Click here for previous

REFERENCES

AYRES, P. (1980). The implications of high speed low volume spraying for the efficiency of herbicides used in winter cereals. *Proceedings British Crop Protection Conference—Weeds,* **3,** 973-979.

CUSSANS, G. W. & AYRES, P. (1978). A feasibility study on a low ground pressure spraying vehicle. *Proceedings British Crop Protection Conference—Weeds,* **2,** 633-640.

CUSSANS, G. W., MOSS, S. R., POLLARD, F. & WILSON, B. J. (1979). Studies of the effects of tillage on annual weed populations. *Proceedings EWRS Symposium on the Influence of Different Factors on the Development and Control of Weeds,* 115-122.

ELLIOTT, J. G., CHURCH, B. M., HARVEY, J. J., HOLROYD, J., HULLS, R. H. & WATERSON, H. A. (1979). Survey of the presence and methods of control of wild-oat, black-grass and couch grass in cereal crops in the United Kingdom during 1977. *Journal of Agricultural Science, Cambridge,* **92,** 617-634.

ELLIOTT, J. G. (1980). The economic significance of weeds in the harvesting of grain. *Proceedings British Crop Protection Conference—Weeds,* **3,** 787-796.

FROUD-WILLIAMS, R. J. (1981a). *The effect of reduced cultivation systems on arable weed floras, with emphasis on factors likely to influence germination and establishment.* Ph.D. Thesis, University of Reading.

FROUD-WILLIAMS, R. J. (1981b). Germination behaviour of *Bromus* species and *Alopecurus myosuroides. Association of Applied Biologists Conference on Grass Weeds in Cereals in the United Kingdom,* 31-40.

MANTLE, P. G. & SHAW, S. (1977). Role of weed grasses in the etiology of ergot disease in wheat. *Annals of Applied Biology,* **86,** 339-351.

MOSS, S. R. (1978a). The effect of aminotriazole, glyphosate and paraquat applied to *Alopecurus myosuroides* seeds. *Proceedings British Crop Protection Conference—Weeds,* **2,** 483-489.

MOSS, S. R. (1978b). The effect of straw disposal method and cultivation on *Alopecurus myosuroides* populations and on the performance of chlortoluron. *Proceedings British Crop Protection Conference—Weeds,* **1,** 107-112.

MOSS, S. R. (1979a). The influence of tillage and method of straw disposal on the survival and growth of black-grass, *Alopecurus myosuroides,* and its control by chlortoluron and isoproturon. *Annals of Applied Biology,* **91,** 91-100.

MOSS, S. R. (1979b). Black-grass—a threat to winter cereals. *Technical Leaflet,* ARC Weed Research Organization, **15,** pp. 3.

MOSS, S. R. (1980a). The agro-ecology and control of black-grass, *Alopecurus myosuroides* Huds., in modern cereal growing systems. *ADAS Quarterly Review,* **38,** 170-191.

MOSS, S. R. (1980b). Some effects of burning cereal straw on seed viability, seedling establishment and control of *Alopecurus myosuroides* Huds. *Weed Research,* **20,** 271-276.

MOSS, S. R. (1980c). A study of populations of black-grass (*Alopecurus myosuroides*) in winter wheat, as influenced by seed shed in the previous crop, cultivation system and straw disposal method. *Annals of Applied Biology,* **94,** 121-126.

MOSS, S. R. (1981a). The response of *Alopecurus myosuroides* during a four year period to different cultivation and straw disposal systems. *Association of Applied Biologists Conference on Grass Weeds in Cereals in the United Kingdom,* 15-21.

MOSS, S. R. (1981b). Techniques for the assessment of *Alopecurus myosuroides. Association of Applied Biologists Conference on Grass Weeds in Cereals in the United Kingdom,* 101-107.

MOSS, S. R. (1982). Seed production and shedding of *Alopecurus myosuroides* Huds., in winter cereal crops. *Weed Research* (in press).

NYFFELER, A. & BLAIR, A. M. (1978). The influence of burnt straw residues or soil compaction on chlortoluron and isoproturon activity. *Proceedings British Crop Protection Conference—Weeds,* **1,** 113-119.

PHILLIPSON, A. (1974). Survey of the presence of wild-oat and black-grass in parts of the United Kingdom. *Weed Research,* **14,** 123-135.

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 in a clay loam soil and a silt loam soil. *Weed Research* (in press).

WILSON, B. J. (1979). The effect of controlling *Alopecurus myosuroides* Huds. and *Avena fatua* L. individually and together, in mixed infestations on the yield of wheat. *Weed Research,* **19,** 193-199.

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.

Controlling weeds during grass establishment

F W KIRKHAM, R J HAGGAR and J G ELLIOTT

More than half the land in agricultural production in the UK is under grass. About 30 per cent of this grass is less than five years old, an area equal to more than half that currently in cereal production. Thus, temporary grass is a very significant element in UK agriculture and is undoubtedly worthy of more agronomic attention than it has received in the past, particularly at the establishment stage.

Baker (1962), and Morrison and Idle (1972), have shown that many sown swards are rapidly invaded by native species which can occupy more than 50 per cent of the sward within 12 months of sowing. One recent survey (Haggar, 1979a) revealed that broad-leaved weeds, particularly common chickweed (*Stellaria media*), and weed grasses, particularly the meadow-grasses (*Poa* spp.) and volunteer cereals, were a problem in about half the swards surveyed, most of which were autumn-sown.

Rye-grasses constitute about 90 per cent of all the grass sown in the UK and all but a small and declining proportion of these are perennial rye-grasses. This reflects a trend towards long-term leys resulting largely from increased establishment costs.

PAST TO PRESENT

Herbicides have been available to control broad-leaved weeds in young grass since the introduction of MCPA and 2,4-D in the 1940's, followed by the development of mecoprop and dicamba in the early 1960's. WRO work in the late 1960's demonstrated that control of indigenous grasses in young rye-grass was possible (Blair & Holroyd, 1968). Methabenzthiazuron, used either pre- or post-emergence, was the most promising herbicide to emerge at that time (Blair, 1970). Subsequent WRO work also confirmed the potential of ethofumesate applied pre-emergence (Blair, 1972). Methabenzthiazuron was approved in 1974 for weed grass control in direct-sown rye-grass seed crops; approval of ethofumesate followed in 1975. Blair *et al.* (1976) showed that methabenzthiazuron could also be used pre-emergence in spring barley undersown to rye-grass. Haggar (1979b) demonstrated that, applied pre-emergence, it compared favourably with cultural techniques for reducing weed ingress and increasing the long-term survival of rye-grass in a spring-sown sward.

WRO herbicide work was complemented by competition studies between rye-grass and meadow-grasses which emphasised the need for early control of these species, preferably by pre-emergence treatments (Wells & Haggar, 1974; Haggar, 1979c). Early competition from meadow-grasses reduced tillering and dry matter production of rye-grass, although total dry matter production was not always impaired in the short term. Subsequent field trials in establishing autumn-sown leys showed that the control of annual meadow-grass and chick-weed considerably improved rye-grass establishment and herbage production (Haggar & Bastian, 1976; Haggar & Passman, 1978; Haggar & Kirkham, 1981). In one of these trials, pre-emergence applications of ethofumesate and methabenzthiazuron were compared for their long-term effects on sward composition and yield (Haggar & Kirkham, 1981). Spraying with ethofumesate produced swards with a very high rye-grass content, leading to increased dry matter production over two harvest years.

CURRENT RECOMMENDATIONS

By 1978, WRO work had encouraged Fisons (now FBC) to extend their recommendations for ethofumesate to include leys. Methabenzthiazuron is now also approved for use in leys, but only in perennial rye-grass either direct-sown or undersown in spring barley or wheat. As yet these are the only two herbicides recommended for the control of both broad-leaved and grass species in establishing swards, although several others are available for broad-leaved weed control. The use of these two herbicides is fairly complementary; ethofumesate works best in the cooler months of autumn and winter, while methabenzthiazuron is more appropriate for use between March and October. However, both herbicides are damaging to clovers.

FURTHER OPTIONS

Current recommendations for methabenzthiazuron in grassland are restricted to perennial rye-grass and do not include an early post-emergence treatment. However, several Italian and hybrid rye-grasses can tolerate both pre- and early post-emerence spraying, although there are differences between varieties (Kirkham, 1981).

Recent work at WRO has concentrated on achieving adequate weed control in swards sown in the autumn without a cover crop, since this is rapidly becoming the most popular time and method of establishing grasses. In this situation, ethofumesate has proved more reliable than methabenzthiazuron, although, at the current prices and recommended rates, the treatment is at least three times as expensive. Furthermore, although ethofumesate is fairly persistent during the colder months (Haggar & Passman, 1981), spraying in early autumn does not prevent subsequent weed ingress during the early spring (Haggar & Kirkham, 1981). This can be particularly heavy when autumn grazing or a severe winter have left a weakened or thin sward. Successive applications of lower doses of these two herbicides can prolong the period of activity and cut herbicide costs by 30-50 per cent compared with the recommended ethofumesate treatments (Kirkham & Haggar, 1982).

A third herbicide, metamitron, has recently been tested for pre-emergence control of annual meadow-grass and chickweed in a rye-grass sward, following promising results in the glasshouse (Richardson *et al.*, 1976; Kirkham & Richardson, 1981) and in preliminary field trials (Kirkham, unpublished). Alone, and in mixture with methabenzthiazuron, it controlled annual meadow-grass more economically than ethofumesate, although it was less effective against chickweed. Mixing ethofumesate with metamitron improved chickweed control but with no real cost benefit over ethofumesate on its own.

Plant breeders in Northern Ireland have introduced a novel approach to weed control by breeding increased resistance to specific herbicides into rye-grass cultivars (Faulkner, 1975). Both dalapon- and paraquat-resistant cultivars have been bred, although the increased resistance to dalapon is not evident until the plants are fairly well established. With paraquat-resistant cultivars, the difference is noticeable from the one-leaf stage onwards and, at WRO, paraquat controlled annual meadow-grass, chickweed and creeping bent (*Agrostis stolonifera*) without damaging establishing plants of either the resistant rye-grass cultivar Stormont Causeway or the white clover cultivar Blanca (Kirkham, 1980). However, there are marked differences in resistance between white clover cultivars, those with larger leaves being generally more resistant than those with smaller leaves.

In recent WRO work in the glasshouse, the tolerance of soil-acting herbicides by perennial rye-grass has been increased by dressing the seed with safeners (Richardson & Kirkham, in press). The phytotoxicity of seven out of sixteen herbicides applied pre-emergence was significantly reduced by dressing the rye-grass seed with naphthalic anhydride. Another compound, R-25788, also gave protection against two of the herbicides. These results are being followed up in a field trial in 1982.

A SYSTEMATIC APPROACH TO SWARD ESTABLISHMENT

The WRO initiative, maintained since the 1960's, has helped to stimulate more interest in the establishment and maintenance of temporary grass. Indeed, it was at the instigation of WRO that a British Grassland Society symposium was held in December 1980 to produce guidelines for establishing grass swards. Forty-six people actively involved in various aspects of grassland management were present, including representatives from nine research establishments, six chemical companies, three seed companies, various ADAS regions, the North of Scotland College of Agriculture, and the University College of North Wales.

Some useful definitions and criteria were established. For instance, a sward was considered to be established by the April of the year after sowing; at this stage the target tiller populations for crops grown for conservation were agreed to be 6,000 per m^2 for perennial rye-grass and 2,000 per m^2 for Italian rye-grass. By the same date a grazed perennial rye-grass sward should contain at least 20,000 tillers per m^2. To achieve these targets would require establishing 200-400 plants per m^2, depending on sowing date; even so this could probably be achieved by using less than half the amount of seed which is usually sown provided weeds, pests and diseases are all adequately controlled.

CURRENT WRO RESEARCH

The threshold population levels at which specific weeds begin to affect sward productivity in either the short- or the long-term need to be defined. This is particularly true of invading grasses which are less likely to affect the harvesting and utilization of herbage than many broad-leaved species and are also more likely to persist. Furthermore, because rye-grass cultivars differ markedly in speed of establishment and growth habit, they may also differ in their susceptibility to weed invasion. Therefore, current work aims to establish how the choice of crop cultivar and the density of the grass weeds can influence the benefits to be gained from weed control.

A comparison of 'weedy' versus 'non-weedy' swards has already shown that perennial rye-grasses are more susceptible to invasion by black-grass (*Alopecurus myosuroides*) and annual meadow-grass during establishment than Italian or hybrid cultivars; in this respect perennial rye-grass cultivars also show some differences (Fig. 1A & B). In a second experiment, annual meadow-grass populations of 2,800 and 6,000 plants/m^2, recorded six weeks after sowing in September, reduced perennial rye-grass yields in the following June by about 18 per cent and 45 per cent respectively, compared to sprayed plots. However, populations of up to 7,000 per m^2 caused only a 12 per cent reduction in yield of Italian rye-grass. Black-grass was much more competitive than annual meadow-grass and 370-450 plants/m^2 were sufficient to reduce yields of both perennial and Italian rye-grasses by amounts equivalent to those caused by 6,000-7,000 plants/m^2 of annual meadow-grass. Some of these plots, photographed on 11 May 1981, are shown in Fig. 2. Harvest data for

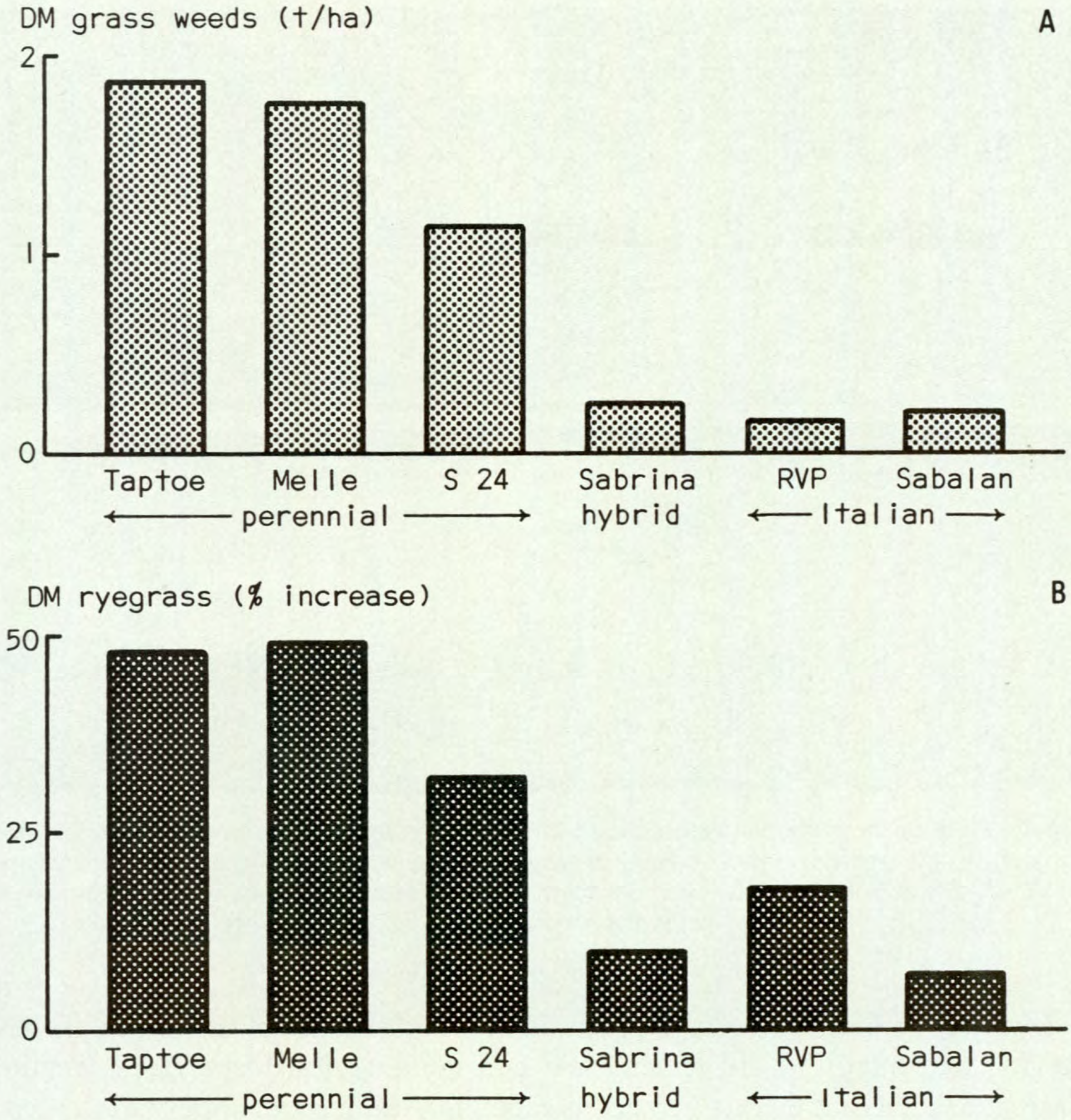

Fig. 1. (A) Yield of annual meadow grass and black-grass growing with six unsprayed ryegrass cultivars; (B) the yield response of the same six ryegrasses to pre-emergence weed control by ethofumesate at 1.4 kg a.i./ha.

1981 and 1982 will be complemented by *in vitro* digestibility and nitrogen determinations. This will enable us to work out how these two weed species have affected the metabolisable energy (ME) output of each sward-type.

We do not yet know how far the eventual botanical composition of a pasture is determined by weed invasion during establishment. However, we hope to answer this question by monitoring sward composition under both cutting and grazing regimes on sprayed and unsprayed plots over a period of up to 6 years.

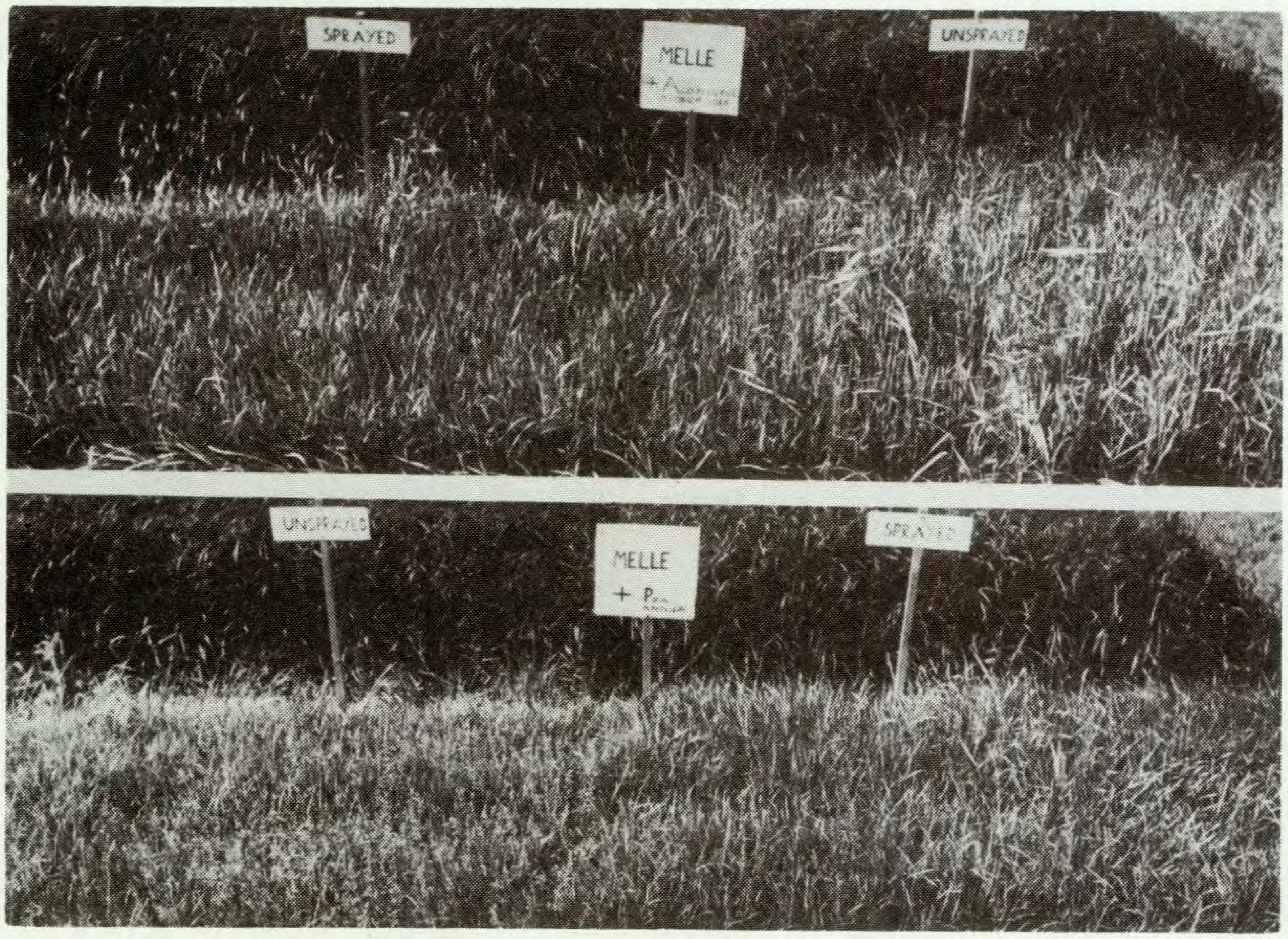

Fig. 2. Plots of the perennial ryegrass cultivar Melle infested with black-grass (upper) and annual meadow-grass (lower). Half of each plot was sprayed pre-emergence with ethofumesate at 1.4 kg a.i./ha. High densities of each weed species (see text) almost halved the yields of perennial ryegrass in the unsprayed plots.

