WEED CONTROL PROGRAMME FOR MAIN CROP CARROTS

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Summary The 4 predominant weed species were *Poa annua*, *Matricaria* spp., *Stellaria media* and *Urtica urens*. None of the herbicide treatments significantly affected plant stand. When assessed 54 days after sowing linuron pre-emergence reduced overall weed cover by 60%. Of the post-emergence treatments chlorbromuron was the best, giving some control of *Matricaria* spp. Linuron post-emergence was an effective herbicide but failed to control *Matricaria* spp. The other treatments were unsatisfactory. The best overall treatment was linuron pre-emergence plus chlorbromuron post-emergence.

Résumé Les 4 adventices les plus importants étaient *Poa annua*, *Matricaria* spp., *Stellaria media* et *Urtica urens*. Aucun des traitements herbicides n'a eu d'influence significatif sur la densité de peuplement. Une évaluation 54 jours après le semis a révélé une réduction de 60% dans la totalité des adventices survant une application de linuron en pré-semis. En post-levée le chlorbromuron s'est montré le plus efficace ayant supprimé en quelque degré des *Matricaria* spp. le linuron en post-levée s'est montré efficace sauf contre les *Matricaria* spp. Les autres traitements ont été insufficants. Les meilleurs resultats ont été obtenu avec le linuron en pré-levée, suivi du chlorbromuron en post-levée.

INTRODUCTION

Linuron is widely used as a pre-emergence herbicide on commercial carrot crops but there is a current trend to rely solely on post-emergence materials. (Rickard, 1977). Also chemicals approved for use on carrots under the Agricultural Chemicals Approval Scheme and included in the Ministry's Short Term Leaflet (STL) No. 52 are being mixed by growers but the effects of these mixtures on plant stands and yields on mineral soils have not been investigated. Recently a new liquid formulation of metoxuron has shown promise for early post-emergence weed control and this warranted further study. Herbicide evaluation trials on carrots with linuron and metoxuron (Roberts and Hewson, 1968) show that these chemicals were non-phytotoxic when applied at the 2- and 3-leaf stage respectively.

METHODS AND MATERIALS

Soil type: the soil type was a fine sandy loam of the Skipworth series, overlying lacustrine clay. It caps in heavy rain and is liable to blow when dry.

Experimental layout: randomised block with 3 replicates. Plot size 1.5 metre by 6 metre.

Experimental treatments: The following post-emergence treatments were applied to the experiment either with or without a pre-emergence application of linuron at 0.55 kg ai/ha.

metoxuron 3.52 kg ai/ha
metoxuron 4.32 kg ai/ha
linuron 0.55 kg ai/ha plus metoxuron 3.52 kg ai/ha
pentanochlor 2.24 kg ai/ha
chlorbromuron 0.55 kg ai/ha

Method and timing of application: variety Markananta was sown on 6 May 1977. Herbicides were applied in 784 litre/ha by Knapsack sprayer. The pre-emergence treatments were all applied at one time and within 3 days of drilling. The post-emergence sprays were applied as near as weather conditions allowed to the stage recommended on the product labels.

Method of recording: plant stand counts from 4 x 1.5 metre rows were taken prior to application of the post-emergence treatments and repeated 3-4 weeks later. Weed counts from 10 x 30 cm^2 quadrats were taken prior to application of the post-emergence treatments, recording the weeds by species. An estimate of percentage weed cover was also taken. Nineteen days later a further assessment was made taking the percentage total weed cover the proportion of the cover attributable to each species. Time taken to hand weed the plots was then taken. Hand weeding consisted of hand pulling the biggest weeds in a manner similar to that undertaken commercially.

RESULTS

Linuron pre-emergence had no significant effect on plant stand when assessed 53 days after sowing viz table 1.

Table 1

Mean plant stand/m of row on 28.6.77 before post-emergence sprays

pre-em. treatments	mean
linuron	13.39
control	12.53
S.E. ± 1.16	

None of the post-emergence treatments affected plant stand as shown in table 2.

Table 2

Mean plant stand/m of row on 25.7.77 after post-emergence sprays

Pre-emergence treatments	post-emergence treatments						
	control	linuron	metoxuron w.p.	metoxuron liquid	linuron + metoxuron w.p.	pentan-ochlor	chlor-bromuron
linuron	13.29	-	11.87	14.71	11.37	12.80	12.19
control	-	11.87	10.83	12.14	13.94	10.55	11.05
S.E. ± 1.096							

Linuron pre-emergence reduced the overall percentage weed cover compared to no pre-emergence spray from 44.44% to 26.33%. This was due to improved *Matricaria* spp. and *U. urens* control as shown in tables 3 and 4.

Table 3

Weed assessment 29.6.77 (before post-emergence sprays applied)

Species as % of total cover

pre-em. treatment	Poa annua	Urtica urens	Stellaria media	Senecio vulgaris	Matricaria spp.	Capsella bursa-pastoris	Others
linuron	57.51	7.38	19.84	1.24	9.10	1.07	3.87
control	37.47	12.75	19.87	0.39	21.45	2.31	5.76

Table 4

Weed assessment 29.6.77 (before post-emergence sprays applied)

Pre-emergence treatments	Weed cover as % of total ground cover
linuron	26.33
control	44.44

S.E. ± 11.92

Weed assessments on 19 July after the post-emergence sprays were applied showed chlorbromuron with or without linuron pre-emergence and also linuron post-emergence to be significantly better than just linuron pre-emergence. Metoxuron w.p. was completely ineffective because of a thunderstorm within hours of application. Metoxuron liquid applied after the storm was reasonably effective but failed to control *P. annua* see table 5.

Table 5

% ground cover by weeds 19.7.77 (after post-emergence sprays) (averaged over 3 replicates)

Pre-emergence treatments	post-emergence treatments: control	linuron	metoxuron w.p.*	metoxuron liquid	linuron + metoxuron w.p. ø	pentanochlor	chlorbromuron
linuron	48.3	-	66.7	55.0	91.7	25.0	1.3
control	-	5.3	98.3	26.7	28.3	63.0	7.7

S.E. ± 11.28

* thunderstorm shortly after application
ø only applied 7 days prior to assessment

Weed distribution was variable which explains why some of the plots treated pre-emergence with linuron still had a higher percentage weed cover after the post-emergence treatments were applied in comparison to linuron pre-emergence alone.

On 19 July all plots except the recently applied metoxuron + linuron were hand weeded and timed to calculate a comparative weeding cost. The metoxuron + linuron plots were weeded on 3 August, table 6.

Table 6

Time taken to handweed plots (mins per 9 m^2) on 19 July (averaged over 3 replicates)

pre-emergence treatment	post-emergence treatments						
	control	linuron	metoxuron w.p.	metoxuron liquid	linuron + metoxuron w.p. *	pentan-ochlor	chlor-bromuron
linuron	1.91	-	2.24	2.17	3.99	1.30	0.34
control	-	0.56	5.86	1.86	1.07	3.53	0.83

S.E. $\pm$ 0.459

* weeded 3.8.77

Linuron pre-emergence was as good as any other herbicide programme and none of the other treatments took significantly less time to handweed. Weeding time tended to be related to percentage weed cover which as stated was variable. The linuron application post-emergence, and the chlorbromuron treatment with and without pre-emergence linuron took the least time to handweed.

