but the results might well be different with more effective coverage at these doses.

Dr. G. L. Hodgson. All the trials made by the Unit of Experimental Agronomy were sprayed with the Oxford Precision sprayer. We have not as yet done any detailed work on droplet size or various methods of application but I agree that it could well have some effect.

Mr. J. Norris. We have done no detailed work on droplet size. However we have seen results by various methods of application. Our own trials have largely been sprayed with the Oxford Precision Sprayer but we have observed that trials with tractor driven sprayers have given consistently better results than the Oxford Precision Sprayer. In some cases fixed wing aircraft applications have been very disappointing and the rotary atomizer does not appear to be entirely suitable for this work. If may be that the terrain was not very suitable and that the pilot was more anxious about his own safety than about spraying. In 1957 and again in 1958 we did trials using a helicopter with a conventional spray boom. Here the plane was able to get near to the bracken and the results were quite good.

Dr. Elsie Conway. One word on formulation: there may be some people here who will remember that two years ago Mr. Forrest and I reported on amino triazole. We had had no results at all and said that we did not consider that this chemical should be considered very much further. This was when we were using one particular formulation but lately we have been working with another formulation with quite different results. I would say that the question of formulation is a very pertinent point.

Mr. S. Everest-Todd. The main problem associated with 4-CPA and bracken lies in the transportation of the chemical from the frond to the rhizome. One of the difficulties to be overcome is the entry of a lethal quantity of the chemical without it causing necrosis of the leaf tissue. Impurities in formulations of 4-CPA, such as the chemical intermediates, phytotoxic solvents or wetting agents, could reduce the effectiveness of the application to the bracken plant.

Information is not yet available as to the quantity of 4-CPA required to kill a given volume of bracken nor do we know how much of the chemical reaches the rhizome. I am convinced that in many cases the 4-CPA applied has failed to reach the rhizome, or even enter the vascular tissue, due to chemically induced necrosis of the leaf occuring shortly after application. In some of my own experiments where I used pure 4-CPA in a formulation free from contact herbicidal properties and possessing a resistance to climatic interference the absorption and translocation within the plant system was sufficient to produce a toxic effect over an extensive section of rhizome. In some cases this has been observed 2 ft from the point of entry.

Dr. Elsie Conway. That is a very interesting point. I am quite certain that the whole crux of the matter is the extent to which we can get the chemical along the rhizome. I would be interested to know, when Mr. Everest Todd says he has traced 4-CPA in the plant, whether the chemical was travelling apically or basically. We have found that the chemical will go very quickly towards the apex from below a treated frond but so far we have not been able to trace much basal movement. We have only traced movement of up to 16 cms.

Mr. S. Everest-Todd. I am pleased to report that the movement in this case was basal.

Mr. E. B. Scragg. On the subject of methods of application of bracken control chemicals, we, in the North of Scotland, carried out trials in 1959 using a knapsack-type engine-driven air-blast sprayer. The rate of application was 1½ gal of a proprietary 4-CPA formulation in 20 gal water/ac. Results were similar to those described by other speakers and varied from no apparant control to a fair degree of suppression. There appeared to be some correlation between the degree of control achieved and the vigour of the bracken before spraying. Where the bracken was very tall and dense, poor control was achieved, where it was short and open a better result was obtained. Drift spraying using the air blast machine proved quite ineffective.

Mr. G. D. Holmes. Experiments comparing amino triazole, dalapon and 4-CPA were carried out by the Forestry Commission on two sites in Southern England in July 1959 and the results broadly confirm those described by Dr. Hodgson. The main points emerging have been (1) the superiority of amino triazole at 10-20 lb/ac over dalapon (10-20 lb/ac) and 4-CPA (5-10 lb/ac) (2) no compound gave a degree of control which would be of great practical importance (in forestry), the best amino triazole treatment giving a 50 per cent reduction of frond height and only a 15 per cent reduction in frond numbers in the season following treatment (3) no harmful residual effects were found on larch, Corsican pine, and Norway spruce planted in October, 3 months following spraying.

The possibility of aerial application of herbicides to bracken has been mentioned, and I would urge caution in the application of aerial sprays in the vicinity of young forest plantations owing to the risk of damage by spray drift. We have made tests on the susceptibility of major tree species to drift of 4-CPA and amino triazole and find that larch, Douglas fir, pine and to some extent spruce are all liable to injury, notably foliage scorch and shoot malformation from sprays applied in July or August. This type of damage could be of great economic importance if malformation extends to the leading shoots of young crops.

Dr. R. C. Kirkwood. Dr. Hodgson did point out that some of our treatments caused an increase in the number of fronds in the year following treatment. Perhaps the stimulation of frond bud development was indicative of the usual growth regulator effect with small doses, as compared with large doses which have a toxic effect.

Mr. R. Prasad.. In reply to Dr. Kirkwood's suggestion that the prevailing environmental conditions might have contributed to the diverse and conflicting results of Dr. Hodgsons trials, I may add that at Oxford we have examined the effects of some environmental factors on the effectiveness of dalapon. Using two aquatic weeds, Lemna minor and Salvinia natans, we have found that both temperature and light intensity enhance the inhibitory action of dalapon, the effects of temperature being greater than those of light intensity.

SESSION 5

Chairman: Sir James A. Scott Watson

PROBLEMS OF ADVICE AND EDUCATION

PROBLEM OF ADVICE AND EDUCATION: THE FARMERS' POINT OF VIEW

G. E. Limb
National Farmers Union
(Read by Mr. H. C. Mason)

Having been asked to speak on the problems of advice and education, it appears evident to me that the organisers of this Conference are very conscious of the fact that such problems exist, and are doing a very good thing in bringing these problems into the open so that we can see what they are and what should be done to overcome them.

It is, of course, one of the prime objects of the British Weed Control Council to disseminate information and it must be a matter of concern to the Council if the farmer's needs for advice and education are not being met to the full.

Since it is my purpose today to draw attention to problems I must tend to be critical of the present state of affairs but I hope none of you would be misled into thinking that I am prejudiced, either against herbicides or against the agricultural chemicals industry which has so eagerly developed these new products and whose research is still carrying forward the frontiers of knowledge on this fascinating subject of selective weed control.

We must remember that the introduction of these potent new tools to agricultural practice has in so small measure been responsible for the great increase in output from our industry, which is now producing nearly 70 per cent more than pre-war in spite of a reduction in labour and land resources. Indeed, I think the development of chemical weed control has been one of the most remarkable post-war developments affecting agriculture, and the rapidity with which these products have been taken up by our farmers surely makes nonsense of the often repeated statement that there is a 20-years gap between research and application of the results in agriculture.

Prior to the introduction of CLC (MCPA) towards the end of the war we had only traditional methods of weed control available, supplemented by the uncertain results obtained from copper sulphate or sulphuric acid sprays and the occasional use of finely powdered kainit as a scorching agent.

How little we knew about chemical weed control in those days, and yet how far we have progressed in the last 15 years in the development of this new science and its application on a world-wide scale.

The earliest reports on CLC (MCPA) seemed to suggest that all one had to do was to apply it to corn crops, when all the corn would grow and all the weeds would die, and had it all been as simple as that no problems of advice and education would have arisen.

We have now got to the state when there are some 70 or more separate chemicals recognised for their herbicidal properties, most of which have names as long as your arm, so that special committees have to sit on both sides of the Atlantic to evolve cryptic common names and that strange blend of letters and numerals so beloved by the herbicide chemist, so that not surprisingly one chemical may sometimes be known by more than one name.

Of the score or so chemicals in regular use in this country there may in some cases be as many as 50 separate brands of one chemical, each being offered under its own distinct brand name, many of which bear no connection with the name of the chemical.

Just as the variety of products available to the farmer is tremendous so also the variety of weeds to be controlled is formidable, running into hundreds, involving problems of recognition and identification, particularly at the seedling stage. Having located a product which will control the major weeds, problems of finding the correct dilution and the best time of application in relation to both crop and weed and consideration of possible long-term effects on the crop or injury to neighbouring crops have to be taken into account, while precautions have to be considered to protect the operator when using toxic chemicals.

This new science has been developing so fast that for the fifth time since 1953 the technical workers in this field of weed control are gathered together to rub shoulders and hear of the latest research and fresh developments in the use of weedkillers, but we must recognise that this Conference is designed primarily to attract people at a scientific level. The need for a regular exchange of views at this level emphasises the need for a regular channel of information to be established to the ultimate users who are continually extending the commercial application of weed control and spraying millions of acres of crops each year on the 400,000 agricultural holdings in Great Britain. The occupiers of these holdings, however, are men skilled in animal and crop husbandry with generally but little basic knowledge of chemistry, although few can be as ill-informed as the mass of the public, which appears to suspect all chemicals used in agriculture as something undesirable and harmful.

On the one hand we have this rapidly expanding new science in which it is not easy for the technicians themselves to keep abreast of all the new developments, while on the other hand we have a multiplicity of relatively small farmers to whom the whole process of selective weed control with growth regulating substances and the like is, if not something unnatural, at least something very different from all traditional husbandry practice.

We must examine, therefore, to what extent this complex subject has been presented in understandable terms and not insulated by its own technical jargon and see how effective the channels of communication have been in ensuring that the requisite information is made available to the man in the field.

Looking back to the original CLC (MCPA) when this was introduced during war-time, it was shrouded in mystery and secrecy, and I sometimes suspect that the trade has never really tried to dispel this aura of mystery from agricultural chemicals, and indeed, by adding a surfeit of fancy names, they have made an already complex subject a maelstrom of confusion.

Let us congratulate the ingenuity of the coiners of brand names but let us recognise that they are largely responsible for creating the confusion and obscuring the name of the basic chemical in a product. Indeed, there seems to have been a surprising reluctance by some manufacturers to name the active chemical ingredient in a herbicide and only recently the A.B.M.A.C. have, at the request of the N.F.U., agreed to recommend their members to name the chemical ingredients on the labels of containers, but advertisements still appear for products without any reference to ingredients, and presumably farmers are expected to have sufficient confidence in the herbicide trade to buy a pig in a poke and use such materials.

I do not really mind you having all these trade names if you really want them, although I would have thought it sufficient for a manufacturer to identify his products with the name of the firm, such as Smith & Brown's MCPA, Smith & Brown's MCPB etc., but I am sure it is wrong for the brand name on a label to be in larger print than the name of the basic ingredient. Surely there must be a parallel between the agricultural chemicals and fertilisers, and while a fertiliser may be designated as 'X' brand basic slag or superphosphate, there is no attempt made to disguise that it is slag or superphosphate and the sooner this state of affairs becomes the practice with the herbicides the better, so that we farmers do not have to waste our time learning lots of fancy names for products which are basically the same.