Increases in fertilizer costs have stimulated a resurgence of interest in clover for its contribution to soil fertility and herbage quality. Most swards contain very little clover, often due to weed competition leading to poor establishment after sowing. Chickweed is potentially very damaging to clover, because of its smothering growth habit. Therefore, we are currently comparing several herbicides for chickweed control in establishing grass/clover swards. So far, both benazolin and bentazone have proved very effective, although bentazone is much quicker-acting than benazolin. We are also investigating whether additives such as Actipron and ammonium sulphate can increase the efficiency of these compounds still further.

No clover-safe herbicide has yet been developed to control weed grasses during the establishment of grass/legume swards, so we are continuing to screen herbicides for this purpose with a reasonable prospect of eventual success (Kirkham & Richardson, 1981).

If white clover is to be fully exploited in mixed swards a more positive approach to its establishment is needed than is usually adopted. We therefore plan to identify which species need to be controlled, and at what densities, as part of our systematic approach to the successful establishment of clover-based swards.

REFERENCES

BAKER, H. K. (1962). A survey of English grasslands. *Proceedings 6th British Weed Control Conference,* 23-30.

BLAIR, A. M. (1970). Herbicides for control of grass weeds when establishing ryegrass. *Proceedings 10th British Weed Control Conference,* 495-499.

BLAIR, A. M. (1972). Selectivity of NC 8438 between ryegrass and weed grass species. *Proceedings 11th British Weed Control Conference,* 301-305.

BLAIR, A. M. & HOLROYD, J. (1968). Herbicides to control seedling weed grasses in newly sown leys and pastures. *Proceedings 9th British Weed Control Conference,* 484-487.

BLAIR, A. M., DRENNAN, D. S. H. & HOLLY, K. (1976). The selectivity of methabenzthiazuron between barley, perennial ryegrass and *Poa trivialis. Weed Research,* **16,** (6), 379-383.

FAULKNER, J. (1975). A paraquat tolerant line in *Lolium perenne. Proceedings European Weed Research Society Symposium Status and Control of Grass weeds in Europe,* 349-359.

HAGGAR, R. J. (1979a). Grass reseeding survey 1977-78. *Occasional Publication British Grassland Society, Hurley,* pp 13.

HAGGAR, R. J. (1979b). The influence of herbicides, nitrogen fertilizer, seed rate and method of sowing on the establishment and long-term composition of a perennial ryegrass ley. *Weed Research,* **19,** (1), 231-239.

HAGGAR, R. J. (1979c). Competition between *Lolium perenne* and *Poa trivialis* during establishment. *Grass and Forage Science,* **34,** (1), 27-36.

HAGGAR, R. J. & BASTIAN, C. J. (1976). Controlling weed grasses in ryegrass by ethofumesate with special reference to *Poa annua. Proceedings British Crop Protection Conference—Weeds,* 603-609.

HAGGAR, R. J. & KIRKHAM, F. W. (1981). Selective herbicides for establishing weed-free grass. I. Evaluation of ethofumesate and methabenzthiazuron. *Weed Research,* **21,** (3/4), 141-151.

HAGGAR, R. J. & PASSMAN, A. (1978). Some consequences of controlling *Poa annua* in newly sown ryegrass leys. *Proceedings British Crop Protection Conference—Weeds,* 301-308.

HAGGAR, R. J. & PASSMAN, A. (1981). Soil persistence of ethofumesate applied to autumn-sown perennial ryegrass for *Poa annua* control. *Weed Research,* **21,** (3/4), 153-159.

KIRKHAM, F. W. (1980). Weed control by paraquat during the establishment of paraquat-resistant ryegrass. *Proceedings British Crop Protection Conference—Weeds,* 477-482.

KIRKHAM, F. W. (1981). The effect of pre- and post-emergence spraying with methabenzthiazuron on the herbage production of six ryegrass cultivars. *Annals of Applied Biology* **97,** (Supplement, 2), 54-55.

KIRKHAM, F. W. & HAGGAR, R. J. (1982). Selective herbicides for establishing weed-free grass. The effect of mixtures and sequences of herbicides, including ethofumesate and methabenzthiazuron. *Weed Research,* **22,** (1), 57-68.

KIRKHAM, F. W. & RICHARDSON, W. G. (1981). The pre-emergence selectivity of twelve herbicides between perennial ryegrass, white clover and four grass-weed species. *Annals of Applied Biology* **97,** (Supplement, 2), 46-47.

MORRISON, J. & IDLE, A. A. (1972). A pilot survey of grassland in S.E. England. *Technical Report Grassland Research Institute 10,* pp 76.

RICHARDSON, W. G. & KIRKHAM, F. W. (in press). The effect of two safeners as seed dressings on the pre-emergence activity of sixteen herbicides against perennial ryegrass. *Annals of Applied Biology* **98,** (Supplement, 3).

RICHARDSON, W. G., DEAN, M. L. & PARKER, C. (1976). The activity and pre-emergence selectivity of some recently developed herbicides: Metamitron, HOE 22870, HOE 23408, RH 2915, RP 20630. *Technical Report Agricultural Research Council Weed Research Organization,* **38,** pp 55.

WELLS, C. J. & HAGGAR, R. J. (1974). Herbage yields of ryegrass swards invaded by *Poa* species. *Journal of the British Grassland Society,* **29,** (2), 109-111.

Recent research into the antagonism of the wild-oat herbicide diclofop-methyl by herbicides for the control of broad-leaved weeds

H F TAYLOR and M P C LOADER

The advantages in terms of cost and convenience of applying more than one herbicide in a single spray operation are well appreciated and the use of herbicide 'tank mixes' is now common practice. However, such procedures are not without their problems and there are many reports of herbicides losing their effectiveness when used in this way. These incompatibilities are seen both in the field and in glasshouse tests. Wild-oat herbicides seem to be particularly prone, with barban, benzoylprop-ethyl, flamprop-methyl, flamprop-isopropyl and diclofop-methyl all suffering a reduction in performance when mixed with auxin-type herbicides like 2,4-D. (Holroyd 1960; Miller & Nalewaja 1974; Walter, Müller & Koch 1977). Whilst the formulations of herbicides intended for tank-mixing may often require modification, the difficulties are frequently more deep-seated, and the antagonisms may result from interactions within the plant itself. It is such an example, the antagonism of diclofop-methyl by plant growth substances of the 2,4-D type, which is the subject of this article.

ANTAGONISM OF DICLOFOP-METHYL BY 2,4-D

Preliminary experiments with glasshouse grown wild-oat seedlings had indicated that diclofop-methyl (Hoegrass) was most effective when the plants were sprayed at the 1½ to 2 leaf stage and also that cultivated oat (var. Margam) could be conveniently substituted for the weed species. This variety was therefore used routinely, but periodic tests were made with wild-oats to check the validity of our results.

The magnitude of the interaction between diclofop-methyl and 2,4-D varied with environmental conditions but the wild-oat plants photographed two weeks after spraying with each herbicide separately, and a mixture, (Fig. 1) indicate how severe the interaction can be. After longer periods the differences became even more marked as the plants treated with diclofop-methyl on its own died, while the others continued to grow. A better understanding of the interaction is therefore gained from experiments in which the oat plants are sampled at different times after treatment (Fig. 2). After an initial check in growth, probably due to scorch, those plants which had been treated with the mixture made a rapid recovery. The 2,4-D treatment by itself had little effect upon growth and

Fig. 1. Wild-oat seedlings 14 days after spraying with diclofop-methyl (left); 2,4-D as amine salt (right); and a mixture of the two herbicides (centre).

this makes the interpretation of the experimental results much easier than it could have been had both herbicides caused significant toxicity. However, 2,4-D did not prove to be the most severe antagonist to diclofop-methyl.

INTERACTION OF DICLOFOP-METHYL WITH OTHER PLANT GROWTH SUBSTANCES

In addition to 2,4-D, interactions with diclofop-methyl have been reported for a number of herbicides including MCPA, dichlorprop, mecoprop and dicamba. As all these chemicals have strong auxin-type activity, it was tempting to conclude that this was a pre-requisite for the antagonism. Were this so, it would have provided a valuable guide to the mechanisms which are involved, and this aspect was carefully examined by comparing the effects of active and 'inactive' plant growth substances.

Unfortunately such 'inactive' chemicals are of little commercial interest and are not readily available, even for research purposes. However, the inactive

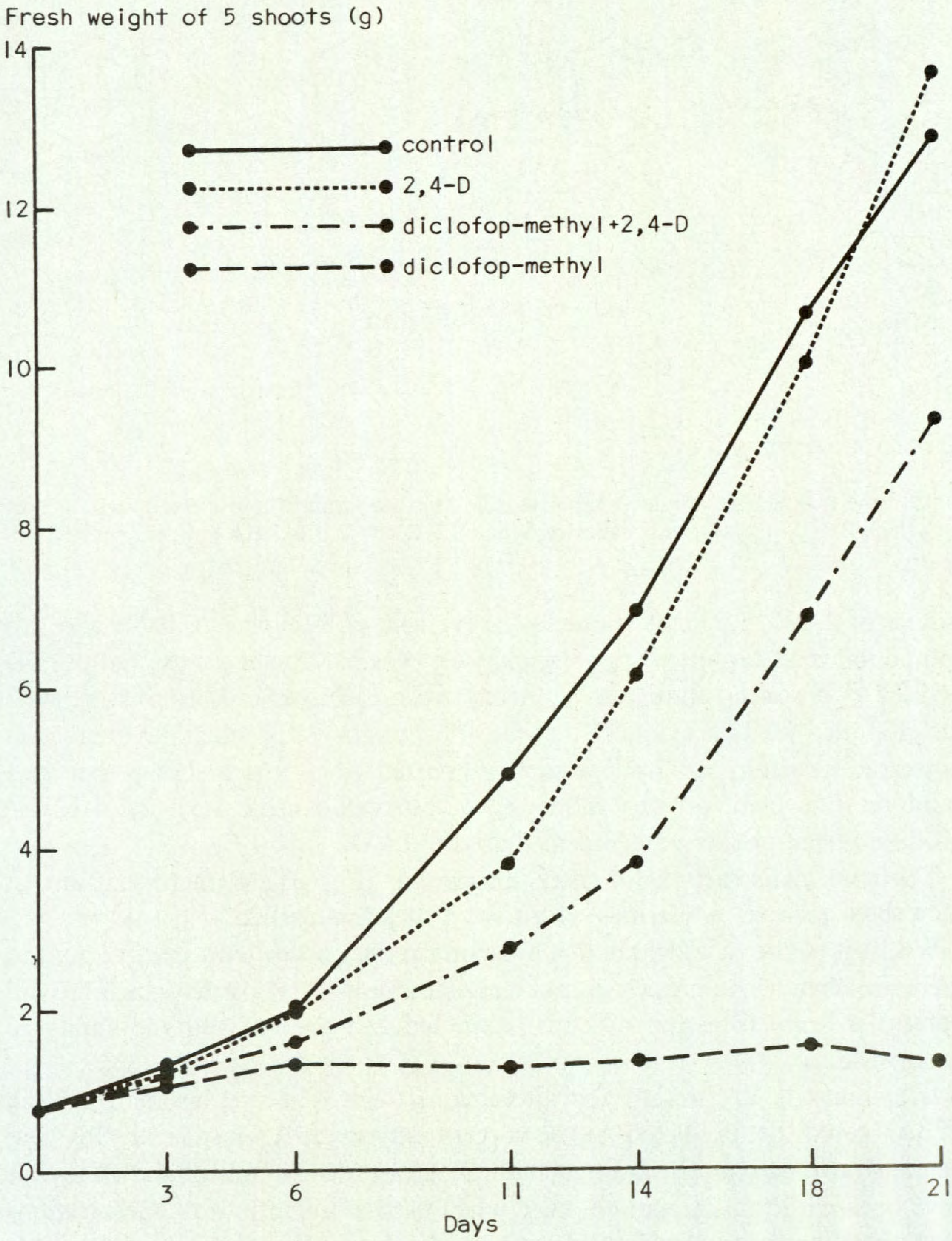

Fig. 2. The growth of oat seedlings for 21 days after spraying with diclofop-methyl, 2,4-D, or diclofop-methyl + 2,4-D. Values are the means of 5 replicates, each of 5 plants.

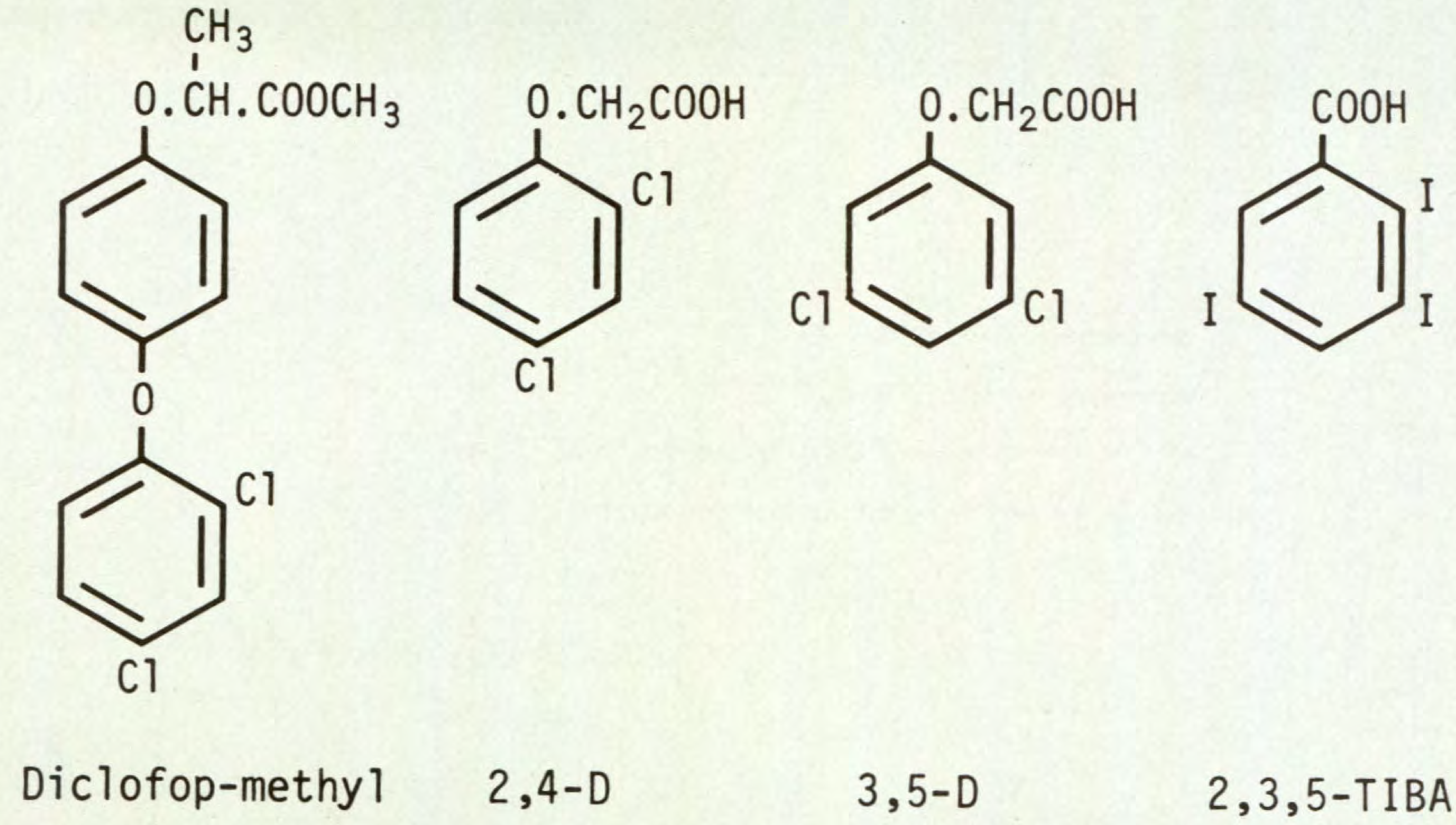

Fig. 3. The chemical structures of the herbicide diclofop-methyl and three antagonists of which 2,4-D has high auxin activity, while 3,5-D and 2,3,5-TIBA have no activity.

isomer of 2,4-D, 3,5-dichlorophenoxyacetic acid (3,5-D) was available and this compound made an interesting comparison possible. Surprisingly, both 3,5-D and 2,4-D produced similar antagonisms when each was used in mixture with diclofop-methyl. This evidence that the effect might occur when the interactant possessed no auxin activity was soon supported when it was shown that a second inactive plant growth subtance, 2,3,5-triiodobenzoic acid (2,3,5-TIBA) produced even greater antagonism than did 2,4-D.

The chemical structures of these compounds (Fig. 3) are interesting in that they show marked similarities with that of diclofop-methyl.

Whilst it is safe to conclude that antagonism does occur with inactive auxins, there are likely to be properties, such as stability in plant tissue, which are important in the expression of both auxin induced growth and the ability to antagonise.

If stability is a criterion for interaction, then 2,3,6-trichlorobenzoic acid (TBA) could be predicted to be a very strong antagonist, and this was demonstrated early in this investigation. The largest antagonisms shown to date have been with this compound, even when used at much lower concentrations than those necessary for the substituted phenoxyacetic acids. It is clear that these results do not support the simple explanation that herbicides like 2,4-D antagonise by stimulating growth and thereby overcoming the growth inhibition attributed to the diclofop-methyl.

SEPARATE APPLICATIONS OF DICLOFOP-METHYL AND ANTAGONISTS

The application of herbicides as mixtures may produce unexpected results for a number of reasons. Whilst it is unlikely that the two active ingredients will react chemically, other effects like changes in pH may cause *in vitro* hydrolysis of esters (including diclofop-methyl) and mixing may also reduce the efficiency of formulations (Appleby & Somabhi, 1978). Interaction studies must take account of these factors or better still, eliminate them. This may be achieved by applying the components separately to the plant.

A number of experimental techniques may be used to do this but the most satisfactory one utilises the rapid uptake of plant growth substances through roots. The pots in which the oat plants are growing are stood in trays containing solution of the potential antagonist and the plants are then sprayed with diclofop-methyl in the normal way.

Results obtained using this technique demonstrated that plants which were receiving 2,4-D or TBA through the roots made a progressive recovery following the initial damage caused by the formulated diclofop-methyl. The possibility that the growth substance could have entered the plant through the coleoptile region of the shoot was eliminated by covering the seeds with black polythene granules at the time of planting. These granules were only removed after treatment, ensuring that the lower shoot had no direct contact with either herbicide. Soil distribution studies also revealed that little 2,4-D or TBA reached the soil surface during the early treatment period.

As with the herbicide mixture experiments, both 2,4-D and TBA were antagonistic, with TBA producing the greater effect even at lower concentrations. As TBA is particularly resistant to degradation in the soil it may be safely concluded that it was the herbicide and not a metabolite which was involved in the interaction.

These experiments show unequivocally that the interactions between diclofop-methyl and 2,4-D, 2,3,6-TBA and also 2,3,5-TIBA were not primarily the consequence of physical or chemical changes occurring through the mixing of formulated materials. It was therefore logical to examine the fate of diclofop-methyl within oat tissue in the presence and absence of antagonists.

