	73
Hoe 35609	720	71	91	82	84
Alloxydim-sodium	1875	54	82	75	68
Hoe 35609 (sequential*)	480 + 480	68	87	95	96
Hoe 35609 (sequential*)	720 + 240	71	91	93	95
Untreated (% cover)		15	25	39	53

* 1st application - 25-30 cm shoot growth

2nd application - 5 weeks later

Potatoes

Early post-emergence treatments with standard potato herbicides such as monolinuron + paraquat often give very good control of *A. fatua* and a good suppression of *A. repens*. However, in situations where late germination of *A. fatua* and regrowth of *A. repens* are a problem the results in Table 3 show that Hoe 35609 provides a very useful addition to the farmer's spray programme.

Additives

At the moment research into this area is incomplete, but results so far indicate that there may be some benefit against *A. repens* but little or none against annual grasses.

ACKNOWLEDGEMENTS

The authors would like to thank the many farmers who kindly provided trial sites and their colleagues in the different countries who conducted the trials.

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ANNUAL AND PERENNIAL GRASS WEED CONTROL WITH FLUAZIFOP-BUTYL IN OILSEED RAPE, POTATOES AND OTHER BROAD-LEAVED CROPS

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Summary. In oilseed rape herbicide programmes, fluazifop-butyl as a post-emergence spray at 0.25 kg a.i./ha gave very good autumn control of Hordeum vulgare, Bromus sterilis, Alopecurus myosuroides and Lolium perenne and was superior to that from TCA incorporated into the soil before drilling. Significant yield increases of rape seed were obtained following the use of fluazifop-butyl in programmes with other herbicides; with propyzamide these increases were as high as 25%. In similar programmes, TCA gave lower yields although the differences were not always significant. Agropyron repens was well controlled by fluazifop-butyl at 0.75 kg a.i./ha in potatoes, brussel sprouts, onions, leeks and winter beans. No crop phytotoxicity was observed in these crops at rates up to 1.5 kg a.i./ha. These trials have demonstrated that fluazifop-butyl gives the opportunity for a more flexible approach to grass weed control in a range of broad-leaf crops. Keywords, Hordeum vulgare, Alopecurus myosuroides, Agropyron repens, brussel sprout, onions, beans.

INTRODUCTION

The recent trend in the United Kingdom towards more winter cereals, has been accompanied by a marked increase in grass weeds and volunteer cereals in broad leaf crops within the arable rotation. In 1981, over 30% of winter oilseed rape had Avena fatua, Alopecurus myosuroides and Agropyron repens present, whilst nearly 20% of both potato and pea crop were similarly affected by grass weeds. (Farmstat & Cereal Survey P.A.R. 1981).

Plowman et al (1980) and Finney and Sutton (1980) reported the selective activity of the herbicide fluazifop-butyl* on perennial and annual grass weeds growing in a very wide range of broad-leaf crops. Finney and Sutton (1980) emphasised the flexibility of the compound with its suitability for early and late post-emergence applications, and suggested that this allows the farmer to assess his particular weed problem and select an optimum programme of grass and broad-leaf weed control. Sager (1980) welcomed the introduction of post-emergence products such as fluazifop-butyl which have a high level of crop selectivity and good efficacy that is not impaired by variations in soil type.

This paper reports experimental field work on the integrated use of fluazifop-butyl with other herbicides in oilseed rape and potatoes, grass weed control in trials on other broad-leaf crops such as beans, brussel sprouts, leeks and onions, and the reaction of farmers who have used the herbicide in commercial oilseed rape crops.

* Fluazifop-butyl is marketed under the trade name 'Fusilade' which together with 'Agral' are trade marks of Imperial Chemical Industries PLC.

METHODS AND MATERIALS

The trial results given in this paper are from replicated, fully randomised field trials carried out in the United Kingdom during 1980, 1981 and 1982. Plot sizes varied between crops; oilseed rape - 3 to 4 m x 40m; potatoes 6 rows x 10m and the other crops a minimum of 3m x 12m. All treatments were applied in 200-260 l water/ha using a hand held CO_2 spray boom with Teejets at a minimum of 2 bars. Fluazifop-butyl was always applied as a 25% w/V e.c. with a surfactant ('Agral') added to the final spray solution at 0.1% V/V.

In oilseed rape, the number of weeds per 5 x $1m^2$ were assessed in the first two weeks of November and again in the following March. Harvest yields were taken using the farmer's combine or a Claas 'Compact 25' harvester, and were adjusted to 92% DM. In potatoes, similar weed assessments were made 6 weeks after spraying, and 2 rows x 8m were hand-dug per plot for tuber yield. In other broad-leaf crops, weeds were counted 35 to 78 days after spraying(using a minimum of 5 x $1m^2$ quadrats per plot).

For statistical analysis, weed counts were square root transformed, although for clarity de-transformed data are presented. In all tables, figures in vertical columns with the same letter are not significantly different at P> 0.05 unless stated otherwise.

Table 1

Trials with fluazifop-butyl in 1980-82: Site Details

Trial	Location	Date of Spraying: Fluazifop-butyl	Date of Spraying: Other herbicides	Variety	Crop Growth Stage at Spraying
OILSEED RAPE -					Leaves
WM1/80	Alcester, Warwicks	24/9	10/10	Jet Neuf	2-3
WM2/80	Wootton Wanen, Warwicks	25/9	13/10	Jet Neuf	3-4
EA1/80	Diss, Norfolk	13/10	31/10	Jet Neuf	5-6
EA2/80	Stowmarket, Suffolk	13/10	30/10	Jet Neuf	6
SE1/80	Brighton, Sussex	15/9	26/9	Jet Neuf	3
SE2/80	Horsham, Sussex	9/10	4/11	Jet Neuf	2-4
POTATOES -					
SAI1/81	Anstruther, Fife	21/6	-	Estima	50% haulm cover
SAI2/81	Methven, Perth	10/6	-	King Edward	"
OTHER CROPS -					
Brussel Sprout					
WM1/80	Evesham, Worcs	23/7	-	Peer Gynt	Budding
Onions					
NE1/82	Heckington, Lincs	14/5	-	Robusta	2 lvs
Leeks					
NE2/82	Boston, Lincs	1/6	-	Elephant Hilmar	2 lvs
Field beans					
NE3/82	Sleaford, Lincs	21/5	-	Maris Bead	15-20 cm ht

RESULTS

In oilseed rape, fluazifop-butyl as a post-emergence spray gave a high level of control in the autumn of annual weeds including Hordeum vulgare, Bromus sterilis and A. myosuroides. Applied between mid-September and mid-October (when the crop had 2 to 6 leaves and the weeds were from 3 leaves to tillering) it gave significantly ($P > 0.05$) better control than a soil-incorporated, pre-drilling treatment of TCA (Table 2). Lolium perenne was also well controlled. These observations were made soon after the application of the other herbicides used in the autumn programme but before the activity of these products was evident.

No crop damage was observed after fluazifop-butyl application or following any of the other herbicides used in the autumn.

Table 2

Effects of fluazifop-butyl or TCA based autumn herbicide programmes on the number of grass weeds per square metre in oilseed rape in November 1980 and in mid-March 1981

	H. vulgare			B.ster	L. per	T.aest	A. mys	
	WM1/80	SE1/80	WM2/80	WM1/80	WM2/80	EA1/80	EA2/80	SE2/80
Assessed November '80								
Untreated	8.0	25.5	27.2	83.4	18.6	-	-	135
F-butyl 0.25 kg a.i./ha	0.5	0.0	0.6	1.4	1.3	-	-	0.0
TCA 10.45 kg a.i./ha	4.9	5.7	24.6	24.0	2.0	-	-	14.0
Assessed March '81								
Untreated	-	-	16.4	65.6	10.0	17.3	12.5	-
F-butyl 0.25 kg a.i./ha followed in autumn by*								
.propyzamide	-	-	0	0	0	0	0	-
.propyzamide/3,6-d.p.a	-	-	0	0	0	0	0	-
.carbetamide	-	-	0	0	0	0	0	-
.benazolin/3,6-d.p.a	-	-	0	0.3	1.4	0	0.4	-
TCA 10.45 kg a.i./ha followed in autumn by*								
.propyzamide	-	-	0	1.8	0	0	0	-
.propyzamide/3,6-d.p.a	-	-	0	1.1	0	0	0	-
.carbetamide	-	-	0.8	4.4	0.6	0	0	-
.benazolin/3,6-d.p.a	-	-	13.1	22.3	3.1	0	3.7	-

* The other herbicides in the programme were applied at the following rates: propyzamide 0.7 kg a.i./ha; propyzamide plus 3,6-dichloropicolinic acid 0.7 kg + 0.07 kg a.i./ha; carbetamide 2.1 kg a.i./ha; benazolin plus 3,6-dichloropicolinic acid 0.63 kg a.i./ha + 0.12 kg a.i./ha.