DISCUSSION

Metoxuron or metoxuron plus linuron applied after 3 true leaves on a light sandy loam mineral soil as recommended by the manufacturers is too late as weeds can be 30 cm or more tall at this time. Wet or windy weather can prevent spraying on time as happened in 1978 and weeds like Polygonum persicaria and Chenopodium album grow too late for effective control. Metoxuron suspension concentrate was disappointing in the control of P. annua but effective against most other weeds present. Pentanochlor applied at the 2 true leaf stage when weeds were emerged and up to 3 cm tall gave some initial weed scorching particularly on Stellaria media, but it compared badly with chlorbromuron or linuron as a post-emergence spray.

On this soil type post-emergence sprays alone are probably inadequate unless a better early post-emergence treatment becomes available. In fact, a mixture of pentanochlor plus chlorpropham plus metoxuron has gained approval for use on carrots in 1978 at the one true leaf stage, and a current trial at Stockbridge House Experimental Horticulture Station has shown it to be very effective even against small weeds. On an organic soil where metoxuron can be used at the 2 true leaf stage prospects for omitting a pre-emergence spray are much better than on mineral soil. Chlorbromuron and linuron post-emergence both gave a high level of weed control but both were weak on Matricaria spp. Linuron as a pre-emergence material gave a substantial control of these weeds.

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FUTURE TRENDS IN CEREAL WEED CONTROL

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Mr. Elliott this morning looked at the present position of cereal weed control and its future from an economic point of view. I have been invited to consider the technical trends. Since both aspects are closely linked, it is unavoidable that there will be some duplication, but I shall do my best to keep clear of economics.

Ten years ago when I was asked to discuss the position in cereal weed control and to make some predictions, I found this fairly easy. Specialists in the major cereal growing areas of Europe agreed at the time on most points. There was, however, some disagreement on one important aspect: would the profitability of cereal production continue to increase and thus justify high cost for weed control, or would it become less intensive, resulting in the use of cheaper herbicides at lower rates? We now know, of course, in which direction it has developed, and there seems to be no reason to assume that this trend of cereals in many countries being produced in a highly intensive way - aiming at maximisation of yield - should not continue.

When I consulted leading cereal specialists in Europe during the last few months, and asked them what, in their opinion, were the major trends in cereal weed control, I found that few agreed on the same points, and were only able to indicate some trends which were rather less dramatic and clear than those which one could indicate ten years ago.

Nevertheless, I was able to isolate several trends, and would like to discuss these under four major headings:

1. Herbicides
2. Changing weed populations and resistance of weeds and cereals to herbicides
3. Application problems and the question of minimum cultivation
4. Finally, I shall discuss some "philosophical" aspects related to the question of "maximisation of yield" and "integration of weed control" with other agronomic measures.

1. HERBICIDES

Almost exactly ten years ago I produced a chart which illustrated the main group of herbicides with emphasis on their trends at the time and anticipated trends for the next few years.

This old diagram showed the appearance and disappearance of dinitros; the spread of the basic hormones 2,4-D, MCPA; the phenoxy-butyrics; the mixtures of various types and finally the first appearance of wild oat and blackgrass herbicides.

With the help of my colleague, Mr. R.J. Ayres, I have tried to update this chart and to predict the trends for each of the herbicides for the next seven or eight years. The slide shows:

1. The use of dinitro-compounds has, in the UK at least, long since ceased.

2. The use of straight MCPA or 2,4-D, the first selective hormone herbicides, still continues but is slowly decreasing, but not necessarily fading out however.

3. The herbicides MCPB and 2,4-DB are almost independent of other herbicide groups, since their function is specialised - weed control in undersown cereals. It seems that the area of this crop probably reached a peak during the early 1970's and we are now seeing a slight decline in the use of the butryne herbicides.

4. The broad-spectrum herbicide mixtures are extremely important. Developed to control weeds which proved resistant to early hormone herbicides, these herbicides have proved the mainstay of broad-leaved weed control in cereals for 15-20 years. Their use may, however, have reached a peak, due on the one hand to increased use of blackgrass herbicides which also control important broad-leaved weeds, but secondly perhaps to gradually increasing interest in the next group of herbicides on the chart.

5. This group, which began with the introduction of what one might call the new contact herbicides of the ioxynil/bromoxynil type in the early 1960's was initially slow to gain momentum. However, quite sophisticated mixtures of these and other materials with hormone or even residual herbicides to give the broadest possible spectrum of weed control are on the increase, and this concept is not unlikely to be developed further.

6. & 7. The next two groups have been developed to counteract the increase in grass weeds which has occurred in cereal growing areas. We now have a relatively large number of extremely competent herbicides for the control of both wild oats and blackgrass. Their use has been increasing during the 1970's and may even continue to do so for some time yet - indeed, until the grass weed problems are largely overcome.

8. The final group does not as yet constitute a new group of herbicides, but rather a new use for existing herbicides. This began with low rates of black-grass herbicides being used for the control of broad-leaved weeds, and it is possible that we may even see specific herbicides being developed for this use in the future.

The chart obviously is an over-simplification, but it indicates in summary three major trends and new developments:

1. The combined control of grass weeds and broad-leaved weeds either by specially designed mixtures or by the introduction of new herbicides.

2. The introduction and increasing use of pre-emergence herbicides in winter cereals.

3. A very marked improvement in the scope for effective wild oat control, both pre- and post-emergence.

2. THE CHANGING WEED FLORA AND PROBLEMS OF WEED AND CROP RESISTANCE

For the second part of my paper I should like to forget herbicides and concentrate on other aspects of weed control in cereals.

Firstly, let me consider the problem of changing weed populations, the possibility of resistance developing in important weeds in cereals and the question of the tolerance of important cereal varieties to herbicides.

Looking back, we find changes which are known to all of you. First the reduction of weeds susceptible to what we used to call the old hormone herbicides; followed by the spreading of broad-leaved weeds, which were resistant to these old hormones. Then as a result of the development of new herbicides or mixtures we can see the reduction of many of these so-called hormone resistant weeds. In consequence of these developments, grass weeds (wild oats, blackgrass and other species) increased. Finally, perhaps not yet indicated in this slide, as a result of herbicide usage, a reduction of very heavy infestations of the key grass weeds (wild oats and blackgrass) in several European countries.

What are the trends for the future? As indicated by the recent national survey one can foresee in this country a further reduction of heavy infestations of wild oats and blackgrass, but on the other hand a further increase in the number of fields with light infestations. The question whether attempts for the complete elimination of wild oats and blackgrass are justified is an economic one, and outside the scope of my paper.

In my recent tour of several European countries, I tried to find out whether experts are concerned about an increase of weed species which previously were of minor agricultural significance. Nothing very dramatic seemed to have emerged, but there appears to be a trend for some grass weeds other than wild oats and blackgrass, in particular ryegrass, Poa trivialis and Bromus spp., to increase and to develop into a major problem in cereals.

Let me turn now to the possibility of genetic resistance to certain herbicides developing in important weeds in Europe. Until a few years ago, herbicide experts used to ignore this possibility, and some degree of complacency has occurred on this point when we compared our situation with that of entomologists and mycologists.

The old argument was that since weeds normally only produce one generation per year, it would take a long long time before genetic resistance would emerge as a problem. It seems from information I was given in France that the time is approaching when this problem will need more serious consideration. There are indications in France that in genera such as Chenopodium resistant strains are emerging, thus possibly necessitating higher dosages of herbicides. This in turn would raise problems of crop tolerance.

I want to turn to the question of the tolerance of cereal varieties to herbicides and the possible consequences resulting from a development of less susceptible genetic strains of weeds. This is an interesting area for speculation, and I hope you will agree with me that a speaker invited to talk about future trends is not only entitled but forced to speculate.