Perhaps we should first look at education to see to what extent the rudiments of the subject are being taught to the new entrants to agriculture who may be attending part time Day Release Courses, Farm Institutes or Agricultural Colleges, and while it is reassuring to find there is reference to weed control in the syllabuses, the time devoted to it as a separate subject must be limited and student experience in the practical application cannot be extensive. These young people have at least had some basic training in this science and must have an advantage over the many established farmers who completed whatever formal technical training they had before the advent of these products and in consequence have had to pick up their knowledge of the subject as they go along, and that largely from commercial sources. Even with students, the multiplicity of brand names must cause confusion in their minds, as they are taught to recognise a spray by the chemical name or symbol of its active ingredient (e.g. mecoprop) and the use of brand names if carefully avoided, whereas when the student has to deal later with these materials it is by their particular brand names that they are bought and used.

I think a permanent series of demonstration plots at each of the Institutes and Colleges might be sponsored by an independent organisation such as the British Weed Control Council, and that these would serve a very useful purpose in illustrating the full scope of chemical weed control and giving future farmers an opportunity of seeing what a range of products there are available to supplement the MCPA with which they are undoubtedly familiar.

When we come to consider the needs of the established farmer it may be suggested that farmer-representation at a conference such as this should be stronger but let us make no mistake, this conference is pitched at a research and technical level and the farmer is only concerned with the practical application of materials that are already in commercial production. There is therefore a gap to be bridged between this conference and the final user, and we could have hoped that these Weed Control Conferences would have been followed by regional conferences promoted by the N.A.A.S. for the benefit of farmers in each locality; indeed, since we have to look to the officers of that organisation for the practical and independent interpretation of so many of the matters being discussed at this Conference, it is disappointing to find that they are not more strongly represented here today. Several of the larger commercial firms marketing spray chemicals have their own well-trained staff available to give advice to farmers and I fear that farmers often turn to the commercial advisers on this subject rather than to the independent advisers in the N.A.A.S. Sometimes, however, the boundary between adviser and salesman is difficult to distinguish and the salesman is frequently but ill-equipped on the technical side.

If we are to examine the printed literature on the subject of weed control, the Handbook published by this Council is undoubtedly the most up-to-date and comprehensive reference book on the subject, but unfortunately it has been prepared for the use of technical people and its practical value to the farmer is limited. As has often been pointed out, the susceptibility of different species of weeds listed in this book is related to stated doses of active ingredients and yet information on such content of chemicals is only available in the case of the MCPA and 2,4-D products included under the Approved Scheme. When this vital information is sought for other products we are assured that the content of active ingredient can be misleading on account of the over-riding differences due to methods of formulation. If this is so, are the recommendations in the Handbook as valuable as we have been led to believe?

Why all this mystery, which inevitably breeds distrust, so making education and advisory work in an already complicated subject more difficult. At a time when there is public criticism of the use of chemicals in crop protection farmers would be well advised to have nothing to do with products for which information on the active chemical content is not available or obtainable.

Since the Weed Control Handbook has to be such a scientific work, I would welcome a popular edition possibly published as a Ministry bulletin, which would then supplement the few official advisory leaflets on this subject. There is, of course, no overall shortage of paper devoted to information on herbicides and I have stacks of literature from some of the leading agricultural chemical firms.

Some of the handbooks published by these firms are excellent but would be very much more valuable if they were published by some independent authority.

While referring to publications I must congratulate Mr. Bradford on the excellent handbook he has prepared which sets out clearly basic information on the use of different chemicals and includes the different brands available and prices. The Weed Control Council or the A.B.M.A.C. could provide a useful service by making more information of this type available.

The National Farmers Union has for many years looked on the Approved List published by the Crop Protection Products Approval Scheme as being a most valuable guide to help in sorting out the great variety of products on the market and even greater reliance might have been placed in this list had it not been for the fact that new products could not be officially approved for some time after their introduction. With the new Agricultural Chemicals Approval Scheme we trust that these difficulties have been overcome and that there will be no reason why every worthwhile chemical should not be quoted in the Approved List; indeed, once the new scheme has come into force I can see no justification at all for any farmer purchasing a product not approved under this scheme, and I hope that the List will be a standard work of reference by farmers before any purchases are made.

Information is needed, not only to assist in the selection of the best product for use in specified circumstances but a major advisory problem is presented by the need to ensure their correct use to avoid unnecessary damage to neighbouring crops, birds and other livestock and also of course to the people who apply the chemicals and those who finally consume the crop which has been sprayed.

Much information is given in the instructions printed on the container or provided in a separate leaflet, and there is bound to be difficulty in putting over all the requisite information in sufficiently precise terms on a container label.

If all the varied circumstances of usage are to be taken into account the volume of information must inevitably detract from the attention given to items of detail but it is of vital importance that the users can be left in no doubt as to the dangers arising from the handling or application of the product. Spray drift is a problem that has been with us since selective herbicides were first introduced, and while I am encouraged by some of the research that has been undertaken on this subject, the problem is by no means solved as yet and the combined efforts of all concerned with herbicides must continue both to find sprays less liable to drift and to ensure that the conditions under which such hazards can arise are more fully understood by all responsible for their application.

Under the Notification Scheme conditions are laid down under which toxic products may be used, so that there is no fear that harmful residues may remain on the crop at the time of marketing. This information is of vital importance but these recommendations cannot be considered in isolation from the chemical and here again the user must rely on the advice given in the instructions for use, and so long as he can be sure that provided he carries out these instructions in every particular detail, that no harmful consequences can arise, then this aspect of the problem of advice and education is much simplified.

Selective weed control by herbicides has made tremendous progress and these new developments have been introduced at the same time as the mechanical revolution of the industry which has also raised education and advisory problems of its own.

Much remains to be done, and I am sure further progress will be made as some of the confusion of nomenclature can be eliminated, and that the more discerning farmer of the future will demand more precise information about products before he buys or uses them and that the gullible farmer who will buy an unknown product with a fancy name will soon be a thing of the past.

PROBLEMS OF ADVICE AND EDUCATION. A MERCHANT'S POINT OF VIEW

M. S. Bradford
National Association of Corn and Agricultural Merchants

First of all I must emphasise that this short paper expresses only my own opinions and ideas on the subject. These ideas have sprung from personal experience, gained since the exciting day when I first saw the effect upon charlock in winter wheat of applying MCPA formulated as a dry powder.

What are the particular problems relating to the education of the user in the application of herbicides from the point of view of the often much maligned middle man, or merchant, who sells to him? There are no problems if the merchant believes that it is outside his province to provide anything more in the way of a service than delivery of the herbicide he is requested to provide, at the right time, and at the right price, whatever that may be. I firmly believe that the remaining few who trade under that particular misapprehension are already finding their chemical business rapidly disappearing and rightly so.

Given then that there is a problem relating to user-education, in what way can your merchant play his part, and what does he consider his part to be? Basically the requirement is for the man on the tractor to apply through an efficiently working spray-machine, the chemical which will give the greatest return in profit to the man who bought it. This does not necessarily mean the chemical which will give the best purely technical control of the weed-problem present.

Is it the merchant's job then to get this knowledge to that man - and if so, how? My view is that the merchant has a vital role in disseminating sufficient knowledge to the man who does the actual work. Gone is the fools paradise of the days when virtually only MCPA was available to the farmer, and was principally used for the control of weeds which were highly susceptible. The farmer is now offered herbicides which enable him to overcome a great number of problems of varying complexity. Problems requiring considerable precision, and knowledge, in the use of the chemicals concerned - if they are to be used properly. Misuse due to ignorance can result in promising materials and techniques being quite wrongly considered a waste of money. One "eminent" failure in the district can offset the good of dozens of the unsung applications which did what was required of them.

I do not consider that anything but harm can come from advice on the use of herbicides being given by anyone insufficiently briefed to do so. A high degree of technical knowledge is also to my mind almost useless unless related to the practice of application: so that, if for no other reason than for the marriage of knowledge and practice within a merchant's organisation it is desirable to run at least one spraying unit on a contract basis for both routine and commercial work, and for trial or experimental work carried out with the co-operation of one's more progressive customers.

I mention this point here because it leads into my next one, namely that in this way over the years a fund of practical knowledge is obtained which is of invaluable service in fitting the solution to the problem, and sometimes not least in importance, the capability of the user who is faced with it. I doubt if anyone is in a better position to judge this very ability of the user, than the merchant, who has probably known him for many years, and is in constant touch with his farm, and his general farming methods. From another point of view, one of the greatest safeguards the farmer has when accepting his merchant's advice on the use of herbicides, as apposed to anyone else's, is that their business connections cover a wide field, and no merchant wishes to prejuduce his other trading interests by giving thoughtless advice on the use of herbicides.

At this point you may be beginning to wonder what I consider to be the manufacturer's role in all this in relation to the merchant's. It is my belief that many manufacturers are beginning to find that economics are forcing them to beam their selling effort to those merchants who offer a complete post sales technical service on the farm within their own organisations. These merchants can thus save the vast amount of time previously spent on the users' farms by the manufacturers' technical sales force. Particularly is this so in my own part of the country where farms are small and the potential from each individual call likewise small. The emphasis seems to be shifting to a pattern of manufacturers introducing new chemicals and techniques to the merchant, selling their known products as wholesalers, and letting the merchant do the actual retailing and most of the servicing at farm level. I am sure most manufacturers would consider it folly to try and carry a merchant who was merely a storekeeper by doing all his retail selling for him, particularly where that merchant was in competition with one who was prepared to do the job properly by providing his own after sales service. I would not leave this point without mention of the valauble and ever-increasingly efficient work of the N.A.A.S. in relation to advice on the use of herbicides. In my own county at any rate, we work in close and cordial co-operation with them.

From the foregoing remarks you will now have realised that I consider the merchant has in fact some small part to play in educating his customers as to the best use of the wares he has to offer. Having decided therefore to sell chemicals in this way, how can he go about obtaining the necessary knowledge, and how does he apply that knowledge for the benefit of his customers? There is probably no single ideal way of doing these things, as each merchant has different problems to face. There are vast differences in sizes of trading area, in the pattern of farming in various districts, and in the number of commodities in which your merchant already trades. I think there is one basic essential, however, and that is the presence in his organisation of at least one individual who is sufficiently well trained and practical to be capable of heading a special department dealing with herbicides, and at the same time probably fungicides and insecticides. The value of a contract service within this department I have already mentioned. You then have to strike a balance. Making all one's representatives highly technical in this field means their having less time to obtain the broader agricultural knowledge necessary to function properly within a selling organisation which probably includes farm seeds, fertilisers, feeding stuffs, and the hundred and one other things a merchant sells.

