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PROBLEMS ASSOCIATED WITH HERBICIDE FIELD EXPERIMENTS ON SUBMERGED AQUATIC WEEDS

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Summary Experiments on aquatic weeds involve a complex series of problems not encountered in terrestrial work. This paper lists some of these problems and suggests ways of overcoming or minimising them. The sampling of water weeds and invertebrates is discussed and some other effects on the ecosystem considered.

INTRODUCTION

Submerged aquatic weeds pose problems for the field experimenter that are not encountered by those working with terrestrial plants. Many of these problems are concerned with the practical difficulties of observing the plants themselves and making quantitative assessments under water. Others arise from the fact that any activity or treatment that has an effect on the target organism also directly or indirectly affects the environment. This makes a comparison between treatments much more complex and sometimes impossible. It is not only the experimenters' activities that cause these changes but also the normal fluctuations in environmental conditions and plant populations that occur from year to year. The report on the Bere Stream by Ladle and Casey (1971), illustrates that the composition and form of the original communities is in constant change. It is thus much more difficult to draw comparisons between treated and untreated plots and to select uniform sites than it is on land.

This report reviews the experimental methods now in use that attempt to overcome these difficulties, in the hope that the experience gained so far will be of help to future experimenters.

CHOICE OF SITE FOR HERBICIDE EXPERIMENTS

The choice of site depends not only upon the type of experiment required but also upon the local conditions of water use and water flow. Priority must be given to the avoidance of any risk to irrigated crops and fishing interests, and to obtaining the co-operation of interested parties.

Flowing water should be avoided whenever possible because under conditions of flow dilution occurs and it is impossible to maintain the required concentration of herbicide. Also there is the danger of the herbicide being carried down stream and contaminating other treatments and the rest of the water course.

The site chosen must have as uniform a weed population and water depth as possible. The size and shape of the water body will determine to a large extent the type of experiment most suitable. A large uniform area such as a lake may lend itself to sub-division for a replicated experiment, whereas drainage ditches however stagnant they may appear to be, are always liable to flood and are generally only suitable for simpler designs.

The site must also be accessible to the experimenter and preferably not to the public. Assurances should be obtained that the experimental area will not be interfered with for the period of the experiment to allow for adequate assessments. This may include regrowth measurement in the following season.

CHOICE OF EXPERIMENTAL DESIGN

Replicated experiments

It is not possible to use the more advanced experimental designs used in agronomic experiments, but under some circumstances simple randomised block designs may be applicable. In this case it is necessary to isolate plots so that individual treatments may be applied within each block and cross-contamination avoided. In a lake, one way this may be done is by prefabricating enclosures constructed with wooden frames supporting polythene sheeting. The corner posts of the frames must be pointed and protrude about 15 cm below the lower cross bar so that they can be driven into the bottom until the cross bar and polythene 'skirt' is buried in the mud. This is essential to form an adequate seal and to prevent the loss of herbicide. Satisfactory enclosures have been made from 5 x 5 cm timber but less robust frames have been used in the United States of America (Gallagher, J.E. et al, 1968). Prefabricated enclosures of about 4 m^2 have been found satisfactory and can be positioned where required with space left between them to prevent cross-contamination. This size also provides acceptable experimental conditions for a period of a few weeks, but, because the water has been isolated from the main water-body, seasonal changes in biological populations and solutes will differ and eventually conditions within the enclosures will become atypical and unreliable for comparison with the other enclosures. However, for short term experiments (up to 2 months in the summer) this type of layout is valuable.

Attempts have been made to replicate treatments in separate drainage ditches and this can be successful if the weed populations are similar and careful records are made before treatment. The main risk then is an unequal flow of water which will affect herbicide concentration and, therefore, the time the plants are exposed to the chemical. Regular monitoring of residues will help, but it will not be possible to apply a statistical analysis of variance to the results.

Replication in the same channel may be done by inserting barriers made of polythene sheeting or hardboard across the water course and pressing their bases well into the bottom mud. In most channels, however, it is impossible to stop water movement entirely in this way and a large gap (50 m or more) should be left between plots. Residue data should be obtained from the treated water to ascertain the herbicide concentration at intervals throughout the experiment.

Unreplicated experiments

This type of experiment may involve several treatments and therefore barriers or enclosures are normally necessary. However, by reducing the number of plots it is often possible to increase their size thus avoiding the problem of atypical conditions associated with small plots. Where experiments are unreplicated there is no need to randomise the layout and the controls should be placed upstream as an additional safety measure to prevent contamination. Unreplicated experiments involve the risk that results may be lost when, for instance, a plot barrier breaks. It is usually advisable to repeat the trials on a number of different sites in the same year as a precaution against this risk and to provide confirmation of the results.

The use of large plots has important advantages over the smaller enclosures as it can generally be assumed that any difference between the biological systems in treated and untreated water will be a result of the treatment and not induced by enclosure. However, to be sure of this it is necessary to have an untreated, uncontaminated body of water containing the test species in close proximity to the treated plots. This will provide a check on the natural seasonal development of the plants.

Frequently it is not possible to insert barriers across ditches and the treatments must then be separated by untreated "buffer zones". The length of these buffers will depend upon the movement of water expected and the formulation of herbicide being used, but they should usually be no less than 100 m long. All aquatic herbicides will diffuse as well as move with the water and the value of the experiment will be enhanced by regular monitoring of the concentration in the treated portion.

It is sometimes preferable to treat a whole lake at once without attempting to divide it up with enclosures or barriers. The value of the results of this kind of experiment depends upon the amount of care and effort put into the sampling and assessment by the experimenter. If done well it can provide a large amount of valid information as, for example, that reported by Way et al (1971) from the Oxton Lakes.

