SESSION 6A

BROAD-LEAVED WEED PROBLEMS IN CEREALS

BROAD-LEAVED WEED CONTROL IN CEREALS: PROGRESS AND PROBLEMS - A REVIEW

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INTRODUCTION

The conference of the Association of Applied Biologists, March 1982 on broad-leaved weeds in cereals was set in context by Hubbard (1982) that defined the object of cereal husbandry - that of maximising yield - and put the control of weeds secondary to this objective. Yield was described as an interaction of variety, nutrition, pathology and husbandry. The latter is attributed a higher place in the achievement of high yields elsewhere (Murphy, 1981). Whilst Hubbard was concerned to show that herbicide use is mainly an insurance against yield loss the attainment of successful weed control is not always so easy as the exercise looks on paper.

The problems posed by broad-leaved weeds cannot be isolated from the other weeds on a farm, nor the need for other crop protection measures. Whilst it is feasible to reduce broad-leaved weed populations in the soil (Cussans, 1976) other factors may continually work to increase weed populations. The continuing increase of cereal acreages must continually favour suitable environments for their survival. If the trend continues, all cereal pests will be increased.

Table 1

The change in cereal crops in the period 1972-1982

Year	Crop - 000's ha			
	Wheat	Barley	-winter	-spring
1972	1094	1905		
1978	1236	1866		
1979	1347	1855	572	1283
1980	1415	1835	723	1112
1981	1462	1844	799	1045
1982	1664	2221	960	1261

Since cereal growing now amounts to mono-culture on many farms the effects on the weed flora will reflect this in showing a decline of weeds common to pasture and mixed rotations and an increase in weeds suited to cereals (Chancellor, 1976). This is important when one also takes into consideration the effects of minimum and nil tillage, the earlier drilling dates of winter cereals and the progressive decline in spring cereal drilling.

The weed flora and its biology

There has been little research on broad-leaved weeds in cereals. There are a few isolated surveys of broad-leaved weeds (Fisons, 1972; Carnegie, 1974; Scragg, 1974; Chancellor, 1976; Harvey, 1980; Roberts, 1982) all of which give little information on changes due either to control methods or husbandry. How this deficiency can be overcome is difficult to foresee in the present economic climate. One source of information might be from weed seed impurities in seed tested at the official seed testing stations (Tonkin, 1982). Although little is to be found on the biology of broad-leaved weeds in cereals there is more biological data on individual weeds in papers on weed seed dormancy and survival (Chancellor, 1976; Roberts, 1982). Where individual weeds have been considered it is very often in relation to their control (Smith, 1982) rather than their biology.

The problems posed by broad-leaved weeds are due to their ability to survive control measures or their resistance to herbicides. If a weed species is resistant to most herbicides and is also favoured by a change in husbandry then it can quickly increase to very serious proportions. This has occurred in winter cereals where the need to control Alopecurus myosuroides (black-grass) led to the sole use of substituted ureas. The result has been that hitherto unfamiliar weeds have become serious pests. Lithospermum arvense (field gromwell), Veronica persica (common field speedwell), Lamium purpureum (red dead-nettle), Viola arvensis (field pansy) and Galium aparine (cleavers) are all weeds associated with such treatments. Susceptible weeds able to survive control measures are those that can germinate in almost all conditions and set seed in the shortest time. The conditions for germination of these species is adequate moisture and a low minimum germination temperature (Roberts, 1982). Stellaria media (common chickweed) is one such species and as a result is the commonest occurring broad-leaved weed in cereals and almost any other annual crop. Such a species is therefore able to take any advantage that may occur following a break-down in control due to climate, spray timing and crop management.

The broad-leaved weed flora in cereals is a reflection of weed biology factors plus crop husbandry which in turn are influenced by climate and soil conditions (Scragg, 1980). The effect of cropping on the weed flora is shown in tables given in the Fisons communication (Fisons, 1972) which was compiled before the current swing to autumn sown cereals and when spring barley in arable rotations was seldom exceeded in acreage by winter wheat (table 2).

Table 2

Weed species recorded separately in spring and winter sown cereals

	Source					
	(a) ADAS Devon and Cornwall		(b) FISONS SURVEY			
	1980		1967		1972	
	Spring	Winter	Spring	Winter	Spring	Winter
Chenopodium album	7		43	18	50	13
Fumaria officinalis	2	1	25	15	20	12
Galium aparine			35	49	22	52
Galeopsis spp.	1		23	12	28	9
Matricaria spp.	2		38	52	44	53
Polygonum aviculare	5		73	46	69	42
Polygonum convolvulus	3		66	28	64	25
Polygonum persicaria	3		45	15	50	19
Rumex spp.	2	1	28	30	14	12
Sinapis arvensis	4	2	69	39	58	33
Stellaria media	8	9	83	77	87	89
Viola arvensis	1	1	7	7	13	14
Veronica spp.	3	5	40	52	33	55

(a) Number of sites
(b) Percentage area infested

The ADAS data referred to in table 2 (Harvey, 1980) and that showing weed distribution (Roberts, 1982) indicate that there have been no major changes since 1972 in weed distribution and that geographical effects are still apparent (table 3).

Table 3

The regional distribution of broad-leaved weeds in the United Kingdom

	% of total hectarage infested	North	South	East	West
Capsella bursa-pastoris	5	XX	XX	XX	XX
Galeopsis spp.	5	XXX	X	XX	X
Galium aparine	16	X	XX	XXX	X
Lamium spp.	5	XX	XX	XX	XXX
Matricaria spp.	18	XX	XX	XXX	XX
Polygonum aviculare	8	XX	XXX	XXX	XX
Polygonum convolvulus	6	XX	XXX	XXX	XX
Polygonum lapathifolium and P. persicaria	10	XX	XXX	XXX	XX
Sinapis arvensis	9	XX	XXX	XX	XX
Stellaria media	33	XXX	XXX	XXX	XXX
Urtica urens	6	X	X	XX	X
Veronica spp.	5	X	XX	XXX	XX
Viola arvensis	5	X	XXX	XX	XX

Relative importance: X - locally occurring, seldom a problem
XX - widely occurring, sometimes a problem
XXX - commonly occurring, often a problem

These geographical differences tend to be associated with cropping as a result of climatic differences (Scragg, 1974). Spring sown barley is now very much a crop of the North and West of Britain. In Scotland and Northern Ireland Scragg shows that the weed flora is dominated by S. media, Galeopsis tetrahit (common hempnettle) and Polygonum lapathifolium (pale persicaria) with local high populations of Chrysanthemum segetum (corn marigold) and Spergula arvensis (corn spurrey). In England and Wales the flora is dominated by S. media, Chenopodium album (fat hen), Polygonum convolvulus (black bindweed) and Polygonum aviculare (knotgrass) with local problems due to high populations of G. aparine, Fumaria officinale (common fumitory) and Tripleurospermum maritimum (scentless mayweed) (Makepeace, 1982). The figures given in table 3 (Roberts, 1982) reflect the relative abundance of individual broad-leaved weeds but the amounts seem well below anything recorded in trials where untreated populations have been measured.

The effect of broad-leaved weeds on cereal yields

There is direct competition between broad-leaved weeds and the cereal crop when weed populations are high (Scragg, 1980; Courtney, 1982). This is especially so in spring sown cereals grown in the North and N. Ireland. In contrast to this situation the summary of cereal spraying in the 1960s (Evans, 1969) which was carried out on mainly spring barley in the South and East of England concluded that at 297 sites farmers would have lost no or very little yield by withholding spraying for a year. There is little guidance on the levels at which it is economic to spray or when yield reduction is likely to occur (Cussans, 1980). In general it can be said that broad-leaved weeds will compete more effectively with less vigorous crops or crops suffering from stress factors. The current high yielding crops are very vigorous but the increase in dwarfing habit may allow the more competitive broad-leaved weeds to compete and reduce yield. This situation is reflected in more recent trials (Elliott, 1980) in which in mixed grass and weed floras benefit in yield could be attributed to grass weed control but not to the control of broad-leaved weeds. In ADAS and WRO trials (Evans, 1978; Orson, 1980; Orson, 1982; Wilson, 1982) the control of broad-leaved weeds has generally benefited yield but with no difference from autumn applications of herbicides compared to spring applications or vice versa.

If one accepts that there is a benefit in yield from spraying broad-leaved weeds then the cost is justified. If however populations are low and not tending to increase there is a question of whether there will be a cost benefit from spraying and other potential benefits must be taken into account (Elliott, 1978 & 1980). These benefits encompass such aspects as speed of combining, cleanliness of sample, effects on drying etc. Despite these complexities some firm guidelines on when not to spray would be a considerable benefit in the face of the problems of tank-mixtures, crop growth stage, variety, and cost.

The control of broad-leaved weeds in cereals

The control of broad-leaved weeds in cereals has long been dealt with by means of herbicides. This however does not necessarily rule out cultural methods of weed control. The broad-leaved weed flora has been shown to be affected by different husbandry methods (Cussans, 1976; Froud-Williams, 1981; Pollard et al, 1982). It has been shown that populations of broad-leaved weeds are decreased considerably by direct drilling, less so by minimum cultivation techniques and maintained at a constant level by ploughing. The exceptions to this appear to be some of the more difficult to control weed species such as Legousia hybrida (Venus's-looking glass), V. arvensis and Veronica spp. The importance of this information is that cultural techniques might be used as an aid to reducing broad-leaved weeds. It must be said at this point that reduced tillage systems favour annual grass weeds and perennial weeds.

The control of individual broad-leaved weeds by herbicides can be found by reference to one of the comprehensive publications dealing with the subject (Fryer & Makepeace, 1977; MAFF, 1982). Between them they show the response to individual herbicides and proprietory products. What they do not show is the reason that the results associated with the use of the recommended products is often not in line with the published recommendation. An example of this situation can be seen with S. media. It is listed as susceptible to almost all herbicides and even MCPA, 2,4-D and ioxynil/bromoxynil are noted as giving a useful control in ideal conditions when the plants are small. None the less it is still a very serious weed. The recommendations on labels are therefore very highly conditional and only in the strictest set of conditions can they be a guide to reliability as well as control (Smith, 1982; Bradford & Smith, 1982).

Table 4

The control of difficult weeds in winter cereals with pre-emergence herbicides

	Herbicide				
Weed	linuron	trifluralin + linuron	methabenz-thiazuron	pendimeth-alin 3/4 1	terbutryne
Galium aparine	MR	MS	R	MR	R
Viola arvensis	MS	MS	MS	S	S
Veronica persica	MS	S	S	S	MS
Veronica hederifolia	MR	S	MR	S	MR
Lamium purpureum	MS	MS	S	S	S
Lamium amplexicaule	-	S	S	S	-
Aethusa cynapium	-	S	-	-	-
Myosotis arvensis	S	S	S	S	-
Lithospermum arvense	-	S	-	-	-
Chrysanthemum segetum	-	MS	-	-	-
Legousia hybrida	-	S	-	-	-
Scandix pecten-veneris	-	S	-	-	-
Aphanes arvensis	S	S	S	S	S

Key: S - susceptible MS - moderately susceptible MR - moderately resistant
R - resistant

With the above as a qualification of recommendations it is instructive to look at the herbicide recommendations given for those weeds considered to be difficult to control. Tables 4, 5 and 6 are an interpolation from published information and are necessarily of a general nature (Fryer & Makepeace, 1977; MAFF, 1982; Trow-Smith, 1982).

Table 5

The control of difficult weeds in winter cereals with autumn applied herbicides

Weed	Herbicide: mecoprop	bromoxynil + ioxynil	bromoxynil + ioxynil + mecoprop	cyanazine + mecoprop	3,6-dichloro-picolinic acid + bromoxynil + mecoprop
G. aparine	S	-	S	S	S
V. arvensis	MR	-	-	-	S
V. persica	MS	S	S	S	S
V. hederifolia	MS	S	S	S	S
L. purpureum	-	S	MS	S	S
L. amplexicaule	-	-	-	-	-
A. cynapium	-	-	-	-	-
M. arvensis	-	S	S	S	S
L. arvense	MS	-	S	-	-
C. segetum	-	MS	-	-	S
L. hybrida	-	-	-	-	-
S. pecten-veneris	-	-	-	-	-
A. arvensis	-	-	-	-	S

Key: S, MS, MR, R - as per table 4

Table 6

The control of certain difficult weeds in winter sown cereals with 'spring'applied herbicides

Herbicide code

1. MCPA
2. mecoprop
3. dichlorprop
4. ioxynil + bromoxynil
5. ioxynil + bromoxynil + mecoprop
6. cynanazine + mecoprop
7. 3,6-dichloropicolinic acid + bromoxynil + mecoprop
8. 2,3,6-TBA + dicamba + MCPA + mecoprop

Weed	1.	2.	3.	4.	5.	6.	7.	8.
G. aparine	R	S	S	R	S	S		S
V. arvensis	R	-	MR	-	-	-	MS	R
V. persica	R	MR	MR	S	S	S	MS	MR
V. hederifolia	R	MR	-	S	S	S	MS	-
L. purpureum	R	R	R	S	S	S	MS	R
L. amplexicaule	R	R	R	-	-	MS	MS	R
A. cynapium	R	R	R	-	MR	R	-	-
M. arvensis	MS	R	R	S	S	S	MR	-
L. arvense	MS	R	R	S	S	S	-	MR
C. segetum	R	R	R	MS	MR	R	MS	R
L. hybrida	-	-	-	-	-	-	-	-
S. pecten-veneris	R	R	MR	MS	MS	-	-	MR
A. arvensis	R	R	R	-	MR	R	-	R

Key: S, MS, MR, R - as per table 4

The information above gives grounds for concern when one considers their limitations. Pre-emergence herbicides need adequate moisture, no trash or organic matter, correct depths of drilling etc. The autumn applied materials show potentially good results but most of these recommendations are for very restricted weed sizes and would certainly require access to low-ground pressure sprayers in order to meet the label requirements. If one has to rely on a spring applied herbicide then one is faced with no suitable material for many of the weeds listed.