About 25 years ago, at the first British Weed Control Conference in Margate, the late Dr. Zeller and I expressed the view that plant breeders could perhaps contribute to resolving problems of low selectivity margins by selecting strains more tolerant to herbicides from genetically mixed populations.

A serious problem arose about 10-15 years ago when the first post-emergence wild oat herbicide (barban) was introduced, and when it was found that two of the most popular barley varieties, Proctor and Provost, proved exceptionally susceptible, thus excluding the use of this herbicide on these varieties. This could have led to a situation in which the plant breeder's interest could have come in conflict with that of the herbicide specialist. I recall heated discussions with

Dr. Bell, the breeder of these varieties, in Cambridge. Fortunately new compounds were discovered which solved the problem effectively.

However, in the future, a situation could occur where an exceptionally difficult weed problem in cereals (not necessarily in this country or in Europe) could only be selectively controlled in certain cereal varieties, which may not be acceptable to the cereal grower from the point of view of their yield capacity, or for other reasons such as poor quality or poor disease resistance.

3. APPLICATION AND MINIMUM CULTIVATION

In discussing trends in application techniques and on the future importance of minimum cultivation, I had to rely on the opinion of experts in that field. I certainly cannot claim to have much experience on these subjects.

There is, of course, at this conference an important session which will deal with application problems. The two aspects which dominate this issue are controlled droplet application (CDA) and very low volume application. My colleague, Mr. E.S.E. Southcombe, who will review the research reports in the Application Session, recently published a paper under the heading "Controlled droplet application and low volume - conflict or partnership".

I have the impression that it will be in the field of application techniques and machinery where major advances can be expected in the next 10 years. We have recently seen the introduction of very low volume applications which are likely to become more and more popular. The advantages of being able to spray large areas with the minimum amount of water and perhaps equally important, the possibility of spraying on wet land in the late autumn and winter are obviously of considerable practical importance.

CDA, or controlled droplet application, is a rather more controversial proposition, and the elimination of drift by avoiding the formation of minute droplets is obviously of considerable importance both from an environmental as well as from the point of view of safety to adjoining crops. On the other hand, it is still arguable whether the application of droplets of a constant size, which are unlikely to be optimal for all crops and all conditions is a desirable objective.

It seems that a compromise, by which I mean the application of a spray covering a narrow spectrum of droplets - avoiding small droplets - combined with low volume application, may be the ultimate answer. Therefore, as Mr. Southcombe indicated, the partnership between the two advances in application may well set the trend for the next 10 years.

A significant, indeed a major, development of the last few years was the increase in minimum cultivation techniques in the United Kingdom, of which the ultimate is direct drilling. The next slide, based on figures from ICI, illustrates this trend.

On the Continent of Europe a somewhat similar but in no way quite as pronounced increase in minimum cultivation techniques occurred in France. In contrast, the technique is still relatively unimportant in most other European countries (eg in Germany). The reasons for these differences are not clear to me.

I recall some 15 years ago one of the first public discussions on direct drilling. Many experts predicted a dramatic and ultimately unacceptable increase of perennial weeds, ranging from couch to thistles. This would indeed have occurred, and this curve would have looked very different if the technique had not been associated with the introduction of powerful herbicides such as glyphosate and paraquat. We see here an almost classic example of the inter-relationship and indeed inter-dependence of two basically unrelated agronomic techniques.

There may still emerge some problems which are difficult to define at this stage and which could result from a continued minimum cultivation, but I see no reason to assume that its popularity will not further increase over the next few years and possibly spread in Europe.

4. MAXIMISING YIELD AND INTEGRATED WEED CONTROL SYSTEMS

Having just touched on an example of an inter-relationship between agronomic disciplines or techniques, I would now finally like to express some "philosophical" thoughts on this important aspect.

One popular and attractive phrase these days is that of "maximisation of yield". Mr. Elliott looked at this from the economic point of view, and I shall try to avoid this.

In theory, a "maximisation of yield" should be achieved if each of the many parameters which make up yield is improved to an optimum. Thus, for example, optimum soil preparation with the choice of the best variety, optimum fertilizer, disease and weed control etc. should together lead to the maximum yield.

This would be true if (a) the weather and associated factors would be constant and always suitable for optimum conditions, and (b) if there were no interactions between individual agronomic measures.

However, what may be optimal in one year may be far from optimal in another year, and there appears to be no obvious way out of this dilemma.

Nevertheless, there are two messages which one could perhaps give. What I mean is best illustrated by an example. Plant breeders, particularly in America, have for some time, instead of developing varieties based on single genotypes, mixed different genetic strains, in order to incorporate an element of reliability in new varieties. Applying this principle to our discipline we should perhaps ask ourselves whether we are wise to aim for example at one constant droplet size, or even for the use of a single herbicide.

Furthermore, should not more effort be made to study at least in theory on models the possible interactions between the different agricultural measures? I do not know of any effort at present on any scale to study these basic aspects in principle.

In my closing address to the International Symposium in Sweden last year on "Integrated weed control" I tried to define ideal integration as "the most economical combination of individual measures to produce optimum weed control with a minimum of environmental and health hazards". In using the term "optimum" I had in mind reliability of high performance and not just maximisation under ideal conditions.

We can see in the UK and in isolated cases in Europe attempts to look at the crop as a whole, to work out "prescriptions" or, to use a practical term "package deals". This may well turn out to be the most important trend in the future of cereal weed control. The number of important variable factors involved, however, makes the problem of "complete programmes" exceedingly difficult. Such prescriptions could well ultimately be based on computerisation.

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ISOPROTURON - A BROAD-SPECTRUM APPROACH TO WEED CONTROL IN WINTER CEREALS

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Summary Isoproturon is a selective herbicide for the control of *Alopecurus myosuroides* in winter cereals. In field trials and commercial applications since its introduction in 1972, isoproturon gave up to 97% control of *A. myosuroides*. Application of 2.5 kg/ha a.i. pre- or post-emergence in autumn was generally more effective than a spring treatment with 2.1 kg/ha a.i. Applied in autumn or spring, isoproturon also controlled other annual grass weeds, including *Avena* spp. and many broad-leaved weeds. Higher yield increases, up to 56% compared to untreated crops, resulted from autumn/winter treatment compared to 32% following spring application. There has been an increase in the use of autumn-applied, broad-spectrum residual herbicides. These give effective, long-term control and the early removal of weed competition results in higher crop yields than from spring treatment. This trend is leading to the elimination of problems related to timing, identification of crop growth stages and varietal tolerance normally associated with the more specific spring-applied substituted urea and phenoxy-hormone herbicides.

Résumé L'isoproturon est un désherbant selectif pour contrôler les *Alopecurus myosuroides* sur les céréales d'hiver. Dans des essais pratiques et des applications commerciales depuis son introduction en 1972, l'isoproturon a donné un contrôle des *A. myosuroides* allant jusqu'à 97%. Une application de 2.5 kg/ha a.i. avant ou après la poussée d'automne s'avéra généralement plus efficace qu'un traitement au printemps avec 2.1 kg/ha a.i. Appliqué en automne ou au printemps, l'isoproturon contrôle également d'autres mauvaises herbes annuelles, dont l'*Avena* spp. et beaucoup de mauvaises herbes a feuilles larges. Un rendement accru, allant jusqu'à 56% par rapport aux récoltes non traitées suivait un traitement automne/hiver alors qu'une application au printemps ne donnait qu'une augmentation de 32%. Il y a eu une utilisation accrue des désherbants résiduels à spectre large appliqués en automne. Ceux-ci donnent un contrôle efficace a long terme et l'élimination précoce des mauvais herbes donne une récolts meilleure que celle suivant un traitement. Cette tendance conduit a une élimination des problèmes associés avec le temps, l'identification des étapes de croissance des récoltes et la tolérance des variétés normalement associee avec les désherbants plus particuliers appliqués au printemps avec urée et phénoxie-hormone de remplacement.