In our case my Company believes that as many representatives as possible should be briefed to a point when they can understand the broad principles involved assess the difficulty of a problem, and if necessary refer it back immediately to either myself or my deputy. To arrive at this stage they have probably availed themselves of the excellent technical courses for which the merchant is greatly indebted either to the major manufacturers, or to the efforts of their own Institute of Corn and Agricultural Merchants. As far as I am concerned, apart from such courses and such conferences as these, my technical knowledge, such as it is, has been gained through years of looking upon the search for information in this sphere as a hobby, irritating to my friends no doubt, and resulting in the consumption of huge quantities of midnight oil. Seriously though - it is extremely difficult to know how I would set about affording, for instance, my son a thorough knowledge of this vast subject if he were to decide he wanted to become technically qualified. Neither a degree in agriculture, nor a degree in chemistry would be what he was looking for.

Having obtained a nucleus of knowledgeable representatives we try, within our own organisation, to increase their knowledge under my guidance in the field and to keep them up-to-date by annual revisions, usually with the wholehearted assistance of our manufacturer friends.

Next is the problem of education of the user. Much can be done to impart basic principles by the many excellent films produced by the major manufacturers, which when shown to selected audiences, and with free rein given for discussion, can greatly assist, particularly if the actual sprayer operators can be present. We run many such business and pleasure evenings during the winter months. We have issued for the past two years, and I hope will continue to do so, an Annual Chemical Year Book, which gives simple basic facts relating to most of the chemicals on the market, including dosage rates, hints on maintenance and operation of equipment etc., even, sometimes, prices which are not out of date by the time we go to print. This is produced in a size which will go into the pocket, and we understand has done quite a lot to assist in a realisation of the main pitfalls which can trap the unwary.

I consider these methods help in fulfilling our role in a general basic education in the use of herbicides, but it is my firm belief that it is well-nigh impossible, and probably undesirable, to try to educate the majority of users to a high technical standard of knowledge of herbicides. You have got to advise them, write down your advice, and then hope the sprayer operator doesn't misread what you have written.

I am quite certain that many farmers have now decided that the whole business is much too complicated for them really to understand, or, to put it another way, the time required to be spent before such a state of understanding could arise would not be an economical proposition on a relatively small unit. Such units are in the majority in the West of England. As they often say "If I have a sick animal that is presenting a problem beyond the simple drench, I call in a vet - why, if I have a sick crop, presenting a problem beyond the simple application of say MCPA, not call in an expert in that particular sphere?" To solve this sort of problem we have developed a servicing scheme whereby farms are walked by appointment. A detailed written report on each field visited is sent to the farmer the following day. If a report is particularly urgent it is made out on the spot. The report gives a synopsis of the problem presented by the field with detailed recommendation of chemicals and techniques to be used where such a procedure is considered a paying proposition. One copy of the report goes to the Manager of our branch in whose area the farm is situated, and one copy to our files. Incidentally, we make a rule never to offer advice, or diagnose a problem over the telephone. This may sound obvious, but it is surprising how great the temptation to do so becomes in a busy period when the problem appears straight forward. We have learned from bitter experience, however, that rarely do things turn out to be exactly as described when we see the actual field.

To facilitate the best possible planning of work, which is necessarily hectic during the peak season, we cover most of the farms which avail themselves of this service on a regular annual or biannual basis. I feel that written reports after a visit are valuable because they imply an acceptance by the merchant of a measure of responsibility for the accuracy and calibre of the advice given. It also ensures against being told later that the grower was sure you said MCPA and not MCPB which in the absence of written confirmation of advice would be difficult to refute! The farm walk system does involve problems, however; such problems as the walking of crops too early to spot a late germination of Galium aparine for instance in a crop showing only Chenopodium album seedlings at the time of inspection. The adviser must have a considerable and accurate knowledge of the identification of weed species in the very early stages of growth - otherwise he cannot make a sufficiently early start on his inspections to enable him to see all the crops required of him in the time at his disposal.

All these problems, and the way the merchant tackles them raises the question of cost. If the farmer thinks it represents a really useful service he must be prepared to pay for it, at any rate to the extent of not expecting the merchant to cut his margins so that the whole business becomes uneconomical. In the majority of cases in my part of the country this is understood, but I sometimes get a little tired of haggling over perhaps a few shillings an acre, in chemical costs, when the advice one has given has been responsible for avoiding what would have been an almost complete lack of control of the weed concerned, with a consequent loss of several hundredweights per acre in crop yield, and several pounds per acre in cost of harvesting, not to mention the waste of the cost of chemical.

Perhaps I should mention just one other small problem - chemical names! Obviously it is unlikely that herbicides will ever be sold merely by reference to the name of the basic chemical or chemicals involved, but it would make things a little easier for merchant and farmer alike if some order could be brought to the sort of chaotic situation where the same basic chemical is given a different common name by, shall we say, commerce and the British Standards Institute.

To summarise briefly, I consider that the merchant has a very definite role to fulfil in the education of the user of herbicides, and that if he handles herbicides as part of his business it is incumbent upon him to play his part in this work. It seems to me, however, that it is not a realistic target to make of every farmer user a highly technical expert in relation to herbicides, but that every effort should be made to get him to that state of mind where he realises that a little knowledge is a dangerous thing. To carry out the merchant's part in the general effort to arrive at such a stage of education he has many problems to face. Probably his first problem is the assessment of the extent to which his Company is prepared to become involved in the handling of herbicides, bearing in mind factors such as the potential existing in his trading area, the competition he is going to have to face there, and the fact that the minimum requirements of a merchant so doing are going to involve him in considerable expense and effort.

I consider the main requirements, and probably the minimum requirements are as follows:

1) The setting up of a special department to deal with herbicides, and at the same time insectides and fungicides.

2) The employment of someone with sufficient technical and practical knowledge to manage the department and the advisory servicing of the chemicals sold.

3) A system whereby representatives can be briefed sufficiently to enable them to recognise the difference between an involved problem and a simple one, and to have a basic knowledge of weed identification and herbicide practice.

4) Means of keeping these representatives up-to-date with commercial developments as early as possible.

5) Probably essential is the provision of a contract spray service which should provide a constant source of learning how to turn theory into practice.

6) A system for answering questions on specific field problems by visits, confirmed in writing, which produce accurate advice, given early enough for it to be of practical use.

7) A set programme where groups of users can be kept informed in general terms of progress in this field by the printed word, visual means such as films and slides, and by general discussion.

If your merchant is thinking on these lines I am certain he will be able to rely for assistance in putting his thoughts into practice on those manufacturers who have already done such great work in the dissemination of technical information in this field.

PROBLEMS OF ADVICE AND EDUCATION : A MANUFACTURER'S POINT OF VIEW

E. Holmes

Association of British Manufacturers of Agricultural Chemicals

The manufacturer's problem, like that of the Ministry and the merchant, is, basically, to ensure that the farmer is aware of the technical and economic possibilities of the use of weedkillers - on different weeds, in different crops, under the particular conditions of his holding. The difference is that he then tries to persuade the farmer to use his particular products. To this end the manufacturer must have a highly skilled technical staff at his home base, and a competent field force working for his sales department in regular contact with selected merchants and farmer customers.

The technical staff at the home base may, in the case of a small company, consist of a few graduates each skilled in his own particular discipline - chemistry, physics or engineering, agronomy or botany. But with large companies the organisation may be much more elaborate and consist of a research and development department in addition to a separate technical service department. The former will be carrying out basic plant physiological and chemical work on herbicide problems, exploratory work on potential new herbicides, small and large scale screening, field evaluation and so on. For these purposes this department will be contacting farmers primarily from the point of view of their unsolved or only partially-solved herbicide problems and to provide areas where particular weed problems may be investigated.

The technical service department on the other hand will be concerned primarily with taking new products from the Research & Development department, seeing them through their inevitable teething troubles when they get into the hands of farmers, referring intractable problems back to R. & D, and generally helping their commercial colleagues in the office and in the field to exceed their sales forecasts. In the early days of a new product members of technical service department will do a great deal of work going out with the field representatives to visit and expound the new story to merchants and farmers. As progress is made the field representatives take over more of this work, coming back to the Technical Sales department only when they get stuck, and leaving that department to get on with even newer products. Because of their spearhead activity these technical service men are expected to know all the answers to questions which arise from the customer's own particular problems. This calls for great experience and diplomacy, for the customer expects decisiveness, often on questions to which there is no immediate answer.

Because there are some 409,000 holdings of over 5 acres in the United Kingdom it is obviously difficult for the staff of any company, however large, to visit a significant proportion of them. The manufacturer must, if he aims at nation-wide distribution, use the services of a great number of merchants; with the aid of their representatives he multiplies up his total field force and, therefore, the number of farm calls.

Before referring to the detail of providing advice and education to merchants and farmers, I would mention one more general and controversial matter.

I well remember that when I led the industry delegation to give evidence before the Zuckerman Working Parties we were criticised for giving too much information, to the extent that the print was so small that few users bothered to read it.

Even when a real effort is made to give clear, concise and readable instructions one can never rely on them being read. I once investigated a complaint in which MCPA had failed to control a moderately resistant weed which should, nevertheless, have been well within its capabilities; the farmer ultimately admitted he had not read the directions but had used the same rate as a neighbour who was only concerned with control of yellow charlock.

I repeat, the difficulty is that though the printed word may be detailed, perhaps too detailed because of the desire to be explicit, there is no way of ensuring that directions are followed. Perhaps the answer would be for the manufacturer to disclaim all responsibility for anything but the chemical and physical properties of the product, and make the user completely responsible in law for his successes and failures on the farm!

Before leaving the subject of labels I would draw attention to a comment made by Justus C. Ward of the U.S.D.A. at the Denver meeting of the Weed Society of America last February. He said that the registered pesticide label is "the most expensive literature in the world". When one considers what it costs today (a) to keep large research, development and service departments going, (b) to obtain biological, toxicological and residue data to satisfy approval and registration authorities and (c) to put up plant to make products before one can draw up a label, I feel Dr. Ward is about right.

Data sheets are usually prepared to summarise for new products the sort of information I have just mentioned and to call forth ideas as to how else a product might be useful. They are primarily for the use of other research men and organisations, sometimes for the technically interested merchant, rarely for the farmer.