In the following spring, better grass control was still evident on fluazifop-butyl treated plots compared with those treated with TCA, but winter kill and the grass weed activity of certain of the other herbicides had made these differences less marked. Counts on Triticum aestivum in trial EA2/80 showed complete control with both fluazifop-bytul and TCA in the spring (Table 2).

Significant yield increases were obtained following the autumn use of fluazifop-butyl in trial WM1/80 where there was a high population of B. sterilis on the untreated plots (Table 3). The increases varied with the other herbicides used in the autumn programme, fluazifop-butyl followed by propyzamide providing the maximum increase of 25%. Programmes including TCA, which earlier in the season had retarded flowering compared with fluazifop-butyl, gave lower yield increases, though the differences were not always significant.

Yield increases were also noted in trial WM2/80, as was earlier flowering on fluazifop-butyl plots compared with TCA, but while there was some similarity with the yield trends found in WM1/80 the differences were not significant.

No increases were noted in the other two trials where yields were measured, and in EA2/80 there was a significant loss of yield with some TCA programmes.

Table 3

Seed yields of oilseed rape (as percentage of untreated) following fluazifop-butyl or TCA based herbicide programmes

	WM1/80	WM2/80	EA1/80	EA2/80
Untreated (t/ha)	(2.43)cd	(2.98)	(2.74)	(2.33) ab
F-butyl followed by*				
.propyzamide	125 a	115	99	96 ac
.propyzamide/3,6-d.p.a	119 ab	110	96	100 a
.carbetamide	118 ab	107	93	96 ac
.benazolin/3,6-d.p.a	116 ab	106	93	95 ac
TCA followed by*				
.propyzamide	109 b	108	96	94 a
.propyzamide/3,6-d.p.a	116 ab	112	97	91 c
.carbetamide	116 ab	108	94	91 c
.benazolin/3,6-d.p.a	94 d	110	91	93 bc
		NS	NS	

* The other herbicides in the programme were applied at the following rates: propyzamide 0.7 kg a.i./ha; propyzamide plus 3,6-dichloropicolinic acid 0.7 kg + 0.07 kg a.i./ha; carbetamide 2.1 kg a.i./ha; benazolin plus 3,6-dichloropicolinic acid 0.63 kg a.i./ha + 0.12 kg a.i./ha.

In potatoes, A. repens was well controlled by fluazifop-butyl applied at the 2 to 4 leaf stage. In one trial where there were circa 20 couch shoots per square metre with 3 to 4 leaves at the time of spraying, fluazifop-butyl gave an increase of 10% in tuber yield (Table 4). Three weeks prior to applying fluazifop-butyl all the plots in these trials had received a spray containing 600 g a.i./ha of paraquat at 10% crop emergence to control germinated annual, broad-leaf and grass weeds, and in SAI1/81 this programme of herbicides gave a marked and significant yield increase.

Table 4

Numbers of shoots/m^2 of *A. repens* 4 to 6 weeks after foliar applications of fluazifop- butyl in potatoes, and subsequent tuber yield (t/ha)

Trial	SAI1/81		SAI2/82	
gms a.i./ha	Shoot No.	Yield	Shoots No.	Yield
0	19.8 a	36.2 bc	6.9 a	49.8
375	4.5 b	-	1.0 b	-
500	4.7 b	-	0.4 b	-
750	4.0 b	39.8 ab	0.7 b	48.7
1500	2.9 b	41.4 a	0.2 b	50.6
No Herbicides	not recorded	26.1 e	not recorded	45.2 NS

A. repens was also well controlled by fluazifop-butyl applied to brussel sprouts, onions, leeks and winter beans when the *A. repens* had 3-4 leaves. Poorer control was obtained with alloxydim-sodium and this was not unexpected since the application was made earlier than recommended (Table 5).

Table 5

Effects of Fluazifop-butyl applied post-emergence on numbers of *A. repens* shoots/m^2 in various broad-leaf crops

Days After Treatment		78	42	35	42
Crop		Brussel Sprout	Onion	Leeks*	Winter Beans
Trial		WM1/80	NE1/82	NE2/82	NE3/82
Untreated	-	22.6 ab	399 a	51.7 a	275.0 a
Fluazifop-butyl	0.25	-	-	-	-
	0.38	5.7 cd	-	14.2 c	13.6 b
	0.50	2.0 d	-	-	-
	0.75	1.3 d	24.0 cd	1.5 d	2.0 c
Alloxydim-sodium	1.88	11.1 bc	67.0 b	27.7 b	-

* per metre row of crop.

No damage whatsoever was observed with rates of fluazifop-butyl as high as 1.5 kg a.i./ha on these crops (Table 5).

DISCUSSION

The trials reported in this paper have demonstrated the ability of fluazifop-butyl to control graminaceous weeds in broad-leaf crops. Rates of 0.25 to 0.375 kg a.i./ha have given a high level of control of *H. vulgare* and other annual grasses, whilst good control of *A. repens* was achieved with rates between 0.5 to 0.75 kg a.i./ha. The trials also confirmed the wide margin of selectivity of fluazifop-butyl in a variety of broad-leaf crops.

In commercial practice the efficacy of fluazifop-butyl was further endorsed following a market development programme in which 100 oilseed rape growers in England and Scotland in 1981 were asked to test the product under their own field conditions at 0.25 to 0.38 kg a.i./ha. 82% of them reported that they found fluazifop-butyl gave better control of annual and perennial grasses (H. vulgare, A. fatua, B. sterilis, A. myosuroides and A. repens) than their standard grass weed programmes within the same field. The remainder of the group said it was as good as their traditional methods.

Implicit in post-emergence control of weeds is a measure of additional management control and flexibility. Fluazifop-butyl now gives the grower the opportunity to manage his grass and broad-leaf weed control programmes more effectively and at an early stage of crop development. Proctor and Finch (1976) have drawn attention to the damaging effects on oilseed rape of early autumn competition from volunteer barley (H. vulgare). Finney and Sutton (1980) demonstrated how fluazifop-butyl used in this way can enhance the autumn vigour of oilseed rape and our work has shown that besides providing an excellent method of limiting annual grass weeds in the arable rotation, fluazifop-butyl enables considerable yield increases to be achieved.

In oilseed rape, fluazifop-butyl with its good activity against grass weeds ably complemented all selective herbicides tested, whereas it was evident that their partnership with TCA was not as good, particularly where the other chemical in the programme was unable to control the grass weeds that had survived the pre-emergence treatment.

The need to co-ordinate grass and broad-leaf weed control was further emphasised in the Scottish potato trial SAI1/81; maximum tuber yield followed a programme of broad-leaf weed control with paraquat at crop emergence and A. repens control with fluazifop-butyl in the crop.

Very high populations of A. repens were encountered in the trials on onions, brussel sprouts, leeks, and beans and good control over the next 6 to 12 weeks was achieved with a single spray of fluazifop-butyl at 0.75 kg a.i./ha. This is very encouraging, particularly as the application to A. repens at the 3 to 4 leaf stage gave better control than alloxydim-sodium, but growers are usually looking for control which extends beyond the current season. Other work by Siddall and Cousins (1982) indicated that A. repens control with fluazifop-butyl in sugar beet did persist to a significant degree into the following season and therefore fluazifop-butyl used in broad-leaf crops can offer an opportunity to extend the control of this important perennial grass weed.

ACKNOWLEDGEMENTS

The authors wish to thank colleagues within ICI Plant Protection PLC for permission to use their data and help in gathering, collating and analysing data in this paper. Co-operation from farmers is also gratefully acknowledged in the trial and development programme.

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ANNUAL AND PERENNIAL GRASS WEED CONTROL IN SUGAR BEET FOLLOWING SEQUENTIAL AND TANK MIX APPLICATION OF FLUAZIFOP-BUTYL AND BROAD-LEAF HERBICIDES

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Summary. In sugar beet, post-emergence fluazifop-butyl at 0.25 kg a.i./ha gave excellent control of well tillered *Alopecurus myosuroides*, *Hordeum vulgare*, and *Avena fatua* having 4 or 5 leaves. Speed of activity against *A. fatua* increased with the rate of chemical applied.

High levels of *A. fatua* control were achieved when fluazifop-butyl was tank mixed with sequential applications of phenmedipham or metamitron. Similarly, the activity of phenmedipham and metamitron in controlling broad leaf weeds was unchanged by fluazifop-butyl.

Fluazifop-butyl applied to *Agropyron repens* and *Arrhenatherium elatius* with 2 to 6 leaves at rates between 0.5 and 1.0 kg a.i./ha gave good control. Better control of a heavy infestation of *A. repens* was obtained with a split application. *A. repens* control with fluazifop-butyl persisted into a spring barley crop sown the following season.

Over three seasons, fluazifop-butyl either as a tank mix or in sequential programmes with phenmedipham or metamitron caused no leaf phytotoxicity of sugar beet, apart from one year where tank mixes damaged some crops sprayed under drought and temperature stress; even so, this was transient and had no effect on yield or sugar content.