INTRODUCTION

Since the introduction of growth regulator type herbicides over 30 years ago there have been major changes in the weed flora of arable land (Fryer and Chancellor, 1970). The sensitive broad-leaved weeds were soon being replaced by more tolerant broad-leaved species which have, more recently, become superseded by a range of perennial and annual grass weeds. The important species in this latter group include Avena spp., Alopecurus myosuroides, Agropyron repens, Agrostis gigantea and Poa spp. This increase in the importance of, and area infested by, grass weeds has accompanied the general increase in more intensive cereal production in the United Kingdom.

Economically, one of the most important of the grass weeds is A. myosuroides. An early paper (Long, 1929) indicated the enormous potential of A. agrestis (= A. myosuroides to drastically affect the yield of winter cereals. Long was able to suggest only hand-hoeing as a means of control. More recent work (Thurston, 1972) has shown that A. myosuroides seriously decreases crop yields. With less than 10 plants/m^2 yields are unaffected, but losses of 13, 32 and 37% of a 5.54 t/ha weed-free crop have been recorded when infestations of 30, 100 and 300 plants/m^2, respectively, were present.

A. myosuroides may emerge following one of two germination peaks (Thurston, 1972), either in the autumn or spring. In winter cereals the more important peak is likely to occur in autumn, giving rise to an early competitive influence in these crops. However, a feature becoming increasingly important, due possibly to genetic, climatic or cultural factors, is the appearance of spring-germinating A. myosuroides in winter cereals, spring cereals and broad-leaf crops. (Elliot et al, 1977).

The mechanical methods for control of Alopecurus advocated by Long (1929) have since been replaced by chemical treatment. However, variations in the growth habit of this grass weed have created problems in the choice of herbicides and timing of their applications. Shorter persistence herbicides, such as terbutryne or metoxuron, applied in the autumn tended to miss spring-germinating weeds. Spring applied herbicides such as barban, controlling only seedling Alopecurus, were not effective enough to control well-tillered, autumn-germinated plants. These herbicides, together with cultural methods of control, involving spring cropping, late drilling of winter cereals and more regular rotational "breaks", have gradually been superseded by a more advanced type of herbicidal approach. The products involved are required to control A. myosuroides throughout a season from a single application made at any time from drilling through to the spring.

In 1969 L'Hermite et al first reported the development of such a herbicide and in 1970 Smith and Tyson described the U.K. trials with chlortoluron. Two years later, another herbicide, isoproturon, was described (Rognon et al, 1972; Thizy et al, 1972). The U.K. trial results with this product were reported in 1974 by Hewson.

Apart from controlling A. myosuroides both these products will control a range of other annual grass weeds and a wide spectrum of broad-leaved weeds from a single application made during the early part of the season.

This paper describes the experiences of Hoechst UK Limited with Arelon formulations of isoproturon produced by Hoechst A.G.

METHOD AND MATERIALS

Replicated field plot trials have been carried out since 1972 on farms throughout the East and South East of England. Applications were made to the full range of commercially-grown winter wheat barley varieties. The trials were sited in areas and on soils where A. myosuroides was considered to be a serious problem.

Isoproturon, (75% w.p. or 56% water dispersion), chlortoluron (80% w.p. or 50% water dispersion) and metoxuron (80% w.p.) were used. All applications were compared to an untreated control. Plots of 2 x 5m were arranged in a randomised block design with three replicates. All applications were made with a Van der Weij "AZO" sprayer at a pressure of 2.5 bar with fan jets delivering 300 l/ha.

Unreplicated variety trials, involving more than fifty varieties each year from 1972 to 1978 at six U.K. sites were carried out at double and normal recommended application rates. Applications were made at three times; pre-emergence, post-emergence in autumn/winter and post-emergence in spring.

Pre-emergence treatments were normally applied within seven days of drilling. Winter post-emergence spraying was carried out at the 1-3 leaf stage of crop and A. myosuroides and spring post-emergence treatment when crop and weeds had 3 leaves to 2-3 tillers. Broad-leaved weeds were generally treated up to the young-plant stage.

Counts of A. myosuroides seed heads were made in June, and of Avena spp. panicles in July; crop yields, were assessed by a plot combine harvester.

RESULTS

Control of A. myosuroides

The mean results from each trials series for each year (year indicates harvest date for the series) are in Table 1. The average control over the period 1973/78 from pre-emergence treatment was 92%, from early post-emergence 95% and from spring applications 86%.

Table 1

Control of A. myosuroides

% reduction in number of seed heads from pre- and post-emergence applications

Timing	Chemicals	kg/ha a.i.	1972	1973	1974	1975	1976	1977	1978
Pre-emergence	Isoproturon	2.5	-	95	96	88	96	85	94
	Chlortoluron	2.5	-	96	96	81	94	-	-
Early-post-emergence (winter)	Isoproturon	2.5	-	-	97	95	91	96	97
	Chlortoluron	2.5	-	-	94	93	52	-	-
Post-emergence (spring)	Isoproturon	2.1	93	94	91	94	62	92	76
	Chlortoluron	2.1	85	89	78	-	-	-	-
	Metoxuron	4.4	-	84	85	-	-	-	-
Number of trials			7	19	10	9	8	32	25

Control of Avena spp. and other weeds

The mean results for each year for control of Avena spp. are given in Table 2.

Table 2

Control of Avena spp.

% reduction in number of panicles

Timing	Chemicals	kg/ha a.i.	1973	1974	1975	1976	1977	1978
Pre-emergence	Isoproturon	2.5	73	85	49	80	74	91
	Chlortoluron	2.5	79	78	22	85	-	-
Early-post-emergence (winter)	Isoproturon	2.5	-	81	-	89	96	80
	Chlortoluron	2.5	-	75	-	84	-	-
Post-emergence (spring)	Isoproturon	2.1	82	68	-	52	85	65
	Chlortoluron	2.1	69	59	-	-	-	-
	Metoxuron	4.4	70	67	-	-	-	-
Number of trials			10	5	2	4	3	15

The average control of Avena spp. for the year 1974 and 1976/78 for pre-emergence, early post-emergence and spring applicatons was 83, 87 and 68% respectively. Apart from controlling Avena spp. when applied pre- or post-emergence in winter and post-emergence in spring, isoproturon also gave good control of Lolium spp., Poa annua, P. trivialis and Apera spica-venti. Full details of the susceptability of these grass weeds and of broad-leaved weeds are included in early papers (Thizy et al, 1974 Rognon et al, 1972 and Hewson, 1974). Only Galium aparine, Veronica spp. and pernnial broad-leaved weeds have shown consistent tolerance to isoproturon.

Crop Yield

Crop yield data was obtained from many trials and is summarised in Table 3. Of the four years 1973 and 1976-78, average yields were 140, 127 and 122% respectively for pre-emergence, early post-emergence and spring applications.

Varietal Tolerance

No crop damage was observed in any year with double the commercial rates of application pre- or post-emergence on any variety.