Most manufacturers spend a great deal of thought, manpower and money on leaflets and more elaborate brochures. The latter usually contain a large amount of carefully selected and expensively edited and printed information which some farmers find most useful. Frankly, however, I am very doubtful whether more than a small percentage ever justify the great effort put into them. And this is not entirely the farmer's fault. I remember visiting one of our merchants and seeing neat piles of our literature ranged on his shelves. But some of it was five, some ten years old.

Press articles, provided they are really informative and not too biased, can be most helpful. Editors seem to prefer pretty well known names as writers, but this imposes even stricter limitations regarding lack of bias. For example, if Holmes writes an article, he has to be most careful or his readers will say - "More publicity for that company". Competitors say it anyway!

Lastly, under the heading, the printed word, I mentioned advertisements. These call for little comment from me. They are primarily designed to keep the name of a particular branded product, and that of the manufacturer, in front of the using public. In the nature of things they very rarely impinge on my subject of "advice and education".

WORD OF MOUTH

Under the heading of "making known" by word of mouth I comprehend a wide range of talks and lectures to the manufacturers' own technical and field representatives, agents and their representatives, contractors and their staffs, agricultural societies, N.F.U. and Y.F.C. groups, individual farmers and farmer groups and occasionally broadcasts.

In my own particular company we hold regular conferences with our own technical and field staffs; special conferences when we have a new weedkiller, technique or machine to describe.

Similarly we arrange frequent meetings with our agents and their representatives with the object of helping them to put the correct story over to their customers and, of course, helping us to reach a far wider farmer audience. Here I would make a special point. Very seldom does weedkiller business, or even crop protection business collectively, represent more than a small percentage of the agent's total turnover. As a result I am frequently and pleasantly surprised at the amount of time they are prepared to devote to our products. I think the answer must be that we are much more likely to provide new products than, say, the manufacturer of fertilizers, feeding stuffs and binder twine. We thus provide talking points and excuses for the agents' representatives to visit their customers.

Contractors and their staffs are met regularly and here, as is self-evident, discussion ranges over machinery and techniques at least as much as over products.

Mainly during the winter the technical staffs of all companies are regularly committed to series of lectures to and discussions with agricultural societies of all kinds, N.F.U. and Y.F.C. parties and of course local farmer groups. Incidentally, I can say from my own experience that in any one season it is curious how quickly a pattern of questions emerges and continues throughout that season.

Few industrial technical men have frequent opportunities to address growers on radio or television but, as one who has done a certain amount of it, I would state the obvious. Talks must be studiously objective, at least on the home programmes, and even indirect references which might be construed as advertising will be cut out by the producer. When, as inevitably happens occasionally, anything of this kind slips through it is promptly pounced on by competitors.

VISUAL AIDS

A rather miscellaneous list appears under what I call visual aids: films and film strips, weed charts, show exhibits, and field demonstrations and farm walks.

My own company has made a great number of films of various kinds over the past twenty years. From experience I prefer 16 mm in colour. For the average farmer audience, and provided a competent representative is in charge of the proceedings, it is better not to provide sound; the lecturer can then give a commentary slanted to suit the particular type of audience and the locality. A set commentary can occasionally offend an audience by not using, for example, the local names of weeds; in the absence of a sound track a skilled commentator can make a virtue of some incident that may seem wrong in a particular locality. When, of course, you want to use films in different countries, it is cheap, in the absence of a sound track, to introduce suitable captions.

The difficulty with films, is that, to do a really good job, they must be limited to a single theme. This is suitable for a product or a new spraying technique, but it is liable to become too difficult if the new theme is complicated by the introduction of comparative methods for use under different conditions or in particular parts of the country.

To illustrate a series of specific points widely separated in a lecture and, of course, for providing data it is much better, and cheaper, to use 35 mm film transparencies. May I say, however, that even when you have an enormous library of transparencies, it is extraordinarily difficult to find exactly the shots you need.

The use of charts is obvious. Not only can they be helpful in the course of lectures but they usefully adorn agents offices and agricultural college lecture rooms. But they must be well done, with several weed stages shown. I've never been satisfied with our own.

Show exhibits are usually a mixture of several things I have already mentioned - plus photographs, trade samples and, sometimes, machines. The primary object of course is to keep your name in front of your customers, but you also hope to induce interest and provoke questions. After that it is up to the company's representative. It is most important to have the exhibit adequately manned.

Field demonstrations, again well done, can be an enormous aid to weedkilling education. But they must be coupled with farm walks during which the amounts and conditions of application, of what product through which machine, can be described and discussed.

The last few remarks bring me to a final statement, used frequently in the past but nevertheless still true. I have a brother who farms on a reasonable scale. He doesn't believe a word I tell him about our new weedkillers; he doesn't believe our advertisements or our leaflets. He looks over the fence and, when his neighbour uses such a product and it seems to do good, he tries it the following year on a small scale. If it still does good under his conditions he uses it on a farm scale. After that you might think he was selling me something!

I conclude that despite all the labels and leaflets, and all the lectures and films, the best way to tender advice and provide education on weedkillers is to encourage progressive farmers to use new products at strategic points well distributed over the country. Then leave the generality of farmers to look over the fence.

Discussion on preceding three papers, opened by Mr. R. B. Ferro, National Agricultural Advisory Service

Mr. Ferro. This Session is entitled "Problems of Advice and Education" and having listened to the three speakers there is no doubt that there are problems in bringing the knowledge of weed control and all that it entails to the user and non-user of herbicides. I will not attempt to differentiate in this context between advice and education and, for the sake of simplicity, let us call it merely informing the user. But who is the user that we wish to inform? Not, I suggest, so much the farmer or grower who diligently searches for the latest information and is capable of reaching his own decisions, but rather the man who is making less than the optimum use of the latest methods and who is so often reluctant to seek information. We must also include the farm workers, who carry out the precise field work without which successful results will not be obtained. These are the men we must have in our mind in our discussion which is of extreme importance to us all; and, I hope, we shall hear from some of our overseas delegates who are faced, at home, with similar problems.

Dr. Holmes discussed the various means available to manufacturers to inform users about their products and emphasised that the underlaying purpose was to sell the product. Perhaps it is this thought that prompted Mr. Mason to lament that many users sought guidance from commercial advisers rather than from the independant advisers in the N.A.A.S. Mr. Bradford told us how, as a merchant, he was attempting to overcome these difficulties and meet the needs of his customers.

The N.A.A.S. is independent and at times we are asked to advise on the suggestions put to farmers by others. That type of enquiry will, undoubtedly, remain, as will the direct enquiries to us about treatment about particular weeds. Of greater significance I am sure, is developing work of the N.A.A.S. in advising on the Farm Organisation as a business, the type of work that is often referred to as Farm Management. Weed Control is one of the management factors to consider, affecting as it does the cropping, crop production methods, mechanisation and labour organisation on the farm. I was impressed by the frequency yesterday of references to the economics of weed control and, undoubtedly, this will gain greater prominance as the seasons go by. It is during this work that we can do a great deal to bring weed control into focus and give the farmer a clear understanding of its significance.

However independent N.A.A.S. may be, it can never deal with all the day-to-day enquiries on herbicide usage, nor is there any need for it to do so when we consider the other facilities that there are. To me, therefore, it is clearly a case of all concerned playing their full part, N.A.A.S., the manufacturers, the merchants, the farm institutes, colleges, university departments and, of course, the Weed Research Organisation, and it seems to me that the discussion could well fall under four headings:-

1. How best can we integrate our efforts. Much has already been done through local contacts, local conferences and discussions. It is essentially local integration that is required.

2. How best can the "informers" be kept fully in touch with developments and have the information as quickly as possible.

3. How can the jargon of weed control and the meaning of herbicides be simplified so that it is comprehensible to those who have yet barely a nodding acquaintance with the use of herbicides.

4. What is the simplest form of approach to the user. To be effective it must be simple and easily understood.

Mr. J. A. R. Lockhart. I was disappointed that no one who is concerned with lecturing to students on herbicides was asked to read a paper in this session, but I am pleased to find that most of the problems which the lecturer encounters were aired by the speakers - particularly Mr. Mason of N.F.U. Headquarters. The subject of herbicides now required about 20 lectures compared with 1 or 2 ten years ago and this is often difficult to fit into a full course. The Weed Control Handbook has been very helpful. I am satisfied that the new approved products scheme is a considerable improvement on the old scheme and I hope that most products which come on the market will be approved about the same time. I am not very happy about the fact that the scheme is officially financed by the firms whose products are approved and it is just possible that the scheme could be improved if additional finance was provided by other interested sources and/or by the Ministry. Reports along the lines of those given in "Which" or "Shoppers Guide" are perhaps too much to ask for, although they would be very welcome. I apologise for again bringing up the problem of "Trade Names" - they are a real menace and most of the trouble is due to many firms who only buy the chemicals from the manufacturers and give them fancy names. I feel that firms who do the valuable research work should be allowed some freedom in labelling their products but the others should not be allowed to complicate matters by coining names which mean nothing. In fact, some scheme could possibly be developed whereby Royalties were paid to the research worker's firm and this need not mean an increase in cost to the farmer - in fact it would probably allow for a reduction in cost. I find it very difficult to compare costs of herbicides produced by various firms: students and farmers would very much like to be able to do this. Mr. Bradford's Booklet is not the last word by any means, but it is definitely a big step in the right direction.

Dr. R. E. Slade. Might I suggest that the Weed Control Handbook should publish only those advertisements which show the composition of the products the advertisers wish to sell?

Mr. H. W. Salmon. I would like to be allowed to congratulate the first speaker of this paper. I feel he has most adequately dealt with the farmers' point of view. After all the farmer is the ultimate customer and I hope the suggestions in the paper will receive most careful consideration by the Council and manufacturers present. I am rather disappointed that there is no paper on "Weeds in Cereals and Undersown Crops". I find great difficulty in controlling chickweed in the latter, and would also suggest that the control of mayweed coupled with the control of other prevalent weeds by the same chemical still leaves room for improvement.

Dr. E. Holmes. I think Dr. Woodford should be answering this: there is too much to try to fit in a Conference of three days and the Organising Committee has to be selective. It takes items of current interest and leaves out those things which have been adequately dealt with in the past or where there is nothing much new to say.

Mr. H. Geary. In answer to some of Mr. Limb's criticisms I must say that I am always amazed at the efficiency with which spray chemicals are used by the farmer - this achievement is due to the efforts made by the leading manufacturers and such organisations as Mr. Bradford's. I feel that this section of agriculture has developed very quickly in the short space of 15 years, due to the dissemination of knowledge to the farmer, particularly when one considers the comparatively slow development by the farmer in the use of fertilizers and animal feeding stuffs which have been available in some form since the beginning of man. This young industry has developed to the present high level due to the effort by all concerned who serve the farmer, for which in return he pays so little and achieves so much.