ASSESSMENT OF RESULTS

Herbicide experiments are primarily concerned with the effect of a chemical or a number of chemicals on a range of submerged vascular plants and filamentous algae. Because of this, particular care has to be given to obtaining accurate and acceptable records of the species there before as well as after treatment. It is also valuable and sometimes necessary to assess the effect of the treatments on certain environmental factors, particularly dissolved oxygen levels, and on other organisms that might affect fish production.

Assessment of weed growth

It is not easy to work in water without disturbing the plants and mud and therefore accepted quantitative methods are unreliable, if not impossible. Cutting and weighing has been done in studies on the productivity of rivers (Edwards and Owens, 1960) by cutting all plant growth in a transect across a river and standardising dryness by spinning for a given length of time in a domestic spin-drier. Attempts to use the same principles in stagnant water have not yet proved successful mainly because of the difficulties encountered in removing the plant material from a column of water. Stem counts are equally difficult.

The most important principles for a successful experiment are firstly to know what plants are there at the time of treatment, secondly to know which species survive the treatment and thirdly to obtain evidence that the species that were killed would have survived if they had not been treated.

Basically, the main need is to make careful records of the species distribution before and at intervals of time after treatment. These may be either simple observations along a ditch or more complex mapping, but the greater care taken in the collection of the data the more valuable is the result.

Submerged weed populations are usually a mixture of numerous species and, early in the year, they are difficult to distinguish from above the water. It is necessary to take weed samples for identification and this can be done by either rake or a small grapnel on a rope. Identification is specially difficult in the early growing period when only the vegetative parts are available, but it is very important that it should be accurate and if necessary specimens should be sent to an herbarium for naming. If there is any doubt about its identity it is advisable to mark a plant of the same species growing in the control plot so that it may be examined while flowering and fruiting. A new key to the identification of water plants is nearing completion by S.M. Haslam of the Natural Environmental Research Council at Cambridge and will specialise in British species.

Way et al (1971) in their work on the Oxton Lakes used regular visual estimates of biomass on a 1-5 scale at intersections of a grid to assess the effect of paraquat on the submerged plants. They then compared the records by means of different sized dots on a series of maps for species and sampling dates. This gave a very good record of the changes that took place, however, it is probably more detailed than required for many herbicide investigations.

It is often important to record the relative size of the plants as well as their presence and a method of doing this by means of symbols representing visual estimates has been used by Hoogers and van der Weij (1971).

In a uniform stand of one or two species adequate records may be obtained by drag sampling with a rake or grapnel. However, when the weed flora is mixed this cannot be relied upon to give a representative sample of the population unless a large number of samples are taken. In a mixed population it is better to use permanent transects and quadrats. The area that each species occupies can then be estimated as a percentage of the total transect area and plotted or sketched onto a transect plan so that the position of each may be located at subsequent assessments.

The use of photometers to estimate light extinction and thus weed densities has received considerable attention and is discussed with the general problem of macrophyte sampling in the IBP Handbook No. 12, (Vollenweider, R.A. (Ed.) 1969). It is not, however, applicable to mixed species stands and is very difficult to operate if filamentous algae are present because they tend to wrap around the photocel and disrupt light measurements.

Assessment of other aquatic organisms

Phytoplankton, zooplankton and other invertebrate animals are often migratory and shortlived and populations fluctuate throughout the year. It would be necessary to build up a detailed picture of these population fluctuations over a number of years in order to demonstrate minor changes resulting from a herbicide treatment. However, only gross changes are usually of interest and these can be detected by monitoring before and after treatment as reported by Newman (1967). Sampling devices have been developed by freshwater research organizations and university departments and are discussed in the IBP Handbooks (Vollenwider, (Ed.) 1969 and Edmondson and Winberg (Ed.) 1971).

Assessment of environmental factors

The most important environmental factor involved is the level of dissolved oxygen because the main risk to fish and other animals following the use of herbicides is usually deoxygenation. Newman (1967) reported a drop from 10 mg/l. of oxygen to 0.44 mg/l. in 8 days in a lake following application of paraquat at 1 mg/l.

Measurement of dissolved oxygen in the field is a simple matter now that portable dissolved oxygen meters are available. It involves introducing an electrode into the water and reading off the percentage saturation and recording water temperature. These data can then be converted to mg/l. of dissolved oxygen. However, to obtain a representative sample a number of readings from different points is required and care should be taken to avoid placing the electrode near the bottom where anaerobic conditions are normally found. As it is seldom possible to take continuous readings it is advisable to measure dissolved oxygen at the same time of day on each occasion to minimise the effect of differences in the day-to-day rate of photosynthesis and consequent oxygen evolution. The most reliable sampling time is at dawn before photosynthesis starts but this is seldom possible and a compromise has to be found.

DISCUSSION

Aquatic ecosystems are in a state of continuous change and this must be borne in mind when planning field experiments and interpreting results.

Most herbicide experiments in water are primarily concerned with the gross effects on higher plants and large floating mats of algae. They can usually be assessed satisfactorily by "before and after" records. However, the value of the results depends upon the amount of time and trouble given to obtaining accurate records of the plants present, and their distribution, before as well as after treatment, and also upon a study of the behaviour of the same species in an untreated control containing a similar community.

It is much more difficult to determine the effect of herbicide treatments on the invertebrate and phytoplankton communities because of the natural fluctuations caused by their mobility, shorter life-spans and greater vulnerability to environmental changes. Reliability will be improved only by repeated experiment and the gradual accummulation of data and experience, although occasionally gross effects may be observed.

Experiments must also be repeated to obtain reliable data on the effect of a herbicide on dissolved oxygen levels because no two ecosystems are identical, and differences in bacterial populations, for example, in superficially similar communities, may produce very different results.

Overcoming these difficulties with more sophisticated experimental designs, is seldom possible in aquatic situations because replicated experiments are difficult to carry out. The physical problems involved and the development of atypical conditions in isolated bodies of water limit their use to exceptionally uniform situations. Unreplicated experiments repeated at different sites and incorporating a high standard of recording are usually more suitable and yield better results.