EFFECTS OF ANTAGONISTS ON DICLOFOP-METHYL METABOLISM

The ester, diclofop-methyl, is hydrolysed in plant tissue to the parent acid, diclofop, also herbicidal, and this is then detoxified more slowly in the oat by conjugation (Fig. 4, Shimabukuro, Walsh & Hoerauf, 1979).

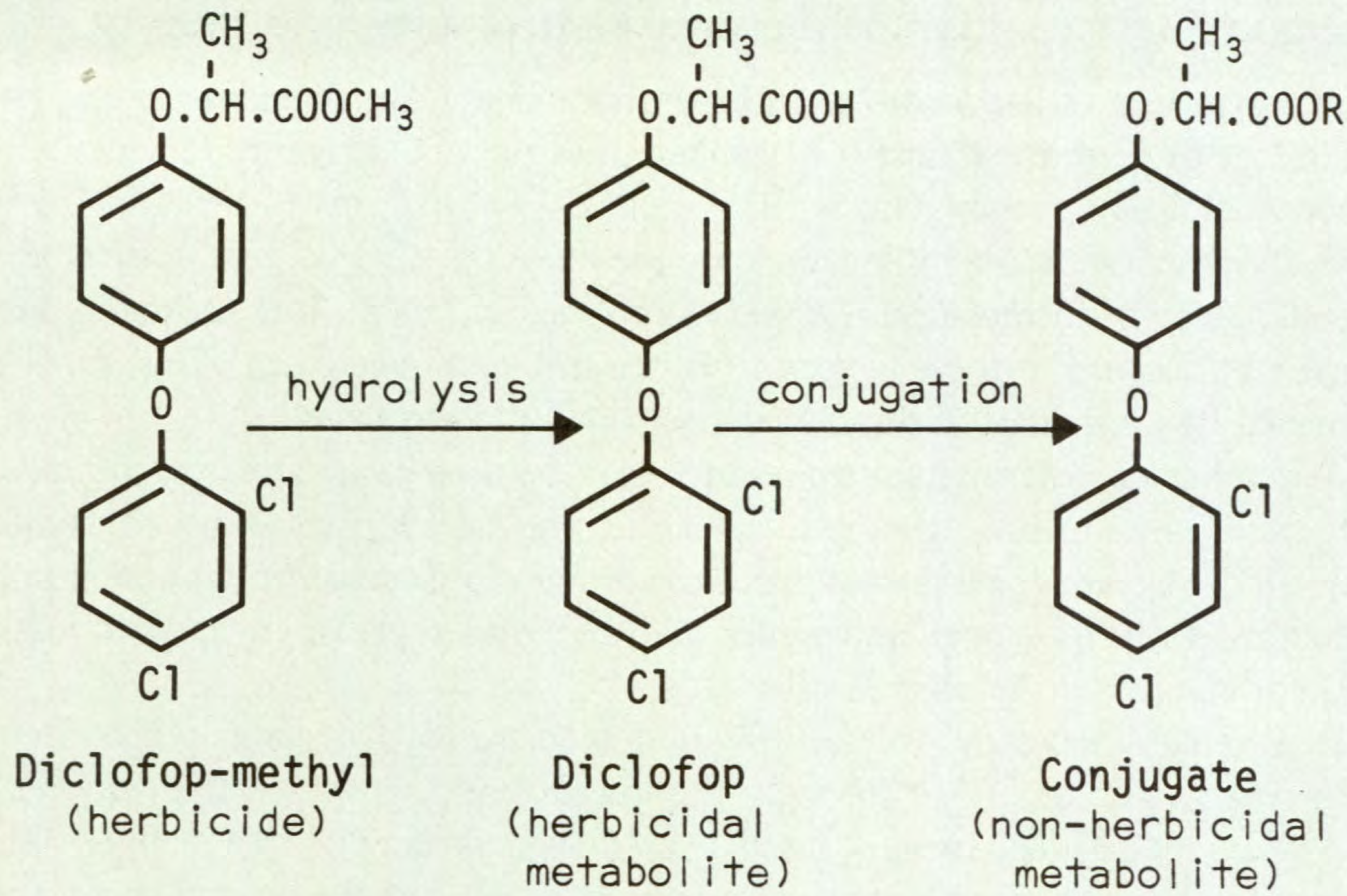

Fig. 4. Metabolism of diclofop-methyl by oat seedlings.

Any unchanged diclofop is translocated to the base of the plant where its damaging effects result in the cessation of growth of the young leaves and their subsequent death. The most logical involvement for an antagonist would therefore be either to retard diclofop translocation or to hasten its conjugation. In fact these processes may not be unrelated, for conjugation and reduced polar transport have been demonstrated for other compounds.

To test this hypothesis ^{14}C-diclofop was applied to sections cut from oat seedlings which had previously received treatments of potential antagonists through their roots. After incubation for periods of up to 24 hours the tissue was extracted and in each case the relative amounts of residual herbicide and conjugate were assessed following separation by chromatography.

Within about an hour hydrolysis of the ester was shown to be complete but, after longer incubation periods, the 'control' oat tissue had a higher residual diclofop content (and corresponding less conjugate) than the tissue cut from plants which had received 2,4-D or TBA solution through their roots. The differences in these rates of conjugate formation proved to be very consistent but frequently, in the case of 2,4-D, they were not large. More important however, has been the finding that five different antagonists increased the amount of conjugate present, whilst the addition of non-antagonists did not do so.

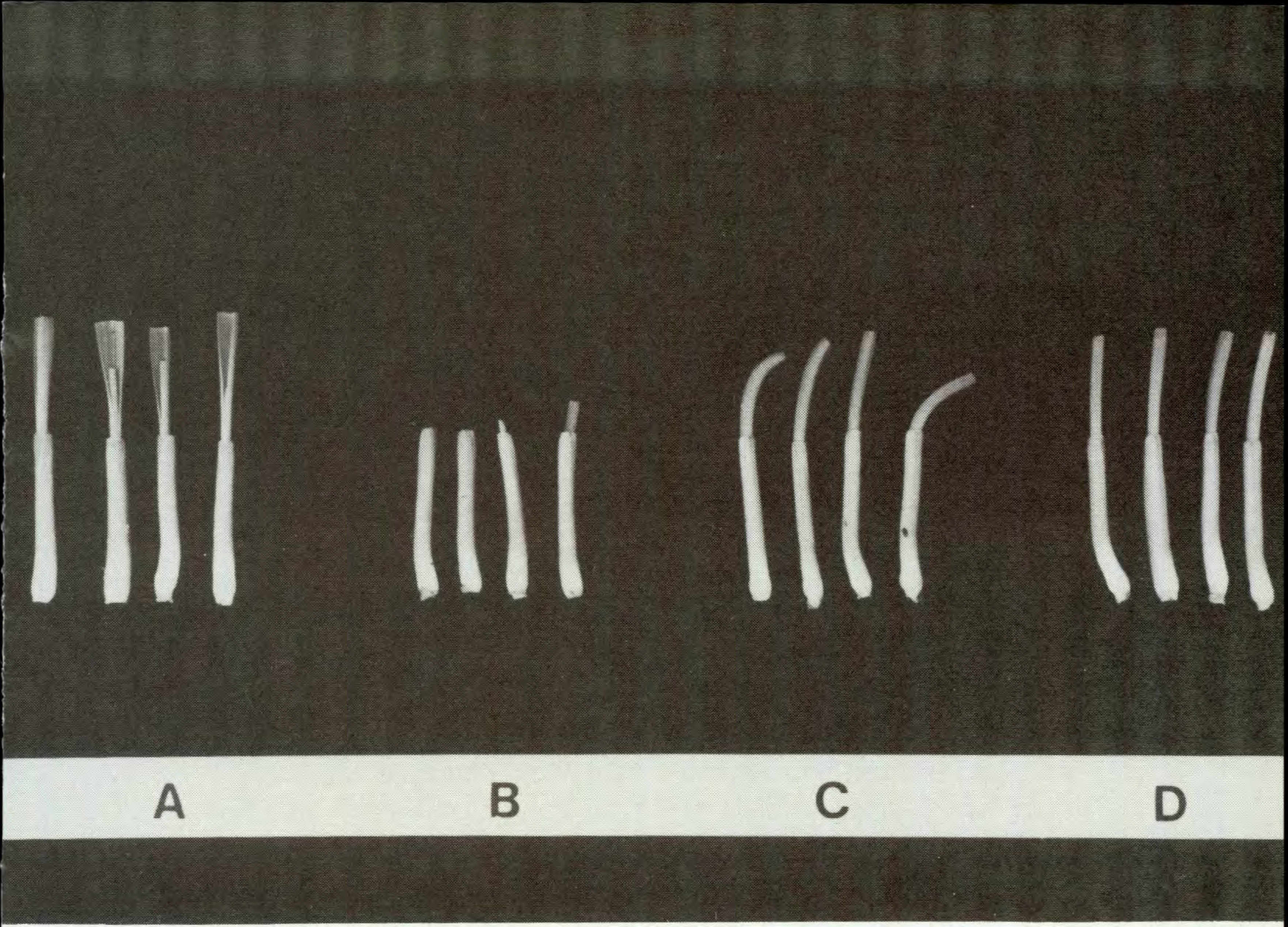

Fig. 5. Growth of second and third leaves from excised oat sections, following treatment with diclofop (B), TBA (D) and a mixture of these herbicides (C). Control sections are included (A).

This strong evidence that 2,4-D, TBA and other antagonists hasten the detoxication of diclofop in oat tissue offers one explanation for their antagonistic properties. However it does not preclude other possibilities, particularly as the chemical structures of herbicide and interactant are often so similar (Fig. 3). To meet the need for more precise methods for the simultaneous assessment of these antagonisms and the associated metabolic effects, a new experimental procedure was developed.

EXCISED SHOOT SECTION TEST

Oat seedlings are treated by pipetting solution containing very small amounts (usual 1-2 μg) of herbicide into the sheath of the first leaf. The response thus occurs in the intact plant before 20 mm long sections are cut from the seedlings. These sections are then incubated on agar for subsequent growth assessments or extraction with solvents for metabolic investigations. The photograph (Fig. 5) shows the extension of the second and third leaves after incubation for 24 hours. Whilst sections which had been cut from seedlings treated with diclofop (B) produced little or no growth, the leaves of those treated with a mixture (C) had extended.

This test has many advantages. It is particularly valuable because precise amounts of interactants are applied in quantities so small as to permit the use of radio-labelled and other expensive chemicals. Uptake is also rapid, so that sequential application may be made accurately. Further advantages are the considerable savings in glasshouse space and in the time taken to complete an experiment.

CONCLUSION

The interaction between the wild oat herbicide diclofop-methyl and 2,4-D has been investigated in considerable detail. A wide range of herbicides and other related compounds have been employed to indicate the extent of the antagonism, and metabolic studies have shown a close correlation between an increased rate of diclofop conjugation and antagonism. Some of the interactions have assumed a magnitude which has suggested the use of certain 'antagonists' as possible crop safeners for use with cultivated oat. This attractive facet of the work is now being pursued. For this and other studies the development of the excised section technique should be most useful. It would seem to have many applications not only in the assessment of the gross effects of herbicides on monocotyledonous plants but also for the subsequent detailed studies required to establish some of the mechanisms involved.

REFERENCES

APPLEBY, A. P. & SOMABHI, M. (1978). Antagonistic effect of atrazine and simazine on glyphosate activity. *Weed Science*, **26,** 135-139.

HOLROYD, J. (1960). The use of barban for the control of *Avena fatua. Proceedings British Crop Protection Conference—Weeds,* 487-494.

MILLER, S. D. & NALEWAJA, J. D. (1974). Influence of broadleaf herbicides on wild-oat control with SD 29761. *Research Report North Central Weed Control Conference,* 91.

SHIMABUKURO, R. H., WALSH, W. C. & HOERAUF, R. A. (1979). Metabolism and selectivity of diclofop-methyl in wild oat and wheat. *Journal of Agricultural and Food Chemistry,* **27,** 615-623.

WALTER, H., MÜLLER, F. & KOCH, W. (1977). Interaktion von Diclofopmethyl mit anderen Nachauflaufherbiziden. *Zeitschrift für Pflanzenkrankheiten und Pflanzenschutz, Sonderheft VIII,* 389-402.

Managing rural amenity sites with chemicals

E J P MARSHALL

In England and Wales 160 country parks and 200 picnic areas, amounting to some 20,000 ha of amenity land, are registered with the Countryside Commission. There are further extensive areas of countryside set aside for amenity use, including unregistered parks, picnic sites and areas under development. While the greatest proportion of this area is grassland, other types of vegetation are represented within these sites. Local authorities are responsible for the majority of these amenity areas, and in today's climate of economic restraint cost-saving management methods are sought.

Mowing and grazing are the traditional methods of managing amenity grassland and local authorities are increasingly letting larger areas of grass to farmers for haymaking or grazing. However, in small areas and areas which are visited irregularly by wardens or cannot be fenced in, grazing is impractical. Likewise, there are many situations where regular cutting is neither practical nor economic. Steep slopes may be cut very infrequently, while many rural sites may receive only two or three cuts each year, less than some managers and the public would like. While woody plants may be kept in check by such a regime, tall coarse grasses soon dominate the sward and short herbs are lost. Managers would therefore welcome the development of inexpensive alternatives to mowing or grazing, to encourage short grasses and swards containing more common flowers. Chemicals could provide both the means of achieving improved standards of maintenance and of creating more interesting and pleasing swards in amenity areas.

However, in this context the public regard chemicals with suspicion, and many managers regard them simply as weedkillers. Thus, their use is largely limited to achieving total weed control on parking areas and paths, though selective herbicides are occasionally used on urban grassland. However, chemicals have a large potential for manipulation of vegetation. This potential has already been demonstrated in agricultural grasslands, particularly to arrest the deterioration of pastures. Techniques of pasture renovation using herbicides and fertilizers to change sward composition have been reviewed by Haggar and Squires (1979). Similar methods might be used to achieve different objectives on amenity sites, though fertilizers which increase sward growth would be inappropriate for rural situations. Particular weed problems, for example the invasion of woody species, might also be solved inexpensively by the precise use of chemicals. In 1979 the Countryside Commission sponsored a project at the Weed Research Organization to investigate the potential of some of these ideas.

The aim of this project is to assess the feasibility of using chemicals for the maintenance of amenity areas in the countryside. Grassland management is the main subject of this study, though a small number of scrub control trials are also being conducted. While the objective of agricultural sward manipulation is an increase in grassland productivity, the aims in treating amenity grass are rather different. Lower sward height, reduced grass bulk, control of vigorous grasses, encouragement of short herbs and the attainment of a good visual impression are all desirable ends. Reductions in the amount and height of grasses might be achieved by herbicides or growth retardants. These chemicals may delay or retard spring growth and they may also selectively remove coarse grass species. An increase in common wild flowers would be a useful additional result of grass suppression.

HERBICIDES IN AMENITY SWARDS

The initial investigations assessed the ability of a series of herbicides to achieve selective control of grass species, and reduce grass bulk. Trials were set out in picnic sites, country parks and rough grassland in Worcestershire, Warwickshire and Oxfordshire. The herbicides were applied to these swards in spring, summer and autumn with a logarithmic sprayer (which reduces the dose of chemical by half every 5m along a 20m plot) to determine potentially useful times and doses. The dose ranges which gave reductions in grass bulk are summarised in Table 1. Most grasses were controlled by the herbicides at high rates. The exceptions were established cocksfoot (*Dactylis glomerata*), which was resistant to propyzamide at 3.5 kg/ha, and common couch (*Agropyron repens*) which was resistant to asulam and carbetamide both at 6.0 kg/ha. The

Table 1. Dose ranges and time of application of herbicides which have subsequently given worthwhile reductions in grass bulk on amenity swards. Data from log-sprayed plots

Chemical	Dose range (kg/ha a.i.)		
	Spring	Summer	Autumn
aminotriazole	2.0-3.5	0.5-1.5	1.1-2.0
asulam	2.0-4.0	—	1.5-3.5
dalapon	1.4-4.5	1.3-2.5	2.2-5.5
ethofumesate	—	—	4.0-8.0
glyphosate	—	0.5-1.5	0.2-0.7
linuron	1.5-4.0	—	—
paraquat	—	1.0	0.3-1.0
propyzamide	1.3-2.0	0.5-1.0	0.8-1.0

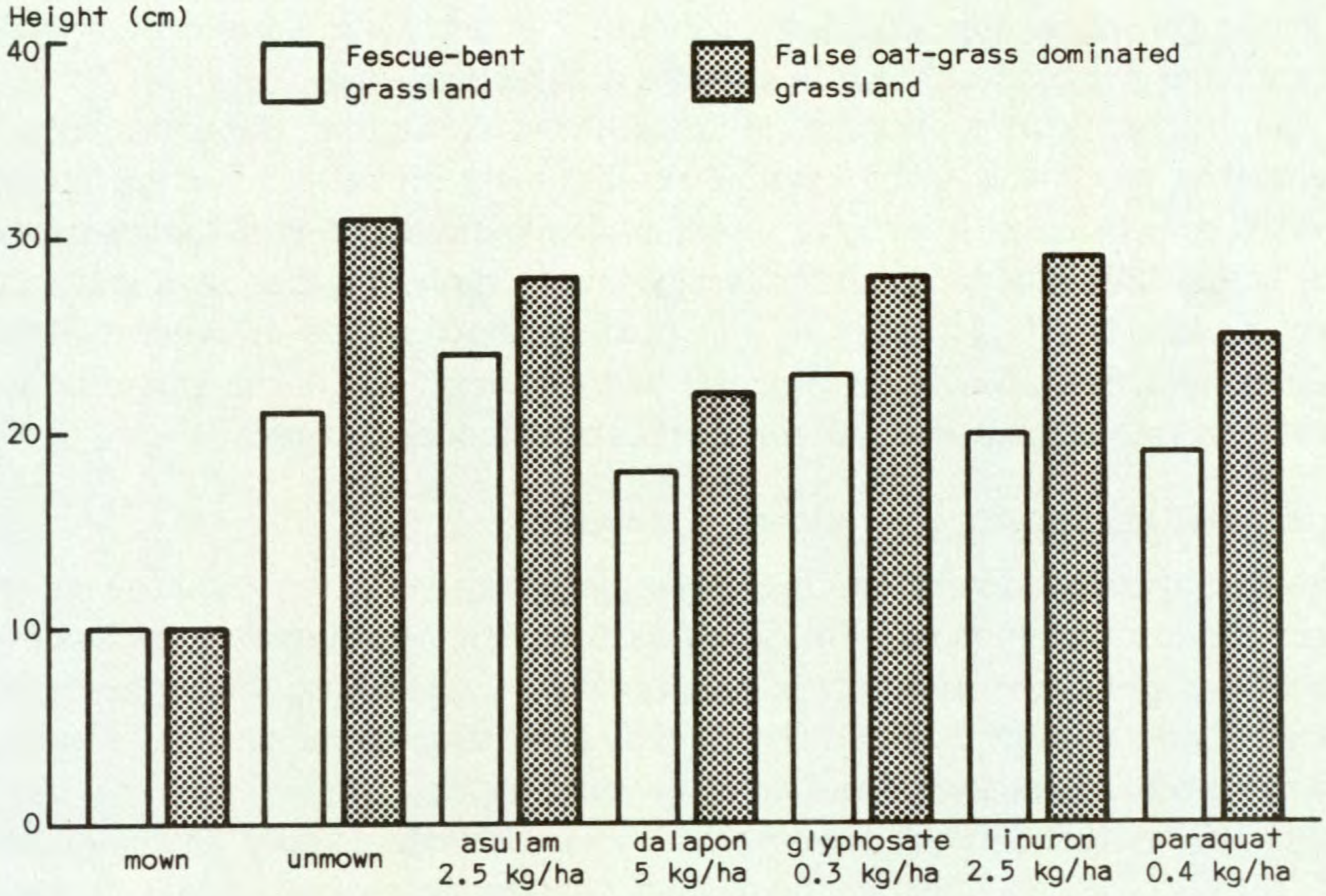

Fig. 1. Sward heights of two grasslands measured in June, after herbicide applications the previous autumn.

only species selectively eliminated was Yorkshire fog (*Holcus lanatus*); both linuron at rates of 1.5-3.0 kg/ha, and asulam at rates of 2.0-4.0 kg/ha, controlled this species in mixtures.