New herbicide developments

In situations such as that above it is to new herbicides that the grower first turns for an answer. To this end there is some hope but not necessarily a solution to broad-leaved weed problems.

Pre-emergence herbicides. We are faced with a wide choice of materials in addition to those shown in table 4. These are linuron + monolinuron, trifluralin + linuron + trietazine, trifluralin + terbutryne, trifluralin + isoproturon, bifenox + linuron and chlorsulfuron + methabenzthiazuron. Pendimethalin looks one of the best materials for the majority of broad-leaved weeds but the dose is critical and there is need for a full dose in order to control *G. aparine* and 'mayweeds'. It is of considerable interest for its potential against *V. arvensis*, *Veronica* spp. and *Lamium* spp. Bifenox as a pre-emergence material with linuron has also shown up well on *V. arvensis* and to a lesser extent on *G. aparine*. It appears to have considerable potential on the other difficult weeds such as *Veronica* spp. and *Lamium* spp. More field information is required as its introduction has been clouded by the transitory white spotting on cereal foliage.

Of the new herbicides most attention has been given to chlorsulfuron (Palm & Allison, 1980; Ray, 1980; Swann, 1982; Swinchatt, 1982; McAteer, 1982; Orson, 1982). Trial results indicated that the material has a wide spectrum of action. As used in mixture with methabenzthiazuron at 15-20 gms/ha + 1575 gms/ha respectively it has shown good control of *G. aparine*, *Veronica* spp., *Lamium* spp. and many other weeds since its introduction (Bradford & Smith, 1982). These results need more field usage to confirm them but they are encouraging even though the mixture is restricted to use on wheat at present.

Post-emergence herbicides. This area of use gives considerable cause for confusion at present due to the difference between early post-emergence materials such as methabenzthiazuron and chlorsulfuron and conventional materials applied up to first and second node stages of the crop, which in the case of winter barley could be from December to April.

There are now a number of recommendations for 'autumn' use shown in table 5. Of those herbicides listed the cyanazine + mecoprop and the 3,6-dichloropicolinic acid mixture show considerable promise. Of the newer mixtures available for later timings bifenox + mecoprop has given good control of *G. aparine* and is also recommended for control of *Veronica* spp. and many other weeds.

Other herbicide developments. Quite apart from the development of new herbicides there is scope for improvement of existing results with current herbicides. This is reflected in the emergence of autumn recommendations as reflected in table 5. The practicality of the application of such timings will inevitably involve the use of low ground pressure spraying machines. These in turn involve the use of higher than normal ground speeds and relatively low volumes of water use. This must therefore alter the quality of spray applied compared to the normal 'spring' recommendation of around 100-250 l/ha. Results under these conditions of application need to be monitored as part of the recommendation to ensure that it is the timing that is producing the herbicide result and not the spray quality.

The most interesting development is discussed later in this conference (Bradford & Smith, 1982). This consists of the use of what is commonly referred to as the 'low dose' sequential application technique. It consists of reduced doses of conventional herbicides applied at a very early stage of weed growth. The technique has been evolved for post-emergence herbicide application in sugar beet (Breay et al, 1982). Initially it does not appear practicable in cereals until one appreciates the potential for raising levels of weed control reliability compared to our existing standards.

Cereal tolerance to herbicides

The limitations of use of many herbicides was investigated long before our present methods of cereal growing were developed (Tottman, 1982) and it is with considerable interest that results in tolerance trials show that we may have more flexibility than hitherto assumed. There is now more information showing that applications of some herbicides show little risk of affecting yield when applied at the first node stage of growth (Askew & Scourey, 1982; Kyndt & Fallon, 1982). It is of note that much of our knowledge of broad-leaved herbicide tolerance arises from mixtures containing phenoxy herbicides. If we can extend the availability of single constituents, as is now the case with ioxynil and bromoxynil, there would appear to be no reason why each should not have its own tolerance 'window' which would itself be determined by prevailing environmental conditions. By this means one could perhaps remove any tolerance restrictions for certain herbicides such as ioxynil, bromoxynil, 3,6-dichloropicolinic acid, bentazone, bromofenoxim and others. This approach may also enable better use of existing restricted herbicides such as dicamba and mecoprop. It is of interest that in the above work salts of mecoprop were safer to the crop than esters.

Economic and other considerations

There has been no real comment in this review on the problems caused by perennial broad-leaved and the easy-to-kill annuals. This is not to indicate that they do not cause problems but rather that one must accept that on the whole the control of most broad-leaved weeds is carried out successfully. There are problems of late emerging polygonaceous weeds and Papaver rhoeus (common poppy) which may increase with earlier herbicide use but these would not appear to constitute problems of any but a local nature at the present time. Similarly the upsurge of perennial weeds with the increase in minimum and nil tillage situations has partly been overcome by the use of pre-harvest application of glyphosate (O'Keeffe, 1982) and partly by some reversal to ploughing as an antidote to the grass weed problems that minimum and nil tillage has caused. This situation however may not stay stable and if minimum tillage systems become permanent there could be a sharp increase in perennial weeds germinating from seed and already problems have been encountered from the germination of Heracleum sphondylium (hogweed), Mentha arvensis (corn mint), Stachys sylvatica (hedge woundwort) and Sambucus nigra (elder).

From the commercial aspect of cereal growing the cost of herbicides cannot be ignored. To return to the points raised by Hubbard the greatest potential to maintain profits must be from high input cereal growing systems. He quotes break-even yields of 6.2 tonnes/ha for winter wheat and 5.7 tonnes/ha for barley. As primarily an insurance input the control of broad-leaved weeds must have a relatively low cost ceiling. This is reflected in some herbicide costs. The listed retail prices of some pre-emergence herbicides have fallen over the last two years by 25%. The costs of post-emergence herbicides have risen for the same period by the same rate as inflation. The pressure on prices is making the on-farm price even lower than the listed prices. Those quoted by Trow-Smith of £19.75/ha for trifluralin + linuron compare with £13.50/ha on farm and chlortoluron quoted at £37.24/ha compare with £27.00/ha on the farm for large farm units.

Such reductions may be welcome to the grower but may alter the whole structure of use. One could see for example the use of pre-emergence herbicides as low cost prophylactic sprays that could be followed by a sequence of low-dose treatments when necessary. The rather dangerous aspect of such low cost approaches is that if current trends continue it makes further product development in the field unprofitable and whilst existing weed problems would be effectively dealt with no commercial work would be done to counter new weed problems as they developed leaving ADAS to do the work. This process may be already under way. The use of specialist consultants for on-farm technical advice is already circumventing existing conventional trade channels of advice. This could ultimately result in the herbicide manufacturer withdrawing from giving herbicide recommendations, beyond those necessary for clearance, and leaving this to professional agronomists. It would be then up to these specialists and ADAS to find the answers to the problems caused by broad-leaved and other weeds in cereals.

REFERENCES

Askew, M. F.; Scourey, L. R. K. (1982) The effect of some herbicides and herbicide sequences on the yield of two winter wheat cultivars in the absence of weeds. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 211-218.

Breay, T.; Dumcliffe, R.; Kennedy, A.; Matthews, K.; Madge, R.; May, M.; Boydell, M. (1982) Herbicides - the repeat low dose method. British Sugar Beet Review, 50, (1), 7-23.

Bradford, A. M.; Smith, J. Annual broad-leaved weed control in winter cereals. ADAS 1982 results. Proceedings 1982 British Crop Protection Conference - Weeds, (In preparation).

Carnegie, H. M. (1974) A survey of dicotyledonous weeds in spring sown cereals in north-east Scotland. British Crop Protection Council, Monograph No. 9, 106-114.

Chancellor, R. J. (1976) Weed changes over 11 years in Wrenches, an arable field. Proceedings 1976 British Crop Protection Council - Weeds, 2, 681-686.

Courtney, A. D.; Johnston, R. T. (1982) The influence of competitive stress and the application of a herbicide based on 2,4-DP/MCPA on the components of yield in spring barley. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 239-246.

Cussans, G. W. (1977) The influence of changing husbandry on weeds and weed control in arable crops. Proceedings 1976 British Crop Protection Conference - Weeds, 3, 1001-1008.

Cussans, G. W. (1981) Strategic planning for weed control - a researcher's view. Proceedings 1980 British Crop Protection Conference - Weeds, 3, 823-832.

Elliott, J. G. (1978) The economic objectives of weed control in cereals. Proceedings 1978 British Crop Protection Conference - Weeds, 3, 829-841.

Elliott, J. G. (1981) The economic significance of weeds in the harvesting of grain. Proceedings 1980 British Crop Protection Conference - Weeds, 3, 787-797.

Evans, S. A. (1969) Spraying of cereals for the control of weeds. Experimental Husbandry, 18, 102-110.

Evans, S. A.; Harvey, J. J. (1978) Annual broad-leaved weed control in winter wheat: autumn and spring treatments compared. Proceedings 1978 British Crop Protection Conference - Weeds, 1, 41-47.

Fisons Ltd (1972) Fisons 1972 weed survey. Personal communication.

Froud-Williams, R. J.; Chancellor, R. J.; Drennan, D. S. H. (1981) Potential changes in weed floras associated with reduced-cultivation systems for cereal production in temperate regions. Weed Research, 21, (2), 99-109.

Fryer, J. D.; Makepeace, R. J. (1977) Weed Control Handbook, Vol. II Recommendations, Blackwell Scientific Publications, Oxford.

Harvey, J. J. (1980) A survey of weed incidence and control in cereals in Devon and Cornwell 1980. Personal Communication.

Hubbard, K. R. (1982) Cost effective cereal systems. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 1-10.

Kyndt, C. F. A.; Fallon, P. (1982) Further trials with an HBN:phenoxyalkanoic herbicide applied at various growth stages in winter cereals. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 219-226.

Ministry of Agriculture, Fisheries and Food (1982) Weed control in cereals 1982, Booklet 2253, (82).

McAteer, S. (1982) The effect of weed competition on the growth and yield of spring barley cultivar Midas. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 247-254.

Murphy, M. C. (1981) Report on farming in the Eastern Counties 1978/80. Agricultural Economics Unit, University of Cambridge.

O'Keeffe, M. G. (1982) The control of perennial broad-leaved weeds by the application of the isopropylamine salt of glyphosate pre-harvest in wheat and barley. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 97-102.

Orson, J. H. (1980) Annual broad-leaved weed control in winter wheat and winter barley autumn and spring treatments compared. Proceedings 1980 British Crop Protection Conference - Weeds, 1, 251-258.

Orson, J. H. (1982) Annual broad-leaved weed control in winter wheat and winter barley, autumn and spring treatments compared. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 43-52.

Orson, J. H. (1982) New herbicides gain ground. Farmers Weekly, 97, (9), 25-27.

Palm, H. L.; Allison, D. A. (1980) World wide review of the new cereal herbicide - DPX 4189. Proceedings 1980 British Crop Protection Conference - Weeds, 1, 1-6.

Pollard, F.; Moss, S. R.; Cussans, G. W.; Froud-Williams, R. J. (1982) The influence of tillage on the weed flora in a succession of winter wheat crops on a clay loam soil and a silt loam soil. Weed Research, 22, (3), 129-136.

Ray, T. B. (1980) Studies of the mode of actions of DPX 4189. Proceedings 1980 British Crop Protection Conference - Weeds, 1, 7-14.

Roberts, H. A.; Neilson, J. E. (1982) Seed banks of soils under vegetable cropping in England. Weed Research, 22, (1), 13-16.

Roberts, H. A. (1982) Seasonal patterns of weed emergence. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 153-154.

Scragg, E. B. (1974) Regional weed problems - dicotyledonous weeds in tillage crops. British Crop Protection Council, Monograph No. 9, 19-32.

Scragg, E. B. (1980) Cost-effective weed control in spring barley in the north of Scotland. Proceedings 1980 British Crop Protection Conference - Weeds, 1, 69-76.

Smith, J. (1982) The control of common chickweed (Stellaria media), cleavers (Galium aparine), speedwells (Veronica spp.) and field pansy (Viola arvensis) in winter cereals, ADAS results 1979-81. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 173-182.

Swann, N. B. (1982) Autumn application of chlorsulfuron for the control of broad-leaved weeds. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 77-86.

Swinchatt, M. L. (1982) The use of chlorsulfuron for the control of weeds in spring barley. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 117-126.

Tonkin, J. H. B. (1982) The presence of seed impurities in samples of cereal seed tested at the Official Seed Testing Station, Cambridge in the period 1978-1981. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 163-172.

Tottman, D. R. (1982) The effects of broad-leaved weed herbicides applied to cereal crops at different growth stages. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 201-210.

Trow-Smith, R. (1982) How to choose and use a weedkiller. Farmers Weekly, 97, (9), 6.

Wilson, B. J. (1982) The yield response of winter cereals to autumn or spring control of broad-leaved weeds. Aspects of Applied Biology 1, Broad-leaved Weeds and their Control in Cereals, 53-62.

A COMBINATION OF BIFENOX AND LINURON FOR BROAD-SPECTRUM PRE-EMERGENCE WEED CONTROL IN WINTER CEREALS

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Summary. Bifenox plus linuron at 1200 + 500 g a.i./ha was applied pre-emergence on winter wheat and winter barley in 67 trials over four seasons, covering a wide range of locations and soil types. Effective control was obtained of all winter-germinating broad-leaved weeds encountered, including problem weeds such as *Galium aparine* and *Viola arvensis*. *Poa spp* and *Lolium perenne* were also controlled. Good yield increases of both wheat and barley were obtained as a result of weed control. Bifenox plus linuron proved safe to wheat, but caused temporary early damage to barley in some years, although with little effect on later growth or yield. Dose responses, problem weeds, crop damage, grain yield.