The limitations placed on the results from unreplicated experiments in other areas of research, however, must also apply to aquatic weed studies and the danger of drawing premature general conclusions must be fully appreciated by workers in this field.

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A TRACTOR MOUNTED PLOT SPRAYER

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Summary In 1968 a plot sprayer was designed for trial work with the object of bridging the gap between the knapsack sprayer and the commercial farm sprayer which is often difficult to use on a small scale. Primarily the design was tailored to meet the needs of those engaged in work with sugar beet herbicides, although potentially this machine can be used for a variety of situations. The main features of the sprayer are:-

(1) Accuracy in operation
(2) Quick and easy alteration of volume or herbicide rate
(3) Adaptability between overall and band spraying
(4) Minimum pipework
(5) Operating pressure up to 100 lb/in^2
(6) Quick interchange of nozzles to give volumes up to 100 gal/ac
(7) Lances moveable to match row widths
(8) Flexibility in plot size, including large plots for demonstration purposes
(9) Standard tractor mounting on the three point linkage
(10) Reasonably compact for transport

INTRODUCTION

With an increasing number of herbicides becoming available to sugar beet growers, it was apparent in 1968 that further trial and demonstration work would be necessary.

In this connection it was considered desirable to have a sprayer, capable of a high degree of accuracy, which would fill the gap between the knapsack sprayer commonly used for trial purposes and the cumbersome farm sprayer difficult to use on a small scale with any degree of certainty.

Consequently a plot sprayer was designed incorporating the following features:-

(1) A high degree of accuracy
(2) Quick alteration of volume and dosage rates
(3) Adjustable to match varying drill widths
(4) Adaptable to band or overall spraying
(5) Reasonably compact for transport on a car trailer
(6) Readily mounted on most types of tractor

The prototype was built by the British Sugar Corporation Ltd., and sponsored by the Sugar Beet Research and Education Committee during the winter of 1968/69.

DESIGN AND CONSTRUCTION

Design features The machine consists essentially of three main units all of which are mounted directly on the headstock.

(1) Power unit - consisting of the suction hose, pump, pressure reducing valve, on/off valve, distributor manifold, pressure gauges and two line filters.

(2) Cradles - designed to carry four 5 gallon pre-mixed containers readily accessible from the power unit.

(3) Booms - interchangeable either for overall or band spraying.

A more detailed description of these units follows:-

Power Unit A 10 gal/min roller vane pump produces more than adequate output for spraying and agitation. A standard pressure reducing valve provides spraying pressures of up to 100 lb/in^2 and the distributor with six lines each individually controlled by on/off valves, is fed through the main on/off valve.

Surplus liquid is fed -

(a) through the return flow agitation system operating under pressure, and

(b) to the inlet of the pump.

The need to keep pipe work to a minimum in a machine of this nature is apparent, and was the reason for mounting the pump on the headstock complete with power drive shaft rather than directly on the p.t.o. Even so approximately 22 fl. oz of liquid remain in the system and this must be pumped out between treatments.

As a safeguard two pressure gauges are provided and these are readily detachable for protection when not in use by a bayonet fitting, which also allows the gauges to be turned quickly to face front or rear.

As an additional safeguard two line filters, with interchangeable 100 and 50 mesh screens are incorporated in the circuit, one on either side of the pump.

Cradles These are mounted adjacent to the power unit and allow the suction hose to be moved freely to any one of the pre-mixed 5 gallon Jerricans as required. Return flow agitation is utilised for thorough mixing within the containers and is controlled by a quick acting on/off valve.

Additional cradles are also available to allow a further four containers to be carried, but these Jerricans have to be interchanged with the originals when required.

Booms For the type of work this machine was designed for boom widths have been limited to the commonly used sugar beet drill widths, e.g. 5 rows at 20 in. and 6 rows at 18 in., and each lance can be moved to align with individual rows. However if necessary, far greater widths could be covered.

Lances Each of the six lances is made up from standard components supplied by the Spraying Systems Co., and consist of a diaphragm check valve, i.e. a spring loaded anti-drip device, and a bayonet type socket for quick and easy nozzle tip attachment, which simplifies changes of volume rate in the field.

A wide range of 'Quick-Tach' TeeJets are available and give volumes of 15-100 gal/ac at pressures of 15-100 lb/min^2, although for sugar beet herbicide work pressures are normally limited to 20-40 lb/in^2.

Overall Spraying At the widths already mentioned, i.e. up to 9 ft, a simple rigid angle iron boom is employed.

Band Spraying Individual units, with independent height control of each nozzle through a parallel linkage and a small wheel running on or close to the beet row, are mounted on a separate tool bar, and are adjusted to match the row widths.

DISCUSSION

The sprayer is now widely used within the company, in fact each of the 16 sugar factories now have a machine, and in addition two outside research organisations have been similarly equipped.

The simplicity and ease of operation of this sprayer make it particularly suitable for demonstration work together with basic research and screening trials, especially if sizeable plots are desirable. Plot sizes commonly used in this work are one drill width i.e. 8 ft to 9 ft by 25 yds. However plots considerably larger than this are quite feasible, or conversely may be much smaller if desired.

Although originally designed for tractor mounting, this sprayer could be adapted to fit other vehicles, i.e. Land Rover.

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TOWARDS MORE EFFICIENT FIELD EXPERIMENTATION

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Summary The techniques of experimentation required for the evaluation in field trials of new potential herbicidal products are outlined. The design and development of suitable equipment to implement these trials are described and methods for their subsequent assessment are discussed.

INTRODUCTION

The Boots Company Research and Development effort in agriculture covers all aspects from the synthesis of new active ingredients through the various stages of glasshouse and preliminary field testing up to the point of marketing. The area dealt with in this paper is that involving the programme of field testing of potential products for the U.K. market, reference being limited to the herbicide context in field crops.