Mr. J. S. W. Simonds. I am horrified still to find elements of suspicion between the various bodies who advise the farmer on herbicide useage. Surely we all have only one object in view, profit for the farmer. From that profit it is hoped that the farmer will be able to pay his merchant and from such monies received the manufacturer hopes he will be paid by the merchant. Further unless the farmer makes a profit he will be unable to pay his taxes which keep alive and pay for the various Ministerial Agricultural Bodies.

SESSION 6

Chairman: Dr. W. G. Templeman

THE CONTROL OF GRASS WEEDS

AGROPYRON REPENS - AN INTRODUCTION

G. R. Sagar*

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Agropyron repens is a pernicious weed of arable land and although many regard it as a symbol of bad farming, increasing mechanisation and the reduction in the farm labour force have tended to make the conventional methods of control uneconomic. It is natural, therefore, that attempts have been made to find alternative means to control the weed. The introduction of the powerful rotary cultivators and the production of herbicides which will kill grasses, stand out as major lines of recent advance.

The undoubted success of the rotary cultivator in controlling rhizomatous grasses does not involve the removal of the couch as did some of the older methods but depends on the stimulation of dormant buds and the destruction of the resulting shoots. The best growth stage at which to 'strike again' at the regenerating weed is determined as I shall later show, by a knowledge of the biology of the species.

Control methods which depend on the use of chemicals rely for their success on many factors, both environmental and innate. It is the innate factors which will concern me most since they are the least easily measured and assessed.

It was perhaps too much to hope that TCA, dalapon or amino triazole would be as immediately successful in controlling Agropyron repens as were the substituted phenoxyacetic acids in ridding our corn of many dicotyledonous weeds. Let it be sufficient at present to say that the degree of control of Agropyron repens in the field by any of these chemicals is unpredictable, varying from occasional complete success to complete failure. It is my task to suggest some of the causes of this variability.

THE IMPORTANCE OF SEED AS A MEANS OF SPREADING AND INTRODUCING AGROPYRON REPENS

Palmer (1958) states 'A. repens spreads and reproduces principally by means of its rhizomes; since fertile seed is rarely formed.' Although A. repens is self sterile and since owing to extensive vegetative spread one genetical

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individual might be expected to occupy a large area, thus bringing about a degree of spatial isolation, I have recorded a high level of seed production for A. repens where the weed was allowed to complete its flowering cycle. From one such stand (Headington, Oxford), 58 per cent of the flowers produced seed which germinated in soil. It is clear from my own observations in the field that this seed will germinate immediately it is shed, that is, in the autumn of the year of its production. A combine harvester which returns the waste to the field at the time of the harvest could be almost as efficient as a seed drill in sowing A. repens if that species was a weed of the harvested crop. Cooke (personal communication) claims that the spread of A. repens in the Holland district of Lincolnshire can be correlated with the changeover to combine harvesting.

Standard laboratory germination tests of crop seed may fail to detect viable A. repens since the seed will germinate successfully only with a fluctuating temperature and not at a constant 5, 10, 15, 20, 25 or 30°C.

Mr. J. R. Thomson, Department of Agriculture for Scotland, (personal communication) has reported that 'In the year 1956-7 the following proportions of seed samples received for test contained enough couch for some to be found in the standard purity test'.

	From Denmark	From England
Cocksfoot	25 per cent	3 per cent
Perennial Ryegrass	85 per cent	5 per cent

The Committee for Transactions in Seeds have recommended that a much more strict control should be kept over the spread of A. repens with crop seed. (Anon, 1957). Ovservations suggest, however that the landowner himself must guard against dissemination of seed of A. repens by his own machinery. Regeneration of A. repens populations from seedlings may mask the efficiency of a spray treatment.

THE BIOLOGY OF AGROPYRON REPENS WITH REFERENCE TO THE CONTROL OF THE WEED

Palmer (1958) has described how the rhizomes which grow horizontally below the soil surface during the late spring and summer, erect in the autumn to produce an aerial shoot which survives throughout the winter. This shoot develops tillers and produces new rhizomes in the following spring. By investigating a stand of A. repens which was not disturbed by cultivations, Palmer was able to relate the beginning of rhizome production and tillering to the calendar. He was also able to demonstrate that each overwintering shoot normally gave rise in late March or early April to three tillers and 3-4 rhizomes and that in July, some rhizome buds grew out to produce lateral rhizomes. Further, he showed that this pattern of development was modified if the individual was grown free from interference from other plants, when tillers themselves produced subtillers and rhizomes. Thus the plant was capable of exploiting a virgin habitat by producing numerous rhizomes and Palmer quotes '... such a plant may produce as many as 50 rhizomes in a single growing season.' Anyone who has tried to control A repens will need no reminder of this potential.

It has been possible during the last 12 months to relate Palmer's work to the pattern of behaviour of A. repens under conditions of agricultural practice.

When a rhizome system is broken up by ploughing or other cultivation, one or more of the rhizome buds, hitherto dormant, grow out to produce aerial shoots which altimately tiller and produce rhizomes in the manner described by Palmer. The only difference is that the pattern of development is no longer related to the calendar. This would confirm Palmer's (1958) findings that the onset of rhizome production is under the control of environmental factors and that the cessation of horizontal rhizome growth may be correlated with senescence of the parent shoot. Applied to farming practice this finding means that it should be possible, by cultivation, to bring A. repens to any stage in its growth cycle if it should prove that the weed is more successfully controlled by chemicals at, e.g. the time when the rhizome production commences, rather than later when the parent shoot begins to age.

Palmer (1958) has reported that the parent shoot dies back in the autumn when the new rhizome tips have erected as aerial shoots, but that in the following season one or more buds occasionally grow out from the old stock and produce tillers and rhizomes. Because the morphology of the rhizome system can be related to the growth pattern of the weed an examination of entire rhizome systems allows a determination of the longevity of the rhizomes. In an undisturbed stand of A. repens at Headington, Oxford, it was found that rhizomes disappeared during the third year after their production. Thus in May 1960, rhizomes produced in 1960, 1959, 1958 and 1957 were found, although the latter were frequently moribund.

Nevertheless, all the living rhizomes of such a system bear dormant buds which become available for regeneration if the intact system is damaged. A primary rotary cultivation produces such a regeneration, bringing about a depletion in the number of dormant buds as well as returning the Agropyron repens to the beginning of its growth cycle, i.e. a single shoot which will produce tillers and new rhizomes. Subsequent cultivations serve to break off the new sprouts, to encourage more dormant buds to grow out, to expose the segments to desiccation and perhaps to deplete to some extent the food reserves in the rhizome segments. The relative importance of bud removal and food depletion is not known. It has been suggested (Fryer, personal communication) that disc harrows may also be effective in breaking up the rhizomes but it is generally agreed that rotary cultivators will be most efficient.

BIOLOGICAL FACTORS WHICH MAY AFFECT THE EFFICIENCY OF HERBICIDE TREATMENTS

There is little doubt that save under exceptional circumstances, a herbicide applied to the foliage of a plant must move down to the below ground organs in the phloem. Although the factors which cause movement in the phloem are in dispute, it is clear that substances do not move aimlessly about the plant, but travel to regions where they are used or stored. On the mass-flow hypothesis, downward movement in the phloem will be greatest when the demand for metabolites below ground is also greatest. On the other hand if different substances move independently in the phloem, they must do so in response to a gradient between the 'source' and the 'sink'. It would seem of paramount importance that, at the time of the herbicide application, the below ground organs should be in a state of rapid growth.

As a segment of rhizome of A. repens regenerates, there will be, for a time at least, a movement of materials from storage tissues to the new shoot and roots. Following this, there will be a period when the new shoot produces sufficient assimilate to be dependent no longer on rhizome reserves. Movement of materials at this stage will be from photosynthetic regions to sites of active cell division and cell extension. Later still, metabolites will be moved from leaves to new tillers and new rhizomes. It seems celar that the maximum below ground activity of the weed occurs during the period of rhizome growth.

The conclusion from this briefly developed argument is that a translocated herbicide applied to the foliage of A. repens will move downwards most efficiently during the period of new rhizome growth. Nevertheless, environmental factors may affect this movement, for temperature and light intensity must be such that active photosynthesis occurs. Field applications of translocated herbicides in late autumn or early winter are likely to yield uncertain results since the growth of new rhizomes will be slow and will in any case vary from day to day depending directly on temperature, and indirectly via the photosynthetic rate on light intensity and day length.

It is clear, from a consideration of the growth form of A. repens that in an undisturbed stand of the weed in the spring of, e.g. 1961, there will still be present rhizomes produced in 1961, 1960, 1959 and probably 1958. These rhizomes will be connected via the base of the parent plants of 1961, 1960 and 1959 but apart from the 1961 rhizomes, they are unlikely to be metabolically active and therefore unlikely to import any substances from the above ground part of the plant. Nevertheless, the ageing rhizomes still bear buds which are capable of regeneration. It is, in fact, difficult to suggest any mechanism which would lead directly to the accumulation of a herbicide by the rhizome buds, no matter what the age of those buds, and even more difficult to conceive of a mechanism which would lead to the movement of the herbicide into older rhizomes of the system. And yet such movement is essential if control is to be complete.

It could be argued that death of the apices which receive a direct supply of the chemical could lead to the sprouting of dormant buds and consequent retranslocation of the herbicide to the new regions of metabolic activity. However, a chemical like dalapon, which in low doses promotes dormancy, is liable to reach the sprouting bud initially in very low doses, arresting the activity and consequently preventing the accumulation of a lethal dose.

There are two possible solutions to these problems.

1. Cultivation prior to spraying will break up the rhizome system, inducing many dormant buds to sprout and appear as above ground shoots. This cultivation will also serve to reduce the maximum distance that a herbicide must be moved as well as increasing the general metabolic activity of the weed. Thus the herbicide would not need to move so far and might be expected to move faster.

2. Johnson (1958) has shown that applications of ammonium nitrate break the dormancy of rhizome buds even when it is enforced by low doses of dalapon. Applications of ammonium nitrate prior to or soon after spraying might be expected to increase the metabolic activity of the rhizome buds and lead in consequence to the accumulation of lethal doses. In addition, Dexter (1936) showed that applications of nitrogen to stands of Agropyron repens resulted in an increased shoot: rhizome ratio, leading to a greater relative area of foliage for spray retention.

The sole purpose of this introductory paper is to throw light on some of the peculiarities in the life cycle of A. repens which might affect the success of chemical and cultural control measures.