DISCUSSION

Effective control of A. myosuroides was achieved throughout a seven year period using isoproturon, applied either pre- or post-emergence in the autumn or post-emergence in the spring. On average, better weed control and greater yield increases resulted from the earlier treatments (Tables 1, 2, and 3). Other workers have found the same trend towards higher yields from earlier applications even though, in some cases, levels of weed control from winter and spring applications were almost identical. (North and Livingston, 1970; Baldwin and Livingston, 1972; Hubbard and Livingston, 1974 and Holroyd, 1977). At the same time the highest yield increases came from trials with the highest density of A. myosuroides on the untreated control plots.

Table 3

Crop yields

Expressed as a % of the untreated control

Timing	Chemicals	kg/ha a.i.	1972	1973	1974	1976	1977	1978
Pre-emergence	Isoproturon	2.5	144	156	-	131	136	137
	Chlortoluron	2.5	148	138	-	-	-	-
Early-post-emergence (winter)	Isoproturon	2.5	-	144	-	116	115	133
	Chlortoluron	2.5	-	122	-	-	-	-
Post-emergence (spring)	Isoproturon	2.1	-	131	132	109	114	135
	Chlortoluron	2.1	-	129	128	-	-	-
	Metoxuron	4.4	-	121	-	-	-	-
Number of trials			11	13	8	5	6	15

Applications made under adverse weather conditions, during periods of prolonged rainfall or drought, resulted in variable levels of control of A. myosuroides and Avena spp. with both isoproturon and the other materials. For example, common to other residual herbicides, application of isoproturon made during the dry spring of 1976 resulted in lower levels of weed control than in other seasons.

In addition to control of Avena spp. and A. myosuroides, with autumn or spring applications, a range of other annual grass weeds was controlled. Applications made pre- or post-emergence, at the rates giving control of Avena spp. and A. myosuroides also gave control of Lolium spp. P. annua, P. trivialis and Apera spica-venti (Rognon et al, 1972; Thizy et al, 1972 and Hewson, 1974).

Autumn or spring applications of isoproturon gave control of a wide range of broad-leaved weeds at those rates used for control of grass weeds (Rognon et al, 1972 and Thizy et al, 1972), with many species showing greater susceptibility from early post-emergence application, than from pre-emergence (Hewson, 1974).

The properties previously described, of a herbicide which controls A. myosuroides, Avena spp. a number of other annual grass weeds and a wide range of broad-leaf weeds have contributed to a developing trend in cereal weed control entailing an early-season approach and consequent greater yield increases. Using a single broad-spectrum herbicide with a wide application period has reduced the more traditional requirement for sequential applications of specific herbicides with short periods of use. The low number of ideal spraying days, especially in spring, has greatly reduced the possibilities of using many such herbicides correctly. It has been shown that there are normally only 10-14 "safe" days in the development of cereals when growth-regulator-type herbicides may be applied (Holroyd, 1977) without crop effect. Should a specific herbicide for Avena spp. control be required at the same time, the resulting complications could be either loss of effective control due to compatibility or even possible reduction in crop yield due to incorrect timing of application.

In response to changes in weed flora and in agricultural practices, including minimal cultivation techniques, there has developed a new outlook to cereal herbicide usage. Control of a broad-spectrum of weeds from a single application of a product has derived from using isoproturon as described. Flexible timing autumn or spring, irrespective of crop growth stage, to suit prevailing conditions has further contributed to the trend away from "short term" specific products. The tolerance of all commercially grown varieties of winter cereals to isoproturon has allowed the same approach to weed control to be adopted throughout even the most intensive cereal programme where A. mysouroides, other annual grass weeds and broad-leaved weeds are endemic.

Further developments with isoproturon have included applications at low volumes of 20 - 110 l/ha, using either modified conventional sprayers or controlled-droplet applicators. (Anon, 1978). Also, in trials, mixtures of isoproturon with other herbicides, including ioxynil/bromoxynil and mecoprop, have given wider spectrum broad-leaf weed control and mixtures with reduced rates of diclofop-methyl gave improved control of Avena spp. This work is continuing.

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THE USE OF HERBICIDES IN HARDY ORNAMENTAL CROPS

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Summary Some of the problems encountered when using herbicides in the hardy nurserystock industry are outlined and the current situation with container-grown plants is reviewed.
In trials on field-grown crops simazine 0.55 kg/ha plus propyzamide 0.42 or 0.84 kg/ha followed by 'topping-up' on two occasions with simazine 0.55 kg/ha has been successful on young, lined out plants, some of which are normally regarded as being simazine sensitive. Propachlor 4.35 kg/ha plus propyzamide 0.42 kg/ha followed by two further applications of propachlor was also a satisfactory treatment. Black light-degradeable polythene was effective as a weed control measure until mid-July.

INTRODUCTION

Hardy ornamentals crops are grown mainly under field conditions although in recent years, there has been a swing towards container production and approaching forty million hardy ornamental plants are potted annually into containers. The compost used has a high organic content and is irrigated frequently. In addition, the range of plants is very extensive and they are frequently of high value. The total area involved is tiny compared with other crops so the nurseryman does not receive the attention given to other sectors of the agricultural industry.

In England and Wales hardy ornamental nurserystock occupies about 5128 ha with a wholesale value of around £47 million sales annually. It is appreciated that serious damage cannot be risked by grower or manufacturer but the nurseryman is prepared to accept a slight check or temporary herbicide phytotoxicity symptoms as they can be offset by reductions in the labour bill or fewer adverse effects from weed competition.

There are comparatively few herbicides in the Approved Products Book for use on nurserystock, particularly on unestablished plants. Such materials must obviously have priority in advisory work. Label recommendations are valuable and label suggestions would be of further use. It is realised that there could well be legal problems here and I am sure the difficulties have been discussed frequently, but a satisfactory solution is needed.

In order to gain experience of herbicide usage under various conditions, it is essential to encourage growers to run observation studies themselves. A limited number of trials are carried out by ADAS and other bodies and by collecting data it is hoped to persuade manufacturers and distributors to consider label suggestions if not recommendations.

Container-grown Crops

The most troublesome weeds are usually those with efficient methods of seed or fruit distribution such as Hairy Bitter Cress (Cardamine hirsuta) Willow Herb (Epilobium spp) Groundsel (Senecio vulgaris) Willow (Salix spp) Liverwort (Marchantia spp) and Annual Meadow Grass (Poa annua).

There are three main problem areas, the compost in which the plants grow, the material on which the containers stand and the area surrounding the standing-out ground. The latter is the most difficult over which to exercise control as it frequently does not belong to the nursery and yet provides a source of wind-blown weed fruits.

Sand on which the container stand is often treated with paraquat between crops to eradicate weed seedlings. Trials at Efford EHS have not produced damage when containers were placed on the treated sand but where glyphosate had been used, conifers picked up the material and were damaged.

At present, the two most widely used materials to prevent weed growth in the compost are chloroxuron and simazine.

Chloroxuron 2.2 kg/ha is normally washed off immediately after application to avoid foliar damage and needs to be renewed every five or six weeks. Some growers apply the spray to wet foliage to reduce the risk. It has the advantage over simazine of controlling Liverwort (Marchantia spp) but grass seedlings can prove troublesome and work is in progress to find a suitable additional herbicide.

Simazine 1.1 kg/ha does not need washing off the foliage and lasts about nine weeks but there are over sixty different plants that have been sensitive to simazine on some occasions.