The objective of the field trial programme in question is to investigate all relevant aspects of herbicidal activity and crop safety and to develop recommendations for the safe and effective use of products in U.K. agriculture. A given investigation usually lasts for 2 - 3 years and covers the period from the definition of the candidate potential product up to the point of marketing.

Compounds included at this stage of development are those that have shown herbicidal potential at previous testing stages but on which only preliminary field data are available in relation to mode of action, rates of use and weed spectrum. Thus the field trial programme that forms the background to this paper involves pre and/or post emergence testing of a wide range of rates, possibly of different formulations on a broad spectrum of weeds on all relevant soil types under all relevant climatic conditions and on a wide range of crops and cultivars.

TRIAL TYPE AND LAYOUT

Such a programme calls for a large number of trials. Dose response trials involving numerous rates of use are set up on different soil types in areas of different climate. Weed spectrum tends to vary with soil type and climatic area, but given sufficient sites there is usually enough overlap of weed species to allow measurement of the influence of soil type and climate on response to the herbicide under test. Timing trials for both weed and crop usually involve fewer rates of use being applied at a series of growth stages.

All such trials call for the siting of a large number of plots in areas of homogeneity of soil, crop, weed species and stage of growth. For this reason plots need to be as small as can accurately and conveniently be sprayed. In almost all cases plot size is decided on field factors or on the means available for harvesting. It would of course be theoretically possible to vary plot size from trial to trial according to weed density and other factors but in a large programme of trials it is desirable to standardise plot size within a given trial type as this leads to standardisation of spraying technique and the amounts of materials and water required, all of which tends to minimise the chance of error. Thus plot size for weed control trials requires to be a compromise area, that on average will allow for sufficient of each weed species present to be reasonable evenly distributed across each plot. In our experience over many years, a plot size of 3 yd x 10 yd has fulfilled this requirement satisfactorily for the majority of weed dose response and timing trials in most field crops.

For measurement of crop yield, plot size requires to be related to the method of determining yield and within the limits of accuracy needs to be sufficiently small to allow their siting in homogeneous areas. With crops such as sugar beet and potatoes for hand lifting, a plot of drill width x 15 - 20 yd has proved to be satisfactory, assuming fourfold replication. With cereals, using 6 ft cut commercial combine harvesters it has been established that cuts of 40 yd length were necessary with sixfold replication. This will be discussed in more detail under "Assessment".

In the case of observational trials on crop varieties it is usual to make use of facilities on the trial grounds of plant breeders and to spray across the varieties, provided there are no great differences in growth stage. Under these circumstances size of plot is dependent on number of varieties and the length of the rows available.

Reference has several times been made above to the need for arranging as many small plots as possible in areas of homogeneity. Sometimes it is more practical to overcome field variation another way, namely by siting a limited number of large plots across the variations in the field. This approach is particularly applicable to the later stages of the programme when rate and optimum timing have been established and it is necessary to compare the new product with existing standards in say 100 - 200 locations across the country. Here, large (1 - 2 acre) unreplicated plots sited across the field variations give a very good picture of reliability under widely varying conditions, the large number of trials serving to compensate for lack of replication.

In small plot trials, plots are laid out in replicated blocks separated by 3 yd wide alleyways for access. Plots are marked by 4 ft, unpainted, 1 in square wooden stakes located 4 yd apart, the middle 3 yd of which are sprayed. The unsprayed strips left by this procedure are an invaluable means of monitoring any variation across the trial area. The corner stakes of a trial are coloured, which enables the plots to be recognised when the crop is fully grown. In exceptional circumstances extension pieces are fitted to the corner stakes of the trial. The corners are also marked by sinking 'mice' (small wooden pegs with wire tails) into the ground. These are an invaluable aid should stakes be knocked down or removed. In cereal trials stakes remain until harvest but in crops such as sugar beet and potatoes they are sometimes temporarily removed to facilitate pesticide application, the corners remaining marked by 'mice'. In addition to these means of locating plots, careful measurements are made from fixed points in hedge, fence or wall.

Except where results are to be subjected to statistical analysis as in the case of yield trials, distribution of treatments within the block is usually by mathematical design rather than at random. This may sound the most blatant heresy but long experience has shown the impracticability of classical randomisation except in the very rare text book type situations where density and stage of weed growth are distributed 'perfectly' over the trial area. The policy is to place together those treatments which it is particularly important to compare, the chance of any environmental gradient producing a bias in favour of particular treatments being largely avoided by arranging treatments differently in the separate blocks. Thus much of the effect of field variation is eliminated. The practice of leaving unsprayed strips of crop in between all plots also contributes greatly in this direction.

APPLICATION

Reference is restricted in this paper to the application of herbicides in liquid form, methods varying according to plot size.

Traditionally, application to small plots was made by a variety of production knapsack sprayers variously modified to improve accuracy. Such sprayers are still used for certain specific situations, for example, the spraying of very rough tilths in the winter cereal context and for application in restricted situations such as in orchards, or on dyke banks etc.,

For small scale application in the majority of arable and grassland situations, work was commenced in 1955 on the development of the Lenton Small Plot Sprayer a summary of the development and main details of which are given below.

For application in the large plot reliability trials referred to earlier, use is made of a good quality commercially available field sprayer, mounted on a well maintained tractor, carefully checked, fitted with new tested jets and carefully calibrated before use.

Lenton Small Plot Sprayer

In order to be able to apply the required dosage uniformly over the whole plot it is essential that the following requirements are met.