Further trials of the potentially useful herbicides were made, using finite doses in order to make more detailed observations on sward height and species composition. The results of autumn applications to two swards within a Worcestershire picnic area are presented here. One area was a frequently-mown fescue-bent (*Festuca-Agrostis*) sward, while the other, dominated by false oat-grass (*Arrhenatherum elatius*), was cut less than once a year. The composite heights of the swards (not the height of the flowering culms) were measured in June, following herbicide application the previous autumn (Fig. 1). In the previously mown fescue-bent area, herbicides did not achieve a short sward. The number of species was reduced, particularly among the legumes, and the frequency of coarse oat grass was increased, though these changes were largely the result of the cessation of mowing. The herbicide effects were limited to eradication of ribwort plantain (*Plantago lanceolata*) by glyphosate, and a reduction in the frequency of cocksfoot on dalapon and paraquat plots. In the unmanaged oat-grass sward, slight but significant height reductions were recorded on dalapon and paraquat plots, while no changes in species frequencies were found. The herbicides dalapon and paraquat have given sward height reductions at other trial sites.

Similar herbicide applications at low doses in the autumn in other amenity grassland areas have given variable results, most probably reflecting initial sward compositions. In general, results to date indicate that while single doses of herbicides can reduce grass bulk in some situations, on their own they can not replace mowing, as they do not produce short swards or prevent plant litter increasing. Combined herbicide and mowing trials are in progress, in conjunction with longer-term studies of compositional changes.

GROWTH RETARDANTS IN AMENITY SWARDS

Maleic hydrazide (MH) has been sold for many years for retarding grass growth in rural situations. The WRO trials have also included two new compounds, mefluidide and PP 333, with MH. Preliminary studies using a logarithmic sprayer indicated that spring applications gave the best results. The effects of the retardants were dose-dependant, ranging from no suppression to retardation accompanied by unacceptable sward discoloration (Table 2). The data illustrate the relatively narrow dose range of MH in comparison to melfluidide. Applications in summer produced inconsistent retardation, while only the compound PP 333 gave significant reductions in sward height the following spring when applied in the autumn. However, retarda-

Table 2. Doses of retardants resulting in no suppression, or suppression accompanied by discoloration after spring application

	Dose (kg/ha a.i.)	
Retardant	No suppression	Suppression accompanied by discoloration
MH	3.5	6.5
MH+2,4-D	3.5 (MH)	6.5 (MH)
mefluidide	0.1	1.2
PP 333	0.5	4.5

(from Marshall [in press])

Table 3. Summary of the attributes of three growth retardants

Chemical	Mode of uptake	Speed of effect	Period of growth suppression (weeks)	Ability to suppress flowering	Retardation of fine grasses	Retardation of coarse grasses
MH	Foliar	+	8-10	+	+	++
mefluidide	Foliar	+++	10	++	+	++
PP 333	Soil	+ (dependant on rainfall)	>14	—	++	±

Fig. 2. Ten weeks after treatment with mefluidide, the grass on the left-hand plot is much shorter than that in the right hand, untreated plot.

tion was then accompanied by sward discoloration. It was noted that all the retardants gave less retardation in areas containing standing dead vegetation than on short green swards.

Further detailed trials have been made to ascertain the duration and effectiveness of retardation, the effects on flowering, and any selective effects on sward composition. The elimination of flowering culms of grasses, which MH does not wholly achieve, may reduce sward height and improve site appearance. Willis (1972) has already reported the changes in species composition induced by repeated annual applications of MH and MH + 2,4-D. Alternative retardants might show selectivities between species which could affect their suitability for amenity use.

A summary of the results found so far is given in Table 3. Mefluidide is the most promising of the growth retarding compounds investigated so far (Fig. 2). It is quick acting, reliable from site to site, and an effective suppressant of flowering in grasses. It can encourage the predominance of fine grasses in treated swards (Marshall, in press). MH and MH + 2,4-D are less effective than mefluidide but give significant growth retardation and suppression of flowering. PP 333, a soil-acting compound when applied without wetters, is active longer than the other compounds, but does not affect flowering. There were indications that coarse grasses are encouraged on PP 333 treated plots.

SCRUB CONTROL

Recent progress in scrub control has included the development of novel methods of applying chemicals as well as the use of new compounds. Several compounds and application methods have been used in trials to control hawthorn on chalk downland in Hampshire and to control birch and pine on heathland in Surrey. Glyphosate (0.7%) applied by knapsack sprayer to the

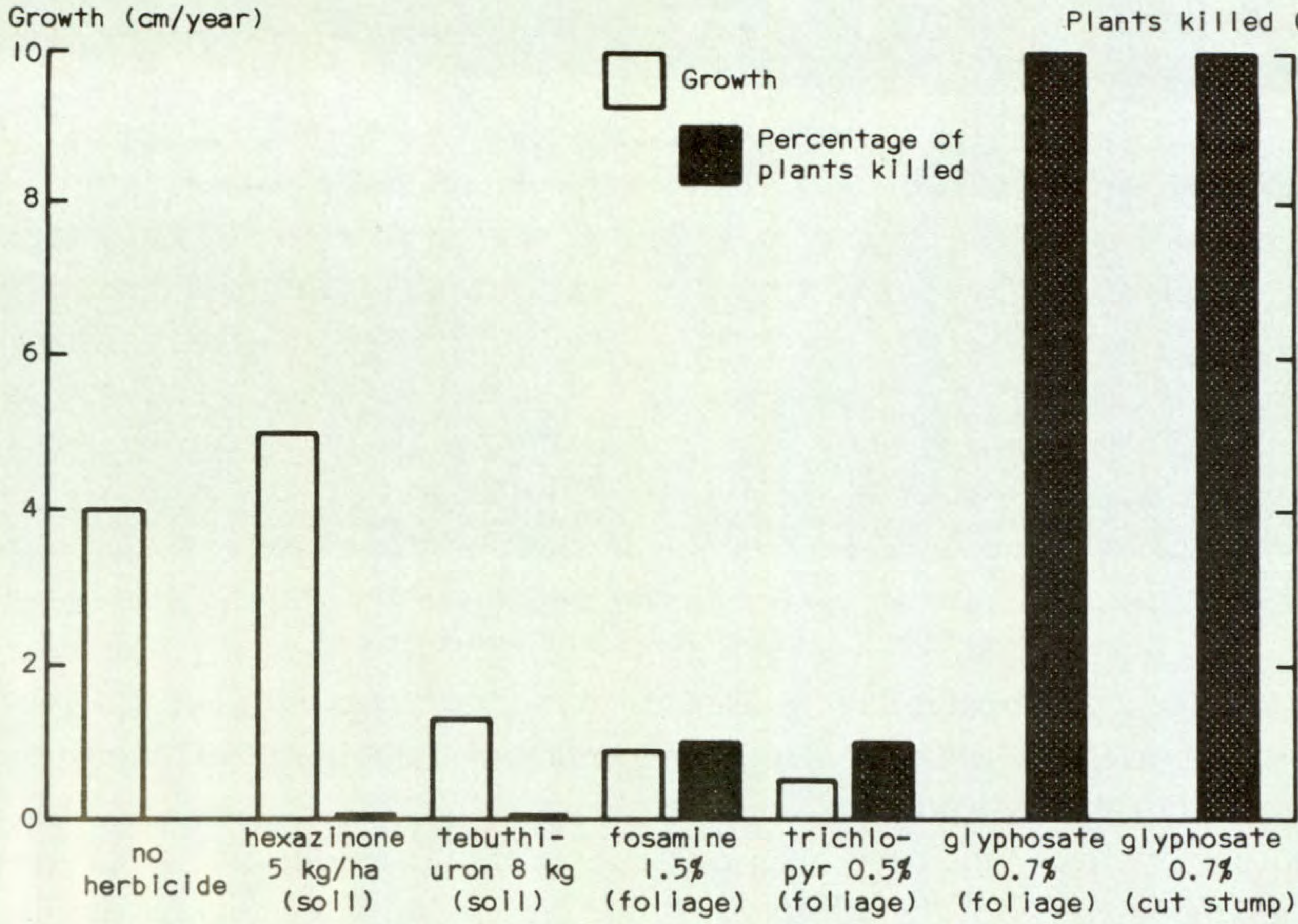

Fig. 3. The effect of several herbicides on hawthorn bushes, measured by height increase after 12 months and number of bushes totally killed.

foliage or by painting the cut stump has produced 100% control of hawthorn regrowth (Fig. 3). Fosamine and trichlopyr sprayed on the foliage from a knapsack had not achieved total control after 12 months, although no new leaf was produced during the season. Applications of hexazinone and tebuthiuron to the soil using a syringe, a method similar to the granule techniques reported by Bjerregaard *et al.* (1978), had not killed any bushes after 12 months, though tebuthiuron had reduced hawthorn growth. Effects on the associated downland sward were variable. Both glyphosate and fosamine killed some of the surrounding vegetation. However, as the area around the target bushes was dominated by other undesirable species such as upright brome (*Bromus erectus*), cocksfoot and blackberry (*Rubus* sp.), the effects were probably not disadvantageous. In heathland no effects were noted on the surrounding heather (*Calluna vulgaris*), and the degree of control of birch achieved by the chemicals (Fig. 3) was similar to that obtained on hawthorn. The stumps painted with 0.7% glyphosate were an exception, as regrowth on all stumps was observed after 12 months. Smearing 0.7% glyphosate on to birch saplings with a herbicidal glove (Holroyd, 1972) controlled 30% of treated bushes. Small pines were well controlled by tebuthiuron, as already reported by Turner and Richardson (1978).

THE FUTURE

Chemical management techniques are already used in amenity areas for total weed control, and the control of undesirable plants, such as docks, nettles and woody species. Their potential role for the subtle manipulation of species assemblages has yet to be widely demonstrated except for more general weed control operations, but WRO studies indicate that they could be useful. Programmes based on chemicals may yet provide a cheap and effective alternative to frequent mowing for the improvement of areas of coarse grass and tall broad-leaved weeds. The use of herbicides to maintain short swards appears less promising. However, the current feasibility study has allowed only short term investigations of the effects of chemical treatments, and longer-term studies may reveal further useful effects. Growth retardants appear to have a large potential for amenity sward maintenance, as they have been shown to achieve reductions in both sward height and numbers of grass flowering heads. Their use may allow savings in expenditure and improvements in the standards of maintenance of amenity areas. In addition, they may effect beneficial changes in species composition. The implications of repeated annual use of chemicals for sward ecology require investigation, not least because the results may be relevant to areas other than amenity sites, such as headlands, hedge bottoms and other uncropped land on the farm. The use of retardants, and herbicides, need not adversely affect species diversity. Indeed, chemicals might well be used in conjunction with the introduction of wild flower seed into amenity swards (Marshall, 1981). Provided the present pilot project, scheduled to end in September 1982, can be extended or alternative funding secured, further studies should reveal the most useful techniques for particular situations.

REFERENCES

BJERREGAARD, R. S., KEATON, J. A., McNEILL, K. E. & WARNER, L. C. (1978). Rangeland brush and weed control with tebuthiuron. *Proceedings of 1st International Rangeland Congress, Denver,* 654-656.

HAGGAR, R. J. & SQUIRES, N. R. W. (1979). The scientific manipulation of sward constituents in grassland by herbicides and one-pass seeding. *Proceedings of the British Grassland Society Occasional Symposium,* **10,** 223-234.

HOLROYD, J. (1972). The herbicidal glove—a new concept for the localised application of herbicides to weeds in susceptible crops. *Proceedings of the North Central Weed Control Conference,* **27,** 74-76.

MARSHALL, E. J. P. (1981). Flowery mead slot. *GC&HTJ,* **190** (20), 13, 15.

MARSHALL, E. J. P. (in press). Chemical control of grass growth in rural amenity areas. *Cost-effective Amenity Landscape Management, Horticultural Education Association, 1982 Study Course.*

TURNER, D. J. & RICHARDSON, W. G. (1978). Pot experiments of the Weed Research Organization with forest crop and weed species. *Technical Report Agricultural Research Council Weed Research Organization,* **46,** pp 13.

WILLIS, A. J. (1972). Long-term ecological changes in sward composition following application of maleic hydrazide and 2,4-D. *Proceedings of the British Weed Control Conference,* 360-367.

The British Crop Protection Council and WRO: an interwoven history

J D FRYER

It is only those whose involvement in crop protection in Britain began many years ago who are likely to be aware of the origins of the British Crop Protection Council. Fewer still will know of the connection between BCPC and the Weed Research Organization whose 21st anniversary in 1981 provided a timely opportunity for historical reflection.

ROLE OF THE ARC UNIT OF EXPERIMENTAL AGRONOMY

Perhaps the most significant of the events leading up to the formation of BCPC was the foundation in 1950 by the Agricultural Research Council of a research unit in Oxford called the ARC Unit of Experimental Agronomy. One of its main objectives was to carry on and develop the work of Professor G E Blackman who during World War II had pioneered the development of chemical weed control in British agriculture. Starting with sulphuric acid, copper salts and mineral oils for the control of broadleaved weeds in cereals, onions and carrots, Blackman's team then went on to lay the foundation for the practical use of the dinitrophenol herbicides (DNOC and DNBP) and then MCPA and 2,4-D, the first of the revolutionary hormone weedkillers.

When the unit was formed several British companies were already active in marketing the few selective weedkillers then available and the chemical industries in Europe and North America were making massive investments in the synthesis and screening of new compounds as potential herbicides and other pesticides.

In Britain there had developed an urgent need both for a clearing house for the new information on herbicides coming from all parts of the world and for a centre for independent research and advice. Some members of the Unit at Oxford, led by the Assistant Director Dr E K Woodford, accepted this challenge and decided to do what they could to promote communication and collaboration between the many organizations concerned with the exciting development of chemical weed control. They were actively supported in their task by a liaison officer (J F Ormrod) of the National Agricultural Advisory Service (NAAS) who provided a link between the Unit, official advisers and the farming community.

Supported by NAAS Crop Husbandry and Grassland Officers, the Unit made an approach to the Ministry of Agriculture to see if it would sponsor an *ad hoc* meeting of interested organizations to explore attitudes, review current work on weed control, and identify outstanding problems and proposals for dealing with them. The Ministry agreed and a meeting was held at Whitehall Place, London, on 5 November 1952, attended by 40 participants.

Organizations represented, in addition to the Unit of Experimental Agronomy and the Ministry of Agriculture, included the Association of British Insecticide Manufacturers (ABIM) (later to become BAA), the British Agricultural Contractors Association (BACA) (later to become NAAC), the Commonwealth Agricultural Bureaux, the National Institute of Agricultural Botany, the Rothamsted Experimental Station, the Long Ashton Research Station and the Grassland Research Institute.

In my notes of the meeting I recorded that the Chairman summed up by saying that weedkillers must be regarded only as an aid to good husbandry and not a substitute for it—a comment with which many would agree to-day! A unanimous decision was taken to appoint a small group to consider in detail the major points raised during the discussion. The group would consist of representatives of the ARC Unit at Oxford, manufacturers, contractors, the NFU, the Plant Pathology Laboratory and the Ministry. The five topics identified in the official record for attention comprised: (i) dissemination of information on weed control, especially between industry and official bodies; (ii) means of educating public opinion on weed control and spraying matters; (iii) the possibility of holding national or possibly regional conferences on weed control; (iv) the economic aspects of weed control; (v) the possibility of arranging a co-ordinated programme of experiments and observational studies.

The first meeting of the group, which was chaired by Mr C V Dadd, NAAS Crop Husbandry Officer at Cambridge, was held on 16 December 1952; the discussion centred on the possibility of holding a weed control conference in the autumn of 1953. At its second meeting, the group gave itself the title *Weed Control Joint Committee* (WCJC) and considered the function of a standing committee to formulate recommendations for the use of herbicides; the need for a handbook on weed control for farmers was also discussed. Thereafter the committee concentrated on three topics: dissemination of information; a national weed control conference; and the requirements for research and its co-ordination. The committee also gave much attention to the setting up of an organization to succeed it which could carry on and develop its functions, including the sponsorship of future conferences. After nine meetings, the committee's work came to an end when its offspring, the British Weed Control Conference, was held at Margate in November 1953. The committee also published a report which identified practical weed problems and reviewed the need for strengthened research and development work in weed control. This report also laid the basis for a second which outlined the requirements for improved dissemination of information and liaison. Both reports had far reaching consequences (referred to later) as also did the setting up by the committee of a sub-committee charged with preparing recommendations concerning weed control for submission to the General Meeting of the envisaged First National Weed Control Conference. Chaired by Dr E K Woodford, with its members coming from the ARC Unit, ABIM and BACA, the Recommendations Sub-Committee (as it soon became known) reviewed all the commercial and non-commercial information available at the time on herbicides and prepared agreed recommendations for their use. These were included in the sub-committee's report to the Margate conference and were subsequently reprinted from the conference proceedings and made available on sale, price one shilling, post free. This report and the voluntary co-operation between all those who contributed to it were later to form the basis of the world-renowned *Weed Control Handbook* (Blackwell Scientific Publications, Oxford).

ESTABLISHMENT OF THE BRITISH WEED CONTROL COUNCIL

During the closing stages of the highly successful 1953 British Weed Control Conference a resolution was placed before a general meeting of delegates who gave it unanimous approval. It read as follows:

> "that an organization be formed to be known as the National Weed Control Conference with the following objects:
>
> a) to arrange a national weed control conference at such intervals as shall be considered desirable and to publish its proceedings;
> b) to consider such other activities ancillary to the above or concerned with the exchange and dissemination of information on weed control and allied subjects as may from time to time be discussed;
> c) that the National Weed Control Conference shall be governed by a Council. The first Council shall be elected at this conference and hold office until the next, at which it shall present a constitution for ratification."

Thus a year later, at the business meeting held during the 1954 British Weed Control Conference at Harrogate, the constitution of the British Weed Control

Council was adopted and BWCC came formally into existence. Its member organizations were as follows:

Ministry of Agriculture and Fisheries, Department of Agriculture for Scotland, Department of Agriculture for Northern Ireland, Agricultural Research Council, Colonial Office, National Farmers' Union, British Agricultural Contractors' Association, Association of British Insecticide Manufacturers, National Association of Corn and Agricultural Merchants, Association of Applied Biologists and the Society of Chemical Industry.

THE ACHIEVEMENTS OF BWCC

The British Weed Control Council built successfully upon the foundations laid by the Weed Control Joint Committee. Its importance in promoting communication and collaboration between all organizations concerned with crop protection cannot be over emphasized. The Council's principal activities remained the organization of weed control conferences (later to be affectionately known as the Brighton Conferences) and the dissemination of the information and recommendations published in the Weed Control Handbook, which, at least in the early days, provided the basis for most commercial recommendations for herbicide use as well as for the official approval of efficacy under what is now the Agricultural Chemicals Approval Scheme. The Council also undertook the organization of symposia on specific aspects of weed control for research workers and other specialists. The first was held in 1956 on the then new and exciting phenoxy butyric acid herbicides.

A further innovation was the introduction, in 1964, of the Council's Annual Reviews of Herbicide Usage, in which user experiences of herbicides, their benefits and their problems, were collected from throughout the country by BWCC member organizations and collated into detailed reports for informal discussion by nominated specialists. These reviews still take place each year and have done much to bring to the attention of all concerned the practical difficulties of herbicide usage and to promote communication between those who are in a position to help in their solution.

The success of the British Weed Control Council encouraged those of its members who were also concerned with pest and disease control to form in 1962 a sister organization, the British Insecticide and Fungicide Council (BIFC). The first President was Dr (later Sir Harold) Sanders who had succeeded Sir James Scott Watson, and Mr A W Billit of ABMAC (Association of British Manufacturers of Agricultural Chemicals—successor to ABIM) was elected Chairman.

FORMATION OF THE BRITISH CROP PROTECTION COUNCIL

It soon became apparent that the functions of the two Councils were broadly similar and complementary, also that they had many common members. In 1965 a study group was set up to consider the desirability of amalgamation. Whilst there was a good deal of controversy, on balance both Councils agreed that there was much to be said for combining together to form a single organization concerned with crop protection as a whole. They met separately for the last time on 28 September 1967 at Agriculture House, London and resolved themselves into a joint meeting at which Sir Frederick Bawden, President of BIFC, put to the vote the proposal for the immediate formation of a British Crop Protection Council. Hence BCPC came into existence. The President and Chairman of the new Council were, respectively, Sir Frederick Bawden and Dr D Rudd-Jones of the Agricultural Research Council.