INTRODUCTION

In recent years, the use of autumn-applied herbicides in winter cereals has become well established. Whilst yield advantages over spring treatment are sometimes marginal (Orson, 1980), early weed control can be beneficial in high weed populations (Wilson, 1980). Other benefits (Clare, 1980) include less risk of damage to the cereal crop, a reduced work-load during the limited number of available spraying days in spring, and avoidance of drift hazards to adjacent spring-sown broad-leaved crops.

One effect of increased use of autumn pre-emergence herbicides has been a change in the relative importance of certain weed species. Makepeace (1978) noted that urea-based products had led to an increase in a number of species, including *Galium aparine* and *Veronica persica*. A combination of herbicides and concurrent changes in farming practice, such as earlier sowing and reduced cultivations, has also led to increases of several species such as *Aphanes arvensis* (Pollard and Cussans, 1981) and *Viola arvensis* (Staddon, 1982). As a result, some longer-established autumn herbicides are proving less effective in certain areas, owing to increased numbers of tolerant species. In these situations, broader-spectrum materials are required.

The herbicidal activity of bifenox was first reported by Kruger *et al* (1974), and its safety in cereals noted. However, U.K. screening trials indicated that although bifenox controlled a wide range of species, some important weeds, notably *Stellaria media*, were resistant, and bifenox was therefore re-appraised as a mixture component. For pre-emergence use in cereals, linuron was selected as an appropriate partner, as the weed spectra were complementary. Mixtures of bifenox and linuron were then extensively tested, and the results are presented below.

METHODS AND MATERIALS

Early trials were carried out with bifenox as a flowable concentrate and linuron as an emulsifiable concentrate, tank-mixed to establish active ingredient ratios. In 1980/81, two formulated mixtures of bifenox + linuron, an emulsifiable and a flowable concentrate, were tested and compared to equivalent dose rates of the tank mixture. All gave similar results, which for convenience have been meaned in this report. In 1981/82, only a flowable concentrate 'Alibi FL', containing 343 g/l bifenox and 142 g/l linuron was tested. As reference treatments, commercial formulations of trifluralin + linuron, methabenzthiazuron and terbutryne were applied at recommended dose rates.

45 replicated and 16 grower trials were carried out on wheat and barley over 4 seasons. Trials were on a range of soil types in 20 counties of England and Wales, covering all the main winter cereal-growing areas. 3-4 trials in each year from 1979/80 to 1981/82 were on weed-free sites, to study yield effects from bifenox + linuron, and the remainder were selected to cover a wide range of winter-germinating weed species. In addition, 6 unreplicated varietal screens on wheat and barley were carried out over three seasons.

Replicated trials were of randomized block design, with four replicates and a plot size of 24 m^2. In grower trials, an unreplicated area of 1 ha was treated with bifenox + linuron and compared to the farmers' standard herbicide, and an untreated control strip.

All treatments were applied to the soil surface 1-8 days after sowing, and before crop emergence. In replicated trials and varietal screens, treatments were applied with a Van der Weij propane sprayer using 80015 Teejets at 250 kPa to give a spray volume of 200 l/ha. Grower trials were treated with the farmer's own sprayer at a volume of 200-240 l/ha.

Crop damage was assessed visually at GS 12 (Tottman and Makepeace, 1979) and again in spring at GS 30, when broad-leaved weed control was also visually assessed. Grass weeds were assessed by quadrat count (10 x 0.25 m^2 per plot) of panicles in June. Replicated trials were harvested with a Hege small-plot combine, and grain yields corrected to 15% moisture content.

RESULTS

Table 1

Dose responses to bifenox

Mean percent control from linuron 500 g a.i./ha + bifenox:

g a.i./ha:	0	600	800	1000	1200
Galium aparine	28	-	46	63	90
Lamium purpureum	75	-	100	100	100
Myosotis arvensis	94	100	98	-	98
Stellaria media	93	87	87	92	91
Veronica hederifolia	18	63	83	-	93
Veronica persica	51	85	95	-	99
Viola arvensis	52	68	68	-	99

Early trials indicated a distinct dose response to bifenox in a number of species, notably *Galium aparine, Viola arvensis* and *Veronica spp*. The exception was *Stellaria media,* the control of which was attributable almost completely to linuron, and was unaffected by bifenox dose rate. However, 1200 g a.i./ha bifenox + 500 g a.i./ha linuron appeared sufficient to give good control of all species encountered, and this dose rate was selected as the basis for further trials.

Table 2

Mean percent control of total broad-leaved weed flora

Herbicide:	bifenox + linuron	trifluralin + linuron	methabenz-thiazuron	terbutryne	(No. of trials)
g a.i./ha	1200 + 500	960 + 480	1575	1500	
1978/79 replicated	84	-	47	-	(3)
1979/80 replicated	87	89	76	79	(7)
1980/81 replicated	96	89	74	85	(16)
1980/81 grower	91	80	70	71	(14)
1981/82 replicated	83	66	50	70	(6)
Mean	91	83	68	77	(46)

Weed control with bifenox + linuron was consistently good over four years of trials, and compared favourably with reference treatments. Spring over-spraying was necessary at only three sites.

Table 3

Mean percent control of broad-leaved and grass weed species

Herbicide (see key following)	bif + lin	tri + lin	meth	terb	(No. of trials)
g a.i./ha	1200+ 500	960 + 480	1575	1500	
Aphanes arvensis	100	99	96	100	(4)
Fumaria officinalis	83	75	84	95	(5)
Galium aparine	87	61	49	45	(7)
Lamium purpureum	100	91	79	45	(4)
Matricaria matricarioides	99	99	99	97	(3)
Myosotis arvensis	81	74	78	78	(4)
Papaver rhoeas	100	100	95	99	(5)
Polygonum aviculare	84	89	50	66	(5)
Senecio vulgaris	99	76	80	99	(4)
Sinapis arvensis	94	78	81	53	(4)
Stellaria media	90	94	82	94	(33)
Tripleurospermum maritimum	98	88	97	89	(16)
Veronica hederifolia	92	73	37	57	(8)
Veronica persica	97	85	70	78	(15)
Viola arvensis	98	68	44	73	(6)
Alopecurus myosuroides	30	52	-	30	(9)
Lolium perenne	89	85	72	85	(2)
Poa annua	96	85	75	87	(8)
Poa trivialis	83	80	78	55	(4)

Herbicide key:		
bif	=	bifenox
lin	=	linuron
tri	=	trifluralin
meth	=	methabenzthiazuron
terb	=	terbutryne

Most important autumn or winter germinating broad-leaved weeds were encountered in these trials, and all were effectively controlled by bifenox + linuron. *Poa spp* and *Lolium perenne* were also controlled, but *Alopecurus myosuroides* proved resistant. Bifenox + linuron proved generally superior to reference products, particularly on *Galium aparine, Lamium purpureum, Viola arvensis* and *Veronica spp,* all weeds which are an increasing problem in winter cereals. On species which continue to germinate during spring (*eg Fumaria officinalis, Polygonum aviculare*), control with bifenox + linuron tended to be reduced from April onwards, suggesting a limit to the persistence of the mixture. However, due to crop suppression, at no site did such late-germinating weeds become a sufficient problem to require over-spraying.

On all species but one, soil type had little or no effect on degree of weed control. However, *Stellaria media* is controlled almost entirely by the linuron portion of the mixture, and 500 g a.i./ha proved inadequate on heavier soils. This was effectively overcome by increasing the linuron dose to 740 g a.i./ha on medium and heavy soils, either by increasing the dose rate of the formulated mixture, or by tank-mixing additional linuron.

Table 4

Mean percent crop damage in replicated trials in autumn and spring

Herbicide: (see key)	bif + lin		bif + lin		tri + lin		meth		terb	
g a.i./ha	1200+ 500		2400+ 1000		960 + 480		1575		1500	
G.S.	12	30	12	30	12	30	12	30	12	30
Wheat										
1978/79	0	1.7	-	-	-	-	0	1.9	-	-
1979/80	0.7	0.9	0.6	2.1	0	2.0	0	1.1	0	2.4
1980/81	1.5	0.3	2.4	0.7	0.2	0.4	0.1	0.2	0.1	0.3
1981/82	0	0	-	-	0	0	-	-	-	-
Barley										
1978/79	0	2.5	-	-	-	-	0	3.0	-	-
1979/80	0	0	-	-	-	-	-	-	-	-
1980/81	7.9	0.1	17.6	0.9	0.3	0.1	0	0.1	0	0
1981/82	2.8	0	5.8	0	0.4	0	0.4	0	0.2	0

Bifenox + linuron at single or double dose rates caused only minor effects to wheat in any year, and also proved safe to barley in two years. However, some damage to barley occurred in the 1981/2 season, and marked damage was caused at certain trials in 1980/81. Similar damage occurred in commercial use in this season.

Barley damage consisted of pale necrotic lesions on the first two leaves, which in severe cases gave the treated area a bleached appearance. However, plants were seldom killed, and usually grew away rapidly, with little effect visible in spring.

Bioassays showed that damage was due to uptake of bifenox by the emerging plumule, and occurred whether linuron was present or not. Further bioassays and field studies indicated that bifenox damage to barley was exacerbated by a number of factors at the time of emergence, including soil moisture, temperature, looseness of seedbed, soil type and rainsplash onto seedlings. A combination of several factors led to the higher damage levels in 1980/81, whereas the reverse was the case in earlier years.

Varietal screens indicated little difference in tolerance to bifenox between varieties, but did show the greater susceptibility of barley compared to wheat.

Table 5

Mean grain yield as percent of untreated control

Herbicide: (see key)	Control (t/ha)	bif + lin	tri + lin	meth	terb	(No. of trials)	LSD 5%
g a.i./ha	-	1200+ 500	960 + 480	1575	1500		
Wheat							
1979	(5.80)	107	-	102	-	(1)	15
1980	(5.11)	102	105	99	97	(7)	12
1981	(7.29)	107	104	105	105	(5)	4
Mean	(6.00)	105	105	102	101	(13)	
Weed-free	(7.07)	98	102	100	98	(5)	
Weedy	(5.33)	108	107	103	103	(8)	
Barley							
1979	(4.66)	110	-	100	-	(1)	NS
1980	(4.65)	107	-	-	-	(2)	17
1981	(3.05)	113	118	113	124	(3)	NS
1982	(5.81)	104	106	105	103	(5)	NS
Mean	(4.74)	108	111	108	111	(11)	
Weed-free	(4.90)	95	96	101	97	(5)	
Weedy	(4.62)	118	125	113	126	(6)	

Bifenox + linuron gave yield increases in both barley and wheat in each year of trials, and compared well with reference products. When trials are divided into weedy and weed-free groups, it can be seen that yield increases are clearly a result of weed control, and barley shows greater yield increases than wheat from pre-emergence treatment. Bifenox + linuron had little effect on yields of weed-free wheat, but a small yield reduction occurred in weed-free barley, which correlates with crop damage noted earlier.

DISCUSSION

Four seasons of trials have shown that a combination of bifenox and linuron at 1200 + 500 g a.i./ha, applied as a pre-emergence surface treatment to winter wheat or barley, gives effective control of most winter-germinating broad-leaved weeds, including a number of species which are of increasing importance in winter cereal-growing areas. Control is generally greater than that given by reference materials, markedly so on certain important species such as *Galium aparine*. Control of *Poa spp* and *Lolium perenne* is also obtained, although *Alopecurus myosuroides* is resistant. This level of weed control is reflected in substantial yield increases in both wheat and barley.

Bifenox plus linuron has proved to be safe to wheat at the rates tested, even at weed-free sites. However, under certain combinations of circumstances, early damage can be caused to barley. This is normally quickly outgrown, and any yield reduction caused is outweighed by increases obtained by good weed control.

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REFERENCES

Clare, R.W. (1980). Cost effectiveness of weed control in British cereal growing. *Proceedings 1980 British Crop Protection Conference - Weeds*, 3, 777-786.

Kruger, P.J.; Ward, D.; Theissen, R.J.; Downing, C.R.: Kaufman, H.A. (1974). Bifenox: a selective weed killer. *Proceedings 12th British Weed Control Conference*, 2, 839-845.

Makepeace, R.J. (1978). Herbicide developments in a changing husbandry era and the new weeds emerging from it. *Proceedings British Association For The Advancement Of Science*, 62-70.

Orson, J.H. (1980). Annual broad-leaved weed control in winter wheat and winter barley - autumn and spring treatments compared. *Proceedings 1980 British Crop Protection Conference - Weeds*, 1, 251-258.

Pollard, F.; Cussans, G.W. (1981). The influence of tillage on the weed flora in a succession of winter cereal crops on a sandy loam soil. *Weed Research*, 21, 185-190.

Staddon, J.A.H. (1982). The effects of changes in cereal husbandry systems on broad-leaved weed control strategy - a farmers' view. *Aspects Of Applied Biology 1, Broad-leaved Weeds And Their Control In Cereals*. 17-20.

Tottman, D.R.; Makepeace, R.J. (1979). An explanation of the decimal code for growth stages of cereals, with illustrations. *Annals Of Applied Biology*, 93, 221-234.

Wilson, B.J. (1980). The effect on yield of mixtures and sequences of herbicides for the control of *Alopecurus myosuroides* Huds. and broad-leaved weeds in winter cereals. *Weed Research*, 20, 65-70.