The volume of water used to apply these herbicides varies according to method of application but by knapsack sprayer as much as 3000 litres/ha are used to achieve even distribution. An attempt to find out how little water was necessary to wash off chloroxuron effectively was inconclusive in 1977 as no damage occurred at the lowest rate of 2250 litres/ha.

Protective discs placed around the plant stem over the compost surface to prevent the introduction of weed seeds has not proved practical in commerce where plastic film was used. Other materials may be more successful.

Herbicide granules have been used successfully in trials but in the nursery there are practical difficulties in applying the correct rate to the various size containers used, particularly the small ones.

Low rates of herbicide application in automatically measured doses in the production lime at completion of potting is worth investigation. Coated granules might be of use to delay release until new roots are established.

Field-grown Crops

The average nurseryman crops his land intensively. Due to the limited area there is little or no opportunity to eradicate perennial weeds prior to planting and some of the crops occupy the land for up to five years. Sometimes land is rented for nurserystock production and under these circumstances the residual properties of the herbicides must be considered so that the land is returned to the farmer in a condition that is safe for his grass or arable crops.

Glyphosate is being used increasingly during preparation of land prior to planting, particularly where couch grass is a problem. If perennial weeds are present at planting time and increase during the cropping period, propyzamide is sometimes used after crop establishment, during the early winter. Many nurserymen are prepared to experiment, particularly if in need of a crash-programme to resolve a particular problem that has arisen and welcome guidance. It is a counsel of perfection to advise planting only in clean land: few can follow it.

Against annual weeds, simazine and atrazine are widely used in rose production. With other nurserystock simazine is most popular but there are problems with sensitive plants, particularly at the lining-out stage. Here young plants, sometimes with an almost bare root system are planted out in beds or rows. Irrigation is often used to aid establishment and a new root system has to be developed quickly, in an area very close to a herbicide-treated zone of soil.

In ADAS a range of herbicides is being used to try to find reasonably safe treatments at Luddington EHS and at Shardlow, East Midlands Regional Headquarters. The nurserystock industry is also keen to improve the situation and co-operate readily to provide opportunities for experiments to be conducted under commercial situations.

Various possibilities have been explored by ADAS in recent trials at a nursery in Frilford, Oxon. The trials have been carried out by B. J. W. Morgan, SE Region Nurserystock Specialist and the Oxford Division ADAS Horticultural Staff.

METHODS AND MATERIALS

The soil type was a sandy loam. The first herbicide application was to a moist soil surface. At the time of the second application, the soil surface was dry, but the trials area was irrigated soon afterwards.

The subjects were planted on 28 March. There were four replicates. The herbicides were mixed and applied with an Oxford Precision Sprayer at a rate of 673 litres/ha. Dr J. Davison, Weed Research Organisation had previously shown improved plant growth where a black polythene film was used as a soil mulch. In this trial, a black light-degradeable polythene film was used so that it would not interfere with harvesting.

One plot was left unweeded to allow the complete spectrum of weeds to be recorded.

The nursery crop consisted of bare root liners of Cornus alba 'Sibirica', Cornus sanguinea, Sorbus aucuparia, Tilia cordata and Viburnum lantana.

Table 1

Treatments and Timing

	1st Application 4 April	2nd Application 1 June	3rd Application 27 July
1.	Light-degradeable polythene	-	-
2.	Simazine 0.55 kg/ha plus 0.42 kg/ha propyzamide	Simazine 0.55 kg/ha	Simazine 0.55 kg/ha
3.	Simazine 0.55 kg/ha plus 0.84 kg/ha propyzamide	Simazine 0.55 kg/ha	Simazine 0.55 kg/ha
4.	Control: hand hoed	Hand hoed 5 June	Hand hoed 20 July
5.	Propachlor 4.35 kg/ha plus propyzamide 0.42 kg/ha	Propachlor 4.35 kg/ha	Propachlor 4.35 kg/ha

RESULTS

Table 2

Numbers of weed seedlings per 3 m^2: 5 June

	Treatment 2 S 0.55+P 0.42	3 S 0.55+P 0.84	4 Control	5 P 4.35
Aethusa cynapium	33	55	140	48
Anagallis arvensis		1	10	
Atriplex patula			4	
Capsella bursa-pastoris			5	
Cerastium holosteoides		4	5	
Chenopodium album	1		6	
Lamium amplexicaule		2	5	
Matricaria spp			15	
Plantago major			10	
Poa annua			25	
Polygonum aviculare	2	1	9	2
Polygonum convolvulus			12	1
Rumex acetosa			4	
Senecio vulgaris			1	
Silene spp			7	
Solanum nigrum		1	4	
Spergula arvensis			25	
Stellaria media	1		16	
Trifolium spp	1		19	2
Urtica urens		1	3	
Veronica spp			2	
Vicia spp	1		12	1
Viola arvensis	7	6	28	10

The most common weed was *Aethusa cynapium* (Fool's Parsley). Whilst the herbicides reduced the number of seedlings, the weed remained a problem and weeds were removed by cutting at ground level to prevent disturbing soil.

The two subsequent applications of simazine, each at a rate of 0.55 kg/ha gave adequate control.

The light-degradeable polythene mulch gave adequate weed control. By mid-July degradation was fairly advanced and bare patches of soil were evident.

Towards the end of June a crop assessment was made and some restriction in growth was recorded on the herbicide treated plots compared with the mulched or hand hoed areas. A month later the differences were far less marked and by September the plants on the herbicide treated plots were highly acceptable commercially.

DISCUSSION

The black, light-degradeable polythene was very successful in controlling weeds until mid-season. By this time, the crop was well established and herbicide application would be less likely to cause damage. At the end of September, there was little polythene to be seen and it could cause no problems at the harvest time.

For the purpose of this trial holes were punched through the polythene film to allow the liners to be planted. Even then, the plant roots had to be severely trimmed. In site of this, the crops ultimately grew well.

All the herbicide treatments were effective and the comparatively low rates of simazine employed were acceptable, even to plants normally regarded as sensitive to this herbicide.

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WEED CONTROL IN BULBS ON PEAT AND MINERAL SOILS

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Summary Following a pre-emergence application of paraquat, good weed control was obtained in Narcissi and tulips on mineral soil by one application of a suitable residual herbicide made at early post-emergence; pre-emergence application gave relatively poor weed control. The most effective and selective herbicides on both Narcissi and tulips were lenacil 2.2 kg/ha, pyrazone 1.4 kg + chlorbufam 1.1 kg, and chlorpropham 2.2 kg plus diuron 0.9 kg. In addition, for Narcissi only, linuron 0.8 kg plus lenacil 0.9 kg, linuron 1.1 kg plus chlorpropham 2.2 kg, prometryne 1.1 kg, and propyzamide 1.7 kg were satisfactory.

On peat soil, in addition to the pre-emergence application of paraquat, two applications of residual herbicides were necessary for season-long weed control. Propachlor at 5.7 kg/ha + chlorpropham 3.3 kg, or simazine 2.2 kg applied at either pre-emergence or early post-emergence followed by a post-flowering application gave long-lasting control. Chlorpropham 3.3 kg substituted for the post-flowering application gave less crop damage with little loss in weed control.

INTRODUCTION

In Ireland, interest in bulb production on peatland has prompted experiments comparing production on peat and mineral soil. Arising from these experiments, effective weed control programmes were sought for each medium.