The availability of fluazifop-butyl now extends the range of products available which enable sugar beet to be effectively used as a cleaning crop during the arable rotation. Keywords, Alopecurus myosuroides, Hordeum vulgare, Avena fatua, Agropyron repens, phenmedipham, metamitron.

INTRODUCTION

In the United Kingdom in 1981, 55% of the 209,000 hectares of sugar beet were infested with *Avena fatua* and *Alopecurus myosuroides*, and approximately 10% with *Agropyron repens*, (PAR Sugar Beet Survey 1981). This increase in grass weeds in arable crops has been associated with the expansion of the winter cereal hectarage.

Good weed control early in the life of sugar beet is a strategy proven by farmer experience, but the tactics required for achieving this are becoming increasingly complex. Any new measures which can simplify and improve these tactics are highly likely to be welcomed by the sugar beet grower.

Finney and Sutton (1980) highlighted the benefits of flexible, post-emergence weed control and reported on the herbicide activity of fluazifop-butyl* and its potential to provide selective, post-emergence grass control in broad-leaf crops including sugar beet.

This paper describes trials with fluazifop-butyl to determine optimum application rates for the control of annual and perennial grass weeds in sugar beet, when applied either as single or repeated post-emergence treatments, and its use in tank mix and sequential treatments with broad-leaf herbicides in weed control programmes.

* fluazifop-butyl is marketed under the name 'Fusilade' which along with 'Agral' are trade marks of Imperial Chemical Industries PLC.

METHODS AND MATERIALS

Trials covering a range of soil types and sugar beet varieties, were replicated and fully randomised, Table 1. Statistical analysis of weed control was carried out on square-root transformed data though de-transformed information is quoted for clarity in the text.

In the tables all figures in vertical columns with the same letter are not significantly different at $P > 0.05$ unless otherwise stated.

Plot size for weed control assessment was 2.5 to 3m x 7 to 15m, and for yield 2.5m x 30m. Spray treatments were applied using hand held CO_2 pressurised spray booms fitted with Tee-jets. Spray volumes of 200-250 l/ha were used at pressures of 2 to 2.1 kg/cm^2.

Fluazifop-butyl was formulated as a 25% w/V e.c. to which a surfactant, 'Agral' was added in the final spray at a concentration of 0.1% w/V unless otherwise stated.

Table 1

Sugar beet trials with fluazifop-butyl 1979-81: Site Details

Trial	Location	Crop Stage of Growth cotlydon/ leaf no.	Spraying Date		Variety	Soil Type
SC1/80	Gt Yeldham, Essex	4/6	27/5		Vytomo	Sandy Loam
SC2/80	Honington, Suffolk	4/6	26/5		Nomo	Loamy Sand
GP1/80	Evesham, Worcs	4/5	21/5		Vytomo	Sandy Loam
GP2/80	Rearsby, Leics	2/4	21/5		Vytomo	Clay Loam
EA1/81	Honington, Suffolk	4 & 4/5	1/6	3/6	Nomo	Loamy Sand
EA2/81	Whepstead, Suffolk	3/4 & 4	30/5	1/6	Bush Mono	Medium Loam
EA4/81	Bury St Edmunds, Suffolk	6	3/6		Nomo	Breckland Sand
EA5/81	Thetford, Norfolk	4	12/6		Bush Mono	Sandy Clay Loam
EA7/81	Bury St Edmunds, Suffolk	4	1/6	2/7	Nomo	Loamy Sand
GP1/81	Basingstoke, Hants	4/6	1/5		Nomo	Sandy Loam
NE5/81	Grantham, Lincs	C.2	18/5	12/6	Bush Mono	Medium Loam

RESULTS

Post emergence applications of fluazifop-butyl to well tillered A. myosuroides and H. vulgare, and A. fatua with 4 or 5 leaves gave a high level of control at 0.25 kg a.i./ha, and only with A. fatua was there a suggestion that a higher rate would significantly improve the level of weed control, Table 2. At site GRP1/80 alloxydim-sodium and diclofop-methyl gave suprisingly good levels of control, though this may partly be explained by the low level of weed on this site.

Similar results were recorded from sites on peat soils but only detailed data from trials on mineral soils are given in this paper.

Table 2

Percentage control (plants/m^2) of A. myosuroides, A. fatua and H. vulgare in sugar beet 4 to 6 weeks after spraying fluazifop-butyl as a post-emergence treatment

Trial Weed	kg a.i./ha	SC1/80 A. myosuroides	EA1/81 A. fatua	GRP1/80 H. vulgare
Untreated (plants/m^2) at assessment		(10.3)a	(20.2)a	(3.3)a
Fluazifop-butyl	0.25	99 cd	97 b	91 cd
	0.38	100 d	99 c	85 cd
	0.5	100 d	-	94 d
Alloxydim-sodium	0.94	56 b	92 b	64 bc
	1.88	98 c	-	91 cd
Diclofop-methyl	1.32	14 a	-	15 ab

During the first week following application, the speed of activity of fluazifop-butyl on A. fatua at 3 to 4 leaves to tillering increased with the rate of chemical applied, but thereafter, though a trend remained, this effect was not always significant. Alloxydim-sodium was notably slower in its action.

Table 3

Percentage kill (plants/m^2 at assessment) of A. fatua in sugar beet following post-emergence sprays of fluazifop-butyl

	kg a.i./ha	Weeks after spraying 1	2	3
Fluazifop-butyl	0.18	20 cd	80 ab	90 c
	0.25	25 c	80 ab	97 a
	0.38	35 b	82 ab	100 a
	0.75	50 a	87 a	98 a
Alloxydim-sodium	0.94	23 c	77 b	85 b

High levels of A. fatua control were achieved when the fluazifop-butyl was followed either with phenmedipham or metamitron two days later and the activity of phenmedipham or metamitron on broad-leaf weeds was not affected by fluazifop-butyl. Detailed results are given in Table 4.

Table 4

Numbers of A. fatua and broad-leaf weeds per sq. m in sugar beet following a post-emergence application of fluazifop-butyl plus sequential applications of either phenmedipham or metamitron. Measurement made 9 weeks after spraying.

	kg a.i./ha			kg a.i./ha	A. fatua	Broad-leaf* weeds
-	-		phenmedipham	1.14	23.3 a	4.4
Fluazifop-butyl	0.25	plus	"	1.14	0.4 bd	5.2
	0.38	"	"	1.14	0.1 d	5.2
	0.75	"	"	1.14	0.8 bd	3.9
-	-		metamitron	3.5	17.4 a	6.6
Fluazifop-butyl	0.25	plus	"	3.5	1.0 bd	11.8
	0.38	"	"	3.5	0.6 cd	8.2
	0.75	"	"	3.5	0.7 bd	11.2
					H. Sig	N/S

Spraying dates: fluazifop-butyl, June 1, 1981 - sugar beet with 4 leaves.
phenmedipham and metamitron, June 3, 1981

* Broad leaf weeds included Stellaria media, Anagallis arvensis, Viola arvensis

Good control of A. fatua and H. vulgare was achieved when either phenmedipham or metamitron were tank mixed with fluazifop-butyl (Table 5). It is worth noting that H. vulgare (grown as a cover crop to protect beet on blowing sand in trial EA4/81) was at ZOC 30 when sprayed, i.e. pseudostem erection. This emphasises the application flexibility of fluazifop-butyl on H. vulgare.

There were few broad-leaf weeds in these trials, but where they were present fluazifop-butyl had no significant effect on the activity on either phenmedipham or metamitron.

Table 5

Effects of tank mixing fluazifop-butyl with either phenmedipham or metamitron on grass weed control in sugar beet

Trial	EA4/81 phenmedipham kg a.i./ha	OR	EA5/81 metamitron kg a.i./ha	PLUS	fluazifop-butyl kg a.i./ha	EA4/81 H. vulgare % Control plants/m^2	EA5/81 A. fatua number plants/m^2
	0.57		1.75		0	13 e	15.2 a
	1.14		3.50		0	18 e	15.8 a
	0.57		1.75		0.38	100 a	1.0 c
	1.14		3.50		0.38	100 a	0.4 c

Sprays applied: EA4/81, H. vulgare, ZOC 30 (3 June);
EA5/81, A. fatua tillering (12 June).

Assessments: EA4/81, 1 July; EA5/81, 31 July.

Trials in 1980 showed good control of A. repens and A. elatius in the three months following a post-emergence application of fluazifop butyl, and a shallow dose response over the rate range 0.5 to 1.0 kg a.i./ha, Table 6. A. repens had 4 to 6 leaves, and A. elatius 2 to 6 leaves at spraying. This stage of spraying is slightly early for alloxydim-sodium and this may partly explain the reduced control achieved with this product. Where a second spray was applied, this was made six weeks after the first. In one trial there was a suggestion that splitting the application of fluazifop-butyl might improve control compared with a single spray and this possibility was examined further in 1981.