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PRE-EMERGENCE BROAD-LEAF WEED CONTROL IN WINTER CEREALS WITH A NOVEL COMBINATION OF TRIFLURALIN, LINURON AND TRIETAZINE

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Summary. Work is described with a novel combination of trifluralin, linuron and trietazine (CR15843) used pre-emergence in winter wheat and winter barley. Data from 94 trials are presented to show annual broad-leaf weed control compared with standards. Additional activity on some annual grass weeds is also described. Crop safety data under different cultivation regimes are shown together with results of work involving mixtures and sequences, some of which are specifically designed to widen the spectrum of activity to include *Alopecurus myosuroides* and *Avena fatua*. The significance of a 3-way combination of active ingredients is discussed. *Alopecurus myosuroides, Poa annua, paraquat, triallate.*

INTRODUCTION

The benefit in terms of yield response by early removal of annual grass broad-leaf weeds from winter wheat has been measured by Wilson and Cussans (1978). Residual herbicides used pre-emergence or early post-emergence which exploit this benefit have gained rapidly in popularity over recent years and combinations of trifluralin with linuron have featured strongly in this development (Wise and Glasgow, 1982).

This paper describes the development of a novel co-formulation of trifluralin, linuron and trietazine involving a series of 94 trials over 2 years. The formulation has since been commercialised as 'Pre-Empt'.

METHOD AND MATERIALS

A total of 63 trials on winter wheat and 31 trials on winter barley were carried out in 1980/81 and 1981/82. The trials were spread over the range of mineral soil types and seed bed preparation techniques throughout England and Scotland.

In addition a further 89 fields were treated by farmers in 1981/82 in an unreplicated comparison with standard products. The evidence produced from these comparisons is not presented in detail since they were largely unsupervised applications under farm conditions where no checks of accuracy were attempted.

Nevertheless the results from them are in close agreement with the data from the controlled experiments and therefore permit some extrapolation of the latter particularly in respect of weed species controlled.

An emulsifiable concentrate co-formulation (CR 15843) containing 208 g/l trifluralin, 54 g/l trietazine and 46 g/l linuron with isophorone was used, applied pre-emergence at 5 or 6 l/ha in a volume of 200-220 litres. Comparison treatments included commercially available formulations of terbutryne, linuron/trifluralin, isoproturon, chlortoluron and bifenox/linuron at recommended doses. Double doses of all treatments were included in small plot trials for crop safety assessments.

Small plot trials (44 on winter wheat and 18 on winter barley) were replicated 4 or 6 times in a fully randomised layout of 10m x 2m plots.

Treatment of these trials together with 4 unreplicated variety screens (including all NIAB listed varieties of winter wheat and winter barley) was by pressurised knapsack sprayer.

Large plot trials (15 on winter wheat and 9 on winter barley) were usually applied by growers through their machines, were unreplicated and consisted of CR15843 applied at 5 l/ha (Light and Medium soils*) or 6 l/ha (Heavy soils*) to an area of 1-2 ha. Comparisons were made with the grower's standard treatment on the remainder of the field. A small area was left untreated to permit weed control assessment.

Weed control assessments were carried out on all plots by visual scoring of the numbers and vigour each species compared with the untreated control on a 0 - 100 scale where 0 = untreated and 100 = total control. A score for overall weed control was derived in the same way.

Crop tolerance assessments were visual estimates of crop vigour on a 0 - 100 scale where 100 = untreated.

* ADAS soil texture scale

Results are presented from these trials on

a] Weed control
b] Crop safety and yields from weed-free trials
c] Variety tolerance
d] Low volume application (down to 70 l/ha)
e] Sequences of CR 15843 with triallate products
f] Tank mixture of CR 15843 with paraquat

RESULTS

a] Weed Control

Control of annual weeds achieved in all weedy replicated trials, assessed in March/April following treatment, is shown in Tables 1 and 2.

Table 1

Mean % weed control

	LS-SCL*			CL-ZyC*		
	5 l/ha CR 15843		4 l/ha trifluralin/ linuron	6 l/ha CR 15843		5 l/ha trifluralin/ linuron
Stellaria media	99	(14)	98	99	(5)	98
Tripleurospermum maritimum	96	(8)	92	95	(1)	90
Viola arvensis	52	(8)	67	90	(1)	85
Veronica arvensis	92	(8)	97	99	(3)	91
Veronica hederifolia	65	(4)	65	85	(2)	83
Lamium purpureum	96	(3)	98			
Fumaria officinalis	68	(2)	90			
Papaver rhoeas	100	(2)	100			
Myosotis arvensis	95	(1)	95			
Aphanes arvensis	100	(1)	98			
Galium aparine				68	(1)	45
Mean b.l.w. control	86		90	89		82
Alopecurus myosuroides	72	(4)	79	79	(4)	77
Poa annua	98	(6)	98	95	(2)	98

Figures in brackets indicate the number of sites at which each comparison was made.

*LS-SCL : Loamy Sand - Sandy Clay Loam
CL-ZyC : Clay Loam - Silty Clay

Data from unreplicated large plot comparisons with standard products under farm-use conditions confirmed the above pattern of activity with particularly encouraging results on S. media and T. maritimum both of which can be major problem weeds in winter cereals in UK.

The high level of control of P. annua and the activity against A. myosuroides compares favourably with that achieved by other similar products.

b] Crop safety and yields

The effect of treatments on crop vigour assessed in March/April in replicated trials on winter wheat and winter barley is shown in Table 2. For comparison purposes data from 5 trials on winter wheat drilled on cloddy seed beds treated in late autumn are included to show the effects of treatment in unsuitable conditions.

Table 2

Mean crop vigour as % untreated

Dose*		Winter wheat Good seed bed	Winter wheat Cloddy seed bed	Winter barley Good seed bed
CR 15843	N	97.8	88.0	97.3
CR 15843	2N	90.0	65.0	96.4
trifluralin/linuron	N	97.6	80.0	88.7
trifluralin/linuron	2N	92.8	60.0	91.0
terbutryne	N	97.0	95.0	91.9
terbutryne	2N	93.2	91.0	80.3
No of sites		21	5	14

* 'N' represents the appropriate dose for the soil type of each trial. The 'N' dose for terbutryne is 1.5 kg a.i./ha and for trifluralin/linuron 0.96 - 1.20 + 0.48 - 0.60 kg a.i./ha.

The importance of well prepared seed beds to ensure maximum safety from all trifluralin based materials is clear from these figures, while the relatively high safety of CR 15843 compared with terbutryne on winter barley is well illustrated.

These features are reflected in the yields from weed free sites treated in 1980/81, shown in Table 3. (Those from trials carried out in 1981/82 were not available at the time of preparation of this paper, but may be obtained on application to the authors).

Table 3

Yield as % of untreated

	Winter wheat		Winter barley	
	N	2N	N	2N
CR 15843	112.4	102.7	116.2	116.0
trifluralin/linuron	114.2	106.1	115.2	122.5
terbutryne	102.2	105.6	107.1	109.5
No of sites	3	2	3	2

c] Variety tolerance

No evidence of differential varietal sensitivity was noted from 4 unreplicated screens at N and 2N dose across all NIAB listed varieties of winter wheat and winter barley.

d] Low volume use

Results from 4 trials to compare low volume and conventional volume application of CR 15843 are shown in Table 4

Table 4

Low volume v Conventional Volume

	Volume	% broad leaf weed control	% *P. annua* control	% vigour
CR 15843 5 1	70	92	100	100
CR 15843 5 1	200	88	100	100
CR 15843 6 1	70	97	100	100
CR 15843 6 1	200	96	100	100

70 l/ha T jet 8001 @ 130 k Pa
200 l/ha T jet 8002 @ 260 k Pa

Performance of CR 15843 was clearly unaffected by a low volume system giving even ground cover.

e] Sequences of CR 15843 with triallate products

In 3 trials CR 15843 treatment was followed by triallate granules (2.25 kg a.i./ha) while in a fourth trial incorporation of triallate liquid (1.7 kg a.i./ha) was followed by treatment with CR 15843. Results from these 4 sites are shown in Table 5 where a comparison is shown with mean results from commercially recommended sequences with triallate using trifluralin 0.96 kg a.i./ha + linuron 0.532 kg a.i./ha, or terbutryne 1.50 kg a.i./ha, or methabenzthiazuron 1.575 kg a.i./ha.

Table 5

CR 15843/triallate sequences

	% vigour	% broad leaf weed control
CR 15843 5 1 + triallate	100	95
CR 15843 6 1 + triallate	100	95
standard* + triallate	100	96

*trifluralin/linuron, or terbutryne, or methabenzthiazuron.

f] Tank mixture of CR 15843 with paraquat

CR 15843 was tested at 5 l/ha or 6 l/ha in tank mixture with paraquat at 1.1 kg paraquat/ha, at 2 sites on winter wheat. The formulation of paraquat used (containing 276 g paraquat dichloride plus 100 g wetting system per litre) proved physically and biologically compatible without any adverse effects on crop safety or weed control compared with CR 15843 alone.

DISCUSSION

The combination of three soil acting active ingredients gives to CR 15843 activity by photosynthesis inhibition (linuron and trietazine) and inhibition of cell division (trifluralin). Additionally trifluralin and to a lesser extent trietazine, offer activity against grass weeds as well as dicotyledons, thereby widening the spectrum of control. In this way activity against several major weeds (eg S. media) is covered by both modes of action.

The result is a product giving reliable performance over a range of conditions, although, in common with all herbicides of this type, adequate soil moisture is necessary for optimum results. Furthermore the presence of the chlorotriazine trietazine helps to provide the persistence necessary to maintain weed control in the crop through the winter months.

The work described here shows that CR 15843 is a unique combination of active ingredients offering pre-emergence control of a range of annual broad-leaf and grass weeds in winter wheat and winter barley. CR 15843 has been shown to combine well with other herbicides used in winter cereals giving flexibility and ease of use in a number of different weed spectra including those with Avena fatua.

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We wish to express our thanks to our colleagues in FBC Limited whose work is reported here, to Monsanto p.l.c. and ICI Plant Protection Division for their collaboration in the work with triallate and paraquat respectively, and to the many farmers in the UK who assisted by allowing these trials to be conducted on their crops.

REFERENCES

Wilson, B.J.; Cussans, G W (1978). The effects of herbicides applied alone and in sequence, on the control of wild oats (Avena fatua) and broad-leaved weeds, and on yields of winter wheat. Annals of Applied Biology, 89, 459-466.

Wise, C.J.C.; Glasgow, J.L. (1982). The evolution of EL-5295, a co-formulation of trifluralin and linuron for the control of weeds in winter cereals in the UK and Europe. Proceedings AAB Symposium 'Aspects of Applied Biology 1' 11-15.

NEW FORMULATED MIXTURES BASED ON ISOPROTURON FOR ANNUAL WEED CONTROL IN CEREALS

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Summary. A total of 207 trials was carried out between 1979 and 1982 with two formulated mixtures based on isoproturon. HOE 16410 5H (containing isoproturon and trifluralin, 400 g/l total a.i.) applied pre-emergence to Winter cereals at 2800 g a.i./ha gave improved control of *Veronica* spp., *Lamium purpureum* and *Viola arvensis* whilst maintaining consistent control of *Alopecurus myosuroides* and other isoproturon-sensitive weeds. HOE 16410 7H (containing isoproturon, mecoprop and ioxynil, 480 g/l total a.i.) gave effective control of *Poa* spp. and a range of broad-leaf weeds including *Veronica* spp. and *Galium aparine* when applied post-emergence to Winter or Spring cereals at 2400 g a.i./ha. For control of *A. myosuroides*, up to 3840 g a.i./ha was required. Both products showed good crop tolerance on all cultivars tested at twice normal rates of application. Broad-spectrum herbicides, trifluralin, ioxynil, mecoprop.

INTRODUCTION

The recent tendency towards earlier drilling of Winter cereals in the U.K. has led to a general increase in Autumn herbicide applications to combat the threat of weed competition early in crop development. Furthermore, the widespread use of residual grass-weed herbicides over many years, which tend to leave such weeds as *Veronica* spp., *Galium aparine* and *Viola arvensis*, has led to an increase in the importance of such species which were traditionally controlled in the Spring. It was clear that a need had arisen for herbicides giving reliable grass-weed control with an increased broad-leaved weed spectrum for use in either Autumn or Spring.

For a number of years excellent control of *Alopecurus myosuroides* and many common broad-leaf weeds has been obtained using isoproturon applied either pre- or post-crop emergence (Hewson, 1974). To widen the broad-leaf weed spectrum, two new herbicide mixtures have been developed based on isoproturon. HOE 16410 5H, a mixture of isoproturon with trifluralin, has extended the spectrum for pre-emergence usage on Winter cereals as previously reported in preliminary papers (Schumacher *et al*, 1980; Roa *et al*, 1981), whilst HOE 16410 7H, a mixture of isoproturon, ioxynil and mecoprop, has proved to be a versatile post-emergence material for both Winter and Spring cereals controlling the majority of annual weeds.

This paper describes the field trials carried out in the U.K. by Hoechst U.K. Ltd. and FBC Ltd. with these products from 1979 - 1982.

METHODS AND MATERIALS

All trials were carried out on commercial cereal crops in East Anglia, the Midlands, Northern England and Scotland covering a wide range of cultivars. Soil types ranged from light sandy to heavy clay soils. No trials were conducted on sites with high organic matter. Trials were designed as randomised blocks with three replicates and a plot size of 10 – 15 m^2. Applications were made using van der Weij "AZO" small-plot precision sprayers at a pressure of 250 kPa delivering 200 (8001 Tee Jet) – 300 (80015 Tee Jet) l/ha through eight spray nozzles spaced 25 cm apart on 2 m spray booms. Broad-leaf weeds were assessed by counting plant numbers in ten 0.1 m^2 quadrats/plot in early Spring following pre-emergence or Autumn applications, or 4 – 6 weeks after Spring applications. Counts of grass seed heads or panicles were made in two 0.5 m^2 quadrats/plot as soon as all had emerged. Crop vigour assessments were made at regular intervals after application using the EWRS scale (Bolle, 1964), and yields were taken using a Hege small-plot combine harvester.