ORIGIN OF THE WEED RESEARCH ORGANIZATION

To return to the connection between the 21st Anniversary of the Weed Research Organization and the British Crop Protection Council. In the 1953 report of the Weed Control Joint Committee on the need for strengthening R & D in weed control the following statement appears: "The Committee . . . considers that the best method to fit in with both existing practices and to allow of development would be to expand the present work of the ARC Unit of Experimental Agronomy by forming an associated unit, independent of the University but adjacent to Oxford, where chemical weedkillers and their application could be studied together with cultural and biological methods of weed control." In a second report (on dissemination of information), started by the Joint Committee and later published by BWCC, the lack of an organized exchange of information or ideas on weed control matters between industry and official organizations was noted. The Council recommended that an Information Centre should be formed and that the logical place to establish such a centre would be at the extension of the Unit of Experimental Agronomy referred to in the Joint Committee's earlier report.

The Agricultural Research Council doubtless having been much influenced by these two recommendations, in due course and after discussion with the Ministry of Agriculture, decided to set up a small independent organization to undertake applied research on weed control and to provide a centre for information and liaison on the subject. After a prolonged search, Begbroke Hill Farm near Oxford was purchased by ARC on 1 April 1960 and those members of the Unit who had been so active in the promotion of the Weed Control Joint Committee and of the British Weed Control Council had the satisfaction of becom-

The lily pond in front of the old barn at Begbroke Hill Farm was a gift from the British Weed Control Council made in recognition of the crucial role of WRO staff in the Council's development.

ing, along with several other colleagues, founder members of the new ARC Weed Research Organization. The subsequent development and achievements of WRO have been recorded, not only in its biennial reports but, most recently, in the commemorative booklet *Twentyone years of achievement 1960-81*, published on the occasion of the 21st Anniversary celebration in 1981 (Chancellor, 1981).

POSTSCRIPT

Those who have visited WRO may be interested to know that the lily pond in the front of the old barn, which is such a pleasant feature of the institute, was a gift from BWCC made in recognition of the crucial part played by WRO staff during the Council's development. For a period before WRO was formed, and before the present arrangement with the Commonwealth Agricultural Bureaux was established, the ARC Unit's output of abstracts of the world's weed control literature was published by BWCC as a monthly journal, *Weed Abstracts*, with considerable benefit to the Council's finances.

REFERENCE

CHANCELLOR, R. J. (1981). ARC Weed Research Organization: Twentyone Years of Achievement 1960-1981. Oxford, ARC Weed Research Organization, pp 20.

LIST OF RESEARCH AND RELATED SERVICE PROJECTS 1980/81

WEED CONTROL DEPARTMENT

Head of Department: J G Elliott

ANNUAL CROPS GROUP (*Leader:* G W Cussans)

1. Herbicide treatments for the control of wild-oat and blackgrass in cereals: Dr P J Lutman, M E Thornton
2. Study of the weed problems of minimum tillage especially the grasses *Alopecurus myosuroides, Bromus sterilis:* F Pollard, S R Moss
3. Long term economic weed control in cereals including rationalisation of herbicide use and agroecology of weeds: B J Wilson, P Ayres
4. Growth of cereals in reduced tillage systems: J G Elliott, F Pollard
5. Control of perennial grass weeds in cereal cropping systems: G W Cussans, P Ayres
6. Effect of high organic matter soils on use of herbicides: Dr P J Lutman, M J May
7. Control of potato groundkeepers: Dr P J Lutman, G W Cussans
8. Cereal tolerance of herbicides: D R Tottman, G W Cussans
9. Factors affecting the success of weed beet in agricultural land: G W Cussans, C J Bastian
10. Studies of the effects of herbicides and weed competition on the establishment and growth of oilseed rape: Dr P J Lutman, M E Thornton

GRASS AND FODDER CROPS GROUP (*Leader:* Dr R J Haggar)

1. The agro-ecology and control of important broad leaved weeds including bracken in grass/legume swards: A K Oswald
2. The role of herbicides in manipulating sward composition with particular reference to clover encouragement: Dr R J Haggar, F W Kirkham, C Standell
3. Minimum cultivation/herbicide systems for establishing grasses, legumes and fodder crops in existing swards: Dr R J Haggar, C Standell, supported by E D Williams of Weed Biology Group
4. The agro-ecology and control of important grass weeds in leys and seed crops: A K Oswald, F W Kirkham

PERENNIAL CROPS GROUP (*Leader:* Dr J G Davison)

1. Fruit crop tolerance of soil- and foliage-applied herbicides: D V Clay, Dr J G Davison
2. Effect of important weeds on fruit production: Dr J G Davison, J A Bailey
3. Response of newly planted fruit crops and nursery stock to weed competition and herbicides: Dr J G Davison, J A Bailey
4. Evaluation of new herbicides for the control of annual and perennial weeds in strawberries: D V Clay, Dr J G Davison

SPECIAL SERVICES

1. Survey and analysis of information about weeds and weed control in agriculture: J G Elliott
2. Supervision, development and maintenance of application equipment for experimental use: M E Thornton
3. Field chemical laboratory: J A Slater
4. Management of Begbroke Hill Farm: J G Elliott, R Dale

WEED SCIENCE DEPARTMENT

Head of Department: Dr K Holly

HERBICIDE GROUP (*Leader:* Dr R J Hance)

1. Evaluation of new herbicides and investigation of specific short term problems: W G Richardson
2. Influence of formulation factors on the activity of herbicides: Dr D J Turner
3. Improvement of methods for the application of herbicides: W A Taylor
4. Basic studies of the interaction of herbicides with one another: Dr H F Taylor, M P C Loader
5. Evaluation of herbicides for forestry: Dr D J Turner, W G Richardson
6. Analysis of herbicides in soil, water and plant material; T H Byast, E G Cotterill
7. Development of analytical methods for herbicides and their decomposition products: T H Byast, E G Cotterill
8. Soil factors affecting the performance of soil-applied herbicides: Dr R J Hance
9. Influence of repeated applications of MCPA, tri-allate, simazine and linuron on fertility of soil: P D Smith
10. Persistence in soil of paraquat applied repeatedly to plant cover or soil: P D Smith

ENVIRONMENTAL STUDIES GROUP (*Leader:* Dr J C Caseley)

1. Effect of environmental factors on the activity of herbicides and growth regulators: Dr J C Caseley, A M Blair, Dr D Coupland, Dr C R Merrit, R C Simmons
2. Development of experimental techniques and equipment for monitoring the environment; establishment of controlled environment systems: R C Simmons, Dr J Caseley

MICROBIOLOGY GROUP (*Leader:* M P Greaves)

1. Effects of herbicides and their metabolites on natural microbial populations and their activities in the soil: J A Marsh
2. The effects of herbicides and breakdown products on the microflora of the root region of plants: M P Greaves, G I Wingfield
3. Interactions between herbicides and the physiology and population dynamics of model microbial ecosystems: G I Wingfield, M P Greaves

WEED BIOLOGY GROUP (*Leader:* R J Chancellor)

1. Periodicity of germination of weed seeds. Chemicals for breaking seed dormancy: R J Chancellor, Dr N C B Peters
2. Vegetative regeneration of weeds: R J Chancellor
3. Grassland weed ecology: E D Williams, R J Chancellor
4. Inter-action of factors affecting competition between crops and weeds: Dr N C B Peters
5. Arable weed ecology: R J Chancellor, Dr R J Froud-Williams
6. Influence of light on seed germination and vegetative regeneration of weeds: R J Chancellor, Dr J Hilton

SPECIAL SERVICES

1. Plant raising facilities for pot experiments: R H Webster
2. Research engineering and instrumentation: R Kibble-White, R W Foddy, J A Drinkwater, C J Stent

EXTRA-DEPARTMENTAL RESEARCH GROUPS

DEVELOPMENTAL BOTANY GROUP (*Leader:* Dr D J Osborne)

1. Dormancy and viability of weed seeds: Dr J Osborne, Dr J A Sargent, Dr R Hooley
2. Importance of stress conditions in seed germination and seedling establishment: Dr D J Osborne, Dr J A Sargent, Dr M Wright
3. Factors regulating perennation and regeneration of plant parts: Dr D J Osborne, Dr J A Sargent, Dr M Wright
4. Control of seed shedding in weed species: Dr D J Osborne, Dr J A Sargent, Dr R Hooley

AQUATIC WEED AND UNCROPPED LAND GROUP (*Leader:* T O Robson)

1. Development of chemical methods of controlling aquatic vascular plants and algae: T O Robson, P R F Barrett
2. Assessment of potential of grass carp for the control of aquatic weeds: M C Fowler, T O Robson (Joint project with MAFF Freshwater Fisheries Laboratory)
3. The role of herbicides and growth regulators in the management of vegetation on uncropped land: E J P Marshall, T O Robson
4. Advisory service on aquatic weed control: T O Robson, P R F Barrett

ODA TROPICAL WEEDS GROUP (*Leader:* C Parker)

1. New herbicide treatments for use in tropical crops against annual and established perennial weeds: C Parker
2. Study of the resistance of sorghum and millet varieties to a range of *Striga* species and strains: C Parker
3. Liaison and advisory work on weed control in developing countries: C Parker, A K Wilson

INFORMATION DEPARTMENT

Head of Department: J E Y Hardcastle

1. Library, information, editorial and public relations services: J E Y Hardcastle, B R Burton, H R Broad, N Kiley
2. Production of *Weed Abstracts:* W L Millen, J L Mayall, P J Kemp, H R Broad, M Turton

ADMINISTRATION DEPARTMENT

Head of Department: B A Wright

1. Photographic services: R N Harvey, J Kilcoyne, J Charlett

LIST OF PUBLICATIONS
1980-81

1019* AYRES, P. The implications of high speed low volume spraying for the efficiency of herbicides used in winter cereals. *Proceedings British Crop Protection Conference—Weeds,* 1980, 973-979.

1008 AYRES, P. Investigations on the growth of *Arrhenatherum elatius* var. *bulbosum* with reference to the effect of tillage, autumn regrowth and reproduction by seed. *Association of Applied Biologists Conference: Grass weeds in cereals in the UK,* 1981, 77-81.

941 AYRES, P & CUSSANS, G W. The influence of volume rate, nozzle size and forward speed on the activity of three herbicides for the control of weeds in winter cereals. *BCPC Monograph,* 1980, **24,** 57-64.

1014 AYRES, P & RICHARDSON, W G. Some pot experiments to investigate potential control of *Bromus sterilis* by various herbicides. *Association of Applied Biologists Conference: Grass weeds in cereals in the UK,* 1981, 265-272.

964 BAILEY, J A. Perennial weeds: their survival and spread. *Proceedings Conference Weed Control in Amenity Planting,* 1980, 22-26.

BAILEY, J A. Black polythene mulches for young blackcurrants. *Technical Leaflet ARC Weed Research Organization,* 1981, **20,** 2 pp.

973 BAILEY, J A & CLAY, D V. The safety and effectiveness of 3,6-dichloropicolinic acid for the control of *Cirsium arvense* in strawberries. *Proceedings British Crop Protection Conference—Weeds,* 1980, 321-328.

1034 BARRETT. P R F. Aquatic herbicides in Great Britain; recent changes and possible future development. *Association of Applied Biologists Conference: Aquatic weeds and their control,* 1981, 95-104.

1063 BARRETT, P R F. Diquat and sodium alginate for weed control in rivers. *Journal of Aquatic Plant Management,* 1981, **19,** 51-52.

1035 BARRETT, P R F. A comparison of two formulations of diquat for weed control in rivers. *Association of Applied Biologists Conference: Aquatic weeds and their control,* 1981, 183-188.

1036 BASTIAN, C J & CUSSANS, G W. The population dynamics of weed beet. *British Sugar Beet Review,* 1981, **49,** (2), 17, 20-21.

966 BLACKMAN, G E & FRYER, J D. Chemical weed control in the tropics. *Ecology Bulletin Swedish National Science Research Council,* 1978, **27,** 210-218.

971 BOATMAN, N D, HAGGAR, R J & SQUIRES, N R W. Effects of band-spray width and seed coating on the establishment of slot-seeded grass and clover. *Proceedings British Crop Protection Conference—Weeds,* 1980, 503-509.

1084 BYAST, T H & HANCE, R J. Decomposition of linuron and simazine incubated with soil containing aged residues. *Proceedings EWRS Symposium—Theory and practice of the use of soil-applied herbicides,* 1981, 56-62.

989 CASELEY, J C. Investigating the effects of weather on foliage-applied herbicides. *Report ARC Weed Research Organization, 1978-1979,* 1980, **8,** 68-75.

1072 CASELEY, J C. Influence of the environment on herbicide activity. *Herbicidas en Hortofruticultura XIII Jornadas de Estudio. Asociacion Interprofesional Para Desarrollo Agrario,* 1981, 1-19.

* The numbers appearing in the left hand margin of this list are the WRO serial numbers for each item. For reprints please quote the number(s) required and remit a reproduction and postage charge at the rate of £2.00 per reprint. Technical Reports and Bibliographies are available (cash with order) at the prices quoted in the list. Technical Leaflets are available free. All publication orders should be addressed to the Secretary, ARC Weed Research Organization, Begbroke Hill, Yarnton, Oxford, OX5 1PF.

963 CASELEY, J C & COUPLAND, D. Effect of simulated rain on retention, distribution, uptake, movement and activity of difenzoquat applied to *Avena fatua. Annals of Applied Biology,* 1980, **96**, (1), 111-118.

999 CHANCELLOR, R J. Dormancy. *Proceedings ADAS Conference Crop Seed and Environment, Malvern, 1979,* 1980, 86-105.

1098 CHANCELLOR, R J. New weeds for old in annual crops. In: *Opportunities for increasing crop yields,* 1980. R G Hurd, P V Biscoe & C Dennis (Eds), London, Pitman, 313-322.

1069 CHANCELLOR, R J. The manipulation of weed behaviour for control purposes. *Philosophical Transactions of the Royal Society, London,* 1981, **B295**, 103-110.

CHANCELLOR, R J (Ed). *ARC Weed Research Organization: Twenty-one years of achievement 1960-81.* Oxford, Weed Research Organization, 1981, 20 pp.

CHANCELLOR, R J & BROAD, H R. *Garden weeds and their control.* London etc. Inkata Press, 1980, 93 pp.

1107 CHAUDHARY, S A, PARKER, C & KASASIAN, L. Weeds of central southern and eastern Arabian peninsula. *Tropical Pest Management,* 1981, **27**, (2), 181-190.

980 CHOW, P N P & TAYLOR, H F. Improved herbicidal performance of DPX 4189 on oil-seed rape by the addition of surfactants. *Proceedings British Crop Protection Conference—Weeds,* 1980, 23-28.

953 CLAY, D V. Indices and criteria for comparing the tolerance of strawberries to herbicides in dose-response experiments. *Weed Research,* 1980, **20**, (2), 91-96.

954 CLAY, D V. The use of separate root and shoot tests in the screening of herbicides for strawberries. *Weed Research,* 1980, **20**, (2), 97-102.

975 CLAY, D V. The effect of application timing and formulation on tolerance of strawberries to oxadiazon. *Proceedings British Crop Protection Conference—Weeds,* 1980, 337-344.

976 CLAY, D V. The influence of application date and growing system on the response of strawberries to propyzamide, simazine and trietazine + simazine. *Proceedings British Crop Protection Conference—Weeds,* 1980, 345-352.

988 CLAY, D V. The role of crop tolerance tests in the development of strawberry herbicides. *Report ARC Weed Research Organization, 1978-1979,* 1980, **8**, 59-67.

996 CLAY, D V. Biological assay methods for herbicide residues. *Paper read at Agricultural Science Service Soil Scientists Conference on Pesticide Residues, London,* 1980, 12 pp.

CLAY, D V. New herbicides for strawberries. *Technical Leaflet ARC Weed Research Organization,* 1980, **16**, 4 pp.

1032 CLAY, D V. Weed control—where next? *Grower,* 1981, **95**, (17), 64, 66, 69-70.

CLAY, D V. Factors affecting the tolerance of soil-acting herbicides by fruit trees. *Technical Leaflet ARC Weed Research Organization,* 1981, **(19)**, 2 pp.

1074 CLAY, D V. Evaluating residual orchard herbicides. *Grower,* 1981, **96**, (16), 36, 41, 43.

1117 CLAY, D V. The tolerance of strawberries to ethofumesate: differences in varietal response and effects of mixtures with phenmedipham. *Experimental Horticulture,* 1981, **32**, 38-48.

1027 CLAY, D V & DAVISON, J F. Strawberry herbicides. New answer to annual weeds. *Grower,* 1981, **95**, (14), 20.

947 CLIPSHAM, I D. The influence of target area on the variability of spray deposits. *BCPC Monograph,* 1980, **24**, 133-138.

992 COLE, D J, DODGE, A D & CASELEY, J C. Some biochemical effects of glyphosate on plant meristems. *Journal of Experimental Botany,* 1980, **31**, (125), 1665-1674.

1106 COOPER, J P, GREEN, J O & HAGGAR, R J. The management of horse paddocks. London. Horserace Betting Levy Board, 1981, 9 pp.
969 COTTERILL, E G. Determination of diuron residues in soil: comparison of determinations by high-performance liquid chromatography and gas-liquid chromatography. *Analyst,* 1980, **105**, 987-990.
962 COTTERILL, E G. Determination of residues of methazole and its metabolites, 1-(3,4-dichlorophenyl)-3-methylurea and 1-(3,4-dichlorophenyl) urea in soil by high-performance liquid chromatography. *Journal of Chromatography,* 1980, **197**, 267-270.
946 COTTERILL, E G. The efficiency of methanol for the extraction of some herbicide residues from soil. *Pesticide Science,* 1980, **11**, (1), 23-28.
1013 COUPLAND, D & CASELEY, J C. Environmental influences on the effect of glyphosate on *Agropyron repens. Association of Applied Biologists Conference: Grass weeds in cereals in the UK,* 1981, 177-186.
979 COUPLAND, D & PEABODY, D V. Control of field horsetail using a soil fumigant containing 1,3-dichloropropene. *Proceedings British Crop Protection Conference—Weeds,* 1980, 595-599.
1091 COUPLAND, D & PEABODY, D V. Response of field horsetail to several thiocarbamate herbicides. *Research Progress Report Western Society of Weed Science,* 1980, 13-14.
1092 COUPLAND, D & PEABODY, D V. Field horsetail control using a soil fumigant containing 1,3-dichloropropene. *Research Progress Report Western Society of Weed Science,* 1980, 15-16.
1028 COUPLAND, D & PEABODY, D V. Effect of four foliage-applied herbicides on field horsetail (*Equisetum arvense*). *Weed Science,* 1981, **29**, (1), 113-119.
1071 COUPLAND, D & PEABODY, D V. Absorption, translocation, and exudation of glyphosate, fosamine, and amitrole in field horsetail *Equisetum arvense. Weed Science,* 1981, **29**, (5), 556-560.
1090 COUPLAND, D & PEABODY, D V. Effects of soil placement on the performance of dichlobenil and vernolate against field horsetail. *Canadian Journal of Plant Science,* 1981, **61**, (4), 971-975.
921 CUSSANS, G W. Weeds in cereals and their control. *Span,* 1980, **23**, (1), 30-32.
1017 CUSSANS, G W. Strategic planning for weed control—a researcher's view. *Proceedings British Weed Control Conference—Weeds,* 1980, 823-832.
1016 CUSSANS, G W. Weed control in cereals—a long term view. *Association of Applied Biologists Conference: Grass weeds in cereals in the UK,* 1981, 355-361.
CUSSANS, G W. Weeds, weed control and cereal yields. *NAC Cereal Unit Course: Yield of cereals,* 1981, 12 pp.
945 DAVIES, E Ll P & TAYLOR, W A. The biological activity of three herbicides when applied by differing hydraulic nozzle types. *BCPC Monograph,* 1980, **24**, 49-55.
994 DAVIES, H A & MARSH, J A P. Effects of chlorpropham, chlortoluron and isoproturon on respiration and transformation of nitrogen in two soils. *Bulletin of Environmental Contamination and Toxicology,* 1980, **25**, (5), 706-712.
1076 DAVIES, H A & GREAVES, M P. Effects of some herbicides on soil enzyme activities. *Weed Research,* 1981, **21**, (5), 205-209.
1073 DAVISON, J G. Black plastics benefit young trees. *Grower,* 1981, **96**, (16), 44, 46.
965 DAVISON, J G. Strategies and programming for weed control in amenity plantings. *Proceedings Conference Weed Control in Amenity Planting,* 1980, 27-35.
974 DAVISON, J G & BAILEY, J A. The response of strawberries to spring applications of pendimethalin. *Proceedings British Crop Protection Conference—Weeds,* 1980, 329-336.
939 DAVISON, J G & BAILEY, J A. The effect of weeds on the growth range of

nursery stock species planted as liners and grown for two seasons. *Proceedings of the Conference on Weed Control in Forestry, Nottingham,* 1980, 13-20.