Table 6

Percentage control (shoots/m^2) of A. repens and A. elatius in sugar beet following post-emergence applications of fluazifop-butyl

		A. repens		A. elatius
		GP2/80	SC2/80	GP1/81
Weeks after spraying	kg a.i./ha	10	11	10
Untreated (shoots/m^2)		(180)a	(960)a	(86.5)a
Fluazifop-butyl	0.5	85 b	80 c	99 b
	0.75	82 b	87 cd	100 b
	1.0	90 b	95 d	100 b
	0.38 + 0.38	-	95 d	-
Alloxydim-sodium	1.88	82 b	54 b	96 b

In August 1981, good control of A. repens was noted in trial EA7/81 (82%) after a single spray of 0.75 kg a.i./ha in early June. Dividing this into two equal applications of 0.38 g a.i./ha did not improve this level of control in August. In contrast, there was an even more severe A. repens infestation in trial NE5, and early applications of fluazifop-butyl were made in mid May to release the young crop from competition. In this situation, split applications gave better control than a single early season spray. (Table 7)

Observation in the following year, when the NE5/81 site had been prepared and planted to spring barley showed that all treatments had reduced the A. repens shoot numbers by circa 70% (Table 7).

Table 7

Percentage control (shoots/m^2) of A. repens in sugar beet following single and divided applications of fluazifop-butyl

				EA7/81	NE5/81	NE5/81
Spray Date	1 spray		-	1 Jun 81	18 May 81	
	-		2 spray	2 Jul 81	12 Jun 81	
Assessment Date				6 Aug 81	30 Jul 81	12 Apr 82
Untreated (shoots/m^2)	-		-	(419)a	(1059)a	(331.9)a
Fluazifop-butyl	0.25	+	0.25	84 cd	83 d	71 bc
	0.38	+	0.38	89 d	77 cd	74 bc
	0.38		-	53 b	47 b	60 bc
	0.5		-	82 cd	53 b	67 bc
	0./5		-	82 cd	56 b	74 bc
	1.5		-	98 e	70 c	80 bc
Alloxydim-sodium	1.88		-	70 bc	48 b	78 bc

A. repens was first sprayed at 4 leaf to early tillering in both trials.

In trials over 3 years, rates of fluazifop-butyl as high as 3.0 kg a.i./ha applied between the 2 to 6 leaf stage caused no visual phytotoxicity e.g. leaf necrosis and chlorosis, or any other effects on root and sugar yield.

Similarly, over three seasons the use of fluazifop-butyl, either as a tank mix or in sequential programmes with phenmedipham or metamitron, has caused no leaf phytotoxicity apart from some instances in 1980 when tank mixes applied to crops under drought and high temperature stress caused leaf damage. Even then, this was transient and had no significant effect on yield or sugar content even at overlap spray rates, equivalent to 3 kg a.i./ha.

DISCUSSION

From the evidence of the trials data discussed in this paper, it is clear that fluazifop-butyl is a highly active post-emergence herbicide providing effective control of both annual and perennial grass weeds in sugar beet.

The control of both annual and perennial grass weeds has been achieved from the 2 leaf to the well tillered stage. Rates from 0.25 to 0.5 kg a.i./ha have been shown to give excellent control of *A. myosuroides*, *A. fatua* and *H. vulgare*, with *A. repens* and *A. elatius* being controlled at rates of 0.5 to 1.0 kg a.i./ha. Soil type had no significant influence on the activity of fluazifop-butyl.

Fluazifop-butyl has been shown to be compatible with broad-leaf herbicides such as phenmedipham and metamitron when applied either in sequential treatments or tank mixes for the control of annual grasses and broad-leaf weeds.

In situations of severe *A. repens* infestation the use of a split application of fluazifop-butyl has been shown to increase control during the life of the crop. In spring barley established in the year following the application of fluazifop-butyl to sugar beet there was a significant and noticeable reduction in *A.repens* so confirming that the chemical may be used by the grower as a practical in crop programme for the long term reduction of grass weed problems.

Fluazifop-butyl exhibits a high degree of selectivity in the control of grass weeds in the sugar beet crop, with the speed of activity being linked to the growing conditions and rate of application, Plowman *et al* (1980). This enables the product to be used effectively as a post-emergence herbicide when the extent of the weed problem is apparent to the grower, so eliminating the guess work associated with pre-emergence herbicides.

The availability to the grower of an effective and selective range of post-emergence grass weed herbicides, including fluazifop-butyl, now provides the opportunity for the sugar beet crop to be used effectively as a cleaning crop within the arable rotation.

ACKNOWLEDGEMENTS

The authors would like to thank their colleagues within ICI Plant Protection PLC for permission to use their data, and to those farmers without whose co-operation in the trial and development programme, this work could not have been completed.

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INTEGRATION OF NEW GRAMINICIDES INTO WEED CONTROL PROGRAMMES FOR PEAS

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Summary An evaluation has been made of the use of new grass weedkillers, alloxydim-sodium, sethoxydim and fluazifop-butyl. Timing of application, yield response and effect on harvesting is discussed. Their integration into programmes with herbicides for broad-leaved weed control in peas for processing, a crop with a short season, is also assessed. Suggestions are made for possible strategies for weed control in the pea crop.

Key words: Peas, grasses, alloxydim-sodium, sethoxydim, fluazifop-butyl, programmes, broad-leaved weed control, pre-emergence, post-emergence.

INTRODUCTION

Effective control of *Avena fatua* in peas can be obtained using tri-allate liquid incorporated pre-sowing, (Armsby & Gane, 1964), but this technique is not always possible in a wet spring. Use of tri-allate granules pre-sowing using light incorporation with the drill or seed harrows, or pre-emergence, may give less consistent results in dry seasons (King, 1976). Populations of *A. fatua* are not always predictable. In 88 experiments over 9 years (Armsby & Gane, 1962), where very severe infestations were expected by the growers, only 44% of the sites had infestations of more than $10/m^2$. Post-emergence applications of diclofop-methyl (King and Handley, 1976), which proved more selective in peas than barban, became a useful addition to the means of control.

Methods giving some measure of suppression of *Agropyron repens* in peas include cultivations, autumn application of dalapon, TCA or pre-emergence paraquat in spring. If glyphosate is applied at the optimum target growth stage in autumn before peas, *A. repens* can be controlled. Although clearance for spring useage has been given, the weed is not usually at the optimum stage at this time in commercial situations. Eradication can now be achieved with glyphosate applied pre-harvest in the preceding cereal crop (O'Keefe, 1980).

Vining pea crops, however, are sometimes grown on rented land where there may not be prior knowledge of a grass weed problem. A new range of post-emergence graminicides active against *A. fatua* and *A. repens*, and many other grasses except *Poa annua*, have become available in recent years. PGRO have carried out experiments in peas with alloxydim-sodium (Knott 1978, 1980), sethoxydim (Knott, 1980) and fluazifop-butyl plus 'Agral' wetter (Knott, 1982). The materials were used in different weather conditions, growth stages of crop and weed, and degrees of weed infestation, and in programmes with pre- and post-emergence herbicides. By collating this data, this paper sets out to illustrate how and when they can best be used by the farmer (given the necessary clearance and recommendation for the two latter materials).

RESULTS

(i) Timing of post-emergence application

Avena fatua

The experiments in peas in 1978 and 1979 using alloxydim-sodium post-emergence, demonstrated superior control of A. fatua at advanced tillering stage, compared with Approved material diclofop-methyl. Previous work (King and Handley 1976), had observed poor control from diclofop-methyl when applied to tillering A. fatua. Slater and Hirst, 1980, reported good control of A. fatua in vegetable crops with alloxydim-sodium applied when the target was from 2 leaf to tillering stage.

Comparisons were made between alloxydim-sodium and sethoxydim at four sites in peas in 1980 and 1981. The action of sethoxydim appeared more rapid, and although excellent control was achieved with both materials when the target weed was at an early 3 leaf stage, sethoxydim was better than alloxydim-sodium where many A. fatua plants had four tillers. In two experiments in peas, in 1982, sethoxydim applied at 3 leaf stages of Avena fatua gave complete control. Where the target weed growth was not active and suffered from frost or drought stress, alloxydim-sodium proved less reliable than sethoxydim.

Fluazifop-butyl plus 'Agral' wetter was evaluated for control of A. fatua in four experiments (Knott, 1982), but was always applied at the 2 or 3 leaf stage and gave good control. However, consistent control was reported in sugar beet (Finney and Sutton, 1980) for growth stages of A. fatua ranging from 2 leaves to 6 tillers. In PGRO experiments fluazifop-butyl appeared to have a faster action than diclofop-methyl, alloxydim-sodium and sethoxydim.

Agropyron repens

Conditions of active growth are similarly required for good suppression of A. repens in peas by the new graminicides, and it also appears that inferior results may be seen where the materials are applied too early in the stage of weed growth.