HOE 16410 5H used in all trials contained isoproturon and trifluralin (400 g/l). In early trials this was formulated as a wettable powder which has since been replaced by an aqueous dispersion, but comparison trials showed no difference in activity between the two formulations. Treatments of HOE 16410 5H were applied to Winter cereals pre-crop emergence between September 23rd and November 16th with a total of 83 trials carried out (harvest year 1979 – 10; 1980 – 16; 1981 – 26 total in two series).

HOE 16410 7H used in all trials contained isoproturon, ioxynil salt and mecoprop salt (480 g/l). In early trials this was formulated as a wettable powder, again being replaced by an aqueous dispersion which gave similar activity in comparison trials. All applications were made post-crop emergence with a total of 124 trials carried out between 1979 and 1982. In Winter cereals a total of 69 trials was sprayed in Autumn or early Spring with <u>A. myosuroides</u> from emergence to Zadoks 14,22 and broad-leaf weeds from emergence to young plant stage (harvest year 1979 – 5; 1980 – 12; 1981 – 26; 1982 – 26), and 21 trials sprayed in mid – late Spring with <u>A. myosuroides</u> beyond Zadoks 14,22 (all 1982). In addition, 34 trials were carried out in Spring cereals (harvest year 1981 – 6; 1982 – 28).

Isoproturon, as ®Arelon Liquid (540 g/l), was included in most trials as the comparison standard. Rates of use were as for current recommendations (i.e. 4.5 l/ha Autumn, 3.75 l/ha Spring). As no commercial recommendation exists for isoproturon alone on Spring cereals, a formulated mixture of isoproturon, ioxynil and bromoxynil (420 g/l total a.i.) was also included for comparison at 4.0 l/ha in these trials.

RESULTS

Data for weed control and relative yields from efficacy trials are presented separately for the two products in Tables 1 – 5.

<u>Crop Tolerance</u>

Applications of HOE 16410 5H to Winter wheat or Winter barley at higher-than-required doses for weed control have shown exceptionally good crop safety. Over all the trials, slight transient crop yellowing was seen occasionally on sites with rough seed beds, but effects were quickly outgrown. No varietal differences have been observed.

Similarly, applications of HOE 16410 7H to Winter or Spring wheat and barley have shown good crop selectivity and no varietal effects have been recorded.

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Table 1

HOE 16410 5H: % Control of *A. myosuroides* in Winter Cereals with Pre-emergence Applications (1979 - 1982)

Treatment	Rate g a.i./ha	Harvest Year 1979	1980	1981 (1)	1981 (2)	1982
HOE 16410 5H	2000	82	79	82	-	-
"	2400	93	85	90	-	-
"	2800	-	-	94	96	96
"	3200	-	-	97	97	97
"	4000	98	96	-	-	-
ISOPROTURON	2430	92	95	97	98	96
Untreated (seed heads/m^2)		340	380	763	146	391
Number of Trials		7	12	11	2	10

Table 2

HOE 16410 5H: % Control of Grass and Broad-leaved Weeds (excluding *A. myosuroides*) and Relative Yields in Winter Cereals (1981 - 1982)

Factor	No. of Trials	HOE 16410 5H 2800 g a.i./ha	HOE 16410 5H 3200 g a.i./ha	ISOPROTURON 2430 g a.i./ha
Stellaria media	21	97	99	97
Matricaria spp.	13	96	96	95
Veronica persica	16	98	99	23
Veronica arvensis	2	96	98	6
Veronica hederifolia	11	86	87	12
Galium aparine	7	53	56	32
Viola arvensis	10	83	87	38
Lamium purpureum	2	96	98	51
Papaver rhoeas	2	99	100	80
Aphanes arvensis	3	95	96	59
Myosotis arvensis	4	98	99	38
Capsella burse-pastoris	1	99	100	96
Mean all broad-leaved spp.		90	92	55
Poa annua	3	95	95	78
Avena fatua	9	82	82	76
Relative Yield (Untreated = 100)	24	149	150	139

Mean Untreated Yield = 5.02 t/ha

Table 3

HOE 16410 7H: % Control of Annual Grass and Broad-leaved Weeds and Relative Yields in Winter Cereals (1979 - 1982)

Factor	HOE 16410 7H 2400 g a.i./ha	HOE 16410 7H 2880 g a.i./ha	ISOPROTURON 2025 - 2430 g a.i./ha
Stellaria media	97 (20)	98 (17)	85 (12)
Matricaria spp.	97 (11)	99 (9)	86 (7)
Veronica persica	96 (17)	98 (16)	46 (6)
Veronica arvensis	99 (1)	99 (1)	-
Veronica hederifolia	96 (6)	97 (6)	65 (1)
Viola arvensis	77 (4)	82 (4)	60 (4)
Lamium purpureum	95 (2)	97 (2)	-
Aphanes arvensis	100 (2)	100 (2)	99 (2)
Polygonum aviculare	98 (5)	100 (3)	93 (4)
Galium aparine	92 (4)	97 (4)	48 (3)
Sinapis arvensis	100 (2)	100 (2)	-
Papaver rhoeas	100 (1)	100 (1)	94 (1)
Myosotis arvensis	98 (4)	98 (4)	33 (1)
Aethusa cynapium	100 (2)	100 (2)	-
Anagallis arvensis	100 (1)	100 (1)	100 (1)
Mean all broad-leaved spp.	96	97	75
Alopecurus myosuroides	91 (44)	94 (44)	96 (32)
Avena fatua	65 (5)	66 (5)	75 (4)
Poa annua	80 (6)	84 (5)	84 (6)
Poa trivalis	83 (3)	84 (3)	87 (3)
Apera spica-venti	100 (1)	100 (1)	100 (1)
Relative Yield (Untreated = 100)	129 (39)	132 (39)	143 (22)

Mean Untreated Yield = 4.28 t/ha ( ) = Number of Trials

Table 4

HOE 16410 7H: % Control of *Alopecurus myosuroides* - Application at Growth Stages beyond Zadoks 14,22 (1982)

Treatment	Rate g a.i./ha	% Control of *A. myosuroides*
HOE 16410 7H	3120	83
"	3840	90
ISOPROTURON	2025	87
Untreated (seed heads/m^2)		230
Number of Trials		13

Table 5

HOE 16410 7H: % Control of Grass and Broad-leaved Weeds and Relative Yields in Spring Cereals (1981 - 1982)

Factor	No. of Trials	HOE 16410 7H 2400 g a.i./ha	ISOPROTURON 1240 - 2025 g a.i./ha	ISOPROTURON, IOXYNIL, BROMOXYNIL 1680 g a.i./ha
Stellaria media	14	97	89	92
Matricaria spp.	3	100	100	100
Veronica persica	4	95	63	87
Veronica hederifolia	2	91	82	100
Viola arvensis	8	85	63	75
Lamium purpureum	2	90	25	90
Chenopodium album	5	99	92	96
Fumaria officinalis	4	98	86	87
Galeopsis tetrahit	5	97	81	87
Polygonum aviculare	5	90	79	76
Polygonum persicaria	4	96	67	82
Polygonum convulvulus	3	91	49	95
Polygonum lapathifolium	2	90	30	88
Sinapis arvensis	2	100	88	93
Spergula arvensis	1	100	100	100
Silene alba	1	100	46	100
Chrysanthemum segetum	1	100	97	100
Mean all broad-leaved spp.		95	73	92
Alopecurus myosuroides	5	91	90	90
Avena fatua	2	95	93	93
Poa annua	11	91	92	84
Relative Yield (Untreated = 100)	18	111	106	108

Mean Untreated Yield = 4.36 t/ha

DISCUSSION

HOE 16410 5H

Over 90% control of A. myosuroides was consistently obtained from isoproturon at 2430 g a.i./ha or HOE 16410 5H at 2800 g a.i./ha in each year the products were tested (Table 1). HOE 16410 5H also gave excellent control of a wide-spectrum of broad-leaf weeds including all the isoproturon-susceptible species (Table 2). Control of the isoproturon-resistant weeds, Viola arvensis and Veronica hederifolia, was usually sufficient to remove the need for specific follow-up treatments, leaving Galium aparine as the only species poorly controlled. Good control of other grass-weeds, including Poa spp. and Avena fatua, was also obtained. These findings confirm the reports of earlier studies with this mixture (Schumacher et al, 1980; Roa et al, 1981). They also support early work on weed control with trifluralin alone in Winter wheat by Kovacs and Mallegni (1970). In these trials good control of a range of broad-leaved weeds including Veronica spp. and Viola arvensis was obtained. It is clear in the mixture with isoproturon that the trifluralin component is responsible for increasing the broad-leaved weed spectrum. Furthermore, the addition of isoproturon to trifluralin is also increasing grass-weed control.

Consistent yield increases (mean = 50%) were seen in efficacy trials from HOE 16410 5H at 2800 or 3200 g a.i./ha, with isoproturon giving slightly lower increases associated with lower broad-leaved weed control (Table 2). Interpretation of yields from such trials is obviously complicated by weed competition effects, but yield data obtained from crop tolerance trials supports the crop safety of these materials from applications both pre- and during crop emergence at twice the above rates.

HOE 16410 7H - Winter Cereals

HOE 16410 7H at 2880 g a.i./ha gave comparable control of A. myosuroides to the standard isoproturon treatment when applied at growth stages of the weed up to Zadoks 14,22. Control from 2400 g a.i./ha was less consistent (Table 3). Efficacy on other grass-weeds, including Poa spp. and Avena fatua was also similar to isoproturon. The somewhat low control of these species resulted from applications at sites where the weeds were well-tillered. At growth stages of A. myosuroides beyond Zadoks 14,22 HOE 16410 7H at 3840 g a.i./ha was required to give equivalent control to isoproturon (Table 4). Efficacy levels in this trial series were generally low associated with the very dry Spring of 1982.

HOE 16410 7H at 2400 g a.i./ha gave consistently good control of most broad-leaf weed species, including Galium aparine and Veronica spp., with only Viola arvensis proving somewhat less susceptible (Table 3). The flexibility of this product ensures that broad-spectrum grass-weed and broad-leaf weed control is available over a long time period after emergence of the crop and weeds.

HOE 16410 7H - Spring Cereals

HOE 16410 7H at 2400 g a.i./ha also gave very good broad-spectrum weed control when applied post-emergence to Spring cereal crops (Table 5). Good control of all the isoproturon-resistant weeds was seen, and overall control was generally superior to the mixture of isoproturon, ioxynil and bromoxynil.

Conclusion

The data presented on HOE 16410 5H and HOE 16410 7H in this paper show that these mixtures based on isoproturon are valuable additions to the current range of cereal herbicides. From a single application they afford broad-spectrum weed control with the added flexibility of Autumn or Spring use on all crop varieties.

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REFERENCES

Bolle, F. (1964). Zum Bonitierungschema für die Prüfung Herbidizide Mittel. Nachrichtenblatt des Deutschen Pflanzenschutzdienstes, Stuttgart, 16, 92 - 94.

Hewson, R. T. (1974). Isoproturon, a new selective herbicide for control of Alopecurus myosuroides in Winter cereals. Proceedings 12th British Weed Control Conference 1974, 75 - 82.

Kovacs, A. I. and Mallegni, C. (1970). Weed control in Winter wheat with trifluralin in Italy. Proceedings 10th British Weed Control Conference 1970, 56 - 62.

Roa, L.; Erny, M. and Leterrier, J. L. (1981). Isoproturon + Trifluraline (1). Une nouvelle association pour le desherbage des orges d'hiver. Onzieme Conference du Desherbage, Colmna, Paris.

Schumacher, H.; Rotelle, M. and Manning, T H. (1980). A new pre-emergence herbicide for weed control in Winter cereals. Proceedings 1980 British Crop Protection Conference - Weeds, 267 - 274.

NEW HERBICIDE MIXTURES FOR FLEXIBLE TIMING POST-EMERGENCE BROAD-LEAF WEED CONTROL IN CEREALS

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Summary Alkali metal salts of benazolin + ioxynil + mecoprop or dichlorprop as aqueous concentrates applied post-emergence in the dose range 0.1 to 0.25 + 0.2 to 0.375 + 1.5 to 2.1 kg/ha ai, effectively controlled broad-leaf weeds in 1981 and 1982 UK cereal trials. The inclusion of benazolin conferred important advantages because of its high level of activity against Stellaria media and Galium aparine, and in mixtures based on mecoprop was more effective against these overwintering weeds than the standards or dichlorprop mixtures. Dichlorprop mixtures were however very effective against Polygonum spp.

Control of Veronica spp., the mayweeds Tripleurospermum spp., Anthemis spp. and Matricaria spp., Papaver rhoeas and Lamium spp. was satisfactory with all treatments.

Treatment with these mixtures over a wide range of growth stages was well tolerated by winter and spring barley and wheat, permitting flexibility in time of application and presenting no volatility hazard to adjacent crops. Benazolin, post-emergence, broad-leaf weed, non-volatile.

INTRODUCTION

In recent years ester based products containing hydroxybenzonitriles plus substituted phenoxypropionic acids have been extensively used in the United Kingdom for broad-spectrum control of dicotyledonous weeds in cereals. These products are well tolerated by the target crop over a wide range of growth stages but vapour drift from the mecoprop or dichlorprop ester component has on occasion caused unacceptable damage to adjacent susceptible crops. This problem can be readily resolved by changing to alkali metal salt formulations but an increased dose of mecoprop or dichlorprop is required to maintain effective weed control. This in turn increases the risk of cereal damage if applied post-jointing (ZCK 31 or later).

A fresh approach to the development of effective non volatile herbicide mixtures, whilst retaining good flexibility of application timing, was therefore necessary and this was accomplished by taking advantage of the valuable herbicidal properties of benazolin (Leafe, 1964, Lush et al., 1965, 1966 and 1968 and Rea et al., 1976). These include high activity against Stellaria media and Galium aparine, the synergising of weed response in herbicidal mixtures and good safety, both to cereals and neighbouring crops such as oil seed rape.