1. Application to be through jets designed and situated so as to give uniform output across the width of the boom.
2. The boom to be adjustable vertically and to remain at constant height from the ground during spraying.
3. The boom to move at constant forward speed during spraying.
4. The spray liquid to be contained in a vessel in which it can be maintained in a state of agitation during spraying, as necessary.
5. The spray liquid to be delivered to the boom at constant pressure under all climatic conditions.
6. The equipment to be capable of applying chemical treatments in each of the following ways:-
    - i) Finite dosages.
    - ii) Logarithmically decreasing dosages.
    - iii) Stepped finite dosages
7. The sprayer to be:-
    - a) Manoeuvrable and capable of use on rough tilths
    - b) Light and easily dismantlable for transport
    - c) Adjustable for row width in crops such as sugar beet
    - d) Designed to ensure minimal mechanical damage to crop

After much experimentation it was decided that our particular purpose was best served by a hand propelled four wheeled machine, the basic framework of which was constructed from mild steel tubing. This relatively light weight, easily weldable, very strong material has stood the test of many years hard work and all machines have been built with it.

Early prototypes of the Lenton Small Plot Sprayer were built with extendable wheelbase but on subsequent machines this facility was omitted since the extra weight was not justified by additional convenience. Suspension consists of standard heavy duty bicycle forks which are welded to the frame and which carry the four fixed vertical axis heavy duty bicycle wheels, large at front (H), small at rear, the diameters of which respectively are 26 in and 14 in.

Several means of mechanical propulsion have been investigated but to date all have given rise to problems on all but the most even of surfaces, whilst the hand propelled model is capable of accurate application over fairly rough tilths. It is recognised that other organisations have developed successful mechanically propelled plot sprayers and the matter is under frequent review.

The boom (A) consists of a bar to which the jet housings are attached, all jets being fed individually from a manifold by equal lengths of P.V.C. tubing, thus ensuring simultaneous supply of herbicide to all jets as spraying commences. A great deal of attention is given to the accuracy of output during spraying. New jets are selected annually after patternator tests and spray pattern across the boom is carefully checked. Having worked with ceramic tipped and brass jets the current preference is for the Watson G80 stainless steel tipped fan jet. Using selected jets of this type the minimum variation across the boom is 5%. Until recently this figure was nearer 10%. Application is generally at 20 gal/ac at 30 lb/in^2.

After working with many purpose built brass vessels the current preference is for stainless steel spray vessels obtained from the Cornelius Company (E). These are strong, light weight, easily cleaned, possess quick release albeit secure lids, will withstand pressures up to 60 lb/in^2 and are available in 2 and 5 gallon sizes.

Due to experience of the unreliability of propane in cold weather, compressed air has invariably been used as a source of pressure. For many years use has been made of light weight ex-airforce air receivers with a working pressure of 150 lb/in^2 but attention has recently been focussed on a type of high pressure alloy vessel (G) capable of being pressurised to 2,500 lb/in^2 and which will enable eighty plots of 3 yd x 10 yd to be sprayed on one filling.

In order to maintain constant speed during spraying, it is essential to provide an accurate speedometer that responds rapidly to changes of speed yet is sufficiently damped to prevent oscillation on uneven ground. Geared down commercial vehicle speedometers gave good service for several years until attention was turned to the building in the Company's workshops of a purpose made electrical speedometer (B) driven by a dynohub.(C). Problems of humidity and oscillation have been overcome and the performance of this model is uniformly accurate under all relevant conditions.

The Lenton Small Plot Sprayer was initially designed for finite dose application but in order to be able to evaluate the herbicidal properties of mixtures of various active ingredients, it became necessary to develop means of applying one ingredient or mixture of ingredients at finite dose and superimposing upon this a further ingredient at logarithmically decreasing dosage. The principles of logarithmic spraying being well established (Hartley et al 1956) it became a matter of developing a suitable concentrate vessel for use with the existing spray vessel and air receiver, using the van der Weij principle for intimate mixing of diluent and concentrate. For general use in post emergence work, a 6 yd half dosage distance was found to be suitable. In this type of trial, fourfold replication is considered to be minimum.

For use in situations where supply of herbicide is very limited, a contraction of the Lenton Small Plot Sprayer has been designed and constructed. This machine, also tubular in construction, is mounted on two wheels in tandem, has a smaller but similar type boom, forward speed being controlled by a speedometer of the same type as that fitted to the four wheeled machine. The spray liquid is contained in a pressurised canister fitted with accurate regulating valve and supported on the back of the operator. Application can be by finite or logarithmically decreasing dosages.

Photographs of both types of sprayer appear at the end of the paper.

ASSESSMENT

Visual and quantitative methods of assessment are used for measurement of both weed and crop response. Each type of method has particular advantages over the other, the two being essentially complementary.

In the assessment of weed control response, the use of a recognised scoring method has the advantage over quantitative methods in that the whole plot is assessed and the process is much more rapid. This means that more trials can be conducted, an important factor in commercial development programmes. The use of visual methods where the score is compounded of many facets such as number of weeds, their size, shape, colour and maturity, imposes some restrictions. For example, only the most experienced staff capable of objective assessment can be used and one member of the staff must be responsible for the assessment of all trials in a given project.

Visual assessment is particularly applicable, for example, to the measurement of broad leaved weed control in cereals where the objective is not so much to kill every weed completely but rather to suppress most of them to a state of moribund insignificance. With grassy weeds such as Avena spp and Alopecurus myosuroides however. the effect is often one of 'all or nothing' and here weed counts fill a much more important role.

In the case of crop assessment, certain aspects such as size, vigour, colour and shape lend themselves to a visual scoring method which, as in the case of weed control, is based on a scale of 0 - 10 where 0 represents no effect and 10 represents complete kill.

Quantitative measurements are of paramount importance in crop assessment and range from population counts on the emerging crop, through the subsequent post treatment assessments of density, height, tillering and occurrence of abnormality, to the measurement of crop yield and to the subsequent measurements of quality such as sugar percentage in beet and the various measurements involved in malting and the processed food context. With the increased emphasis on processed crops and probable increased use of growth regulants it is envisaged that post harvest biochemical assays of crops will become necessary.