Indications were that alloxydim-sodium did not perform well where A. repens was suffering from drought, and sethoxydim appeared more active in these conditions in 1980. Applications of alloxydim-sodium made to plots adjacent to the main experiment a fortnight later after rainfall, when the weed was growing more actively, achieved better suppression. At most sites A. repens was at the 4 or 5 leaf, and tillering stage. At some sites a little regrowth was seen in 1981 and 1982 from plots treated with sethoxydim although overall suppression was good.

Split applications of alloxydim-sodium or sethoxydim performed marginally better than single ones, but not significantly so. In practical terms there is insufficient time and spraying opportunities for a farmer to apply two treatments for A. repens and possibly a broad-leaved herbicide as well.

Fluazifop-butyl plus wetter gave a high level of suppression (Knott, 1982) of A. repens at 4-5 leaf tillering stage in two experiments, even though growth was not very active at one site under drought conditions.

Experience with Agrostis gigantea is more limited than A. repens, but the same comments are applicable.

Crop

Alloxydim-sodium, sethoxydim and fluazifop-butyl plus wetter have been applied to peas at growth stages ranging from 2 to 3 leaves up to those in bud. As yet crop effects do not appear to be related to growth stage at application. Damage effects seen have usually been a result of poor crop health or weather stress conditions.

(ii) Effect on yield of removal of competition from grass weeds

Avena fatua

A summary of results from a number of experiments, where good control of A. fatua was achieved with the exception of alloxydim-sodium at site 6, showing any statistically significant yield increases from treatment with the new graminicides is shown in table 1.

Table 1

Significant yield increases at P=0.05 for graminicides, compared with untreated

Graminicide	Rate (kg ai/ha)	1978		1979		1980		1980		1981		1981		1982
	Site:	1	2	3	4	5	6	7	8	9	10	11	12	13
alloxydim-sodium	(0.94)	NS	NS	NS	NS	SD	NS	NS	NS	SD	NS	NS	NS	NS
sethoxydim	(0.38)	-	-	-	-	SD	NS	-	-	NS	NS	-	-	SD
fluazifop-butyl + wetter	(0.38)	-	-	-	-	-	-	NS	NS	-	-	NS	NS	SD
A. fatua/m^2 at harvest on untreated		2	4	4	6	33	5	10	9	4	8	9	2	38
Spray-harvest days		55	71	59	55	57	70	56	65	34	54	55	53	46

Results showed that removal of competition from A. fatua using these materials, only achieved yield increases where the infestation would be classed as severe (Cussans, 1980) i.e. at 33 and 38 plants/m^2. At site 9, where infestation was low but the crop was thin and suffering from Peronospora viciae and offered weak competition, a statistically significant yield increase was also seen.

In a series of 8 experiments (King, 1976) where Avena fatua competition was removed pre-sowing with tri-allate liquid, and pre- and post-emergence with tri-allate granules or barban post-emergence (6 of the sites) only 1 site, where the infestation was very severe, showed significant yield increases and these were from pre-sowing tri-allate and post-emergence barban.

Therefore early release from competition may not result in corresponding yield increases and delay in using a method of control for A. fatua may not affect yield potential in peas.

Agropyron repens

Table 2 gives a summary of several experiments in peas where suppression of A. repens was achieved, again with the exception of alloxydim-sodium at one site, 4, in 1980. Agrostis gigantea was also present at site 8.

Table 2

Statistically significant yield increases at P=0.05 for graminicides compared with untreated

Graminicide	Rate (kg ai/ha)	1978 Site: 1	1979 2	1979 3	1980 4	1980 5	1981 6	1981 7	1982 8	1982 9	1982 10
alloxydim-sodium	(1.5)	SD	SD	SD	NS	NS	NS	NS	NS	SD	NS
sethoxydim	(0.86)	-	-	-	NS	NS	NS	NS	-	-	NS
fluazifop-butyl + wetter	(0.5)	-	-	-	-	-			NS	SD	NS
No. shoot/m^2 grass weed at harvest on untreated		82	92	202	133	123	82	344	449	467	496
spray-harvest no. days		71	41	37	54	59	40	45	36	46	30

Here results showed significant increases in yield at four out of the ten sites when competition was suppressed by the treatments. Although infestation was very high in experiments 8 and 10 where no increase in yield was achieved, the crop competed well with the weed, or possibly the materials were applied too late to affect yield of peas. The target growth stage occurs late in the life of the pea.

(iii) Integration of post-emergence graminicides with herbicides for broad-leaved weed control

(a) Programmes with pre-emergence herbicides for broad-leaved weeds

Pre-emergence herbicides have been used to control broad-leaved weeds in peas before post-emergence graminicide application in PGRO experiments over a number of years with varying weather conditions, and are shown in table 3.

Table 3

Number of sites for pre-emergence broad-leaved weed control

Graminicide	(Years)	No. sites terbutryne/terbuthylazine	No. sites trietazine/simazine
alloxydim-sodium	(1978-1982)	4	7
sethoxydim	(1980-1982)	3	6
fluazifop-butyl + wetter	(1980-1982)	2	3

Pre-emergence herbicides have also been used in grower-user trials in peas with alloxydim-sodium and sethoxydim, and in many commercial crops with alloxydim-sodium (following clearance from the Pesticides Safety Precautions Scheme).

No adverse effects on the peas or reduced efficacy of control of grass weeds has been observed, compared with sites where the pre-emergence materials were not applied.

(b) Programmes with post-emergence herbicides for broad-leaved weeds

There are no recommendations for use of pre-emergence broad-leaved weed killers on highly organic soils. Bad weather conditions may prevent use of pre-emergence materials on other soil types in some years. In these situations a grower has to rely on post-emergence broad-leaved weed control.

Application before or after graminicides?

Since the new graminicides work best when the grass weed is growing actively, prior treatment with post-emergence broad-leaved weed killers could check grass weed growth or metabolism. Results from observation experiments at two sites in 1979, studying the effects on *A. fatua* and peas, when standard herbicides for control of broad-leaved weeds were applied 7 days before or 7 days after alloxydim-sodium, compared with alloxydim-sodium alone, showed evidence of this effect. There were indications that prior treatment with dinoseb-amine, cyanazine plus MCPB/MCPA tank mix and bentazone/MCPB interfered with control of *A. fatua* achieved from alloxydim-sodium applied 7 days later. The most significant effect was from bentazone/MCPB. When alloxydim-sodium was applied before the other materials there was little effect on *A. fatua* control, and crop effects from these sequential treatments were less than when alloxydim-sodium was used after the broad-leaved weed materials. Similar effects were noted in Europe (personal communication).

Effect of graminicides on pea leaf wax

Herbicides for control of broad-leaved weeds such as dinoseb-amine, rely largely on contact action for activity and the peas need sufficient leaf wax for protection (King, 1978). Subjective assessments were made using the crystal violet test (Amsden & Lewins, 1966) days after application of alloxydim-sodium, or sethoxydim or fluazifop-butyl plus wetter at several sites, and comparisons were made between materials where possible. Results showed that all materials reduced leaf wax, and that alloxydim-sodium appeared to remove pea leaf wax to a greater extent than did sethoxydim or fluazifop-butyl plus wetter. In most seasons where 7 days elapsed after treatment, recovery was sufficient to allow safe spraying with broad-leaved weed herbicide. A 7-day minimum interval was used as a guideline where control of broad-leaved species was necessary.

Post-emergence broad-leaved weed herbicides applied 7 days or more after graminicides

Programmes for several trial sites are shown in table 4, where overall application of broad-leaved weed killers on peas was used at normal recommended rates after graminicide application at a range of rates at least 7 days before.

Table 4

Number of sites for post-emergence broad-leaved weed control

Graminicide	(Years)	dinoseb-amine	cyanazine+MCPB/MCPA or cyanazine+MCPB	MCPB	bentazone/ MCPB
alloxydim-sodium	(1978-1982)	4	4	2	2
sethoxydim	(1980-1982)	4	1	-	-
fluazifop-butyl + wetter	(1980-1982)	2	1	-	-

Results of assessments showed that except for one site where bentazone/MCPB was applied after alloxydim-sodium, crop effects were not increased by use of the programmes compared with application of broad-leaved weed killer alone. Neither rate, nor the graminicide used, appeared to affect broad-leaved weed control achieved, or level of crop damage. However, situations did occur, particularly on fertile soils, where growth stage or broad-leaved weeds was too advanced to achieve adequate control. The optimum target stage for *A. repens* occurs late in the pea crop, and at two sites a sequential spray for broad-leaved weed control could not be made because the peas were in bud or flower, or beyond the safe stage for application of these materials.

Commercially, no problems have been reported where alloxydim-sodium has been used in programmes with materials, with the exclusion of bentazone and bentazone/MCPB.