Mixtures tested extensively in the spring of 1981 and 1982, were based on alkali metal salt formulations of benazolin, ioxynil and mecoprop or dichlorprop, doses of the latter phenoxy components not exceeding 2.1 kg/ha. Results to date are discussed and yield data for 1982, although not yet available, will be presented to the conference in November.

METHODS AND MATERIALS

In 1981 tank mixes of the salts of benazolin + ioxynil + mecoprop or dichlorprop as aqueous concentrates were field tested to select the most effective combinations for further evaluation. Promising results from these trials stimulated an extensive development programme in 1982 with co-formulated mixtures.

Nine sites (8 winter wheat, 1 spring barley) in 1981 and twenty-five sites (16 winter wheat, 7 winter and 2 spring barley) in 1982 with moderate to heavy populations of broad-leaf weeds were selected to compare the efficacy of the experimental treatments with ester and salt based standard products. The stages of application ranged from ZCK 22 to ZCK 32 inclusive and at ten locations in the 1982 trials two stage ranges, ZCK 24-30 and ZCK 31-32, were compared.

Additional sites with little or no weed (4 winter wheat, 3 winter and 2 spring barley) on which experimental treatments and the ester standard were applied, were selected in 1982 for yield determination. Treatment at three growth stages, ZCK 30 or earlier, ZCK 31 and ZCK 32 were compared.

Tolerance of winter and spring wheat and barley cultivars was tested at another two sites in 1982 by spraying across a range of varieties drilled for this purpose.

Plot size ranged from 8-10 x 2-3 m with three replicates for weed observation trials to 20-40 x 3.5 m with 4-6 replicates for yield determination. Applications by precision knapsack and wheeled small plot sprayers were made in 200-300 l/ha of water at 200-250 k Pa.

Periodic visual assessments of crop tolerance and weed control were made on a percentage scale up to harvest. Yield will be taken with Massey Ferguson or Claas combines adapted for small plot work.

Treatment dose ranges were within the following limits:-

Year	Constituents	kg/ha ai
	Experimental mixtures	
1981	benazolin + ioxynil + mecoprop or dichlorprop as alkali metal salts (tank mix)	0.1 to 0.2 + 0.2 to 0.3 + 1.5 to 2
1982	benazolin + ioxynil + mecoprop or dichlorprop as alkali metal salts (co-formulated)	0.1 to 0.25 + 0.2 to 0.375 + 1.5 to 2.1
	Standard products	
1981& 1982	ioxynil + bromoxynil + mecoprop + linuron ester (5 l/ha)	0.25 + 0.25 + 1.4 + 0.5
1982	3,6-dichloropicolinic acid + ioxynil + mecoprop salt (4-5 l/ha)	0.06 to 0.075 + 0.22 to 0.25 + 1.8 to 2.25

Double the above doses were also applied in 1982 as a further test of crop tolerance.

RESULTS

1981 trials

Crop tolerance

Negligible to slight transient crop effects were recorded for all treatments. These were a little more pronounced for the ester standard (Table 1).

Table 1

Crop Tolerance 1981

(maximum effect recorded as percentage loss of vigour)

Site No.*	benazolin + mecoprop + ioxynil (salts) 0.1 to 0.2+0.2 to 0.3+1.5 to 2 kg/ha ai	benazolin + ioxynil + dichlorprop (salts) 0.1 to 0.2+0.2 to 0.3 +1.5 to 2 kg/ha ai	standard ester 5 l/ha (product)
1	5	7	7
2	0	5	10
3	5	5	10
4	5	5	10
5	0	0	0
6	7	7	10
7	5	5	5
8	0	0	0
9	0	5	0

* winter wheat (sites 1 - 8) spring barley (site 9)

Weed control

The major weeds of winter cereal, S. media, G. aparine, Veronica spp., Matricaria spp., and P. rhoeas were well controlled by the experimental treatments (Table 2). Against S. media the mecoprop mixtures were only slightly superior to those based on dichlorprop but much better than the standard, particularly at site 8 where the crop was uncompetitive.

Table 2

Weed Control 1981 June-July Assessment

(percentage score 0 = no effect, 100 = complete kill)

Site No.	S. media			Matricaria spp.			G. aparine			Veronica spp.		
	A	B	C	A	B	C	A	B	C	A	B	C
1	98	97	100	96	95	99	94	92	97	95	95	97
2	99	100	100	97	99	100		-	-	96	97	98
3	98	96	97	95	94	97		-	-	100	99	100
4	-	-	-	-	-	-	97	94	99	97	97	97
5	95	95	90	95	96	98	-	-	-	-	-	-
6	95	90	91	94	95	100	-	-	-	-	-	-
7	99	99	97	98	98	100	95	97	97	-	-	-
8*	93	87	82	94	84	98	-	-	-	-	-	-

Table 2 continued ......

Site No.	Papaver rhoeas			Polygonum convolvulus			Polygonum persicaria		
	A	B	C	A	B	C	A	B	C
1	97	94	100	100	100	100	-	-	-
2	97	94	100	100	99	100	-	-	-
3	99	100	100	98	97	99	-	-	-
9	-	-	-	-	-	-	88	92	100

A benazolin + ioxynil + mecoprop 0.1 to 0.2 + 0.2 to 0.3 + 1.5 to 2 kg/ha ai
B benazolin + ioxynil + dichlorprop 0.1 to 0.2 + 0.2 to 0.3 + 1.5 to 2 kg/ha ai
C ester standard product 5 l/ha
* thin uncompetitive crop

On the basis of these results with tank mix applications, co-formulated mixtures were selected for evaluation in 1982.

1982 trials

Crop tolerance

For all treatments, even at doses double those required for weed control, crop effects were restricted to an occasional slight transient retardation of vigour, with one exception. In this instance, severe damage occurred in winter wheat following application of the standard ester product at ZCK 32 in association with night frost (Table 3).

Table 3

Crop Tolerance 1982 (assessed at ZCK 59 or later)

(Number of sites in each tolerance range)

Application stages & tolerance range	benazolin + ioxynil mecoprop a	benazolin + ioxynil mecoprop b	benazolin + ioxynil dichlorprop a	benazolin + ioxynil dichlorprop b	standard products ester l/ha 5	standard products ester l/ha 10	standard products salt l/ha 5	standard products salt l/ha 10
ZCK 30 or earlier								
Total no. of sites	30	30	30	30	30	30	21	10
Tolerance range:								
0-5% crop effect	30	25	30	29	29	27	21	8
6-10% crop effect	0	4	0	0	1	3	0	2
10-15% crop effect	0	1	0	1	0	0	0	0
ZCK 31								
Total no. of sites	14	14	14	14	14	14	5	2
Tolerance range:								
0-5% crop effect	14	12	14	14	14	14	5	2
6-10% crop effect	0	2	0	0	0	0	0	0
10-15% crop effect	0	0	0	0	0	0	0	0
ZCK 32								
Total no. of sites	15	15	15	15	15	15	8	8
Tolerance range:								
0-5% crop effect	13	14	15	14	13	10	6	6
6-10% crop effect	1	1	0	1	1	4	1	1
10-15% crop effect	1	0	0	0	1	1*	1	1

a 0.1 to 0.25 + 0.2 to 0.375 + 1.5 to 2.1 kg/ha ai
b 0.2 to 0.5 + 0.4 to 0.75 + 3 to 4.2 kg/ha ai
* 15% effect in winter wheat associated with night frost at spraying

Weed control

All treatments performed well against the principal overwintering weeds, S. media, G. aparine, the mayweeds Tripleurospermum spp., Anthemis spp.and Matricaria spp., Veronica spp., P. rhoeas and Lamium spp. (Table 4). Of particular note, high doses of benazolin (0.2 to 0.25 kg/ha ai) in association with mecoprop greatly improved the level and reliability of S. media and G. aparine control. Results for these two species were frequently superior and never inferior to those achieved with all other treatments including the standards (Tables 4 and 5).

In particular, treatments based on benazolin + ioxynil + mecoprop in the range 0.2 to 0.25 + 0.2 to 0.25 and 1.68 to 2.1 kg/ha were the only ones to consistently achieve an excess of 90% control (Table 4). Of the fourteen sites infested with S. media, treatments in this range were superior to the ester standard in seven and to the salt standards in six comparisons. Correspondingly, in the six Galium aparine trials, control was superior to the ester standard on four and to the salt standard on three occasions (Table 5).

Against Polygonum aviculare and P. convolvulus, the dichlorprop mixtures were highly effective and superior to those based on mecoprop (Table 4).

Table 4

Weed control 1982 June-July Assessment

(mean percentage scores and number of sites)

Weed species	benazolin + ioxynil mecoprop c	d	benazolin + ioxynil dichlorprop c	d	standard products ester 5l/ha	salt 4-5l/ha
Stellaria media						
Mean score	97	94	92	90	93	93
Total no. of sites	14	14	14	14	14	14
no. scoring >90%	14	9	10	9	11	11
no. scoring <90%	0	5	4	5	3	3
Galium aparine						
Mean score	95	93	93	92	91	92
Total no. of sites	6	6	6	6	6	6
no. scoring >90%	6	5	5	5	5	4
no. scoring <90%	0	1	1	1	1	2
Tripleurospermum Anthemis & Matricaria spp.						
Mean score	93	90	90	91	88	95
Total no. of sites	11	11	11	11	11	11
no. scoring >90%	7	6	6	6	7	9
no. scoring <90%	4	5	5	5	4	2
Veronica spp						
Mean score	95	95	93	96	95	94
Total no. of sites	8	8	8	8	8	8
no. scoring >90%	8	8	5	8	7	8
no. scoring <90%	0	0	3	0	1	0
P. rhoeas						
Mean score	95	95	95	95	95	95
Total no. of sites	3	3	3	3	3	3
no. scoring >90%	3	3	3	3	3	3

Table 4 continued .....

Table 4 continued

Weed species	benazolin + ioxynil mecoprop c	d	benazolin + ioxynil dichlorprop c	d	standard products ester 5l/ha	salt 4-5l/ha
Lamium spp.						
Mean score	93	95	95	95	92	92
Total no. of sites	2	2	2	2	2	2
no. scoring >90%	2	1	2	2	1	1
no. scoring <90%	0	1	0	0	1	1
Polygonum aviculare						
Mean score	92	91	97	97	97	96
Total no. of sites	5	6	5	5	5	5
no. scoring >90%	4	4	5	5	5	5
no. scoring <90%	1	2	0	0	0	0
Polygonum convolulus						
Mean score	95	99	99	99	98	100
Total no. of sites	1	1	1	1	1	1

c 0.2 to 0.25 + 0.2 to 0.25 + 1.68 to 2.1 kg/ha ai
d 0.1 to 0.125 + 0.3 to 0.375 + 1.5 to 1.875 kg/ha ai

Table 5

Control of S. media and G. aparine 1982 with benazolin + ioxynil + mecoprop*

June-July Assessnent

Treatments	S. media (14 sites) mean score	range	G. aparine (6 sites) mean score	range
benazolin + ioxynil + mecoprop	97	(93-100)	95	(93-100)
ester standard	93	(84-93)	91	(83-96)
salt standard	93	(83-100)	92	(85-98)
Number of sites at which benazolin + ioxynil + mecoprop was superior to:				
salt standard	7		4	
ester standard	6		3	

* 0.2 to 0.25 + 0.2 to 0.25 + 1.68 to 2.1 kg/ha

DISCUSSION

The inclusion of benazolin in the experimental treatments has been of paramount importance in achieving effective and reliable weed control, whilst retaining safety to the target and neighbouring crops.

Two seasons' trials have shown that in combination with mecoprop, outstanding control of S. media and G. aparine can be achieved. In 1981 this was particularly demonstrated in uncompetitive crop conditions where benazolin + ioxynil + mecoprop treatments were clearly superior to the ester standard against S. media. In 1982 benazolin in the dose range 0.2 to 0.25kg/ha in association with mecoprop wasrequired for consistent control of S. media and G. aparine and without exception, levels of control in excess of 90% were obtained. Results were superior to those for the standards at half of the trials at which these weeds occurred and equal in the remainder.

Satisfactory control of other major overwintering weeds was also obtained with these mixtures.

With the inclusion of dichlorprop in the experimental mixtures, performance against Polygonum spp. has been particularly impressive and in crops, especially spring cereals, where weeds of these species constitute a major problem, benazolin + ioxynil + dichlorprop treatments would be of particular merit.

Although all treatments were well tolerated up to 2N dosage in the two seasons' trials over a wide range of crop growth stages, it is recognised that in farm usage occasional damage can follow mecoprop doses in excess of 2.5 kg/ha if applied post-jointing, (ZCK 31 or later). Apart from achieving first class control of S. media and G. aparine with benazolin + ioxynil + mecoprop mixtures within the dose range 0.2 to 0.25 + 0.2 to 0.25 + 1.68 to 2.1 kg/ha, the margin of crop safety for late spraying has thus been substantially increased.

Benazolin combinations with ioxynil and mecoprop or dichlorprop therefore offer an excellent potential for a range of flexible timing products for control of a wide spectrum of broad-leaf weeds in cereals, the precise constituents of which can be tailored to a variety of requirements. Because they are formulated as alkali metal salts there is no volatility hazard to neighbouring susceptible crops.