EAGLE, D J, CAVERLY, D J with assistance from HOLLY, K. Diagnosis of herbicide damage to crops. *MAFF Reference Book,* 1981, **221**, 69 pp.

1054 EDWARDS, R V, HAGGAR, R J, JACKSON, M V & ALDRICH, D T A. The British Grassland Society Dorset site. *Grass and Forage Science,* 1981, **36**, (2) 135-137.

1061 ELLIOTT, J G. The price of loaded wheels. *Soil and Water,* 1979, **7**, (2), 9-11.

943 ELLIOTT, J G. Low volume, low drift and high speed—great new opportunity. *BCPC Monograph,* 1980, **24**, 175-183.

ELLIOTT, J G. Weeds continue to challenge autumn cereal growing. *Newport and Market Drayton Advertiser,* 1980 (Farming Supplement—September).

1018 ELLIOTT, J G. The economic significance of weeds in the harvesting of grain. *Proceedings British Crop Protection Conference—Weeds,* 1980, 787-798.

1097 ELLIOTT, J G. Weed control: past, present and future—a historical perspective. In: *Opportunities for increasing crop yields,* R G Hurd, P V Biscoe and D Dennis (Eds), London, Pitman, 1980, 285-295.

1038 ELLIOTT, J G. Getting out of the rut. *NAC News,* 1981, (June), 11.

ELLIOTT, J G. The role of low ground pressure vehicles. *SAWMA Conference Soil Compaction: causes and cures,* 1981, Paper 6.

995 ELLIOTT, J G. Back to a four-course rotation to beat problem weeds. *Arable Farming,* 1981, **8**, (1), 64.

ELLIOTT, J G. Twenty-one years of WRO achievement. *Technical Leaflet ARC Weed Research Organization,* **22**, 2 pp.

ELLIOTT, J G. Chemical strategies for the rapidly changing cereal situation. *BASF Meeting: The cost effective use of agrochemicals, Stratford-on-Avon,* 1981.

ELLIOTT, J G. Weeds in the 1980s—the adviser, the agronomist or the microchip. *Paper for ICI Wheatrace Prizegiving,* 1981.

1031 ELLIOTT, J G & DALE, R J. Further experience of beef production on permanent pasture in 1976-78. *Grass and Forage Science,* 1980, **35**, (4), 319-321.

FROUD-WILLIAMS, R. The effect of reduced cultivation systems on arable weed floras with emphasis on factors likely to influence germination and establishment. *Ph.D Thesis University of Reading,* 174 pp.

1006 FROUD-WILLIAMS, R. Germination behaviour in *Bromus* sp. and *Alopecurus myosuroides. Association of Applied Biology Conference: Grass weeds in cereals in the UK*, 1981, 31-40.

1059 FROUD-WILLIAMS, R J, CHANCELLOR, R J & DRENNAN, D S H. Potential changes in weed floras associated with reduced-cultivation systems for cereal production in temperate regions. *Weed Research,* 1981, **21**, (2), 99-109.

986 FROUD-WILLIAMS, R J, POLLARD, F & RICHARDSON, W G. Barren brome: a threat to winter cereals? *Report ARC Weed Research Organization, 1978-1979,* 1980, **8**, 43-51.

940 FRYER, J D. Objectives and constraints in the development of spraying systems for arable farming in the UK. *BCPC Monograph,* 1980, **24**, 3-14.

1064 FRYER, J D. Weed control practices and changing weed problems. In: *Pests, pathogens and vegetation.* J M Thresh (Ed.). London etc. Pitman 1981, 403-414.

1070 FRYER, J D. Weed management: fact or fable? *Philosophical Transactions of the Royal Society, London,* 1981, **B295**, 185-197.

1021 FRYER, J D. Herbicides: do they affect soil fertility? *Span.* 1981, **24**, (1), 5-10.

955 FRYER, J D, SMITH, P D & HANCE, R J. Field experiments to investigate long-term effects of repeated applications of MCPA, tri-allate, simazine and

linuron: II. Crop performance and residues, 1969-78. *Weed Research,* 1980, **20**, (2), 103-110.
956 FRYER, J D, LUDWIG, J W, SMITH, P D & HANCE, R J. Tests of soil fertility following repeated applications of MCPA, tri-allate, simazine and linuron. *Weed Research,* 1980, **20**, (2), 111-116.
997 GREAVES, M P. Effects of pesticides on soil microflora. *Paper read at Agricultural Science Service Soil Scientists Conference on Pesticide Residues, London,* 1980, 7 pp.
GREAVES, M P. Stressed environments—pesticides. In: *Methods in microbial ecology.* R G Burns & J H Slater (Eds). Oxford, Blackwell Scientific Publications, 1980.
1056 GREAVES, M P, DAVIES, H A, MARSH, J A P & WINGFIELD, G I. Effects of pesticides on soil microflora using dalapon as an example. *Archives of Environmental Contamination and Toxicology,* 1981, **10**, 437-449.
1094 GREAVES, M P & MALKOMES, H P. Effects on soil microflora. In: *Interactions between herbicides and the soil.* R J Hance (Ed). London etc., Academic Press, 1981, 223-253.
GREAVES, M P, POOLE, N J, DOMSCH, K H, JAGNOW, C & VERSTRAETE, W. Recommended tests for assessing the side-effects of pesticides on the soil microflora. *Technical Report ARC Weed Research Organization,* 1980, **59**, 15 pp, £2.00.
933 HAGGAR, R J. Weed control and vegetation management by herbicides. In: *Amenity grassland: an ecological perspective.* I Rorison and R Hunt (Eds), John Wiley, Chichester, 1980, 163-173.
1022 HAGGAR, R J. Survey of the incidence of docks (*Rumex* spp) in grassland in ten districts in the United Kingdom in 1972. *ADAS Quarterly Review,* 1980, (39), 256-270.
HAGGAR, R J. Advances in grassland weed control. *Technical Leaflet ARC Weed Research Organization,* 1981, **21**, 2 pp.
985 HAGGAR, R J & BASTIAN, C J. Regulating the content of white clover in mixed swards using grass-suppressing herbicides. *Grass and Forage Science,* 1980, **35**, (2), 129-137.
1066 HAGGAR, R J & KIRKHAM, F W. Selective herbicides for establishing weed-free grass. I. Evaluation of ethofumesate and methabenzthiazuron. *Weed Research,* 1981, **21**, (3/4), 141-151.
1101 HAGGAR, R J, KOCH, D W & BOATMAN, N D. Introducing clovers into grass swards by slot-seeding (no-till). *Summaries of Papers XIV International Grassland Congress, Lexington, Kentucky,* 1981, 291.
1067 HAGGAR, R J & PASSMAN, A. Soil persistence and distribution of ethofumesate applied to autumn-sown perennial ryegrass for *Poa annua* control. *Weed Research,* 1981, **21**, (3/4), 153-159.
1108 HANCE, R J. Possibilities for co-operative research in Europe. *Convegno sul terma "Inquiramento del Terreno" una Ricera Coorderata Sull 'Inquinamento del Terreno de Atrazina, Pisa, 1979,* 1981, 19-29.
919 HANCE, R J. Herbicides and the soil. *Chemistry in Britain,* 1980, **16**, (3), 128, 130-131, 156.
998 HANCE, R J. Processes affecting loss of herbicides from soil. *Paper read at Agricultural Science Service Soil Scientists Conference on Pesticide Residues, London,* 1980, 8 pp.
HANCE, R J (Ed). Interactions between herbicides and the soil. London, etc. Academic Press, 1980, xii + 349 pp.
1048 HANCE, R J. Effects of pesticides on plant nutrition. *Residue Reviews*, 1981, **78**, 13-41.

1093 HANCE, R J. Transport in the vapour phase. In: *Interactions between herbicides and the soil.* R J Hance (Ed.) London, Academic Press, 1981, 59-81.

957 HANCE, R J, BYAST, T H & SMITH, P D. Apparent decomposition of paraquat in soil. *Soil Biology and Biochemistry,* 1980, **12,** (4), 447-448.

1100 HANCE, R J, EMBLING, S J, HILL, D, GRAHAM-BRYCE, I J & NICHOLLS, P. Movement of fluometuron, simazine, $C1^-$ and Ce^+ in soil under field conditions: qualitative aspects. *Weed Research,* 1981, **21,** (6), 289-297.

1058 HANCE, R J & HAYNES, R A. The kinetics of linuron and metribuzin decomposition in soil using different laboratory systems. *Weed Research,* 1981, **21,** (2), 87-92.

1062 HANCE, R J & SEGAL, G M. A comparison of the decomposition of atrazine and diuron in soil of different fertilizer content and pH. *Agrochimica,* 1980, **24,** (4), 265-273.

1044 HANLEY, S. The effect of glyphosate on *Scirpus maritimus. Association of Applied Biologists Conference: Aquatic weeds and their control,* 1981, 199-200.

HARDCASTLE, J E Y (Ed). Illustrated by BROAD, H R. *Chemical weed control in your garden.* London, Grower Books, 1980, 24 pp.

11005 HARDCASTLE, J E Y. Weed biology, weed control and herbicides. In: *Information sources in agriculture and food science.* G P Lilley (Ed) London, etc. Butterworths, 1981, 241-265.

HILTON, J R. Phytochrome control of plastic gibberellin levels. *Ph.D. Thesis University of Leicester,* 170 pp.

HILTON, J R & SMITH, H. The presence of phytochrome in purified barley etioplasts and its *in vitro* regulation of biologically-active gibberellin levels in etioplasts. *Planta,* 1980, **148,** 312-318.

1030 HODGE, G & HAGGAR, R J. Evaluation of 4 fluid carriers for enhanced germination of perennial ryegrass and white clover seed under moisture stress. *Annals of Applied Biology,* 1981, **97,** (Supplement 1), 62-63.

HOOLEY, R & McCARTHY, D. Extracts from virus infected hypersensitive tobacco leaves are detrimental to protoplast survival. *Physiological Plant Pathology,* 1980, **16,** 25-38.

KILEY, N. Application research at the Weed Research Organization. *Wilts and Gloucester Standard,* 1981 (Standard Farm Review), 10.

KILEY, N, RICHARDSON, W G & PARKER, C. Preliminary evaluation of herbicides at WRO. *Technical Leaflet ARC Weed Research Organization,* **18,** 5 pp.

981 KIRKHAM, F W. Weed control by paraquat during the establishment of paraquat-resistant ryegrass. *Proceedings British Crop Protection—Weeds,* 1980, 477-482.

1043 KIRKHAM, F W. The effect of pre- and post-emergence spraying with methabenzthiazuron on the herbage production of six ryegrass cultivars. *Annals of Applied Biology,* 1981, **97** (Supplement 2), 54-55.

1042 KIRKHAM, F W & RICHARDSON, W G. The pre-emergence selectivity of twelve herbicides between perennial ryegrass, white clover and four grass-weed species. *Annals of Applied Biology,* 1981, **97** (Supplement 2), 46-47.

938 LUTMAN, P J W. The effects of topical applications of glyphosate and aminotriazole on volunteer potatoes (*Solanum tuberosum*). *Weed Research,* 1979, **19,** (6), 377-383.

944 LUTMAN, P J W. A review of techniques that utilise height differences between crops and weeds to achieve selectivity. *BCPC Monograph,* 1980, **24,** 291-297.

1087 LUTMAN, P J W & THORNTON, M E. Consistency or variability, an investigation into the control of a range of broad-leaved and grass weeds in winter cereals with eight soil-applied herbicides. *Proceedings EWRS Symposium—Theory and practice of the use of soil-applied herbicides,* 1981, 258-266.

1039 MADGE, W R & MAY, M J. Developments in sugar beet weed control. *Annual Review Arthur Rickwood Experimental Husbandry Farm,* 1981, 33-38.

958 MARSH, J A P. Effects of asulam on some microbial activities of three soils. *Bulletin of Environmental Contamination and Toxicology,* 1980, **25**, (1), 15-22.

1052 MARSH, J A P & DAVIES, H A. Effects of dichlorprop and mecoprop on respiration and transformation of nitrogen in two soils. *Bulletin of Environmental Contamination and Toxicology,* 1981, **26**, (1), 108-115.

MARSHALL, E J P. The ecology of a land drainage channel. 1—Oxygen balance. *Water Research,* 1981, **15**, 1075-1085.

1083 MARSHALL, E J P. Flowery mead slot. *GC & HTJ,* 1981, (November), 13, 15.

951 MAY, M J. The work of the WRO Fenland unit. *Annual Review Arthur Rickwood Experimental Husbandry Farm,* 1980, 33-36.

1090 MAY, M. Results of some WRO experiments on the overall application of Betanal E and Goltix using repeated low doses, low volume and high pressure. *British Sugar Beet Review,* 1981, **49**, (1), 52, 53, 66.

1040 MAY, M J. The work of the WRO fenland team. *Annual Review Arthur Rickwood Experimental Farm,* 1981, 39-41.

1104 MERCER, E R, HILL, D in collaboration with MAY, M J & SMITH, P D. Behaviour of herbicides in soil and their uptake by plants. *Annual Report ARC Letcombe Laboratory 1979,* 1980, 58.

942 MERRITT, C R. The influence of application variables on the biological performance of foliage-applied herbicides. *BCPC Monograph,* 1980, **24**, 35-43.

MERRITT, C R. The effects of application factors on herbicide performance. *Technical Leaflet ARC Weed Research Organization,* 1980, **17**, 3 pp.

MERRITT, C R. Studies on the very low volume, controlled drop size application of MCPA, difenzoquat, paraquat and glyphosate. *Ph.D Thesis University of Bath,* 1980, 133 pp.

920 MOSS, S R. A study of population of black-grass (*Alopecurus myosuroides*) in winter wheat, as influenced by seed shed in the previous crop, cultivation system and straw disposal method. *Annals of Applied Biology,* 1980, **94**, (1), 121-126.

1024 MOSS, S R. Some effects of burning cereal straw on seed viability, seedling establishment and control of *Alopecurus myosuroides* Huds. *Weed Research,* 1980, **20**, (5), 272-276.

1020 MOSS, S R. The agro-ecology and control of black-grass *Alopecurus myosuroides* Huds. in modern cereal growing systems. *ADAS Quarterly Review,* 1980, (38), 170-191.

1005 MOSS, S R. The response of *Alopecurus myosuroides* during a four year period to different cultivation and straw disposal systems. *Association of Applied Biologists Conference: Grass weeds in cereals in the UK,* 1981, 15-21.

1010 MOSS, S R. Techniques for the assessment of *Alopecurus myosuroides. Association of Applied Biologists Conference: Grass weeds in cereals in the UK,* 1981, 101-107.

1055 MUSSELMAN, L J & PARKER, C. Surface features of *Striga* seeds (Scrophulariaceae) *Adansonia,* Ser. 2, 1981, **20**, (4), 431-437.

1078 MUSSELMAN, L J & PARKER, C. Studies on indigo witchweed, the American strain of *Striga gesnerioides* (Scrophulariaceae) *Weed Science,* 1981, **29**, (5), 594-596.

1007 OKEREKE, O U, BLAIR, A M & CASELEY, J C. Effects of depth of planting, temperature and soil moisture on seed emergence in soil of *Bromus sterilis* and *Phalaris minor. Association of Applied Biologists Conference: Grass weeds in cereals in the UK,* 1981, 41-46.

1099 OKEREKE, O U, BLAIR, A M & CASELEY, J C. Some factors affecting the activity of isoproturon against *Bromus sterilis* and *Phalaris minor. Mededelingen van de faculteit Landbouwwetenschappen, Rijksuniversiteit, Gent,* 1981, **46**, (1), 83-89.

OSBORNE, D J. Senescence in seeds. In: *Senescence of plants.* K Thimann (Ed). Baton Rouge CRC Press, 1980, 13-27.

968 OSBORNE, D J. Stratagems for survival in seeds. *British Plant Growth Regulator Group News Bulletin,* 1980, **4**, (1), 7-12.

1053 OSBORNE, D J. Dormancy as a survival stratagem. *Annals of Applied Biology* 1981, **98**, (3), 525-562.

1086 OSBORNE, D J. Physiological and biochemical events in seed development. In: *Advances in research and technology of seeds,* Part 6. J R Thomson (Ed) Wageningen, PUDOC, 1981, 43-62.

1045 OSBORNE, D J, SHARON, R & BEN-ISHÂE, R. Studies on DNA integrity and DNA repair in germinating embryos of rye (*Secale cereale*). *Israel Journal of Botany,* 1980/81, **28**, 259-272.

983 OSWALD, A K. Progress in the development of the selective application of herbicides to control *Rumex obtusifolius* in grassland. *Proceedings British Crop Protection Conference—Weeds,* 1980, 209-215.

991 OSWALD, A K. The use of sequential herbicide treatments to control *Poa trivialis* in two perennial ryegrass crops grown for seed. *Proceedings British Crop Protection Conference—Weeds,* 1980, 489-493.

1023 OSWALD, A K. The selective control of *Poa trivialis* by dalapon in perennial ryegrass crops grown for seed. *Weed Research,* 1980, **20**, (5), 305-309.

993 OSWALD, A K & HAGGAR, R J. Weed control in ryegrass sown for seed. *Proceedings 28th Nottingham Easter School in Agricultural Science, 1978,* 1980, 121-135.

1050 OSWALD, A K. Herbicides and seed production by two perennial ryegrass cultivars grown in weed-free conditions. *Grass and Forage Science,* 1981, **36**, (1), 59-63.

1082 PALLETT, K E. The mechanisms of activity and selectivity of the wild oat herbicides. *Proceedings British Crop Protection Conference—Weeds,* 1980, 843-854.

1095 PALLETT, K E & CASELEY, J C. Differential inhibition of DNA synthesis in difenzoquat tolerant and susceptible UK spring wheat cultivars. *Pesticide Biochemistry and Physiology,* 1980, **14**, (2), 144-152.

1077 PARKER, C. Parasitic weeds in developing countries—a brief review. *Pest Control in Developing Countries, GTZ/DSE Conference, Muenster, 1978,* 1980, 14.

977 PARKER, C. Parasitic weeds and their control in the tropics. *Proceedings of Conference International Institute of Tropical Agriculture, Ibadan 1977,* 1980, 22-50.

1029 PARKER, C. Possibilities for the selective control of *Rottboellia exaltata* in cereals with the help of herbicide safeners. *Tropical Pest Management,* 1981, **21**, (1), 139-140.

1109 PARKER, C. The selectivity of some herbicides against *Cyperus rotundus* in cotton. *Proceedings 8th Asian Pacific Weed Science Society,* 1981, 249-253.

1003 PARKER, C, DIXON, N H & CHADWICK, K. *Striga* and *Alectra* on cowpeas. *Haustorium,* 1980, (6), 1-2.

990 PARKER, C & REID, D C. Testing sorghum and other crops for resistance to witchweed. *Report ARC Weed Research Organization 1978-1979,* 1980, **8**, 76-83.

984 PARKER, C, RICHARDSON, W G & WEST, T M. Potential for extending the selectivity of DPX 4189 by the use of herbicide safeners. *Proceedings British Crop Protection Conference—Weeds,* 1980, 15-22.

987 PETERS, N C B & WILSON, B J. Dormancy in wild-oat seed and its agricultural

significance. *Report ARC Weed Research Organization, 1978-1979,* 1980, **8,** 52-58.

982 PHIPPS, P & ROEBUCK, J F. Agricultural Development and Advisory Service/Weed Research Organization, *Avena fatua* case studies. *Proceedings British Crop Protection Conference—Weeds,* 1980, 407-414.

PILMOOR, J and GRANT, J K. The behaviour and mode of action of the phenoxyacetic acids in plants. *Progress in Pesticide Biochemistry,* 1981, **1,** 147-217.

1068 POLLARD, F & CUSSANS, G W. The influence of tillage on the weed flora in a succession of winter cereal crops on a sandy loam soil. *Weed Research,* 1981, **21,** (3/4), 185-190.

1081 POLLARD, F, ELLIOTT, J G, ELLIS, F B & BARNES, B T. Comparison of direct drilling reduced cultivation and ploughing on the growth of cereals. 4. Spring barley and winter wheat on silt loam soils over chalk. *Journal of Agricultural Science, Cambridge,* 1981, **97,** (3), 677-684.

1015 POLLARD, F & RICHARDSON, W G. Chemical control of *Bromus sterilis* in winter wheat and barley. *Association of Applied Biologists Conference: Grass weeds in cereals in the UK,* 1981, 273-281.