Although this hypothesis has been argued with particular reference to A. repens, most of it would seem to be applicable to any rhizomatous perennial treated with a translocated herbicide applied to the foliage. Finally, I wish to acknowledge that part of this hypothesis is not original, but I hope that its completeness will to some extent compensate for this.

Acknowledgements

Thanks are due and are gratefully given to J. Mattock, Esq., and his family for their co-operation in providing a site for my experiments. It is a pleasure to acknowledge the critical yet kindly response which these musings have evoked from my colleagues in the Agricultural Research Council's Units at Oxford. I wish to thank Professor J. L. Harper for his criticism of the manuscript.

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ROTARY CULTIVATION FOR THE CONTROL OF RHIZOMATOUS GRASS WEEDS

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Summary. Rotary cultivation of a couch infested light silt soil in 1959 gave a reasonable control of *Agrostis gigantea* and *Agropyron repens* but the rotary cultivator could not give effective control where tractor power was inadequate. When a chemical (amino triazole, dalapon or TCA✻) was combined with rotary cultivation a rather better control was obtained than from either alone but this was not sufficient to make the combined treatment worthwhile. Rotary cultivation alone appeared more effective than herbicides alone. Of the chemicals used, activated amino triazole appeared the most promising.

INTRODUCTION

It has been shown (Fail 1956) that rhizomatous grasses may be eliminated by 2 to 6 rotary cultivations, kill being attributed to the exhaustion of the small rhizome pieces produced by the initial rotary cultivation.

In order to obtain field experience of this technique in conjunction with chemical sprays, two experiments were laid down in 1959 by the N.A.A.S., Eastern Region, Crop Husbandry Department. Both sites were on a light silt soil with a heavy infestation of couch, mainly *Agrostis gigantea* with some *Agropyron repens*. Fail considered 119 in. of rhizome/sq ft to be a heavy infestation, but these trials had an infestation of about 800 in./sq ft or a "rhizome yield" of about 2½ ton of dry matter /ac.

METHODS AND MATERIALS

First Trial

The chemical treatments were unsatisfactory and only the rotary cultivation treatment will be considered in this paper.

The machine used, a 60 in. Howard Rotovator (made by Rotary Hoes Ltd.), had no easy means of altering gear ratios. It was towed by a Ferguson tractor (diesel TEF 20 in only fair condition) with a minimum forward speed of 2.5 mph. Theoretically, maximum rotor speed was about 170 rpm giving an "increment of cut" or "bite" of 5 in. The land was in deep plough furrows well greened over when treatments commenced in April. Subsequent rotary cultivations were done when the land became well greened over, at approximately fortnightly intervals. The progress of the trial is summarised in Table I.

It was clear that insufficient progress was being made and the trial was abandoned. The failure of the rotary cultivation appeared to be due to the low power of the tractor which was unable to maintain adequate p t o speed at a

✻ Used respectively as the commercial formulations "Weedazol TL", "Dowpon" and "Tecane".

reasonable depth of penetration. In fact the final depth of 4 in. (in comparsion with untreated land) was quite unsatisfactory in view of the depth to which some of the rhizomes had been buried by deep ploughing (11 in.) in the previous autumn.

TABLE I. CONDITION OF RHIZOME AFTER EACH ROTARY CULTIVATION TO DEPTH OF BLADE ACTION (ABOUT 4 INCHES)

First Trial

Dates of Rotary Cultivations	Total Length (in in.) per sq ft	Mean Length (in in.) of pieces	Percentage of rhizome in different length ranges in inches					
			< 4	4-8	8-12	12-16	16-20	> 20
8th April	799	6.6	18	32	22	5	11	12
16th April	645	4.7	32	38	15	9	3	3
1st May	717	5.1	24	30	25	16	5	0

Second Trial

A "Selectatilth Rotovator" (made by Rotary Hoes Ltd.) was used for the second trial and this had gears which could readily be changed to give a wide range of motor speeds of which 180 r p m was used at a forward speed of 2 mph giving a 'bite' of 3.7 in. It was mounted on a Fordson Major Diesel tractor which, for the initial treatments particularly, was used to work as deeply as practicable. The very dry conditions made it difficult to get adequate penetration. The trial followed a dried pea crop. Chemical treatments (amino triazole, dalapon and TCA) were applied on 31st July, 1959 and were followed by either no rotary cultivation, or one, two or three rotary cultivations at monthly intervals, the first being given on 7th August. A later application was made of each material to other plots on 1st September. Treatments are shown in Table II. Rainfall was as follows:

July	1.98 in.
August	1.34 in.
September	.15 in.
October	1.48 in.
November	.36 in.

RESULTS

Second Trial

A fortnight after the last rotary cultivation soil samples were taken to the full depth of rhizome growth from unsprayed rotary cultivated plots. The effect on the couch rhizome is summarised in Table IV.

The trial area was subsequently ploughed to a depth of 9 in. about 4 in. below the depth of rotary cultivation, and drilled with wheat on 30th October.

Final assessments were made on the wheat stubble after the 1960 harvest (in late August and early September 1960). These are presented in Tables II, III and IV.

Unfortunately the ploughing in the previous autumn brought up an appreciable amount of couch rhizome which had been below the depth of rotary cultivation. Probably this could have been avoided by shallower ploughing. However it was thought essential to ensure that any rotary cultivation pan would be broken, although on soils of this type such a pan would be unlikely.

Yields were not obtained from the wheat crop; there was a clear visual response to the treatments controlling couch and no adverse effects were noted except damage to the wheat where TCA had been applied 8 weeks before sowing. (Rainfall during this period was very low).

Visual scorings were made after harvest on the whole trial area while couch leaf density and soil rhizome content were assessed on a more limited scale (Tables 2, 3 and 4 respectively).

TABLE II. SCORING FOR DENSITY OF COUCH LEAF GROWTH ON 29.8.60

(Mean of 3 observers, mean of 3 blocks.
10 = worst, 0 = complete absence)

(Second Trial)

Chemical Treatments (lb/ac)		No. of Rotary Cultivations Nil	One	Two	Three
Dalapon 3	Sprayed on 31st July 7 days before first rotary cultivation	7.2	6.8	6.2	4.4
" 6		6.2	6.3	4.9	3.3
Not sprayed		9.6	8.8	7.7	5.3
TCA 10		8.6	6.2	5.7	4.1
" 20		8.0	5.2	4.8	2.4
Not sprayed		9.6	9.2	6.7	4.2
Activated amino triazole 2		7.0	6.8	3.7	2.2
Activated amino triazole 4		6.0	4.3	2.7	1.4
Not sprayed		9.7	8.0	5.7	4.8
Dalapon 3	Sprayed on 1st September 7 days before second rotary cultivation	7.8	7.3	4.9	3.0
TCA 10		8.0	6.5	5.0	2.3
Activated amino triazole 2		8.0	6.2	5.0	2.6
Not sprayed		9.6	8.5	5.8	3.9
Mean unsprayed		9.6	8.6	6.4	4.6

TABLE III. COMPARISON OF SCORING (TABLE II) WITH ACTUAL STEM COUNTS (8.9.60) EXPRESSED AS PERCENTAGES OF NON-ROTARY CULTIVATED PLOTS

(Second Trial)

Two Unsprayed Strips	No. of Rotary Cultivations			
	Nil	One	Two	Three
Scorings	9.8 = 100	90	73	60
Stem Counts (per sq ft)	70.2 = 100	67	42	31

TABLE IV. WEIGHT OF COUCH RHIZOME (g/sq ft)

	No. of Rotary Cultivations			
	Nil	One	Two	Three
Samples taken 20.10.59	58.6	11.5	2.3	1.4
Samples taken 9.9.60	20.1	12.0	1.9	1.1

DISCUSSION

Up to the present there have been four methods of couch control available to the farmer. Firstly for heavy land there is the summer fallow where the couch is killed by being dried out in largish clods; secondly there is the technique of working out the rhizomes and burning them. Thirdly, where depth of soil is sufficient, the couch may be killed by ploughing it down to a depth of about 14 in. Lastly there has been the possibility of using a herbicide.

On the farm in question the first three had been found ineffective; the soil was too light to dry out in clods, the infestation too heavy and deep to work out economically and there was insufficient depth of soil (11 in. over blowing sand) to kill by burying. TCA had not been tried and although preliminary experience with dalapon was unpromising its use was being contemplated on a large scale as the only possible solution.

Following upon the experience with the rotary cultivator in the first trial, unsuccessful though it was in the circumstances, the farmer purchased a more versatile model and, combined with adequate tractor power, has found it to be very effective in controlling couch, throughout the farm. The farmer has estimated that he can carry out the three rotovations at an overall cost, including tractor depreciation, of £4 per acre. Output he estimates at something like ½ acre per hour. So far as blade wear is concerned there is the advantage of a complete absence of stones so that a set of blades costing about £9 will deal with 200 acres.

In the second trial the scorings show that no chemical treatment by itself gave anything approaching a satisfactory control of couch and all were appreciably poorer than three rotary cultivations. The combination of chemical with rotary cultivation gave a rather better control than either alone although not to a degree which made the combined treatment worth while. The infestation did not increase on the rotary cultivated plots under the wheat crop (Table IV) but it appears to have fallen considerably on the untreated areas. It is of note that visual scorings tended to over-estimate leaf density on the cleaner plots and that leaf density in relation to rhizome was higher on the cleaner plots than on the untreated ones.

It would be unwise to draw general conclusions from these results since they are of only a single year's work on a single soil type and the reactions on different soils and in different weather conditions would seem likely to be variable. Clearly much more study is required on the subject although the trial obviously confirms the promise of Fail's work.

Acknowledgements

Particular thanks are due to the farmer, Mr. A. H. Cooke, who carried out all the rotary cultivations.

The assistance of members of the N.A.A.S. Holland Lincs. staff is acknowledged as is also the help received from Messrs. C. V. Dadd and E. R. Bullen.

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AN IMPORTANT FACTOR AFFECTING THE MOVEMENT OF 2,2-DICHLOROPROPIONIC ACID (DALAPON) IN EXPERIMENTAL SYSTEMS OF AGROPYRON REPENS

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Summary. Two experiments are described which show that the extent of movement of dalapon when applied to experimental two shoot systems of *Agropyron repens* may be dramatically improved by covering the treated shoot with an opaque or transparent cover. The technique of autoradiography has been used and the dangers of extrapolating these observations into field practice are mentioned. If a treated shoot is shaded, then the radioactivity is distributed widely within the experimental system, whereas an unshaded shoot retains the herbicide to a far greater extent. It is suggested that a shade reduces the rate of movement of water in the xylem by increasing the humidity. Since dalapon is readily transferred from phloem to xylem, it is argued that the speed of downward movement of the chemical in the phloem will depend not only on the forces taking it down, but also on the rate at which the xylem draws it from the phloem. It seems likely that the faster the movement of water in the xylem, the more rapidly is the herbicide extracted from the phloem. It is suggested that humidity at the time of spraying and subsequently may be all important in determining the success or failure of dalapon applications in the field.