REFERENCES

Leafe, E. L. (1964), 4-chloro-2-oxobenzothiazolin-3-ylacetic acid - a new plant growth substance herbicide. Proceedings 7th British Weed Control Conference, 1, 32-37

Lush, G. B.; Leafe, E. L. and Mayes, A. J. (1965), Field experience with 4-chloro-2-oxobenzothiazolin-3-ylacetic acid. 2nd Symposium on new herbicides, European Weed Research Council, 201-209

Lush, G. B.; Mayes, A. J. and Rea, B. L. (1966), Field experience with benazolin in admixture with other herbicides, Proceedings 8th British Weed Control Conference, 1, 197-199

Lush, G. B.; Mayes, A. J. and Rea, B. L. (1968), Work on a new herbicidal mixture based on MCPA, dicamba and benazolin. Proceedings 9th British Weed Control Conference, 1, 228-232

Rea, B. L.; Palmer, R. A. and de St. Blanquat, A. (1976), Weed control in rapeseed with benazolin ester and 3,6-dichloropicolinic acid mixtures, Proceedings 1976 British Crop Protection Conference - Weeds, 2, 517-524

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THE CONTROL OF BROAD-LEAVED WEEDS IN CEREALS WITH COMBINATIONS OF BENTAZONE, DICHLORPROP AND CYANAZINE

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Summary. In trials over three years the addition of cyanazine to bentazone + dichlorprop was evaluated for broad leaved weed control in cereals. A mixture of bentazone + dichlorprop + cyanazine was shown to give improved weed control especially of the weed species *Stellaria media*, *Matricaria spp*, *Veronica spp* and *Lamium purpureum* compared to the mixture without cyanazine. Applications were made from crop GS 12 in the winter to crop GS 31 in the spring. Over this period the mixture gave improved weed control and was shown to be safe in crops of wheat and barley. Weed species not adequately controlled by the mixture were found to be *Viola arvensis*, *Myosotis arvensis* and *Poa annua*.

INTRODUCTION

The activity of bentazone alone and in mixture with dichlorprop for the control of broad leaved weeds in cereals was first reported by Behrendt (1970) and Jung et al (1970). The bentazone mixture with dichlorprop was shown to give excellent control of *Anthemis spp*, *Matricaria spp*. *Chrysanthemum segetum*, *Stellaria media* and *Galium aparine*. However, control of *Veronica spp*, *Polygonum aviculare* and *Viola tricolor* was poor.

The use of cyanazine in mixtures with dichlorprop was reported by Luckhurst et al (1972) and shown to give good control of a wide range of broad leaved weeds especially of the *Polygonum spp*. From this work and the original work with bentazone it was apparent that an increased weed spectrum might be obtained by using a mixture of bentazone, dichlorprop and cyanazine. Of particular benefit would be the control of *Veronica spp* and *Lamium purpureum* which have become an increasing problem in winter cereals in recent years.

METHODS AND MATERIALS

Replicated trials were of a randomised block design with plot sizes of 28 to 33.6 square metres. Treatments were applied by Van der Weij knapsack sprayer at a pressure of 250 kPa, at a water volume of 250 l/ha.

The nozzles used were Birchmeir cone 160 except for two trials in 1979 when fan nozzles were used.

Farmer usage trials were unreplicated treatments applied through a variety of farm sprayers with applications being made in 220-248 l/ha water at pressures of 270-300 kPa through fan nozzles.

Weed control was visually scored as percentage weed control compared to the untreated. The ground cover of weeds present was also recorded as a percentage.

Crop vigour was visually scored on a percentage scale relative to the untreated crop which was equal to 100%.

Crop injury was visually scored on a 0 - 10 scale with 10 being crop dead and 4 or less being commercially acceptable.

Formulations

1. Two formulations of bentazone were used:
   a. Aqueous solution containing 480 g/l a.i. as in 'Basagran'.
   b. Aqueous solution containing 260 g/l a.i. bentazone + 340 g/l a.i. dichlorprop as in 'Basagran DP'.
2. Cyanazine is an S.C. formulation containing 500 g/l a.i. as in 'Fortrol'.
3. Standard A containing cyanazine + mecoprop (240 + 1600 g/ha a.i.) applied as 4.0 l/ha 'Cleaval'.
4. Standard B containing bromoxynil, ioxynil + mecoprop (262 + 262 + 1312 g/ha a.i.) applied as 3.5 l/ha 'Brittox'.
5. Standard C containing trifluralin + linuron (960 + 480 g/ha a.i.) applied as 4.0 l/ha 'Chandor'.
6. Standard D containing [bromoxynil + ioxynil] and mecoprop ([570] + 2250 g/ha a.i.) applied as 1.5 l/ha of 'Deloxil' + 3.75 l/ha 'BASF CMPP Amine 60'.

RESULTS

Data for weed control and crop tolerance are given in Tables 1 - 7.

Table 1

% Weed control 2-4 weeks after application (1979)

Treatment	kg a.i./ha	Overall weed control	Stellaria Media	Polygonum aviculare	Lamium Amplexicaule
No. of trials		3	2	1	1
Bentazone + Cyanazine	0.77 0.3	95	96	75	96
Bentazone + Dichlorprop + Cyanazine	0.77 1.02 0.3	98	100	99	97
Bentazone + Dichlorprop	1.04 1.36	85	73	91	30
Untreated % Ground cover weeds		28.7 - 46.2	12.25	13.5	8.2
Weed size at application			2-6 leaf 20 cm diameter	15-20 cm	9 leaf

Table 2

Overall % weed control 6-8 weeks after application (1980)

Treatment	kg a.i./ha	Crop	Winter Wheat	Winter Barley	Spring Barley
No. of sites			8	3	1
Bentazone + Dichlorprop + Cyanazine	0.72 1.5 0.3		82	-	-
Bentazone + Dichlorprop	1.04 1.36		61	68	87
Standard A			65	-	-
Standard B			71	89	98
Bentazone + Dichlorprop + Cyanazine	0.48 1.5 0.2		(72)	91	98
Crop Growth Stage at Application			30 - 31	30	32
Untreated % Ground cover of weeds			59 - 84	36 - 75	35

( ) = 4 sites only

Table 3

% Control of different weed species in 8 Winter Wheat sites 1980

Weed species No. of sites	kg a.i./ha	A 5	B 3	C 3	D 2	E 4	F 4	G 2	H 1	I 2
Treatment										
Bentazone + Dichlorprop + Cyanazine	0.72 1.5 0.3	82	95	94	88	68	50	84	71	55
Bentazone + Dichlorprop	1.04 1.36	72	62	51	26	55	51	87	55	43
Standard A		50	75	80	83	61	37	70	60	34
Standard B		64	74	89	69	67	57	79	82	61
Untreated % ground cover (range) of weeds		25-53	18-31	18-36	5-6	9-32	4-14	12-21	20	15-17
Weed size at application		3-6lf	>20d	Fl	2-7d	3-5lf	6lf-5d	3-4lf	4lf	2-4d

lf - leaf no.
Fl = flowering
d = cm plant diameter

Key to weed species

A *Matricaria spp*
B *Stellaria media*
C *Veronica spp*
D *Lamium purpureum*
E *Viola arvensis*
F *Myosotis arvensis*
G *Papaver rhoeas*
H *Polygonum aviculare*
I *Alchemilla arvensis*

Table 4

Weed control obtained in 5 farmer usage trials with mixtures of Bentazone + Dichlorprop + Cyanazine - Winter 1981

Weed species	No. of trials	Mean % weed control	Weed size
Veronica spp	5	83	Cot - 8 leaves
Poa annua	3	30	1 - 4 leaves
Stellaria media	2	95	Cot - 25 cm diam
Matricaria spp	2	95	10 - 20 cm high
Lamium purpureum	2	88	-
Galium aparine	2	79	Cot - 8 leaves
Viola tricolor	2	48	Cot - 8 leaves
Urtica urens	1	100	5 - 8 cm high
Papaver rhoeas	1	85	2 - 8 leaves
Myosotis arvensis	1	10	2 - 10 leaves

All listed weed species occurred at above 5% ground cover level.

Two slightly different mixtures were used in these trials and the levels of kg/ha a.i. were either .57 + .75 + .32 or .72 + .94 + .25 of Bentazone, dichlorprop and cyanazine respectively.

Table 5

Overall weed control obtained from Winter applications on 4 sites in 1981/82

Treatment	Applcn. Date Crop GS	Site 1 7/12/81 13	Site 2 2/2/82 12-13	Site 3 15/2/82 22-24	Site 4 15/2/82 22
		% Overall weed control			
Untreated - % weed ground cover		19	4	10	10
Bentazone + Dichlorprop + Cyanazine	0.72 kg a.i./ha 0.94 kg a.i./ha 0.25 kg a.i./ha	74	100	98	100
Standard Product A or C		97[A]	100[C]	97[C]	100[C]

Main weeds and size at application

Site 1 = *Stellaria media*, *Myosotis arvensis*, 2 leaf
Site 2 = *Myosotis arvensis*, cot. *Matricaria spp*. cot. 2 leaf, *Galium aparine*, cot.
Site 3 = *Stellaria media* 2-6 leaf
Site 4 = *Stellaria media*, 3-4 leaf, *Veronica persica*, 3-4 leaf.

Table 6

Weed control obtained from Spring applications on 9 sites 1982

Treatment	kg a.i./ha	Site / Crop(1)	% Overall weed control 3-4 weeks after application									MEAN
			1 WW	2 WB	3 WW	4 WB	5 WB	6 WW	7 WB	8 WB	9 WB	
Untreated % Weed ground cover			17	51	23	53	39	10	63	94	54	
Bentazone + Dichlorprop + Cyanazine	0.72 0.94 0.25		99	58	87	63	89	69	60	96	92	79
Commercial Standard D			87	58	96	55	81	78	52	98	91	77
Main weed species(2)			ab	acd	a	acd	af	d	b	a	aceg	
Crop GS at application			26	25	30	25	26-30		30	30	26-30	

(1) WW = Winter Wheat
WB = Winter Barley

(2) Key to weeds and sizes at application

a = *Stellaria media*	10 - 20 cm diam.	lf = leaf
b = *Matricaria spp*	10 cm ht	Fl = flowering
c = *Myosotis arvensis*	5 cm - 10 lf	
d = *Viola arvensis*	Cot. - 8 lf	
e = *Galeopsis tetrahit*	Cot. - 2 lf	
f = *Lamium purpureum*	6 lf - Fl	
g = *Capsella bursa-pastoris*	Cot. - 2 lf	

Table 7

Crop Safety of the Bentazone, Dichlorprop and Cyanazine Mixture

Frequency distribution of sites showing crop injury in categories - 1980

Treatment	kg/ha a.i.	0 - 1.9	2.0 - 2.9	3.0 - 4.0	Over 4.0
Bentazone + Dichlorprop + Cyanazine	0.72 1.5 0.3	7	2	3	0
Standard A		3	2	3	0
Standard B		7	2	3	0

Frequency distribution of sites showing crop vigour - 1979-1982

Treatment	kg/ha a.i.	80 - 90	90 - 99	100	101 - 110
Bentazone + Dichlorprop + Cyanazine	0.72 1.5 0.3	1	4	13	3
Standard A		1	2	1	3
Standard B		0	3	4	3
Standard D		0	1	8	0

DISCUSSION

Weed Control

In 1979 the first trials were carried out to investigate the effect of adding cyanazine to bentazone or bentazone + dichlorprop. These results showed that the cyanazine mixtures gave increased overall weed control and this is illustrated by the results for Stellaria media and Lamium amplexicaule (Table 1).

In 1980 the work was continued with two mixtures of bentazone + dichlorprop + cyanazine (Table 2). The cyanazine mixtures again gave a marked increase in the overall level of weed control obtained compared to both the commercial bentazone + dichlorprop formulation and the two other commercial standards used. This was especially true of Stellaria media, Veronica spp and Lamium purpureum (Table 3). In these trials there was a considerable range of weed size and ground cover and so a good evaluation of these mixtures was possible.

In 1980/81 with the increasing awareness of the need to control weeds early in the life of the cereal crop, five farmer usage trials were carried out during the winter (Table 4). The applications were made between November and January with a number of applications being preceded by or followed by cold temperatures including night frosts and no crop damage was recorded. The levels of weed control obtained with the two mixtures based on bentazone + dichlorprop + cyanazine were good especially of the major weed Stellaria media, Veronica spp, Lamium purpureum and Matricaria spp.

The weaknesses in the bentazone mixtures were shown to be Viola tricolor, Myosotis arvensis and Poa annua.

To evaluate further the Autumn/Winter usage of this mixture, four trials were carried out during December 1981 and February 1982. The level of weed control obtained by the bentazone + dichlorprop + cyanazine mixture was generally excellent and equal to the commercial standard on 3 sites (Table 5). On Site 1 the high level of the relatively poorly controlled Myosotis arvensis reduced the overall level of weed control.

In 1982 the now commercially recommended bentazone + dichlorprop formulation + cyanazine tank mixture was included in nine replicated trials to obtain further information (Table 6). The levels of overall weed control were variable especially where the main weed species present were those already known to be relatively poorly controlled. The level of ground cover by weeds in these trials was generally high and this gave a reliable evaluation of weed control. Overall the bentazone mixture gave similar levels of weed control to the standard which contained bromoxynil + ioxynil + mecoprop. Applications were all made between GS 25 and GS 30.

Crop Safety

Over all trials, over the three years, the levels of crop effect on wheat and barley were commercially acceptable (Table 7). There was an indication that winter wheat crops under stress due to drought or other reasons showed more crop effect especially where cyanazine was incorporated in the mixture.

Yields

The yields obtained with the bentazone + dichlorprop and cyanazine mixtures generally compared favourably with the commercial standards and are available on request to the authors.

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REFERENCES

Behrendt, S. (1970). Results obtained from use of 3 - Isopropyl - 2,1,3 - Benzo Thiadiazinon - 4 - 2,2 - Dioxide in Cereals. Proceedings 1970 British Crop Protection Conference - Weeds, 1, 38-43.

Jung, K.U.; May H.C. (1970). Field Trials in the U.K. with 3 - Isopropyl - 2, 1, 3 - Benzo Thiadiazinon - 4 - 2, 2 - Dioxide (BAS 351H) for the control of broad leaved weeds in cereals. Proceedings 1970 British Crop Protection Conference - Weeds, 1, 44-49.