936 RICHARDSON, W G & TURNER, D J. Pot experiments to evaluate treatments for seeds used in forest nurseries. *Proceedings of the Conference on Weed Control in Forestry, Nottingham,* 1980, 167-174.

RICHARDSON, W G, WEST, T M & PARKER, C. The activity and post-emergence selectivity of some recently developed herbicides: R 40244, DPX 4189, acifluorfen, ARD 34/02 (NP 55) and PP 009. *Technical Report ARC Weed Research Organization,* 1980, **61,** 57 pp, £3.75.

RICHARDSON, W G, WEST, T M & PARKER, C. The activity and pre-emergence selectivity of some recently developed herbicides: UBI S-734, SSH-43, ARD 34/02 (= NP 55), PP 009 and DPX 4189. *Technical Report Weed Research Organization,* 1981, **62,** 59 pp, £3.50.

RICHARDSON, W G, WEST, T M & PARKER, C. The activity and post-emergence selectivity of some recently developed herbicides: SSH-41, MB 30755, AC 213087, AC 222293 and Dowco 433. *Technical Report ARC Weed Research Organization,* 1981, **63,** 60 pp, £3.50.

1075 ROBERTS, J A & OSBORNE, D J. Auxin and the control of ethylene production during the development and senescence of leaves and fruits. *Journal of Experimental Botany,* 1981, **32,** (130), 875-887.

1103 ROBSON, T O. Water hyacinth. *News and Views from the World Bank,* 1980, 9 pp.

1057 ROBSON, T O. Aquatic weed research in Britain. *Journal of Aquatic Plant Management,* 1981, **19,** 47-48.

ROBSON, T O. Review of E C S Little's Handbook of utilization of aquatic plants. *Tropical Pest Management,* 1980, **26,** (4), 459-460.

960 ROBSON, T O & BARRETT, P R F. The concept of localised control of aquatic weeds. *ADAS Quarterly Review,* 1980, (37), 123-128.

SARGENT, J A & OSBORNE, D J. A comparative study of the fine structure of coleorhiza and root cells during the early hours of germination of rye embryos. *Protoplasma,* 1980, **104,** 91-103.

1079 SARGENT, J. The fine structure of the downy mildews. In: *The downy mildews.* D M Spencer (Ed), London, Academic Press, 1981, 183-236.

1080 SARGENT J, SEN MANDI, S & OSBORNE, D J. The loss of dessication tolerance during germination: an ultrastructural and biochemical approach. *Protoplasma,* 1981, **105,** 225-239.

SIMMONS, R C. Properties of natural rainfalls and their simulation in the laboratory

for pesticide research. *Technical Report ARC Weed Research Organization,* 1980, **60**, 24 pp. £1.25.
1085 SIRIWARDANA, T G D, BLAIR, A M & BARTLETT, B O. The leaching of chlortoluron, isoproturon and metoxuron as determined by bioassay of soil columns. *Proceedings EWRS Symposium—Theory and practice of the use of soil applied herbicides,* 1981, 309-317.
972 SKUTERUD, R & CASELEY, J C. Effects of simulated rain on bentazone activity against meadow fescue, timothy and white mustard. *Proceedings British Crop Protection Conference—Weeds,* 1980, 573-580.
1049 STENT, C J, TAYLOR, W A & SHAW, G B. A method for the production of uniform-sized drops using electrostatic dispersion. *Tropical Pest Management,* 1981, **27**, (20), 262-264.
978 TAYLOR, W A. Controlled drop application: its relevance for chemical weed control. *Proceedings of Conference International Institute of Tropical Agriculture, Ibadan, 1978,* 1980, 371-378.
1033 TAYLOR, W A. Controlled drop application of herbicides. *Outlook on Agriculture,* 1981, **10**, (7), 333-336.
948 TAYLOR, W A, CHOW, P N P & OWEN, P G. Influence of surfactants on spray deposition and biological activity of diclofopmethyl on wild oat (*Avena fatua* L.) *BCPC Monograph,* 1980, **24**, 45-48.
1002 TERRY, P J. *Striga* in the Gambia. *Haustorium,* 1980, (6), 2.
1025 TERRY, P J. Weeds and their control in the Gambia. *Tropical Pest Management,* 1981, **27**, (1), 44-52.
1065 TERRY, P J. Weed management in developing countries. *Sixth Conference of the Indonesian Weed Science Society,* 1981, 253-258.
1088 TERRY, P J. Adding to the weed weapon arsenal. *International Agricultural Development,* 1981, (Nov/Dec), 14-15.
1037 TERRY, P J, ROBSON, T O & HANLEY, S. Localized control of aquatic weeds with dichlobenil. *Association of Applied Biologists Conference: Aquatic weeds and their control,* 1981, 165-176.
967 THORNTON, M E & AYRES, P. Review of herbicide application equipment developed at the Weed Research Organization. *Proceedings 5th International Conference on Mechanization of Field Experiments,* 1980, 124-130.
1046 TOTTMAN, D R. Cereal varieties differ in their tolerance of herbicide. *Agritrade,* 1980 (October), 38-40.
1047 TOTTMAN, D R. Varietal differences in the tolerance of cereals to herbicides. *Proceedings NIAB Conference,* 1981, 68-73.
1012 TURNER, D J. The effect of additives on the control of *Agropyron repens* with glyphosate. *Association of Applied Biologists Conference: Grass weeds in the UK,* 1981, 167-168.
1011 TURNER, D J & CUSSANS, G W. Techniques for the assessment of perennial grass weeds. *Association of Applied Biologists Conference: Grass weeds in cereals in the UK,* 1981, 109-114.
961 TURNER, D J & LOADER, M P C. Effects of ammonium sulphate and other additives upon the phytotoxicity of glyphosate to *Agropyron repens* (L) Beauv. *Weed Research,* 1980, **20**, (3), 139-146.
932 TURNER, D J & RICHARDSON, W G. Herbicide evaluation for forestry uses. *Report on Forest Research 1979,* 1980, 55-57.
1001 TURNER, D J, RICHARDSON, W G & CLIPSHAM, I D. Evaluation of herbicides for forest uses. *Report on Forest Research 1979,* 1980, 53-54.
935 TURNER, D J, RICHARDSON, W G, LOADER, P M C & CLIPSHAM, I D. Pot experiments to evaluate herbicides for weed control in young conifer and hardwood

plantations. *Proceedings of the Conference on Weed Control in Forestry, Nottingham,* 1980, 201-208.

970 WATT, T A & HAGGAR, R J. The effect of height of water table on the growth of *Holcus lanatus* with reference to *Lolium perenne. Journal of Applied Ecology,* 1980, **17**, (2), 423-430.

1000 WATT, T A & HAGGAR, R J. The effect of defoliation upon yield, flowering and vegetative spread of *Holcus lanatus* growing with and without *Lolium perenne. Grass and Forage Science,* 1980, **35**, (3), 227-234.

1026 WILSON, A K. *Euphorbia heterophylla:* a review of distribution, importance and control. *Tropical Pest Management,* 1981, **27**, (1), 32-38.

1060 WILSON, A K. Commelinaceae—A review of the distribution, biology and control of the important weeds belonging to this family. *Tropical Pest Management,* 1981, **27**, (3), 405-418.

952 WILSON, B J. The effects of yield on mixtures and sequences of herbicides for the control of *Alopecurus myosuroides* Huds. and broad-leaved weeds in winter cereals. *Weed Research,* 1980, **20**, (1), 65-70.

1009 WILSON, B J. Techniques for the assessment of *Avena fatua* L. *Association of Applied Biologists Conference: Grass weeds in cereals in the UK,* 1981, 93-100.

1004 WILSON, B J. A review of the population dynamics of *Avena fatua* L. in cereals with special reference to work at the Weed Research Organization. *Association of Applied Biologists: Grass weeds in cereals in the UK,* 1981, 5-14.

1041 WILSON, B J. The influence of reduced cultivations and direct drilling on the long-term decline of a population of *Avena fatua* L. in spring barley. *Weed Research,* 1981, **21**, (1), 23-28.

937 WINGFIELD, G I. Effects of asulam on cellulose decomposition in three soils. *Bulletin of Environmental Contamination and Toxicology,* 1980, **24**, (3), 473-476.

950 WINGFIELD, G I. Effects of time of soil collection and storage on microbial decomposition of cellulose in soil. *Bulletin of Environmental Contamination and Toxicology,* 1980, **24**, (4), 671-675.

1051 WINGFIELD, G I & JOHNSON, J M. Deoxygenation of water following use of the herbicide terbutryn simulated in a batch culture system. *Bulletin of Environmental Contamination and Toxicology,* 1981, **26**, (1), 65-72.

WRO ANNOTATED BIBLIOGRAPHIES 1980-81

142 Selected references to the biology and control of *Imperata* species (a supplement to bibliographies nos. 28, 75 and 98), 1976-1980, (84 references). Price—£4.40.

143 Selected references to the biology and control of *Panicum maximum.* 1956-1980, (137 references). Price—£5.50.

144 Selected references to the biology and control of hemiparasitic Santalaceae and Scrophulariaceae (including Striga). (A supplement to bibliographies No. 17, 50, 74, 86, 108 and 134). 1979-1981, (117 references). Price —£4.95.

145 Selected references to the biology and control of Orobanchaceae (A supplement to bibliographies Nos. 23, 49, 77, 107 and 133), 1979-1981 (111 references). Price—£4.95.

MEMBERSHIP OF THE DIRECTOR'S ADVISORY GROUP

as at 31st December 1981

Chairman:

Professor A H Bunting, CMG, DPhil, FIBiol
Professor of Agricultural Development Overseas, Reading University

*Current Members**

Mr S J Bide, Director, Hampshire Arable Systems Ltd

Dr J T Braunholtz, BA, MA, PhD, FRSC, Director of Production and Planning, ICI Plant Protection Division

Professor A T Bull, BSc, PhD, Professor of Microbiology, Biological Laboratory, University of Kent

Professor F T Last, BSc, PhD, DSc, Head, Division of Plant Ecology, Institute of Terrestrial Ecology, Edinburgh Laboratory

Professor G M Milbourne, MSc, PhD, Director, National Institute of Agricultural Botany, Cambridge

Professor N W Moore, PhD, Chief Advisory Officer, Nature Conservancy Council

Mr J J North, Head, ADAS Special Projects Division, Ministry of Agriculture, Fisheries and Food

Professor E H Roberts, BSc, PhD, DSc, FIBiol, Professor of Crop Production, Reading University

Professor G R Sagar, MA, DPhil, Professor of Agricultural Botany, School of Plant Biology, University College of North Wales

Professor P F Wareing, PhD, DSc, FRS, FLS, Department of Botany and Microbiology, University College of Wales

Members retiring during 1980-81

Professor R N Curnow, BA, PhD, Department of Applied Statistics, Reading University

Mr J G Jenkins, Childerly Hall, Dry Drayton, Cambridge

* Members are appointed by the Secretary to the Agricultural Research Council after consultation with the Director. The terms of reference of the Advisory Group are to advise the Director on the development of the programme of the Institute. Appointments are made for three years initially; members serve in a personal capacity and are selected for their personal qualifications rather than for their representation of interests in science or agriculture.

STAFF OF THE ARC WEED RESEARCH ORGANIZATION

As at 31st December 1981

Director and Visiting Professor, University of Reading
J D Fryer CBE, MA, FIBiol

Institute Secretary
B A Wright MBE, MBIM

Secretary to Director
Mrs M E Weedon

WEED CONTROL DEPARTMENT

Head of Department: J G Elliott MA, MIBiol

ANNUAL CROPS GROUP

Leader: G W Cussans BSc

Scientific Staff

P Ayres
C J Bastian
P J W Lutman BSc, PhD
M J May
S R Moss BSc
F Pollard BSc
M E Thornton
D R Tottman BSc, MIBiol
B J Wilson BSc

Assistants

Mrs D M Bailey BA
Miss J E Birnie
R A P Denner
Miss F L Hemmings
A W Lovegrove
Miss J Peet
P A Phipps
S L Woolliams

Student
C Farman

GRASS AND FODDER CROPS GROUP

Leader: R J Haggar BSc, PhD

Scientific Staff

A K Oswald
F W Kirkham
Miss C Standell BSc

Assistants

M Hayes
P G Smith

Student
S Isaac

PERENNIAL CROPS GROUP

Leader: J G Davison BSc, PhD

Scientific Staff

J A Bailey
D V Clay BSc

Assistants

J Lawrie
* Mrs S Jacques

* Part-time

SPECIAL SERVICES

J A Slater BA | M E Thornton | Mrs C M Smith* | J S Akers*

FARM

Farm Director: J G Elliott MA, MIBiol

Farm Manager: R J Dale Dip Farm Man.

F A Penfold | C G Woodhams | A E Wright

Secretarial Staff

Personal Secretary: Miss J M Hoddinott*

Mrs L M Marsland* | Mrs G M Pratley*

WEED SCIENCE DEPARTMENT

Head of Department: K Holly BSc, PhD

HERBICIDE GROUP

Leader: R J Hance BSc, PhD, CChem, FRSC

Scientific Staff

T H Byast LRSC
I D Clipsham
E G Cotterill LRSC
S J Embling
M P C Loader BSc
W G Richardson BSc, MIBiol
P D Smith
H F Taylor BSc, PhD
W A Taylor MIBiol
D J Turner BSc, PhD
T M West

Assistants

Mrs P M Baden*
Miss J M Heritage
Miss S J Norris
Miss P G Owen
Miss L Surman
G P White

ENVIRONMENTAL STUDIES GROUP

Leader: J C Caseley, BSc, PhD, MIBiol

Scientific Staff

A M Blair BSc, M.Phil, MIBiol
D Coupland BSc PhD
M L Hirst BA
J B Pillmoor BSc, PhD
C R Merritt PhD, MIBiol
R C Simmons BSc

Assistants

Mrs C M Bond* BA | Mrs A Quantrill* AIMLS | Miss D F Wyatt

MICROBIOLOGY GROUP

Leader: M P Greaves BSc

Scientific Staff

Mrs S L Cooper | J A P Marsh LRSC | G I Wingfield BSc, MSc

Assistants

Mrs J M Bebb | Miss K L Chadwick | Mrs C M-L Clipsham

* Part-time

WEED BIOLOGY GROUP

Leader: R J Chancellor MA

Scientific Staff

R J Froud-Williams BSc, PhD
Miss J Hilton BSc, PhD
N C B Peters BSc, PhD
E D Williams BSc

Assistant

Mrs P A Simmons

Post-Graduate Research Student

Mrs P M Owen BSc

RESEARCH ENGINEERING and INSTRUMENTATION SECTION

Leader: R Kibble-White BA

J A Drinkwater
R Foddy
N Heath
W Macklin
C J Stent BA

Special Services

R H Webster
R Porteous
S L Burbank

Secretarial Staff

Personal Secretary: Mrs D L Gawne
Mrs J Wallsworth

EXTRA-DEPARTMENTAL SCIENCE GROUPS

AQUATIC WEEDS and UNCROPPED LAND GROUP

Leader: T O Robson BSc, MIBiol

Scientific Staff

P R F Barrett BSc
Miss M C Fowler
S Hanley
E J P Marshall BSc, PhD, MIBiol

Assistant

Ms K E Murdoch

Secretarial Staff

Mrs M F Cox*

DEVELOPMENTAL BOTANY GROUP

Leader: Daphne J Osborne BSc, MA, MSc, PhD, DSc.

Scientific Staff

R J Hooley BSc, PhD
J A Sargent BSc, PhD
M Wright BSc, PhD

Assistant

Mrs S Dunford* BEd

Post-Graduate Research Students

Miss M M McDonald BSc
M McManus BSc

Secretarial Staff

Mrs M H Jones

* Part-time

ODA TROPICAL WEEDS GROUP
Leader: C Parker MA

Scientific Staff

P J Terry B.Tech. (Home based post)
N H Dixon BSc
Mrs A K Wilson BSc

Assistant
Miss D Stringer

Secretarial Staff
Mrs J Souch

ARC LETCOMBE LABORATORY/WRO JOINT BIOMETRICS GROUP
Leader: B O Bartlett MA. Dip. Math. Stat.*

Scientific Staff

W Jenkins BSc. ARIC*
C J Marshall BSc

Assistants

M J Loach*
D Smith

INFORMATION DEPARTMENT

Head of Department: J E Y Hardcastle OBE, BSc, DAS, DTA MIInfSci
Editor, 'Weed Abstracts': W L Millen BA, ALA

Information Staff

Mrs H Broad BSc*
Ms N Kiley BSc
J L Mayall
Mrs M Turton MA AIL*

Librarian: Mrs B R Burton ALA

Secretarial and Clerical Staff
Personal Secretary: Miss K P M Hedges

Mrs D Blackburn
Mrs J A Cox
Mrs S Dale*
Mrs P M Loveridge*

ADMINISTRATION DEPARTMENT

Secretary and Head of Department: B A Wright MBE, MBIM
Assistant Secretary: L G Young
Administration Officer: Mrs A J Dick

Clerical and Typing Staff

Mrs P M Appleton*
Mrs S Cox
Mrs M Cox*
Mrs C Green*
Mrs S Higgs*
Mrs B Hunter*
Mrs H Jordon*
Mrs M C Leach
Mrs T McLoughlin
Mrs D Robson
Mrs J Tonkin* BA
Mrs H R Wills

PHOTOGRAPHY SECTION

R N Harvey FIIP
J M Charlett*
Mrs J Kilcoyne

*Part-time

STATION ENGINEERING SECTION

Station Engineer: J F Hooper MIPE

A D Bland
D Elvidge
A W H Gardner
L S Goodgame
P A Savin
R Wells
P Wickson
A Worth

Stores: T H Evans

Cleaning Staff

Supervisor: T West*

Mrs M Jakeman*
Mrs E N Luke*
Mrs J Robinson*
Mrs M Robinson*

ATTACHED STAFF

MINISTRY OF AGRICULTURE, FISHERIES AND FOOD

Agricultural Development and Advisory Service Liaison Officers

J H Orson, BSc (Agriculture)
A G Jones CDH (Horticulture)

Secretarial Staff

Mrs D G M Roberts*
Mrs C Wheeler*

CHANGES IN RESEARCH, TECHNICAL AND ADMINISTRATIVE STAFF

NEW APPOINTMENTS

Miss C J Standell (*on internal promotion*)	SO	Grass & Fodder Crops Group	1.4.80
N H Dixon	SO †	Tropical Weeds Group	7.7.80
J B Pillmoor	SO †	Environmental Studies Group	1.10.80
Miss J Benson	HSO †	Information Department	1.12.80
J F Hooper	PTO2	Administration Department	2.2.81
S Hanley (*on internal promotion*)	SO	Aquatic Weeds Group	1.4.81
T M West (*on internal promotion*)	SO	Herbicide Group	1.4.81
P Logan	SO †	Aquatic Weeds Group	21.4.81
K J Murphy	SO †	Aquatic Weeds Group	21.4.81
M L Hirst	SO †	Environmental Studies Group	7.9.81

RESIGNATIONS

J Holroyd	PSO	Herbicide Group	22.8.80
K E Pallett	HSO †	Environmental Studies Group	31.8.80
Mrs H A Davies	HSO	Microbiology Group	18.9.80
Mrs D C Reid	SO †	Aquatic Weeds Group	31.12.80
Miss J Benson	HSO †	Information Department	31.3.81
K J Murphy	SO †	Aquatic Weeds Group	31.8.81
P Logan	SO †	Aquatic Weeds Group	5.10.81
P J Kemp	SSO	Weed Abstracts Group	31.10.81

*Part-time † Temporary Appointment

STAFF VISITS OVERSEAS

Overseas visits have been undertaken by members of staff in the period covered by this report as follows:

1980

January	R J Chancellor	Belgium to attend meeting of Expert Sub-Group on Crop Protection Techniques of EEC Standing Committee on Agricultural Research in the Mediterranean Region. Funded by EEC.
	P J Terry	(continuous from May 1979 to July 1980) Gambia, as Technical Co-operation Officer carrying out research, training and advisory duties on behalf of ODA.
February	C Parker	Botswana, to advise on weed research. Funded by ODA.
March	Miss J E Birnie	(until June) France, exchange visit to ITCF.
	Miss D J Osborne	Israel to attend Bat-Sheva Conference, financed by conference organisers.
	H F Taylor	Germany to visit Hoechst, funded by hosts.
April	R J Chancellor	(until August) USA to research and lecture as Visiting Professor at Washington State University. Funded by ARC, Washington State University and Oregon State University.
	R J Hance	West Germany to visit Bayer Laboratories. Funded by Bayer.
May	R J Hance	Belgium and Netherlands to attend symposium and EWRS meetings. Funded by ARC and EWRS.
June	P A Phipps	Netherlands, for liaison visits. Financed by himself.
	W G Richardson	France, to visit chlorsulfuron trials. Funded by Du Pont.
July	Miss D J Osborne	France, to attend European Space Agency Meeting. Funded by ESA.
	C Parker	(To September) Brazil to present paper at Brazilian Weed Conference, and Bolivia to advise on weed research. Funded by conference organisers and ODA.
	N C B Peters	Netherlands, to meet research workers at Wageningen. Financed by himself.
August	R J Hance	France to attend EWRS Meeting. Funded by EWRS.
	Miss D J Osborne	Austria, to attend Peer Group Meeting. Funded by ESA.
October	Miss D J Osborne	France, to attend European Space Agency Meeting. Funded by ESA.
December	R J Hance	Belgium, to visit Monsanto Laboratories. Funded by Monsanto.