The quantitative crop measurements that lend themselves to description in this paper are those related to yield and these are of two kinds. The first is the measurement of yield from plots treated with herbicide treated with N and 2N rate in a weed free situation, which has the effect of detecting any adverse or even advantageous effect on yield, directly attributable to the chemical. The second type of yield measurement is conducted in normal weedy situations where removal of weeds contributes towards the attainment of the true crop potential. Such trials are important in establishing the economic value of the herbicide.

In cereal crops, yield measurements are obtained by taking 6 ft median cuts out of the 3 yd plots, using a Claas Comet combine harvester adapted so that plot yield is weighed on the machine. This commercial type combine harvester gives extremely accurate measurements of yield. The yields of beet, potato and other field crops are still taken by hand from the middle 2 - 3 rows of the plots. In all crops sampling for quality tests is made by the normal accepted procedures.

PRACTICAL USAGE

The experimental techniques and the Lenton Small Plot Sprayer described in this paper have been used successfully for many years. They have for example featured strongly in the development of mecoprop (Lush et al 1958), dichlorprop (unpublished), pyrazon (Lush et al 1962, 1964 and 1966), triallate and diallate (Lush and Mayes 1964) (Lush et al 1968), benazolin (Lush et al 1966 and 1968) and potato herbicide mixtures (unpublished). In addition this type of sprayer has been used extensively in the development of agricultural insecticides and fungicides.

FUTURE DEVELOPMENTS

The techniques used in field development programmes of the type referred to in this paper are continually being reviewed in order to maximise efficiency. Particular attention is being paid to application methods. The development for the Lenton Small Plot Sprayer of a stepped dose adaptation is well in hand. This will improve facilities particularly for dose response testing of new active ingredients.

Many attempts at mechanising forward movement have been made but none has proved to be as accurate as hand propulsion. This matter is under continual review in the hope of finding a suitable and effective means of achieving this objective. New methods of quantitative assessment are also under consideration.

Acknowledgments

The authors wish to acknowledge the invaluable assistance of their colleagues in the Research and Engineering Departments of The Boots Company during the development phases of the Lenton Small Plot Sprayer.

Acknowledgement is also made of the Shell adaptation of the Claas Comet combine referred to in this paper.

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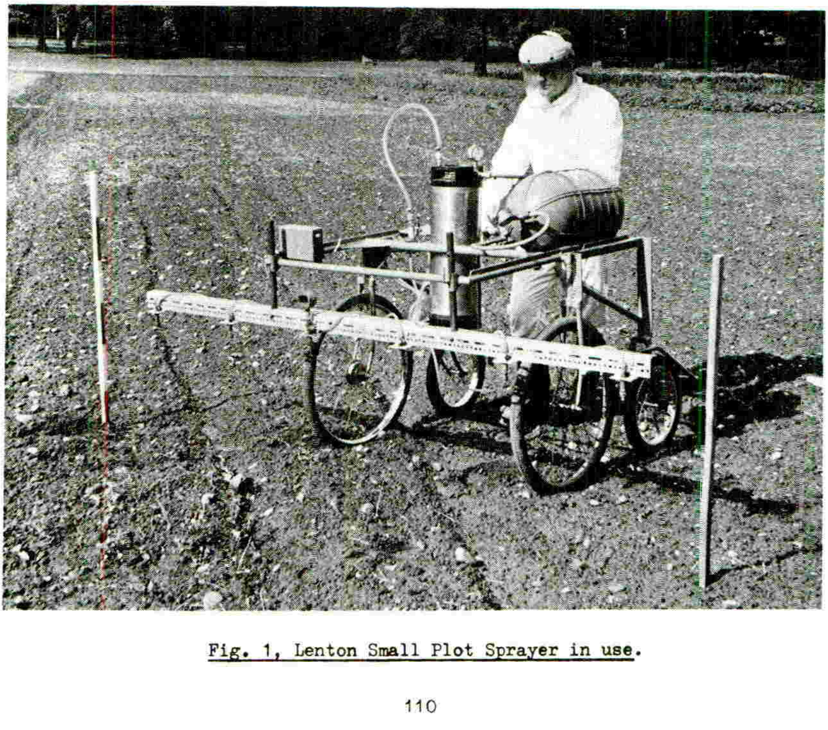

Fig. 1, Lenton Small Plot Sprayer in use.

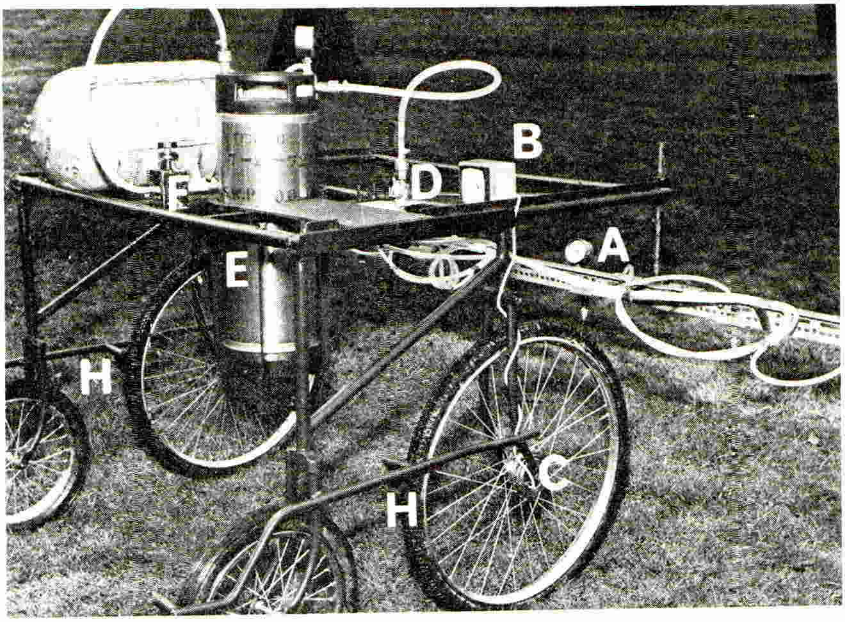

Fig. 2, Details of Lenton Small Plot Sprayer.