INTRODUCTION

During the course of an investigation into the factors controlling the pattern of movement of 2,2-dichloropropionic acid (dalapon) in experimental systems of *Agropyron repens*, an attempt was made to determine how far the transport of dalapon could be correlated with supposed pattern of movement of metabolites. One of the more critical experiments to test such a hypothesis involves shading a part of a plant and demonstrating that a herbicide applied to another part of the same plant moves readily into the shaded portion.

METHODS AND MATERIALS

The production of the experimental systems

Lengths of rhizome were lifted from a garden at Headington, Oxford and transferred to the Department of Agriculture, Oxford. The rhizomes were then cut up into two node segments, the cut being made with scissors mid-way between nodes. The segments were planted in seed boxes placed in an incubator at a temperature of 25°C. 8 days later sprouts began to emerge and the boxes were transferred for 48 hr to a heated greenhouse at 20°C. When the sprouts measured

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ca. 5 cm in length they were lifted and washed in tap water prior to replanting. At this stage the segments were selected for uniformity and only those with a shoot at both nodes were used.

The plants were grown in procelain pots in gravel which had been sifted to remove particles which were less than 1/16th in. in diameter. The segments were planted 2.5 cm below the surface. The water table was maintained 10 cm below the surface of the gravel by means of reservoirs and a syphon device. Nutrient solution was added to each pot at three weekly intervals.

Each shoot tillered and produced rhizomes in the manner described by Palmer (1958), but during this period the experimental material became variable. Facilities did not permit any further selection to be made and the consistency of the results are therefore all the more remarkable.

<u>Treatment</u>

In both experiments sodium 2,2-dichloropropionate (2-C^{14}labelled) was used. The basic solution was of 1.65 mg/ml in water with 1 per cent carbowax 1500 added. The specific activity was approximately 1 millicurie/mM. 10µl of this solution was applied to the plant as a single drop placed in a lanolin ring sited midway along the upper surface of the lamina of the youngest unrolled leaf of one shoot. The plants were harvested 3, 10 or 17 days after treatment. Subsequent procedure was the same as that of Yamaguchi and Crafts (1958) except that dry ice was not used at harvest. The plants were freeze-dried for five days, mounted on lithograph paper, dried at 50°C for 24 hr, pressed and exposed to Kodirex X-ray film for 21 days. Terylene film was used to cover the specimens before they were exposed. The two node segments for Experiment I were collected on 30.11.59 and transferred to gravel in pots on 14.12.59. The pots were placed in a heated greenhouse at the Department of Agriculture, Oxford and auxilliary light was provided throughout the winter. The treatment was applied on 5.2.60. There were two replicates of each treatment and the plants were harvested 3 or 10 days after treatment. The variables were as follows:-

1. Treated shoot shaded.
2. Untreated shoot shaded
3. Both shoots shaded
4. Neither shoot shaded

The shades excluded all light from the selected parts of the plant from the moment that the treatment was applied up to the time of harvest.

For Experiment 2, two node segments were collected on 1.5.60 and planted out of doors at the University Field Station, Wytham on 11.5.60. One shoot of each plant was treated on 1.7.60 after being moved into an unheated greenhouse the day previously. Harvests were taken 10 and 17 days after treatment and there were again two replicates. The variables were as follows:

1. Treated shoot covered with a light-proof shade
2. Untreated shoot covered with a light-proof shade

3. Both shoots covered with light-proof shades

4. Neither shoot covered

5. Treated shoot enclosed by a transparent cover

6. Untreated shoot enclosed by a transparent cover

7. Both shoots enclosed by transparent covers

In this experiment the shades were of polystyrene, those designed to exclude the light being coated externally with four layers of a black cellulose paint.

RESULTS

No quantative data is available from these experiments at present and all the objections inherent in the autoradiographic technique may be quoted. However, the experimental plants are available for future studies.

Experiment 1: (All results after 10 days of treatment)

(a) Without shading, dalapon did not move from treated into untreated shoots. (b) Dalapon moved out of shaded into unshaded shoots. (c) Dalapon did not move from unshaded to shaded shoots. (d) Where both shoots were shaded movement did not occur into the untreated shoot. In one such case a rhizome tip erected outside the shades during the course of the experiment and this shoot accumulated the labelled material. (e) All the shaded shoots were moribund at the end of the experimental period (Fig. 1).

Experiment 2: (Results after 10 days of treatment)

(a) Where no shades were applied dalapon was not detectable in the untreated shoot (Fig. 2). (b) Dalapon moved out of a treated shoot that was covered by a transparent or an opaque shade (Fig. 3). (c) When the untreated shoot was covered it did not accumulate dalapon (Fig. 2). (d) If both shoots were covered by opaque shades, movement was most marked into actively growing rhizome tips, roots and young rhizome sprouts which grew up outside the shades (Fig. 4). (e) When both shoots were enclosed within transparent covers extensive distribution was seen throughout the entire experimental system (Fig. 4). (f) The shoots under the dark shades became moribund during the experiment. (g) Except where both shoots were shaded (see (d) and (e)), the pattern of movement of the labelled material is comparable no matter whether opaque or transparent covers were applied. There were, however, differences in the intensity of the pictures, more dalapon having moved from shoots covered by black shades than from those covered by the transparent.

DISCUSSION

It is most important that the shortcomings of the radioautographic technique should be fully understood before any attempt is made to extend the findings of this work to field practice. It is not intended to discuss this problem here, but to state simply that further experimental work using field doses of dalapon are necessary before recommendation can be made.

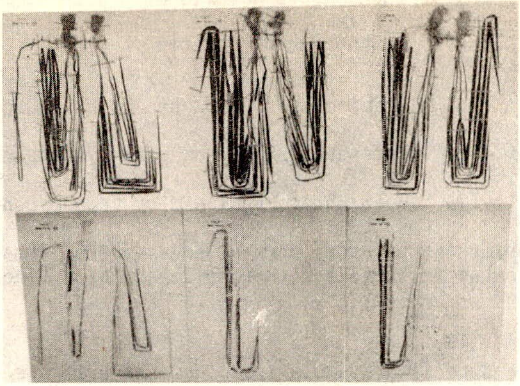

FIGURE 1. AUTORADIOGRAPHS (EXPERIMENT 1)

Lower series is of the plant systems. Upper series is of autoradiographs of corresponding plant systems. (Right hand shoot treated in each case with labelled material) All plants harvested 10 days after treatment (left) no shade applied; (centre) untreated shoot covered with an opaque shade; (right) treated shoot covered with opaque shade. Note the extended distribution of the labelled material when the treated shoot is covered.

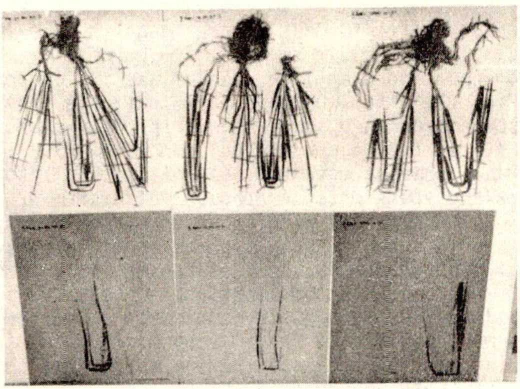

FIGURE 2. AUTORADIOGRAPHS (EXPERIMENT 2)

Lower series is of the plant systems. Upper series is of autoradiographs of corresponding plant systems. (Left hand shoot treated in each case) All plants harvested 10 days after treatment. (Left) no shade applied; (centre) untreated shoot covered with opaque shade; (right) untreated shoot covered by a transparent shade.

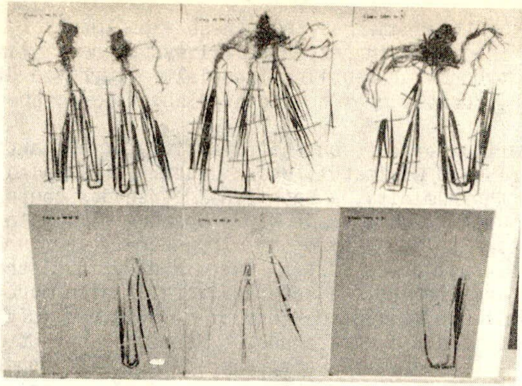

FIGURE 3. AUTORADIOGRAPHS (EXPERIMENT 2)

Layout as Fig. 2. (Left) no shade; (centre) treated shoot covered with an opaque shade; (right) treated shoot covered with a transparent shade. Note the greatly extended distribution of labelled material as a response to the opaque shade and to a lesser extent to the transparent cover.

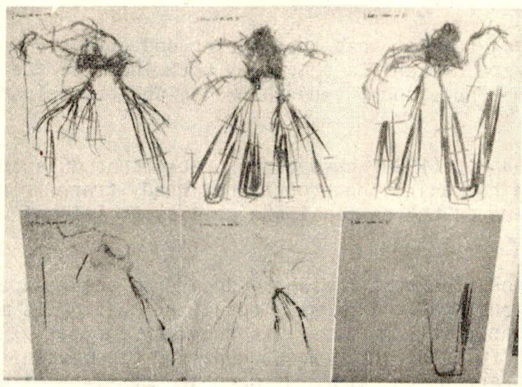

FIGURE 4. AUTORADIOGRAPH (EXPERIMENT 2)

Layout as Fig. 2. (Left) no shade; (centre) both original shoots covered by transparent shade; (right) both original shoots covered by opaque shade. Note (a) the excellent distribution of the labelled material as a response to covering both shoots with transparent shade and (b) the accumulation of labelled material in young aerial shoots and rhizome tips in the right hand picture.

The clear picture that emerges from these experiments is that the application of a shade or shades to the experimental system has a very marked effect on the extent of the movement of labelled material. Improved distribution of the chemical occurs consistently when the treated shoot is covered by a shade.