(c) Tank-mixes

The pea crop has a short growing season and in the UK the time from growing to harvest may be only 12 weeks for early cultivars of vining peas, and a maximum of 22 weeks for peas harvested dry. The number of post-emergence spraying 'windows' in May and early June may be few. Therefore the possibility of a tank-mix of grass weed killers alloxydim-sodium, or sethoxydim, with standard broad-leaved weed materials post-emergence in peas was investigated. Tank-mixes with fluazifop-butyl have not yet been assessed in peas.

Previous work using tank mixes of diclofop-methyl plus dinoseb-amine or bentazone/MCPB showed severe damage to peas, mixes with cyanazine or cyanazine/MCPB were also non-selective and with antagonistic effects on *A. fatua*. Diclofop-methyl plus bentazone appeared marginally selective but broad-leaved weed control was unacceptable.

Table 5

Year	Materials	•Rate	Crop effect	Control grass weed	Control BLW
Logarithmic trials				barley	
1978	alloxydim-sodium + bentazone	3N-0.3N	not tolerant	-	poor
1978	alloxydim-sodium + cyanazine/MCPB	3N-0.3N	not tolerant	-	good
1981	sethoxydim + bentazone/ MCPB (constant rate)	3N-0.3N+N	not tolerant	killed	good
1981	sethoxydim + (cyanazine + MCPB/MCPA) (constant rate)	3N-0.3N+N	not tolerant	killed	good
1981	sethoxydim + MCPB (constant rate)	3N-0.3N+N	tolerant	killed	-
Replicated trials				*A. repens*	*Cirsium arvense*
1980	alloxydim-sodium + MCPB		not tolerant	suppressed	good
				barley	
1980	alloxydim-sodium + MCPB		marginal	killed	good

• Logarithmic trials: rate N was normal rate for *A. fatua* control or broad-leaved weeds (BLW). In 1978, tank-mixes of the materials was applied as a logarithmic dose. In 1981, the tank-mixes consisted of graminicide applied as a logarithmic dose and broad-leaved weed killer applied at a constant normal rate.

Replicated trials: rate N was normal rate of alloxydim-sodium for use in *A. repens* (1.5 kg a.i./ha) plus normal rate of MCPB in peas, applied as a tank mix.

It was concluded that these mixes were not selective in peas and therefore programmes with broad-leaved weed killers must be used.

DISCUSSION

The 'critical period' during which grass weed competition exerts an irreversible effect on pea yield is being studied*, but in some crops their presence before this period does not apparently reduce yield. Results indicate that early release from competition with A. fatua may not produce corresponding yield increase, and delay or use of post-emergence applications may not affect potential yields. Yield increases were only found where infestations were severe, and where the crop offered poor competition. Severe, and very severe infestations of A. repens were effectively suppressed by post-emergence graminicides and corresponding yield increases were seen except at sites where the crop competed well with the weed, or possibly materials were applied too late to affect pea yields, or weed competition was not the limiting factor.

In the pea crop yield benefit is not the only consideration. Control or suppression of grass weeds for easier harvesting is very important. For future benefit complete control of A. fatua should be the aim, to prevent carry-over of seed into following crops which can occur particularly after peas combined at the dry stage of maturity. The new post-emergence graminicides can achieve this, and have the added advantage that application can be made to a known infestation and more economical 'spot' treatment used where practicable. However, glyphosate applied pre-harvest in cereals, or in autumn before peas is still the best option available at present for eradication of A. repens.

Use of the new graminicides in peas

The best control with alloxydim-sodium, sethoxydim, and fluazifop-butyl plus wetter is achieved when the grass weed is growing actively. A. fatua can be killed when application is from early 2 leaf to late tillering stage, and in this respect the new graminicides have more latitude than diclofop-methyl. It appears that the optimum target growth stage for A. repens is 4-6 leaves for the materials. Timing with split applications is not practicable in a short season crop such as peas.

Of the three materials, fluazifop-butyl plus wetter appears to have a more rapid and complete effect on the grass weeds. All materials give good control of A. fatua and a suppression of A. repens which will ease harvesting.

Programmes with broad-leaved weed herbicides

It is usually recommended that pre-emergence materials are used in peas, and under most conditions, season-long control is obtained. Terbutryne/terbuthylazine, and trietazine/simazine have been used successfully in programmes with alloxydim-sodium, sethoxydim and fluazifop-butyl plus wetter. This avoids application of two sprays post-emergence, with an interval of at least 7 days in between, and the consequent problems of few suitable spraying days, and broad-leaved weeds growing beyond the target stage.

Where broad-leaved weeds have to be sprayed post-emergence, e.g. on organic soils, it is recommended that sequential application is 7 days after use of alloxydim-sodium and sethoxydim, for the reason that the target grass weed must be actively growing. It is felt that similar programmes should be used in peas for fluazifop-butyl. In the case of A. repens the target growth stage often occurs late in the life of the pea, and there are restrictions on how late in the crop growth stage a broad-leaved weed killer may be used. However, it is probably more important to control or suppress the more troublesome grass weeds.

* personal communication H. Lawson, Scottish Crops Research Institute.

To conclude, the new graminicides provide very useful alternatives in strategic planning for weed control in the pea crop. There are already recommendations for use of alloxydim-sodium in peas and it is hoped that those for sethoxydim and fluazifop-butyl plus wetter will follow, when the necessary clearance from the Pesticides Safety Precautions Scheme has been given.

Acknowledgements

Assistance is gratefully acknowledged from farmers who provided experimental sites, to the chemical companies May & Baker Ltd. and Imperial Chemical Industries PLC for supplying materials, and to the Statistics Department at the National Vegetable Research Station.

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NEW POST-EMERGENCE HERBICIDES FOR GRASS WEED CONTROL IN SUGAR BEET AND THEIR POTENTIAL FOR CHANGING HERBICIDE MANAGEMENT

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Summary. This paper summarises the experience of specialist advisors in the field of sugar beet production, regarding the integration of the new post-emergence grass herbicides into the existing practices of grass and broad leaved weed control. The advantages/disadvantages of established products are discussed.

The new post-emergence grass herbicides, both marketed and under development, have allowed a more flexible approach to weed control, in that the problem can be treated when it is present, rather than when anticipated as is the case with pre plant products. These also necessitated extra cultivations for incorporation and with some older products the risk of phytotoxicity was always present. The necessity of delaying seeding frequently meant the optimum seeding date was missed hence yields were not maximised.

Experience with the new products has shown good crop tolerance and, that the timing of application with respect to weed growth stage and growing conditions is important, to optimize performance.

Sugar beet, grass herbicides, agronomy, crop tolerance, weed control.

INTRODUCTION

The control of grass weeds in sugar beet has for a long time caused problems for growers and advisors alike, as there has until recently been a shortage of efficaceous, well tolerated products for the control of both annual and perennial grass weeds.

The introduction onto the market of diclofop-methyl for wild oat control, followed by alloxydim-sodium (Ingram et al 1978), for wild oat and couch control, started a change in attitude regarding timing of treatments mixtures etc. New products under development sethoxydim, (Ingram et al 1980) and fluazifop-butyl, (R.E. Plowman et al 1980) are likely to continue this trend, enabling farmers and advisors to optimize their weed control systems.

The opinions expressed in this paper are based on the experiences of a group of specialist advisors and farmers concerned in beet production.

DISCUSSION

The problem - three perennial grasses: Agropyron repens
Agrostis gigantea
Agrostis stolonifera

and four annual grasses: *Alopecurus myosuroides*

Avena fatua

Avena ludoviciana

Poa annua

are the most common grass weeds found in beet, the three perennial grasses being collectively known as couch grass or twitch, by farmers, and as such are not generally recognised individually.

Poa annua is not well controlled by this group of herbicides and as such will not be included in this discussion. Fortunately it is susceptible to many of the standard pre-emergence herbicides, hence programmed control measures are effective.

1. Perennial grasses.

As a group, these grasses have posed a difficult problem to the beet grower when present in the growing crop, and until the introduction of alloxydim-sodium, only dalapon could be used post-emergence.

(a) Dalapon and TCA

Post-emergence treatments with dalapon give very variable results and sometimes unacceptable crop damage, altogether not a very satisfactory situation. In the year of the crop, pre-drilling treatments with TCA have been, and still are, used against couch, approximately 5% of the national crop receiving TCA as a pre-sowing treatment. (British Sugar Specific Field Survey).

The alternative product, TCA is not a satisfactory method of dealing with couch for four reasons:-

1. TCA requires soil incorporation. Soil incorporation may mean extra tractor wheelings on the seedbed and unacceptable levels of soil compaction, hence poor establishment. This is in addition to the problems of excessive moisture loss and loss of seedbed which can occur in some conditions.

2. TCA can damage and kill sugar beet seedlings. This damage can be made worse by sequential pre or post emergence herbicide treatments for the control of broad leaved weeds.

3. TCA soil incorporated, ideally requires an interval between treatment and sowing which may mean later sowing and loss of yield.