There is considerable information on chemical weed control in bulbs on mineral soil especially from the research at Kirton and Rosewarne Experimental Horticulture Stations. As summarised by Moore (1975) the normal programme is to apply a contact herbicide, usually paraquat, well before emergence and then a residual pre-emergence herbicide. This is occasionally followed by a residual herbicide applied early post-emergence and more rarely by an application at the post-flowering stage. The residual herbicides usually recommended are chlorpropham + diuron, chlorpropham + linuron, linuron + lenacil, pyrazone + chlorbufam, and lenacil.

For bulbs grown on highly organic peat soil there is little information on weed control. Few of the herbicides listed above are sufficiently long-lasting in peat.

METHOD AND MATERIALS

Trials were done on Narcissi and tulips grown on medium loam soil at Kinsealy and on fen peat (ca. 95% organic matter) at Lullymore in 1975/76 and 1976/77. A randomized block design with four replications was used in all trials. Individual plots were 3.6 m x 1.5 m consisting of two ridges each 75 cm wide with a 20 cm band of bulbs planted in each.

The herbicides tested were as follows:

chlorpropham	40% e.c.;	chlorpropham	40% e.c. + diuron 80% w.p.;
lenacil	80% w.p.;	chlorpropham	40% e.c. + linuron 50% w.p.;
simazine	50% w.p.;	linuron	50% w.p. + lenacil 80% w.p.;
metoxuron	80% w.p.;	linuron	50% w.p. + prometryne 50% w.p.;
metribuzin	70% w.p.;	propachlor	65% w.p. + chlorpropham 40% e.c.;
prometryne	50% w.p.;	pyrazone	25% + chlorbufam 20%, w.p.;
propyzamide	50% w.p.;		

Herbicides were applied with a pressure-retaining knapsack sprayer in a volume of 450 l/ha of water. Paraquat at 0.6 kg/ha was applied in all trials 2 - 3 weeks before crop emergence. Pre-emergence applications of residual herbicides were made 3 - 7 days before emergence, early post-emergence when tulips were at the furled leaf stage and Narcissi 5 - 10 cm high, and post flowering 2 - 3 weeks after completion of flowering in Narcissi and immediately after flowering in tulips. All dose rates refer to active ingredient.

Assessments of weed density and crop growth were made at least twice during the growing season using linear scales 0 - 10. Weed density was also recorded by counts from whole plots.

In 1975/76, Narcissi cv. Carlton (140 13/15 cm bulbs/plot) were planted mid-September and tulips cv. Apeldoorn (300 8/10 cm bulbs/plot) early October, and crops emerged late December - early January. In 1976/77, Narcissi cv. Golden Harvest (100 15/17 cm bulbs/plot) were planted late October and tulips cv. Rose Copland (240 10/11 cm bulbs/plot) early November, and emergence occurred during the second half of January.

From all treatments where good weed control was obtained with no obvious crop damage, at least 50 daughter bulbs were planted outdoors the following season, and observations were made on foliage and flowering.

RESULTS

Kinsealy 1975/76

The results of single applications of residual herbicides, pre-emergence and early post-emergence, on mineral soil are shown in Table 1. All the herbicides except metribuzin showed good selectivity on both Narcissi and tulips. The main weed species were Fumaria officinalis, Senecio vulgaris, Stellaria media, Polygonum aviculare and Veronica spp. In general, good weed control was obtained with early post-emergence applications but not with pre-emergence applications. In addition to metribuzin, satisfactory weed control was obtained with pyrazone 1.4 kg/ha + chlorbufam 1.1 kg on both Narcissi and tulips, and with linuron 0.8 kg + lenacil 0.9 kg on Narcissi. Pyrazone + chlorbufam gave almost complete control of all weed species present except Stellaria media and Fumaria officinalis which were 90% controlled. Linuron +

lenacil controlled all but Polygonum aviculare and Senecio vulgaris which were controlled 90% and 80% respectively.

Table 1

Effects of single herbicide applications, Kinsealy 1975/76

Herbicide	Dose (kg/ha)	Narcissi Assessment* 2/6 Crop	Narcissi Assessment* 2/6 Weeds	Narcissi Yield (kg/plot)	Tulips Assessment 1/6 Crop	Tulips Assessment 1/6 Weeds	Tulips Yield (kg/plot)
Pre-emergence							
Metribuzin	0.6	9.3	6.9	16.3	8.8	7.2	8.8
Linuron + lenacil	0.8 0.9	10.0	7.3	16.0	9.7	6.2	7.5
Lenacil	2.2	10.0	6.6	17.2	10.0	6.9	9.7
Pyrazone/chlorbufam	2.5	10.0	6.3	16.9	10.0	5.7	9.0
Linuron + chlorpropham	1.1 2.2	10.0	5.8	16.7	10.0	5.0	8.5
Propyzamide	1.7	10.0	5.2	17.0	10.0	5.6	8.9
Post-emergence							
Metribuzin	0.6	8.1	9.3	15.6	6.2	9.6	7.1
Linuron + lenacil	0.8 0.9	9.4	8.4	16.4	-	-	-
Pyrazone/chlorbufam	2.5	10.0	8.5	17.8	9.6	8.9	8.3
Linuron + chlorpropham	1.1 2.2	9.0	7.8	17.3	-	-	-
Propyzamide	1.7	10.0	7.9	16.9	9.3	7.3	7.6
Control	-	10.0	3.3	17.5	10.0	3.8	9.4
LSD (P = 0.05)				3.1			2.4

*scales: (Crop: 0 (complete kill - 10 (no damage)
(Weeds: 0 (dense cover) - 10 (no weeds)

Kinsealy 1976/77

The results of single herbicide applications made at early post-emergence only are shown in Table 2. The predominant weeds were Senecio vulgaris, Stellaria media, Polygonum aviculare, Ranunculus repens and Fumaria officinalis. On Narcissi, only metribuzin caused crop damage, and none of the treatments affected yield. In addition to metribuzin, satisfactory weed control until harvest was obtained with lenacil 2.2 kg/ha, chlorpropham 2.2 kg + diuron 0.9 kg, prometryne 1.1 kg, and propyzamide 1.7 kg. On tulips, metribuzin and treatments containing linuron or prometryne caused crop damage and reductions in yield. Of the non-injurious treatments, long-lasting weed control was obtained with lenacil 2.2 kg, pyrazone 1.4 kg + chlorbufam 1.1 kg, and chlorpropham 2.2 kg + diuron 0.9 kg.

Considering both crops together, both lenacil and propyzamide eliminated almost all weeds except Senecio vulgaris and Stellaria media which were 80 - 90% controlled. Chlorpropham

+ diuron controlled all but Senecio vulgaris and Fumaria officinalis which were controlled 95% and 80% respectively, pyrazone + chlorbufam all but Fumaria officinalis - 90% controlled, and prometryne all but Ranunculus repens and Senecio vulgaris which were controlled 85% and 80% respectively.