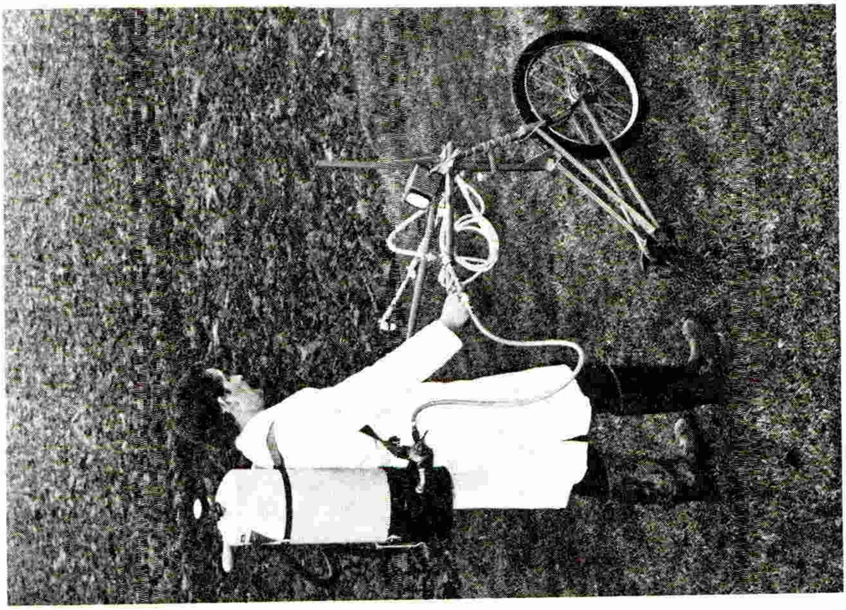

Fig. 3, Sprayer for very small plots.

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REPORT ON THE 1972 CONFERENCE OF THE INTERNATIONAL ASSOCIATION ON THE MECHANISATION OF FIELD EXPERIMENTS

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Summary This paper summarises the highlights of the Third International Conference on Mechanization of Field Experiments, describing briefly some of the more interesting pieces of machinery which were demonstrated at a special exhibition of research equipment.

INTRODUCTION

The Third International Conference on Mechanisation of Field Experiments held at Brno, Czechoslovakia, was organized by the International Association on Mechanization of Field Experiments (IAMFE), and the Czechoslovak Academy of Agriculture. The Conference took place in the University of Agriculture, Brno, from the 10th to 15th July 1972, with an Exhibition and a Demonstration of Research Equipment during the afternoon of the 10th July at the Agricultural Research Institute, Hrusovary, near Brno.

The IAMFE Organisation was founded in 1964. Since then, the Headquarters of the Secretariat and the Information Centre have been at Landbruksteknisk Institute (Norwegian Institute of Agricultural Engineering) Aas, Norway. Previous International Conferences were at Vollebekk, Norway in 1964, and at Braunschweig in the Federal Republic of Germany in 1968. These conferences are held to stimulate interest in the objectives of IAMFE which are to help research and development in agriculture by increasing the efficiency and accuracy of field experimentation through mechanization, thus contributing to the increase of agricultural and horticultural production throughout the world. The Association promotes dessimination of information both through the Conferences and by publication of a Handbook which provides descriptions and illustrations of experimental equipment.

When declaring the Conference open, Jan Rod (Chairman, of Czechoslovak I.A.M.F.E. Conference Organizing Committee and President of the Czechoslovak Committee on Mechanization of Field Experiments and the Committee) asked the basic question "... whether in a conference, dedicated fully to the questions of development, construction and use of special equipment and machinery, the methodology of field experimental techniques should also be handled." He elaborated on this to some extent in his opening speech, but a summary of his remarks would be that both methodology and techniques, coupled with the use of specialised equipment should be complementary and integrated.

There were seven sessions of formal papers which totalled fifty three in all, covering subjects such as: Basic Questions, Plot Drills, Implement Carriers, Pesticide Applicators, Forage Harvesters, Plot Combines, Threshing Equipment and Miscellaneous Items. Several papers presented at the Conference were not included in the original Proceedings, but it is hoped that these will be published in a Supplement at a later date. Approximately 180 Delegates from 40 different countries attended the Conference.

EXHIBITS AND DEMONSTRATIONS

The Exhibitions and Demonstrations included a large number of machines and specialised equipment designed for field experimentation.

In addition to the formal sessions and demonstrations, the Conference provided opportunity for informal discussion on requirements for experimental equipment, and promoted contact both with fellow research workers and manufacturers which will be of use in the future.

It was plain to see from this Conference by the papers presented and the equipment demonstrated, that, as agricultural field research progresses, techniques and experimental equipment become correspondingly more and more sophisticated. Automatically, this means that the cost of developing prototypes and specialised equipment rises continuously. For this reason, in developing countries where research programmes are carried out on limited budgets and workshop facilities are almost non-existent, very little money can be devoted to the development of such equipment. IAMFE hopes to help to overcome this problem by encouraging research workers to assist in compiling a record (IAMFE Handbook) of specialised equipment developed either by Agricultural Engineers or experimenters for the benefit of others.

A large proportion of the equipment discussed and demonstrated was directly connected with Plant Breeding, giving the impression that this type of research was highly mechanised in comparison with other branches of Agricultural Research. Although much of the equipment was developed for specific research projects, many, with or without some minor modifications, would fit into a varied number of research programmes, including those concerned with weed control in all its aspects. Several machines which had proved successful as prototypes are now in production, in fact, some machines, such as small plot combines, have been specifically produced by manufacturers for the requirements of research workers.