1981

January	T O Robson	Belgium and Netherlands to attend Botanical Colloquium and EWRS meeting. Funded by ARC and EWRS.
February	J C Caseley	Japan, to visit government, university and company herbicide research organisations. Sponsored partially by ARC and Japanese companies, and partly by himself.
	P J Terry	Solomon Islands as consultant/adviser on behalf of ODA
		(to May) Indonesia as leader of weed science training course on behalf of ODA
March	E G Cotterill	(to May) France, exchange visit to ITCF
April	M P Greaves	Netherlands, to visit Duphar BV and CABO, Wageningen. Funded by Duphar BV.

	Miss J R Hilton	West Germany to give paper at the Annual European Photomorphogenesis Symposium. Funded by ARC.
May	J C Caseley	Belgium to present paper at International Symposium on Crop Protection and attend EWRS meeting. Funded by EWRS.
		Spain to present invited paper at Weed Control Conference. Funded by Asociacion Interprofesional para el Desarrollo Agraria (AIDA)
	M P Greaves	Switzerland, to visit research stations. Funded by Swiss Federal Authorities and Federal University of Technology.
	P J Terry	Solomon Islands as consultant/adviser on behalf of ODA
June	G W Cussans	France to attend Anglo-French Collaborative Meeting on Cereal Production, and to visit experimental sites. Funded by MAFF.
	R J Haggar	(and July) USA and Canada to attend 14th International Grassland Congress and review work on grassland over-seeding. Funded by Oxfordshire Agricultural Trust and ARC.
	R J Hance	France, to attend EWRS Meeting. Funded by EWRS.
August	Miss D J Osborne	Switzerland to attend Conference of International Society of Developmental Biologists. Funded by conference organisers.
	C Parker	Liberia, to participate in International Symposium on No-tillage Crop Production in the Tropics. Funded by IWSS.
	J A Sargent	Australia, to attend Botanical Congress. Funded by ARC.
September	Miss M C Fowler T O Robson	Netherlands to attend meeting on Anglo-Dutch Collaboration on Aquatic Weed Research. Funded by ARC.
	R J Hance J A P Marsh	Austria, to attend FAO/1 AEA Programme Review Meeting. Funded by FAO.
October	Miss D J Osborne	(and November) China to undertake lecture tour financed by Royal Society and Academia Sinica
	C Parker	Upper Volta to attend 2nd International *Striga* Workshop, on behalf of ODA.
November	R J Hance	Costa Rica, to attend FAO/IAEA Research Co-ordination Meeting. Funded by FAO.
	C Parker	India to attend symposium "Sorghum in the '80s". Funded by ICRISAT
December	J C Caseley G W Cussans Miss M C Fowler J D Fryer R J Hance P J W Lutman T O Robson	France to attend EWRS meeting and Conference. Funded by ARC and/or EWRS
	R J Dale J G Elliott M E Thornton	France to attend Paris Machinery Show. Funded by ARC.

STAFF COMMITTEE SERVICE

Members of WRO staff have served on the following Committees:

Association of Applied Biology
- Pesticides Application Group
- Weed Control in Forestry and Amenity Areas Conference Organizing Committee (with Institute of Foresters and RERG)
- Weed Group Committee

Agricultural Research Council
- Fruit Weed Control Group
- Joint Committee on Health and Safety
- Librarians' Working Party on the Feasibility of a Union Catalogue
- Research and Policy Advisory Committee
- Working Party on Information Services via Computer-backed Networks
- Working Party on Suitability of Soils for Direct Drilling

Agrochimica
- Editorial Board

British Agrochemicals Association
- Environmental Research Committee
- Wildlife Research Panel

British Crop Protection Council
- Annual Review of Herbicide Usage
- Board of Management
- Chemicals Application Committee
- Crop Protection Conference – Weeds – 1980 and 1982 Committees
- Drift Committee
- Education and Communications Committee
- Finance and General Purposes Committee
- Pesticide Manual Advisory Editorial Board
- Programme Committee – Weeds
- Programme Policy Committee
- Publications Committee
- Research and Development Technical Committee
- Research and Development Technical Sub-Committee – Weeds
- Working Party on Weather/Spray Application

British Grassland Society
- Grass as a Crop Group

British Standards Institution
- Technical Committee PCC/1

Department of the Environment
- Standing Committee of Analysts Working Group 6-3

European Economic Community
- Expert Sub-Group on Crop Protection Techniques
- Standing Committee on Agricultural Research in the Mediterranean Region

European Weed Research Society
- Council
- Editorial Board of *Weed Research*
- Education Committee

Scientific Committee
Research Group on Aquatic Weeds
Symposium Organizing and Programme Committees
Working Group on Herbicide/Soils

Food and Agriculture Organization
Consultants Meeting to Recommend Future Pesticides Programme (with International Atomic Energy Agency)

Forestry Commission
Working Group on Forest Weed Control

Imperial College of Science and Technology
Ad hoc Review Panel on Postgraduate Courses in Pest Management

10th International Plant Protection Congress
Executive Committee

International Parasitic Seed Plant Research Group

International Weed Science Society
Executive Committee

Joint Consultative Organization for Research and Development in Agriculture and Food
Crop Protection Committee

Ministry of Agriculture, Fisheries and Food
Agricultural Development Advisory Service/WRO Liaison Group
Agricultural Chemicals Approval Scheme
Scientific Advisory Committee
MAFF/ARC Users Group on Cultivation

National Institute of Agricultural Engineering
Consultative Group on Cultivations

Organization for Economic Co-operation and Development
Ad hoc meeting of Experts in Ecotoxicology Testing

Overseas Development Administration
Sub Committee on Pesticide Application Overseas

Oxfordshire Agricultural Trust
Oxford Awards Committee

Pesticides Safety Precautions Scheme
Environmental Panel

Reading University
Plant Sciences Joint Committee

Royal Agricultural Society of England
Council
Education and General Purposes Committee

Society of Chemical Industry
Editorial Board of *Pesticide Science*
Pesticides Group Committee
Physiochemical and Biophysical Panel

Wilts, Hants and Dorset Seed Growers
Herbage Seed Committee

POST GRADUATE RESEARCH STUDENTS AT WRO 1980-81

Name	*University and Higher Degree*	*Estimated Period at WRO*	*Topic of Research*
S Adalla	Reading; Ph.D	1980-82	Factors affecting the performance of soil-applied herbicides in winter cereals.
S W Adkins	Reading; Ph.D (CASE award)	1978-80	Factors affecting seed dormancy in wild oats
L Hinton-Mead	London; M.Sc	1981	Phytotoxicity of a new algicide
F K Ismael	Reading; Ph.D	1981-84	Factors affecting the control of *Agropyron repens* by glyphosate
A Matin	St Andrews; M.Sc (British Council award)	1978-81	The effect of temperature on the performance of terbutryne as an aquatic herbicide
S J Midgley	Reading; Ph.D (CASE award)	1980-83	The effects of surfactants and inorganic additives on the activity of MCPA and glyphosate
P J Mudd	Bath; Ph.D (CASE award)	1979-81	Degradation of isoproturon in rhizosphere of winter wheat
P D Owen	Hatfield Polytechnic; Ph.D (ARC award)	1979-81	Vegetative regeneration in selected grassland species
A F S Pinho	Reading; M.Phil (British Council award)	1979-81	Some factors affecting herbicide leaching
P Whitehouse	Bristol; Ph.D	1978-81	Factors affecting the activity of wild oat herbicides applied to different positions on the plant
N T Yaduraju	Reading; Ph.D	1981-84	Influence of environmental factors on the chemical control of *Avena fatua*, *A. ludoviciana* and *Phalaris minor* and *P. paradoxa*

VISITING RESEARCH WORKERS AND OVERSEAS TRAINEES AT WRO 1980-81

Name and Origin	*Period at WRO*	*Topic of Research*
Dr J P E Anderson, Institute of Ecology, Bayer AG, Leverkusen, W. Germany	1980 (1 month)	Effects of herbicides on soil microbial function
Dr Eric Beuret Agricultural Station, Changins, Switzerland	1981 (3months)	*Amaranthus* germination
Mr M Boneff, Versailles School of Horticulture, France	1980 (1 month)	Training

Dr Gale Buchanan, Alabama University, USA	1980 (3 months)	Competition of weeds
Dr P N P Chow, Agriculture Canada Brandon Research Station, Canada	1979/80 (12 months)	Mixtures of herbicides
Mr L P Davies Overseas Development Administration	1980 (3 months)	Herbicide application
Dr Antonio Dell'Aquila, Laboratorio del Germoplasma C.N.R., Bari, Italy	1979/80 (12 months)	DNA repair in seed germination
Mr A F Farah, University of Khartoum, Sudan	1980 (2 months)	*Striga* research techniques
Mlle N Gilleron, Ecole Superieure d'Agriculture, Lille, France	1981 (3 months)	Weed control in highly organic soils
Dr G S Hassawy Foundation of Technical Institutes Baghdad, Iraq	1979/80 (12 months)	Effect of temperature and soil water stress on diclofop activity in wild-oats and wheat
Dr G W Ivens, Massey University, N.Z.	1980/81 (9 months)	Biology of gorse
Dr D W Koch, University of New Hampshire, USA	1980 (6 months)	Clover slot-seeding
Mr W Mersie, Institute of Agricultural Research, Ethiopia	1981 (5 months)	Herbicides in teff
Dr L J Musselman, Old Dominion University, USA	1980 (5 months)	Parasitic weeds
Professor Moshe Negbi, Dept. of Agriculture, Hebrew Univ., Jerusalem, Israel	1981/82 (12 months)	Physiological and biochemical research into seed germination
Mr O U Okereke University of Nigeria Nsukka, Nigeria	1979/80 (12 months)	Isoproturon activity against *Bromus sterilis* and *Phalaris* minor
Dr W Pestemer, Biologische Bundesanstalt für Land- und Forstwirtschaft, Braunschweig, W. Germany	1980 (2 months)	Herbicide-soil interactions
Miss P Preston Brooms Barn Experimental Station	1981 (5 months)	Effect of environmental factors on herbicide tolerance of sugar beet
Dr R Skuterud, Norwegian Plant Protection Institute	1980 (3 months)	Effect of rain on bentazone activity

FINANCIAL ASSISTANCE FROM OUTSIDE BODIES 1980-81

Source	*£*	*Purpose*
Commonwealth Agricultural Bureaux	94,000	Compilation of *Weed Abstracts*
Countryside Commission	58,244	Research into the use of herbicides in the management of countryside recreation areas
Cyanamid Ltd	17,163	Research into the factors affecting tolerance of difenzoquat by UK wheat cultivars
DuPont Co	5,500	Research into the factors causing DPX 4189 damage to winter barley
FAO	7,448	Preparation of an annotated bibliography and review on crop losses due to weeds
Forestry Commission	25,790	Research on the uses of herbicides in forestry
ICI Plant Protection Ltd	21,712	Research on the use of diquat-alginate formulations in the control of aquatic weeds
Ministry of Overseas Development and ODA	29,697	Research on the parasitic weeds of the genus *Striga*
	73,956	Support of the ODM/ODA Tropical Weed Control Liaison Officer
Sugar Beet Research and Education Committee	14,301	Research on weed beet

GLOSSARY OF CHEMICALS MENTIONED IN THIS REPORT

An asterisk (*) signifies a common name approved by the British Standards Institution.

aminotriazole	3-amino-1,2,4-triazole
asulam*	methyl(4-aminobenzenesulphonyl)carbamate
atrazine*	2-chloro-4-ethylamino-6-isopropylamino-1,3,5-triazine
barban*	4-chlorobut-2-ynyl-*N*-(3-chlorophenyl)carbamate
benazolin*	4-chloro-2-oxobenzothiazolin-3-ylacetic acid
bentazone*	3-isopropyl-2,1,3-benzothiadiazin-4-one 2,2-dioxide
benzoylprop-ethyl*	ethyl *N*-benzoyl-*N*-(3,4-dichlorophenyl)-2-aminopropionate
bromoxynil*	3,5-dibromo-4-hydroxybenzonitrile
carbetamide*	D-*N*-ethyl-2-(phenylcarbamoyloxy)propionamide
clofop-isobutyl*	isobutyl 2-[4-(4-chlorophenoxy)phenoxy]propionate
chlorpropham*	isopropyl *N*-(3-chlorophenyl)carbamate
chlortoluron*	*N'*-(3-chloro-4-methylphenyl)-*N*-*N*-dimethylurea
2,4-D*	2,4-dichlorophenoxyacetic acid
3,5-D	3,5-dichlorophenoxyacetic acid
dalapon*	2,2-dichloropropionic acid
dicamba*	3,6-dichloro-2-methoxybenzoic acid
3,6-dichloropicolinic acid	

dichlorprop*	(±) 2-(2,4-dichlorophenoxy)propionic acid
diclofop-methyl*	methyl 2-[4-(2,4-dichlorophenoxy)phenoxy]propionate
difenzoquat*	1,2-dimethyl-3,5-diphenyl-pyrazolium
dinoseb*	2-(1-methylpropyl)-4,6-dinitrophenol
diquat*	9,10,dihydro-8a,10a-diazoniaphenanthrene
diuron*	*N'*-(3,4-dichlorophenyl)-*N*,*N*-dimethylurea
DNOC*	2-methyl-4,6-dinitrophenol
ethofumesate*	2-ethoxy-2,3-dihydro-3,3-dimethylbenzofuran-5-yl methylsulphonate
flamprop-isopropyl*	isopropyl(±)-2-(*N*-benzoyl-3-chloro-4-fluoroanilino) propionate
flamprop-methyl*	methyl(±)-2-(*N*-benzoyl-3-chloro-4-fluoroanilino) propionate
fluazifop-butyl	(*RS*)-2-[4-(5-trifluoromethyl-2-pyridyloxy)phenoxy] propionic acid
fosamine*	ethyl hydrogen carbamoylphosphonate
glyphosate*	*N*-(phosphonomethyl)glycine
hexazinone*	3-cyclohexyl-6-dimethylamino-1-methyl-1,3,5-triazine-2, 4-dione
ioxynil*	4-hydroxy-3,5-di-iodobenzonitrile
isoproturon*	*N'*-(4-isopropylphenyl)-*N*,*N*-dimethylurea
linuron*	*N*-(3,4-dichlorophenyl)-*N*-methoxy-*N*-methylurea
maleic hydrazide (MH)	1,2,3,6-tetrahydro-3,6-dioxopyridazine
MCPA*	4-chloro-2-methylphenoxyacetic acid
mecoprop*	(±) 2-(4-chloro-2-methylphenoxy)propionic acid
mefluidide*	5-trifluoromethylsulphonylamino-2,4-acetoxylidide
methabenzthiazuron*	*N*-(benzothiazol-2-yl)-*N*,*N'*-dimethylurea
metamitron	4-amino-3-methyl-6-phenyl-1,2,4-triazin-5(4*H*)-one
1,8-naphthalic anhydride	
nitrofen*	2,4-dichlorophenyl 4-nitrophenyl ether
paraquat*	1,1'-dimethyl-4,4'-bipyridylium
pendimethalin*	*N*-(1-ethylpropyl)-2,6-dinitro-3,4-xylidine
phenmedipham*	3-(methoxycarbonylamino)phenyl *N*-(3-methylphenyl) carbamate
propyzamide*	3,5-dichloro-*N*-(1,1-dimethylpropynyl)benzamide
simazine*	2-chloro-4,6-bisethylamino-1,3,5-triazine
TCA*	trichloroacetic acid
tebuthiuron*	*N*, *N'*-dimethyl-*N*-(5,t-butyl-2,3,4-thiadiazol-2-yl)urea
terbutryne*	4-ethylamino-2-methylthio-6-t-butylamino-1,3,5-triazine
tri-allate*	*S*-2,3,3-trichloroallyl *N*,*N*-di-isopropyl(thiocarbamate)
trichlopyr	3,5,6-trichloro-2-pyridyloxyacetic acid
TBA	2,3,6-trichlorobenzoic acid
TIBA	2,3,5-triiodobenzoic acid

INSTITUTES FOR AGRICULTURAL RESEARCH IN GREAT BRITAIN

The research programmes of all the following Research Institutes, supported from public funds, are co-ordinated by the Agricultural Research Council. Most of them publish reports annually and copies can be obtained from the Secretaries of the Institutes concerned.

ARC Institutes

Animal Breeding Research Organization	West Mains Road, Edinburgh, EH9 3JQ
Food Research Institute	Colney Lane, Norwich, NR4 7UA
Institute of Animal Physiology	Babraham, Cambridge, CB2 4AT
Institute for Research on Animal Diseases	Compton, Newbury, Berks. RG16 0NN
Letcombe Laboratory	Letcombe Regis, Wantage, Oxfordshire, OX12 9JT
Meat Research Institute	Langford, Bristol, BS18 7DY
Poultry Research Centre	King's Buildings, West Mains Road, Edinburgh, EH9 3JS
Weed Research Organization	Begbroke Hill, Yarnton, Oxford, OX5 1PF

State-aided Institutes in England and Wales

Animal Virus Research Institute	Pirbright, Woking, Surrey, GU24 0NF
East Malling Research Station	East Malling, Maidstone, Kent, ME19 6BJ
Glasshouse Crops Research Institute	Worthing Road, Rustington, Little-hampton, Sussex, BN16 3PU
Grassland Research Institute	Hurley, Maidenhead, Berks, SL6 5LR
Houghton Poultry Research Station	Houghton, Huntingdon, PE17 2DA
John Innes Institute	Colney Lane, Norwich, NR4 7UH
Long Ashton Research Station	Long Ashton, Bristol, BS18 9AF
National Institute of Agricultural Engineering	Wrest Park, Silsoe, Bedford, MK5 4HA
National Institute for Research in Dairying	Shinfield, Reading, RG2 9AT
National Vegetable Research Station	Wellesbourne, Warwick, CV35 9EF
Plant Breeding Institute	Maris Lane, Trumpington, Cambridge, CB2 2LQ
Rothamsted Experimental Station	Harpenden, Herts, AL5 2JQ
Welsh Plant Breeding Station	Plas Gogerddan, Aberystwyth, Dyfed, SY23 3EB
Wye College, Department of Hop Research	Ashford, Kent, TN25 5AH

State-aided Institutes in Scotland

Moredun Institute	Animal Diseases Research Association, 408 Gilmerton Road, Edinburgh, EH17 7JH
Hannah Research Institute	Ayr, Scotland, KA6 5HL
Hill Farming Research Organization	Bush Estate, Penicuik, Midlothian, EH26 0PH
Macaulay Institute for Soil Research	Craigiebuckler, Aberdeen, A89 2QJ
Scottish Institute of Agricultural Engineering	Bush Estate, Penicuik, Midlothian, EH26 0PH
Rowett Research Institute	Greenburn Road, Bucksburn, Aberdeen, AB2 9SB
Scottish Crop Research Institute (Dundee)	Invergowrie, Dundee, DD2 5DA
Scottish Crop Research Institute (Midlothian)	Pentlandfield, Roslin, Midlothian, EH25 9RF

Published by the
AGRICULTURAL RESEARCH COUNCIL

and obtainable from
HER MAJESTY'S STATIONERY OFFICE
at the following addresses:

49 High Holburn, London, W.C.1
13a Castle Street, Edinburgh, 2
109 St. Mary Street, Cardiff, CF1 1JW
2 Brazennose Street, Manchester, M60 8AS
50 Fairfax Street, Bristol, BS1 3DE
238 Broad Street, Birmingham, 1
Chichester House, Chichester Street, Belfast
or through any bookseller

ISSN 0511-4128

ISBN 0 7084 02410

Printed by Holywell Press, Oxford
in 10/12 Plantin with Univers headings