4. TCA does not always give satisfactory weed control.

(b) Glyphosate

A pre/post cereal harvest application of glyphosate in the season before beet, overcomes all the problems of soil incorporation, soil compaction and possible herbicide effects on beet. Glyphosate is an efficient herbicide against perennial grasses, when used according to instructions. With *Agrostis* species care must be taken to avoid reinfestation in the crop from germinating seeds.

(c) Alloxydim-sodium

Commercial and trials usage of this material has shown it to give acceptable season long control of couch grass in the growing crop, along with good crop tolerance.

Hence on land that could not have been treated with glyphosate the previous autumn, on newly acquired or rented land, there is now a means of couch control which does not have the risks or limitations associated with TCA or dalapon. There are also some timing and climatic factors which are discussed later which may effect performance.

(d) New Post-emergence materials

Two more new materials have been in wide scale trials, namely:

Sethoxydim
Fluazifop-butyl

Both herbicides can provide an effective answer to perennial grasses in sugar beet, but like alloxydim-sodium should not be thought of as the best method of eradicating the problem. They are similar in performance and crop selectivity to alloxydim-sodium, and have, from trials experience, similar limitations. Their impact in commercial use has yet to be seen.

(e) Timing

Commercial and trials experience with alloxydim-sodium, sethoxydim and fluazifop-butyl, has suggested that timing the treatment correctly is very important. Couch must be actively growing and have approximately 30cm of top growth on the largest shoots at treatment.

Soil and weather conditions are also important. Very dry soil and hot weather, causing grass weeds to suffer drought stress may reduce herbicide activity resulting in poor control, cold slow growing conditions may also reduce activity. Conversely,warm damp conditions which are good for plant growth are likely to promote maximum herbicide activity and therefore good weed control. Delaying treatment until couch has up to 30cm of top growth, gives more time for the soil to warm up, which in turn stimulates bud activity on the rhizome resulting in more effective translocation of herbicide.

To satisfy these conditions, treatments with these materials are likely to be most successful from mid May to mid June, allowing sufficient weed growth but treating before weed competition becomes a serious problem.

2. Annual grasses. Current situation.

Approximately 26% of the National crop receives a pre-drilling treatment against annual grass weeds. The majority of this area, 20% of the National crop, is treated with triallate. Cycloate and a small area treated with TCA make up the balance. (British Sugar Specific Field Survey).

(a) Triallate

Soil incorporated triallate is normally a successful treatment for the control of *Avena spp.*, but the potential problems caused by soil incorporation remain, as outlined in the section on TCA (1(a)).

(b) New post-emergence herbicides

(i) Diclofop-methyl. Diclofop-methyl was the first of a new generation graminicides and was marketed for the control of *Avena spp.*, with useful control of *Alopecurus myosuroides*.

(ii) Alloxydim-sodium. Alloxydim-sodium followed diclofop-methyl into commercial use and this material was shown to be equally well tolerated and equally effective on *Avena* spp., but also controlled other annuals such as *Alopecurus myosuroides* and volunteer and sown cereals.

(iii) Fluazofop-butyl and sethoxydim. These two materials have been under development for the control of annual grass weeds. Trials experience indicates that their performance is comparable to diclofop-methyl and alloxydim-sodium on the appropriate species. The experience of full scale commercial use is awaited before full comparisons can be drawn.

(iv) Timing of application. With all the above materials, experience has shown that treatment must be fully post-emergence, the 2-4 leaf stage of the grass weeds being optimum for the recommended dose rates, higher rates being required at larger growth stages.

As with perennial grasses, good growing conditions, i.e. moist and warm favour activity, whereas drought stress or cold reduce activity. Diclofop-methyl is different in this respect and works best in cool damp conditions.

Hence with the first two materials a new era of safe, effective post-emergence grass control opened up, allowing farmers to treat only the infested areas (as opposed to overall with pre-emergence materials) and to band spray if desired. Since then the second generation products ((iii) above) have been under development.

Cost

Diclofop-methyl, alloxydim-sodium and fluazifop-butyl cost approximately 30% more than triallate, which requires treatment of whole fields and soil incorporation (cost of incorporation not included).

Post-emergence treatments can select infested areas (because the problem is visible) and can be band sprayed. So although at first sight chemical cost/ha may not favour post-emergence treatment, localised treatment or band spraying, and avoiding herbicide incorporation, may result in greater crop productivity and a substantial cost saving over soil incorporated triallate.

As the area treated for annual grasses pre-sowing is large, 26% of the National crop, there must be considerable scope for developing post-emergence treatments against annual grasses. (British Sugar Specific Field Survey).

3. Agronomic aspects

(a) Competition from annual and perennial grasses

Post-emergence treatments open the door for weeds to compete with the crop unless timing of the treatment is correct. Even then high populations of couch and wild oats may compete with the crop before the weed is killed. The flexibility of use of new graminicides in part overcomes this problem, but the effects of weed competition should be recognised by both advisor and farmer. (Scott et al 1972).

(b) Compatibility with other herbicides.

Herbicide treatments against perennial grasses usually occur after broad-leaved weed treatments are finished, so for this situation compatibility is not a serious problem.

Post-emergence treatments against annual grasses are likely to coincide with treatments to control broad leaved weeds and in this situation it would be an advantage if the new graminicides were compatible with phenmedipham or metamitron or preferably both. Alloxydim-sodium already has recommendations for tank mixing with phenmedipham.

(c) Living windbreaks

Both winter rye and spring barley and oats are used as cover crops to control soil erosion by wind.

The problem in the past has been that no effective selective herbicide was available to kill the cover after crop emergence.

New post-emergence graminicides change this situation and have four important advantages over controlling the cover pre crop emergence.

These are:-

1. The cover remains alive to protect the crop at a critical time.

2. Management of the cover crops destruction is simple.

3. Date of drilling the root crop in relation to the stage of growth in the cover crop is less critical.

4. Other grass weeds are controlled when the cover crop is killed.

The control of living windbreaks after crop emergence is now a reality and should lead to an increase in the use of cereals drilled to control soil erosion resulting in better crops on these light soils.

(d) Volume rates

Low volume 80 - 100 l/ha applications of phenmedipham and metamitron are now widely used.

It is therefore important that recommended water volume rates for post-emergence graminicides allow low volume application. This is particularly important when a combined broad leaved weed/grass weed herbicide mixture is used.

More work is required to establish whether or not reduced doses of these new graminicides are effective, when tank mixed with broad leaved herbicides in low volume, low dose systems.

Being translocated products this mode of action is different from phenmedipham and metamitron (contact materials), and the advice at present is to apply the full recommended dose of the grass herbicide in one application.

CONCLUSIONS

The commercially available new graminicides, diclofop-methyl and alloxydim-sodium, and the second generation products fluazifop-butyl and sethoxydim, solve to a greater extent what have been difficult problems for both growers and advisors namely:-

(a) Controlling grasses post-emergence eliminates the problems (serious on difficult soils) caused by soil incorporated pre-drilling treatments.

(b) Post-emergence spraying is a simple more accurate task compared to pre-drilling treatments which require soil incorporation.

(c) Post-emergence treatments have a high margin of crop safety.

(d) Used on their own, post-emergence graminicide treatments can be confined to infested areas, saving chemical and cost.

(e) In broad leaved crops, such as sugar beet, grass weeds growing in from field boundaries can be controlled without the risk of crop damage or loss of crop if a rotavator is used.

(f) Tank mixes require further development but when allowed will save a pass with the sprayer.

(g) The new graminicides allow flexible management of living windbreaks drilled to control soil erosion.

It can therefore be concluded that new post-emergence graminicides have a very important role to play in the overall management of sugar beet weed control.

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EVALUATION OF SOME NEW HERBICIDES FOR THE CONTROL OF AGROPYRON REPENS IN SUGAR BEET

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Summary. In field experiments in 1980-82, fluazifop-butyl at 0.75-1.0 kg a.i./ha and NP55 at 0.6-0.8 kg a.i./ha were tested to control *Agropyron repens* in sugar beet.

In 1982 two additional herbicides were tested. These were CGA 82.725 at rates of 0.4-0.5 kg a.i./ha, and Dowco 453 EE at 0.37-0.5 kg a.i./ha.

Applications were made post-emergence to sugar beet at 2-3 leaves and at 4-12 leaves of the *A. repens*. Satisfactory results, above 90% control of *A. repens*, were obtained with higher doses of the herbicides. The addition of phenmedipham to these herbicides, slightly increased the speed of effect on *A. repens*.

However, there was temporary slowing of sugar beet growth, but there was no subsequent effect on yield.

Fluazifop-butyl, NP55, CGA 82.725, Dowco 453 EE (haloxyfop), tolerance, yield, field tests, post-emergence.

INTRODUCTION

Agropyron repens is one of the most common weeds in Poland. It appears in Poland on nearly all types of soils and infests almost 70% of the cultivated area, out of which 30-50% is infested very seriously, causing yield reductions of 10-20% on a variety of crops. Winter cereals, winter rape, potatoes and sugar beets are worse affected.