Shading has various effects on the physiology of a plant. Dark shades arrest photosynthesis and ultimately cause death. They also raise the humidity. Clear shades raise the humidity. Both types of shades cause temperature changes. The air under a dark shade warms up more slowly in sunlight than does free air which, in turn, lags behind the air under a clear shade. When direct sunlight ceases, free air cools faster than air under a clear shade, whereas the temperature of the air under a dark shade falls even more slowly. On a cloudy day, the amplitude of fluctuations of temperature is greatest under a clear shade and least under a dark shade. Since no attempt was made to record these changes during these experiments, temperature differences must not be neglected in any interpretation of the results. It is known, however, that the maximum temperature difference obtained in full sunlight was 5°C between a transparent and a dark shade, with free air intermediate.

In spite of the temperature differences, it is interesting to note that both opaque and transparent shades produce similar responses, although free air is frequently intermediate in respect of temperature fluctuations and extremes. In view of this, it is difficult to believe that temperature is the primary cause of the differences between shaded and non-shaded systems. It could, however, be important in explaining some of the differences between opaque and transparent shaded systems.

The most obvious feature that transparent and opaque covers have in common when placed over a green plant is that they both increase the humidity of the trapped air and, in consequence, tend to reduce the transpiration rate of the enclosed shoot.

Now, Crafts and Foy (1959) have demonstrated that dalapon shares with amitrole and maleic hydrazide the property of ready transference from phloem to xylem. This confers on the chemical the ability to 'circulate' within the plant system.

The single conclusion that I wish to draw from these experiments is that the increased movement that occurs as a result of shading is mainly due to the reduction in the transpiration rate. To draw any further general conclusions would be folly, but it is of interest to consider the mechanism by which transpiration rate might affect the speed of downward movement of dalapon in this experimental system.

Current interpretation of these experiments and others, (Sagar, unpublished), suggests that dalapon moves down the treated leaf and shoot into the rhizome system in the phloem and that this movement may be accelerated by the presence of actively growing rhizome tips which act as 'sinks' for the herbicide. In addition to this downward movement, it is suggested that dalapon may be constantly transferred from the phloem to the xylem at all stages during its passage down the plant. This transfer might be more readily effected in a monocotyledon where the xylem and phloem tissues are not separated by a cambium and where intercalary cambium is common. It is conceivable, and indeed probable, that the rate of movement of water in the xylem might affect the rate at which the dalapon is drawn from the phloem, less herbicide being removed as water speed decreases. The effect of a shade on a treated shoot would be to slow down or arrest the upward movement of water and in consequence increase the apparent rate of movement of material in the phloem.

At no stage in these investigations has it been possible to rule out the simplest explanation of all which would account for the observations. It is conceivable that at some stage or stages during the period from treatment to harvest, water movement in the xylem has been reversed and that in consequence water plus dalapon in the xylem and dalapon in the phloem have both moved in the downward direction for a greater or lesser length of time. Since much of the xylem tissue is dead and water movement may be regarded as a physical phenomenon, the movement of dalapon in xylem systems would be very much more rapid than its movement in the phloem. This simple interpretation of the results must not be forgotten in future experiments.

Nevertheless, the finding to be passed on to the field investigator is that the humidity at the time of spraying, and subsequently, may be the crucial factor in determining the success or failure of an application of dalapon.

Since amino triazole is even more readily transferred from phloem to xylem (Crafts, 1959) than dalapon, humidity acting on the transpiration stream might also be the key to the variability of the results obtained from the use of this chemical in the field.

Acknowledgments

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THE EFFECTS OF ADDED PENETRANT AIDS AND WETTING AGENTS ON THE RESPONSE OF QUACKGRASS (AGROPYRON REPENS) TO DALAPON

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Summary: Tests using 2-C^{14} labelled dalapon formulations with and without nonionic wetting agents resulted in a definite increase in the amount of dalapon 2-C^{14} recovered from rhizomes, untreated shoots, and leaves when wetting agent had been added to the solution. These increases in the amount of dalapon translocated were measured on uniform plants under conditions which avoided such variables as differences in leaf area covered by droplets of equal volume but with different surface tensions, and differences in the amount of formulation applied per plant resulting from the influence of the wetting agent on retention of the formulation by the leaf. Erratic results have been obtained from time to time in field applications of dalapon. These tests, run under controlled conditions with uniform plants emphasize the need for a properly wetting formulation.

INTRODUCTION

Since its introduction in 1953, 2,2-dichloroproprionic acid (dalapon) has been of considerable interest because of its practical selectivity with grasses. In addition to many field trials, a large number of more detailed experiments bave been conducted in attempts to determine its sites of action in plants, the method by which it is translocated in plants, and its ultimate fate in both plant tissue and soil. A number of experiments have been conducted with and without wetting agents. The present study was undertaken to determine the effect of some surface active agents on the translocation of a sodium dalapon into the rhizomes of quackgrass (*Agropyron repens*).

There is ample evidence in the literature that spray additives which have surface-active characteristics can increase the effectiveness of a number of herbicides. (Currier, H. B. 1954; Foy, C. L. 1958; Hamner, C. L. *et al.* 1947; Hitchcock, A. E. *et al.* 1948; Staniforth, D. W. *et al.* 1949; Woodford E. K. *et al.* 1958).

It has been pointed out (Ennis W. B. *et al.* 1952) that differences may exist in the effectiveness of herbicide formulations even with equal wetting, and that considerable care in the selection of a wetting agent is required.

Daniels (1953) refers to a relationship existing between the ionic character and the relative polarity of a compound which suggests that the addition of suitable surfactants to a strongly ionic, hydrophylic, polar compound such as sodium 2,2-dichloropropionate (sodium dalapon) might very well cause such a formulation to become more compatible with non-polar materials such as those found in the cuticle of plants.

Robbins et al. (1952) state that "increase in polarity enhances the apparent reactivity (of a herbicide) whereas increase in its oil-like (a-polar) properties promotes penetration".

They conclude that since the two processes are apparently opposed, there must be an optimum point in the balance between them; and this in reality represents a compromise between toxicity and compatibility with the cuticle.

Orgell (1957) has observed that cationic and anionic surfactants differ markedly in their effects on absorption of acidic compounds, and Staniforth (1949) states that non-ionic wetting agents differ in action from that of sodium laurel sulphate - an anionic wetting agent.

The observation by Currier (1954) that root absorption of dalapon is enhanced by the addition of a surfactant is of interest since roots are normally readily wetted by water, and thus perhaps confirms the earlier observation of Ennis et al (1952) by indicating some effect on root cell protoplasm. Present knowledge of the effect of surfactants in herbicidal solutions is far from complete; and a 1954 summary by Currier still represents the state of the art fairly well.

Foy (1958) using both C^{14} and Cl^{36} labelled dalapon demonstrated the advantages of using wetting agents with dalapon. For example, on the basis of growth inhibition, it appeared that as much dalapon was absorbed by corn in one hour from sprays containing a surfactant as in two weeks from a solution without a surfactant.

Jansen et al (1960) found a wide range in response to dalapon by both soybeans and corn in tests using 63 different wetting agents in combination with dalapon.

METHODS AND MATERIALS

Prior to the start of this experiment, Jansen's data had been reviewed, and on the basis of his results, a number of surfactants which had improved the herbicidal effects of dalapon on corn and soybeans were tentatively selected for use. Some of these were not readily available, so a further selection was made, and the following surfactants were obtained:

Surfactant	Type	Produced by
Duponal WA Flake	Anionic	E.I. DuPont de Nemours and Company
Ethomeen S-15	Cationic	Allied Chemical Corporation
Tergitol TMN	Non-ionic	Union Carbide Corporation
Polyglycol 26-2	Non-ionic	The Dow Chemical Company

Tests to determine retention on the leaves of quackgrass and tests to determine the required dose of dalapon-2-C^{14} showed that the non-ionic surfactants were superior to both the ionic ones. Accordingly, Tergitol TMN and Polyglycol 26-2 were used in the rest of the experiments.

A formulation of the salt of sodium dalapon was sub-divided and each wetting agent was added to aliquots to give wetting agents concentrations of 0.2 per cent, 0.1 per cent and 0.05 per cent by weight and a concentration of the sodium salt of dalapon equivalent to 10 lb in 60 U.S. gal. These percentages are in the range of the concentrations of wetting agent which are used in field applications of dalapon at recommended rates.

This experiment was conducted with pot-grown plants of quackgrass (Agropyron repens). All test plants were grown from two node sections of quackgrass rhizomes which had been selected for uniform size and weight from a clone. The test plants were produced and held after treatment in a Percival controlled environment chamber with a day temperature of 78°F and a night temperature of 66°F having three four-degree temperature steps between the extremes. The plants were grown under a twelve hour day length with a maximum intensity of 3900 foot-candles at bench height. Light intensity was also regulated through three increments per cycle, with nine hours of maximum intensity light during each 24 hour period.

Plants were selected for uniformity of sprouts shortly after emergence, and again at the three leaf stage. A final selection made when the test was started resulted in an extremely uniform group of plants in the 6-leaf stage of growth, each having a second shoot in the 3-leaf stage of growth. Preliminary trials gave coefficients of variation of from 8 to 10 per cent for plant height, weight, and rhizome weights. Six replicates were used for each treatment.

Test solutions were prepared by dispersing the wetting agent in water, and diluting to the required concentration, then adding unlabelled dalapon-sodium to a concentration equivalent to 10 lb to 60 gal.

A sample of 2-C^{14} labelled sodium salt of dalapon having a specific activity of 0.98 millicuries per millimole was used for the test. The solution employed contained 1.35 microcuries ml.

An area 5 mm by 50 mm on the upper surface of the third leaf of each test plant was walled with lanolin. This area was then supported in a horizontal position, and flooded with ½ ml of the proper dalaponwetting agent solution. A two hundred lambda aliquot of the 2-C^{14} labelled sodium dalapon solution was added to the wetting agent solution on each leaf, after which the leaves were allowed to dry.

After five days, the plants were dissected and the individual leaves, stem, rhizomes, and roots were cut with shears into ½ in. segments. The various parts, except for the treated leaves were ground in a glass homogenizer. The pieces of treated leaf (with the lanolin wall) were placed into vials containing 5 ml of water containing sodium carbonate slightly in excess of saturation. The vials were heated to approximately 99OC, placed in a freezer at OOC for 24 hr, and then crushed with a stirring rod. After grinding or crushing, each sample was centrifuged, and the supernatant liquid removed for analysis.

Counting was done in a Packard tri-carb automatic scintillation counter using a solvent system consisting of 70 per cent redistilled toluene and 30 per cent absolute ethanol and which contained 4 gm of 2,5-diphenyloxazole and 0.1 gm of 1,4-bis-2-(5-phenyloxazolyl)-benzene/l. A ½ ml of supernatant liquid from a sample preparation was added to nineteen and ½ ml of scintillation solution,