Table 2

Effects of single early post-emergence herbicide applications, Kinsealy 1976/77

Herbicide	Dose (kg/ha)	Narcissi Assessments* 31/5 Crop	Narcissi Assessments* 31/5 Weeds	Narcissi Yield (kg/plot)	Tulips Assessments 1/6 Crop	Tulips Assessments 1/6 Weeds	Tulips Yield (kg/plot)
Lenacil	2.2	10.0	9.3	20.6	9.0	9.0	11.5
Metribuzin	0.6	7.7	9.3	19.6	5.3	9.0	9.9
Linuron + chlorpropham	1.1 2.2	9.0	9.0	18.4	5.3	9.0	8.9
Chlorpropham + diuron	2.2 0.9	9.3	9.3	18.6	8.3	8.5	10.6
Pyrazone + chlorbufam	1.4 1.1	10.0	8.7	19.9	9.5	8.9	12.9
Prometryne	1.1	10.0	9.3	20.0	7.3	7.8	9.6
Linuron + lenacil	0.8 0.9	10.0	8.7	18.3	6.5	8.3	9.1
Linuron + prometryne	0.6 0.6	9.0	7.7	19.7	6.3	8.8	8.6
Propyzamide	1.7	10.0	9.3	22.2	8.3	6.8	11.0
Chlorpropham	3.3	10.0	8.0	21.1	9.5	8.0	13.9
Control	-	10.0	6.3	21.7	10.0	4.0	13.1
LSD (P = 0.05)				5.8			3.3

*scales: Crops: 0 (complete kill) - 10 (no damage)
Weeds: 0 (dense cover) - 10 (no weeds)

Lullymore, 1975/76

The single herbicide applications showed good crop selectivity on both Narcissi and tulips (Table 3). All treated plots were essentially weed-free until mid-April. Early post-emergence applications gave longer-lasting weed control than pre-emergence applications. Propachlor + chlorpropham, and simazine were superior to the other herbicides. By mid-June all plots were heavily infested and hand-weeding was necessary.

Lullymore, 1976/77

All treatments, consisting of two herbicide applications, gave acceptable weed control until bulbs were harvested (Tables 4 and 5). In Narcissi all treatments showed good crop selectivity and none affected yield (Table 4). Propachlor 5.7 kg/ha + chlorpropham 3.3 kg applied pre-emergence and post flowering gave best results, with 100% control of Stellaria media and 99% of Poa annua.

Table 3

Effects of single herbicide applications, Lullymore, 1975/76

		Narcissi			Tulips		
	Dose	Assessments* 25/5		Yield	Assessments 25/5		Yield
Herbicide	(kg/ha)	Crop	Weeds	(kg/plot)	Crop	Weeds	(kg/plot)
Pre-emergence							
Propyzamide	2.2	10	6.7	21.2	10	8.0	14.3
Metoxuron	4.4	10	5.7	18.3	10	6.0	14.2
Chlorpropham	3.3	10	7.3	20.4	10	8.0	15.2
Simazine	3.3	10	8.7	19.5	10	8.3	14.5
Propachlor + chlorpropham	5.7 2.2	10	8.3	19.9	10	9.0	16.1
Early post-emergence							
Propyzamide	2.2	10	8.3	19.6	10	8.7	12.5
Metoxuron	4.4	10	6.3	20.9	10	8.3	14.8
Chlorpropham	3.3	-	-	-	10	9.0	14.0
Simazine	3.3	-	-	-	10	9.3	13.7
Control	-	10	4.0	22.3	10	4.3	15.6
LSD (P = 0.05)				5.3			4.4

* scales: Crop: 0 (complete kill) - 10 (no damage)
Weeds: 0 (dense cover) - 10 (no weeds)

In tulips, propyzamide 2.2 kg applied at early post-emergence caused severe crop damage and substantial reductions in yield (Table 5). The most selective two treatments were simazine 3.3 kg, and propachlor 3.7 kg + chlorpropham 3.3 kg, applied early post-emergence and followed by chlorpropham 3.3 kg alone post-flowering. All other treatments caused at least slight crop damage. Simazine applied early post-emergence and post-flowering gave 100% control of *Senecio vulgaris*, 90% of *Stellaria media* and 40% of *Poa annua*. Propachlor + chlorpropham at early post-emergence followed by chlorpropham post-flowering gave 97% control of *Stellaria media*, 53% of *Senecio vulgaris* and 41% of *Poa annua*.

Where daughter bulbs from promising herbicide treatments were planted the following season, no deleterious effects were seen on foliage growth or on flowering.

DISCUSSION

Results on mineral soil suggest that season-long weed control in Narcissi and tulips may be obtained by a single application of residual herbicide. This seems most likely to be achieved by an early post-emergence application of herbicides such as lenacil, pyrazone + chlorbufam, and chlorpropham + diuron, suitable for both Narcissi and tulips. In addition, linuron + lenacil, linuron + chlorpropham, prometryne, and propyzamide are satisfactory for Narcissi. Pre-emergence applications made in December or early January on weed-free soil and long before conditions become favourable for weed growth appear to be largely wasted.

Table 4

Effects of two herbicide applications on Narcissi, Lullymore, 1976/77

Herbicide	Dose (kg/ha)	Assessments* 19/5 Crop	Weeds	% Weed kill 7/6 Sm	Pa	Yield (kg/plot)
Pre-emergence + post-flowering						
Simazine	2.2	10	7.7	90	83	21.3
Propyzamide	2.2	10	8.7	99	98	22.3
Propachlor + chlorpropham	5.7 3.3	10	9.7	100	99	21.5
Early post-emergence + post-flowering						
Simazine	2.2	10	7.7	87	88	22.1
Propyzamide	2.2	10	7.3	91	93	21.1
Propachlor + chlorpropham	5.7 3.3	10	8.3	99	95	21.7
Early post-emergence followed by chlorpropham 3.3 kg post-flowering						
Simazine	2.2	10	6.7	96	68	21.5
Propyzamide	2.2	10	8.0	98	97	20.8
Control	-	10	4.0	0	0	21.1
LSD (P = 0.05)						2.8

* scales: Crop: 0 (complete kill) - 10 (no damage)
Weeds: 0 (dense cover) - 10 (no weeds)

Sm - *Stellaria media*; Pa - *Poa annua*

The results on peat soils indicate that two applications of residual herbicides are necessary in order to obtain weed control up to harvest. Moreover, a post-flowering application appears to be essential. This is probably due to two factors. Firstly, since herbicides are relatively short-lasting in peat, a late topping-up is essential. Secondly, a high level of herbicidal activity is necessary to combat the enormous rate of weed growth in peat from mid-May to mid-July. A satisfactory programme could consist of propachlor + chlorpropham, or simazine, applied pre-emergence or early post-emergence and followed by chlorpropham alone post-flowering.

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References

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Table 5

Effects of two herbicide applications on tulips, Lullymore 1976/77

Herbicide	Dose (kg/ha)	Assessments* 19/5 Crop	Weeds	% Weed kill 7/6 Sm	Pa	Sv	Yield (kg/plot)
Pre-emergence + post-flowering							
Simazine	2.2	8.7	8.0	81	35	79	11.0
Propyzamide	2.2	8.3	7.7	91	65	16	11.1
Propachlor + chlorpropham	5.7 3.3	7.0	8.7	93	88	5	11.4
Early post-emergence + post-flowering							
Simazine	2.2	8.7	9.0	90	41	100	10.9
Propyzamide	2.2	3.3	7.3	58	100	0	6.1
Propachlor + chlorpropham	5.7 3.3	7.7	10.0	99	6	21	11.0
Early post-emergence followed by chlorpropham 3.3 kg post-flowering							
Simazine	2.2	9.7	7.3	86	0	0	12.9
Propyzamide	2.2	4.3	8.0	94	76	0	7.5
Propachlor + chlorpropham	5.7 3.3	9.7	8.3	97	41	53	11.1
Control	-	9.3	3.0	0	0	0	13.9
LSD (P = 0.05)							3.2

* scales: Crop: 0 (complete kill) - 10 (no damage)
Weeds: 0 (dense cover) - 10 (no weeds)

Sm - *Stellaria media*; Pa - *Poa annua*; Sv - *Senecio vulgaris*