Typical Polish climatic conditions favour the development of *A. repens*, especially if the harvest period is rainy. Rain at harvest also shortens the period of "after harvest cultivations" and seriously limits the possibilities of mechanical cleaning of the fields before sowing succeeding winter crops.

A large number of farmers control *A. repens* by amalgamating mechanical and chemical methods, using herbicides such as simazine, TCA and glyphosate. TCA is the most commonly used herbicide in Poland. It is widely integrated in mechanical/chemical methods of control of the weeds in winter rape and sugar beets. However, because of its very limited selectivity to cultivated crops, it is applied at rather low rates 10-12 kg/ha, giving control levels of no more than 50-70% of *A. repens*.

The introduction of new herbicides for the control of *A. repens* in cultivated crops during their vegetative period is of utmost interest to the Polish farmers.

Herbicides such as fluazifop-butyl, NP55 (proposed common name - sethoxydim), CGA 82.725 and Dowco 453 EE have the potential to meet this requirement.

The above products are selective in broad leaved crops and effectively control both annual and perennial grass weeds. These have been reported in different countries by various authors; fluazifop-butyl, Horellon, 1981 and Plowman et al, 1980; for NP55, Drosihn and Huebl, 1979 and Ingram et al, 1980; for CGA 82.725; Maurer, et al, 1981 and Nyffler, und Gerber, 1981.

METHODS AND MATERIALS

The trials were located in the area of Wrocław in commercial crops of sugar beet, where lenacil or chloridazon had been applied pre-emergence.

The soil type was "Black soil", consisting of 2-3% of o.m. 25 m^2 plots with 3-4 replicates were used. The following were compared:

Fluazifop-butyl	25% m/v e.c.
NP55	20% m/v e.c.
CGA 82.725	20% m/v e.c.
Dowco 453 EE	12.5% m/v e.c.

The applications were made post-emergence of sugar beet at the 2-6 leaf stage, when *A. repens* had 4-12 leaves.

The effect of herbicides on *A. repens* during the vegetative period was evaluated, by counting shoots in 1 m^2 areas, as well as taking the percentage ground cover. In addition, during the first 2-4 weeks after application, the reaction of sugar beet and weeds to the herbicides were evaluated using the EWRC 1 : 9 scale.

RESULTS

The reaction of A. repens

From preliminary experiments carried out in 1980, it was shown that fluazifop-butyl at rates of lower than 0.75 kg a.i./ha and NP55 at lower than 0.6 kg a.i./ha did not effectively control *A. repens*. Therefore in succeeding years the activity of higher rates was tested.

In addition, the reaction of *A. repens*, as well as sugar beet, was observed after treatment with these herbicides, in mixtures with phenmedipham or oils (tables 1-2).

Table 1

The effect of control of couch (A. repens) in sugar beets/Wrocław 1981

	Rate kg a.i./ha	Crop Vigour 1-9 3 weeks post spray	Couch Vigour 1-9 3 weeks post spray	Couch % Control	Couch % ground cover
Fluazifop-butyl	0.75	1	4	80.0	11
Fluazifop-butyl	1.0	1	2	97.4	2
Fluazifop-butyl + phenmedipham	0.75 + 0.8	2	3	89.8	7
Fluazifop-butyl + oil	0.75 + 3	1	3	87.3	7
NP55	0.6	1	5	74.0	15
NP55	0.8	1	2	95.3	3
NP55 + phenmedipham	0.6 + 0.8	3	3	84.3	8
NP55 + oil	0.6 + 3	1	4	83.4	9
TCA applied 9 Apr. 1981	10.0	2	5	60.0	18
Hand weeded control x/	-	1	-	99.2	8
Untreated control (shoot nos.)	-	1	9	(235)	38
Date assessed		4/6/81	4/6/81	22/6/81	15/9/81

x/ 2 times = 32 working days/ha

Treatment
Applied 14th May 1981

Table 2

The control of couch in sugar beet
mean of 2 trials, Wrocław 1982

	Rate kg a.i./ha	Crop Vigour 1-9 3 weeks post spray	Couch Vigour 1-9 3 weeks post spray	Couch % control	Couch % ground cover
Fluazifop-butyl	1.0	1	2	93.6	1
Fluazifop-butyl + phenmedipham	1.0 + 0.65	2	2	98.8	+
Fluazifop-butyl + oil	1.0 + 3	1	2	98.1	+
NP55	0.8	1	4	89.8	4
NP55 + phenmedipham	0.8 + 0.65	3	3	97.5	2
NP55 + oil	0.8 + 3	2	3	98.1	3
CGA 82.725	0.4	1	4	86.6	12
CGA 82.725	0.5	1	4	87.9	10
CGA 82.725 + phenmedipham	0.5 + 0.65	2	4	91.0	10
Applied 8.6.82					
Dowco 453	0.37	1	4	92.3	3
Dowco 453	0.5	1	2	96.8	1
Dowco 453 + phenmedipham	0.5 + 0.65	3	1	97.5	+
TCA, Applied 28.4.81	10	2	5	73.5	12
Hand weed control[x]	-	1	-	96.8	7
Untreated control (shoot nos.)	-	1	9	(156)	18
Date assessed		15/6/82	15/6/82	30/6/82	20/8/82

x 2 times = 24 working days/ha

scale 1 : 9 = for crop 1 no effect, 9 complete kill, for couch 1 complete kill, 9 no effect.

Treatment
(Applied 25 May 1982)

During both years of experimentation, in the first weeks after application, fluazifop-butyl showed a little better effect on A. repens control when compared to NP55. However, at the final assessments differences were not significant, but, compared with TCA or hand weeding, the effect of weed control by fluazifop-butyl and NP55 must be evaluated as very good. The addition of phenmedipham, or oil, significantly increased the activity of these products. Two to three days after application, yellow spots could be seen, and subsequently dying foliage of A. repens.

Results in small plot trials have been confirmed on several large scale sugar beet user trials. In 1982, two other products were included, namely CGA 82.725 and Dowco 453 EE (table 2). Both herbicides significantly reduced the number of A. repens shoots in the first week after application. However, three months after the application of CGA 82.725, regrowth of A. repens was observed. It is likely that these were caused by too low rates of the herbicide. This effect was not observed on the plots treated with Dowco 453 EE. It was also noticed that phenmedipham increased the speed of action on the foliage of A. repens and slightly increased the final level of control.

Reaction of sugar beet

In all trials the herbicides had minimal effect on the development and growth of sugar beet. Only temporary symptoms, slight wilting and chlorosis, appeared on plots treated with the products in mixture with phenmedipham. All symptoms had disappeared after 2-3 weeks, and did not have any effect on the yield of sugar beets.

Table 3

Agropyron repens after sugar beet in the spring barley (following crop 1982)

Treatment (Applied 14.5.81)	Rate kg a.i./ha	no./m² of couch shoots 15.5.82	% Ground cover of couch 20.7.82
Fluazifop-butyl	0.75	7	+
Fluazifop-butyl	1.0	1	-
Fluazifop-butyl + phenmedipham	0.75 + 0.8	4	1
Fluazifop-butyl + oil	0.75 + 3	4	+
NP55	0.6	12	5
NP55	0.8	5	+
NP55 + phenmedipham	0.6 + 0.8	15	1
NP55 + oil	0.6 + 3	17	1
TCA/Applied 9.4.81	10.0	35	9
Hand weed control	-	48	12
Untreated	-	107	15

The effect on succeeding crops

In the year following the 1981 beet crop, the trials field was sown with spring barley. Observations of the weed infestation in the spring barley, showed significant differences in number of shoots as well as the percentage of the soil covered by A. repens (table 3).

On all plots treated with fluazifop-butyl or NP55, A. repens remained in minimal quantities, whereas in plots treated with TCA, or hand weeded, as well as in check plots, the infestation of it was rather serious, causing a reduction of cereal yield between 7% with TCA, and 11% on check plots.

DISCUSSION

Weed control in sugar beet, and in particular control of annual and perennial grasses, is an important measure for farmers to optimise their production. Lack of manpower and limited selection of herbicides very often does not permit all the necessary cultivations, or spray treatments in this important Polish crop. These major facts are stressed by a number of specialists and practicing professionals (Zitzewitz und Heckele, 1981). Therefore the introduction of herbicides such as fluazifop-butyl and NP55 (sethoxydim) will bridge the gap in post-emergence control of grass weeds, in particular A. repens.

Following the preliminary 1981 trials, two other candidate products were included, namely CGA 82.725 and Dowco 453 EE.

All these herbicides are highly selective in sugar beet and in a number of other broad leaved crops. Moreover, they may be mixed with other herbicides used in these crops. For example phenmedipham (Ingram, et al, 1980), is of great practical importance. The activity and tolerance of these products in sugar beet was established in small plot experiments at the Institute for Plant Cultivation, Fertilizer and Soil Science and also in large scale trials on farms.

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