Luckhurst, R.J.; Allen, M.C.: O'Doherty P.C. (1972). The Use of Cyanazine Mixtures for Weed Control in Cereals. Proceedings 1972 British Crop Protection Conference - Weeds, 2, 698-708.

Proceedings 1982 British Crop Protection Conference - Weeds

ANNUAL BROAD-LEAVED WEED CONTROL IN WINTER CEREALS - ADAS 1982 RESULTS

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Summary. Two series of ADAS experiments are reported. In Series I the weed control from various pre-emergence herbicides was compared with a standard post-emergence treatment of bromoxynil + ioxynil + mecoprop ester applied in the winter or spring. Pendimethalin and chlorsulfuron + methabenzthiazuron gave the highest total weed control, higher than the standard post-emergence treatment. The control of 4 main weeds, species *Stellaria media*, *Galium aparine*, *Viola arvensis* and *Veronica spp* is discussed.

Series II compared post-emergence herbicides applied in the winter or spring. A promising repeat low dose treatment of bromoxynil + ioxynil tank mixed with mecoprop salt was included on three sites. Of the winter applied treatments bifenox + mecoprop and bromoxynil + ioxynil + mecoprop gave the highest % weed control. There were few differences between spring treatments.

Pre-emergence, post-emergence, Stellaria media, Galium aparine, Viola arvensis, Veronica spp.

INTRODUCTION

At the 1978 and 1980 British Crop Protection Council Weed Conferences, ADAS trials on the comparison of annual broad-leaved weed control in winter wheat and winter barley in the winter or spring were reviewed (Evans and Harvey, 1978 and Orson, 1980). ADAS results from this series were also reported at the 1982 Association of Applied Biologists Conference (Broad-leaved Weeds and their control in cereals) (Orson, 1982). The results showed that there was little yield advantage from autumn broad-leaved weed control compared with control in the spring at crop pseudo-stem erect stage. The effectiveness of the various chemicals on a few problem weeds was analysed (Smith, 1982). Experimental work has continued in the 1981/82 season which is summarised in this paper. The paper also incorporates some data from the earlier work referred to above.

METHOD AND MATERIALS

With the increased number of chemicals available for broad-leaved weed control in cereals the experimental series was split into 2. Series I compared a range of pre-emergence herbicide with product 'Brittox' containing bromoxynil + ioxynil + mecoprop applied in the winter or spring. Series II compared a range of post-emergence chemicals applied at the same timings. The winter applications were from the crop 2 leaf to 3 tiller stage. The intention had been to apply all the winter treatments at the crop 2 leaf stage, but snow prevented spraying some sites until GS 23 in February/March. The spring treatments were all at crop GS 30 (late February to April). The sequential low dose treatment was applied at the winter timing and then repeated in late April or May when the main flush of spring weeds had emerged (crop GS 31-32).

There were 8 sites for Series I (4 in Eastern, 1 in South Western, 2 in South Eastern and 1 in Northern Region) and 5 in Series II (3 in Eastern, 1 each in South Western and South Eastern region). The trials were laid down on commercially grown cereal crops on inorganic soils, textures ranging from sandy loam to silty clay loam. The treatments were applied with knapsack sprayers at a pressure of 220 kPa in 225 l/ha water. The repeat low dose treatment was applied in 100 l/ha water at 300 kPa. A randomised block design was used with 3 replicates, plot size range was 25-80 m^2. Weed control was assessed either by counting number of weeds in several quadrats per plot or by a visual score of each plot when there was a dense weed population and numbers could not be counted. Weed control was usually assessed at least twice. Results presented are taken from the date of the last full assessment, 4 to 8 weeks after the final treatment. Results are expressed on a 0-100% mortality scale where 0 is equivalent to the untreated control.

Herbicide details are shown in Tables 1 and 3. Rates of chemicals were as commercially recommended according to soil type. Yield data was not available at the time of publishing this paper, but will be available on request to the authors.

RESULTS

The Series I percentage weed mortality mean results are presented in Table I. Pendimethalin (1.33 kg ai/ha) and chlorsulfuron + methabenzthiazuron (pre-em) gave higher overall weed control than the post-emergence bromoxynil + ioxynil + mecoprop applied in the winter or spring. The pre-emergence treatments linuron + monolinuron and cyanazine, gave the lowest overall weed control.

Table I

Series I - Percentage total broad-leaved weed mortality 1982

Treatment	Dose/ha kg/ai	Mean Mortality	Range of Mortality	Number sites
Pre-emergence				
linuron + trifluralin	0.6 + 1.2	64	(40-88)	7
linuron + trifluralin (gran)	0.6 + 1.2	60	(25-85)	6
methabenzthiazuron	1.56	59	(29-86)	5
terbutryne	1.5	59	(32-82)	7
bifenox + linuron	1.7-2.42	62	(33-99)	6
pendimethalin	1.0	73	(58-98)	7
pendimethalin	1.33	82	(63-100)	7
linuron + trifluralin + trietazine	1.54	59	(37-84)	4
linuron	0.75	56	(23-75)	7
cyanazine	2.25	48	(14-70)	6
linuron + monolinuron	1.0	52	(30-83)	7
chlorsulfuron + methabenzthiazuron	1.75	77	(62-89)	5
Post-emergence winter				
bromoxynil + ioxynil + mecoprop	1.31	73	(46-99)	7
chlorsulfuron + methabenzthiazuron	1.75	69	(23-93)	5
Post-emergence spring				
bromoxynil + ioxynil + mecoprop	1.84	69	(59-93)	7

Table 2

% Mortality of 4 major broad-leaved weed species ADAS trials 1979 to 1982

Treatment	Mean % weed mortality							
	Stellaria media		Galium aparine		Viola arvensis		Veronica spp	
	Mortality	Number sites	Mortality	Number sites	Mortality	Number sites	Mortality	Number sites
Pre-emergence								
linuron + trifluralin	73	20	25	9	43	14	73	13
methabenzthiazuron	56	18	13	6	33	14	61	13
terbutryne	73	22	27	9	48	14	50	14
bifenox + linuron	70	8	45	6	84	5	62	6
pendimethalin (1.33 kg ai)	88	17	40	8	64	12	96	9
linuron + trifluralin + trietazine	80	3	35	2	35	2	76	4
linuron	89	12	17	6	68	8	36	11
cyanazine	79	6	27	4	34	3	50	3
linuron + monolinuron	75	17	13	8	36	12	35	9
chlorsulfuron + methabenzthiazuron	98	4	84	4	35	1	73	3
Post-emergence winter								
bromoxynil + ioxynil + mecoprop	69	23	67	10	53	14	68	14
chlorsulfuron + methabenzthiazuron	100	5	86	4	10	2	83	2
Post-emergence spring								
bromoxynil + ioxynil + mecoprop	69	23	70	9	39	14	76	15

*1982 trials only
Herbicide doses are as in Table I

Table 2 shows control levels of 4 major weed species in Series I collated with the 1979-81 results (Smith, 1982).

<u>Stellaria media</u>. All pre-emergence treatments except methabenzthiazuron controlled the weed better than the spring applied herbicide. Treatments with pendimethalin, chlorsulfuron + methabenzthiazuron and linuron gave over 85% control. <u>Stellaria media</u> was the most commonly occurring weed in these trial series.

<u>Galium aparine</u>. Weed control levels from most of the pre-emergence herbicides were low. Only chlorsulfuron + methabenzthiazuron (pre and post-em) gave over 70% mean control. The next most effective pre-emergence treatments were pendimethalin and bifenox + linuron which gave only 40 and 45% mean control. Winter and spring bromoxynil + ioxynil + mecoprop treatments gave 67 and 70% control respectively.

<u>Viola arvensis</u>. This weed occurred as commonly in the trial series as <u>Veronica spp</u>. Populations of the weed ranged from 14-208 plants/m^2. Bifenox + linuron, linuron and pendimethalin gave the highest mean % weed control (84, 68 and 64% respectively). Winter application of the standard post-emergence treatment was superior to the spring treatment but less effective than the best pre-emergence herbicides.

<u>Veronica spp.</u> Mean control did not exceed 50% with terbutryne, bifenox + linuron, linuron ± monolinuron and cyanazine. Pendimethalin and chlorsulfuron + methabenzthiazuron (post-em) gave the highest percentage control

<u>Table 3</u>

<u>Series II - Percentage total weed mortality 1982</u>

<table>
<tr><th rowspan="3">Treatment</th><th rowspan="3">Dose/ha kg/ai</th><th colspan="2">Mean % Mortality</th><th rowspan="3">Number sites</th></tr>
<tr><th colspan="2">Treatment timing</th></tr>
<tr><th>winter (b)</th><th>spring (c)</th></tr>
<tr><td>ioxynil + bromoxynil (*)</td><td>0.38</td><td>52</td><td>-</td><td>5</td></tr>
<tr><td>mecoprop salt</td><td>2.5</td><td>46</td><td>74</td><td>5</td></tr>
<tr><td>bromoxynil + ioxynil) + mecoprop (ester))</td><td>1.31 (b) or 1.84 (c)</td><td>81</td><td>74</td><td>5</td></tr>
<tr><td>cyanazine + mecoprop</td><td>1.84</td><td>71</td><td>87</td><td>5</td></tr>
<tr><td>bifenox +) mecoprop)</td><td>1.95 (b) or 2.6 (c)</td><td>82</td><td>83</td><td>5</td></tr>
<tr><td>3,6-dichloropicolinic) acid + mecoprop + ioxynil)</td><td>2.06</td><td>57</td><td>86</td><td>5</td></tr>
<tr><td>ioxynil (*)</td><td>0.56</td><td>70</td><td>-</td><td>5</td></tr>
<tr><td>bromoxynil + dichlorprop (*)</td><td>1.25</td><td>59</td><td>-</td><td>5</td></tr>
<tr><td>bentazone + dichlorprop + cyanazine</td><td>0.96</td><td>74</td><td>86</td><td>3</td></tr>
<tr><td>△ bromoxynil + ioxynil) + mecoprop (salt) (*))</td><td>0.27 + 0.83</td><td colspan="2">95</td><td>3</td></tr>
<tr><td>Mean 6 herbicides excluding (*)</td><td></td><td>69</td><td>82</td><td></td></tr>
</table>

△ Repeat low dose treatment of bromoxynil + ioxynil tank mixed with mecoprop salt applied in winter and spring.

Mean percent weed mortality for series II trials is presented in Table 3. Spring treatments generally gave higher % weed control than winter treatments. Of the winter treatments bifenox + mecoprop and bromoxynil + ioxynil + mecoprop ester gave highest % weed control. There were few differences between spring treatments. The repeat low dose treatment of bromoxynil + ioxynil tank mixed with mecoprop salt gave a mean of 95% control of the broad-leaved weeds.

Table 4

Winter compared with spring control of broad-leaved weeds
ADAS mean results 1978 to 1982 (5 years)

Treatment	Winter barley Mean % weed control	Winter barley Number of sites	Winter wheat Mean % weed control	Winter wheat Number of sites
Post-emergence winter				
bromoxynil + ioxynil + mecoprop (ester)	80	(11)	59	(25)
mecoprop (salt)	47	(11)	50	(24)
Post-emergence spring				
bromoxynil + ioxynil + mecoprop (ester)	73	(13)	74	(27)
mecoprop (salt)	57	(11)	61	(24)

In Table 4 1982 weed control results are collated with previous results from 1978 to 1981 (Orson, 1980 and Orson, 1982). The table distinguishes between results on winter wheat and winter barley with mecoprop ± ioxynil + bromoxynil applied in winter or spring.

DISCUSSION

In the series I trials pendimethalin and chlorsulfuron + methabenzthiazuron produced higher overall broad-leaved weed control than the other residual herbicide treatments which all gave under 70% mean weed control. This may have been due to the greater persistence of the more effective materials in a year when weeds germinated late in the spring. The pre-emergence treatments generally gave over 70% control of Stellaria media. Veronica spp were generally controlled less well with the exception of pendimethalin. The control of Viola arvensis was very variable. It is not surprising that populations of this weed are increasing when the majority of products gave less than 50% control. Galium aparine was the most difficult weed to control; the new herbicide chlorsulfuron + methabenzthiazuron looked promising and gave the highest level of control.

In the series II trials after the very hard winter many weeds were slow to germinate in the spring. Generally there was a higher percent weed control from spring compared with winter treatment. The repeat low dose treatment with bromoxynil + ioxynil tank mixed with mecoprop salt produced very good weed control, higher than any other treatment. More work will be done on this promising technique.

Table 4 weed control results show that winter applied bromoxynil + ioxynil + mecoprop was more effective in winter barley than in winter wheat. This mixture was more effective than mecoprop salt. The latter gave a higher percent weed control when applied in the spring rather than in the winter on winter wheat and barley.

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REFERENCES

EVANS, S.A. & HARVEY, J.J. (1978) Annual broad-leaved weed control in winter wheat : autumn and spring treatments compared. Proceedings 1978 British Crop Protection Conference - Weeds, 1, 41-48

ORSON, J.H. (1980) Annual broad-leaved weed control in winter cereals, wheat and winter barley : autumn and spring treatments compared. Proceedings 1980 British Crop Protection Conference - Weeds, 1, 251-258

ORSON, J.H. (1982) Annual broad-leaved weed control in winter cereals, wheat and winter barley : autumn and spring treatments compared. Aspects of Applied Biology 1, Broad-leaved weeds and their control in cereals, 43-51

SMITH, J. (1982) The control of common chickweed (*Stellaria media*), cleavers (*Galium aparine*), speedwells (*Veronica spp*) and field pansy (*Viola arvensis*) in winter cereals, ADAS results 1979-81. Aspects of Applied Biology 1, Broad-leaved weeds and their control in cereals, 43-51