PAPERS PRESENTED

Five papers were presented on the subject of Pesticide Application, including two which described machines demonstrated. In addition the ARC Weed Research Organization had on demonstration several typical examples of their own experimental spray equipment. The machine demonstrated by Czechoslovakia was a small pushed trolley on which was fitted a jet based on an oscillating perforated sleeve mounted between metal shields preventing spray drift. This equipment was mainly used for the application of liquid fertilizers between row crops. A much larger machine of Norwegian design was mounted on three wheels and used a small petrol engine for pump and propulsive power. Two wheels were in tandem carrying the engine, liquid containers, pump unit and controls etc., whilst the third wheel supported a side mounted boom which could be adjusted to give a variety of working heights. Various spray liquids could be drawn from any one of a number of medium capacity plastic containers mounted in a rack. On the front of the machine a larger container was mounted to provide water for washing out the system between chemical treatments.

A paper by Friedlander and Hofmann (W. Germany) described a number of application machines. These included a plot sprayer for plantation crops, a small - plot sprayer on bicycle wheels, and a large plot self-propelled sprayer. However the most interesting sprayer was a versatile engine driven plot sprayer on a wheeled frame, easily dismantled and capable of applying liquids as corrosive as liquid nitrogen fertiliser at volume rates from 100 to 1,000 l/ha. This machine had various other refinements including the ability to carry a range of conical-based spray tanks.

A paper by Lush and Mayes (U.K.) entitled "Plot Sprayers and Techniques" described another manually propelled machine on wheels developed at the Lenton Research Station for pesticide application, but this is mentioned separately in another paper in the present Session.

Dyck read a paper by Hergert and Cannon (Canada) in which a pump used for research into the use of Ultra-Low Volumes was described. The pump, drop generator and blower were mounted on a small hand push-cart capable of operating in narrow rows. This apparatus was originally designed for investigations into the control of Colorado Beetle, (Leptinotarsa decemlineata) with technically pure pesticides. It is claimed that the application of ULV spray at 420 g/ha gave biological results comparable with a conventional application of the same amount of pesticide in 240 l/ha. Both methods directed the pesticide to the underside of the leaves. The pump makes use of hypodermic syringes for accurate and repeatable applications; this is operated by a series of chain driven flexible shafts and sprockets driven by a ground wheel.

Pesticide application equipment is of obvious interest to weed research workers. Whilst it is not feasible to give a summary of all other equipment discussed and demonstrated, a few items which were considered to be of particular relevance are mentioned here.

Soil sampling has always presented many problems (such as ease of operating the sampling equipment, contamination, storage of cores, and sub-sampling) and has been a source of controversy. Many machines have been developed to attempt to overcome these problems, but have never been quite successful. A paper by Dr. Maag of Ciba-Geigy (Switzerland) reported on the 'Humax' soil borer which was developed to obtain samples for pesticide and herbicide residue analysis and goes a long way to overcome most of the problems. The machine was electrically powered, and consisted of a drill motor, connecting drive shaft, and bore tube fitted with cutting knives. The power can be supplied either from the mains or a portable generator. The efficiency of this machine is largely due to the P.V.C. transparent container which fits inside the bore tube and is held in place by the cutting knives. When the bore tube is pushed into the ground the sample is driven into the P.V.C. container. After the bore tube has been pulled from the ground, the sample (300 mm depth x 50 mm diameter) already sealed in the P.V.C. container is easily removed by detaching the cutting knives. The sealed core can then be labelled and stored in a deep freeze for future analysis. At a later date, the cores can be sub-sampled in a frozen solid state simply by cutting the required lengths with a small circular saw.

Baker (New Zealand) described a system rather than an individual piece of equipment. This was for the simple removal of turf blocks in the field and aroused most interest as this operation is generally a laborious task. In this instance, the turf blocks were used for precisely controlled studies of the mechanical and physical requirements of direct drilling. Nevertheless, it is considered that the techniques used have potential in other aspects of agronomic research and field experimentation. The turf sampler itself, consisted basically of a stirrup-shaped cutter directly mounted onto the three-point linkage of a wheeled tractor. A bin (2.0 m long, 680 mm wide, 210 mm deep) connected to the rear of the cutter by hooks, collected the turf samples as they were cut.

Several small plot combines, all self-propelled and specifically designed for harvesting experimental cereal plots, were presented. The two most outstanding of these were the 'HEGE 125' and the 'SEEDMASTER 125S'; both are in production and manufacturered in Europe. There was very little to choose between these machines, but the SEEDMASTER manufacturered by Walter and Wintersteiger did have the added refinement of a hydrostatic drive. This firm also produces the P.G.V. 125 Fodder Crop Harvester, which they claim will reduce work time on large experimental plots by approximately 50%.

If more detail is required of the equipment described, this can be acquired from either the Proceedings of the Conference or IAMFE Headquarters.

CONCLUSION

In conclusion, it is relevant to draw the attention of research workers to the remarks made by the President of IAMFE, Mr. Egil Oyjord: "Because of lack of technical data on machine performance, it is extremely difficult to evaluate the manufactured and prototype experimental field plot equipment that does exist. Therefore, increased emphasis should be put on testing of existing research equipment and techniques for mechanisation of field plot research. There is also great need for increased research to develop new equipment and techniques for mechanisation of field plot research. It should also be pointed out that the small manufacturers of research equipment for field experiments need assistance to improve their equipment.

Last, but not least, the developing countries should not have to go the long and expensive way of developing their own research equipment, which will be the result if the industrialised countries are not able to give them the needed information and assistance."

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METHODS FOR EVALUATING WEED COMPETITION USING SYSTEMS OF HAND-WEEDING OR HOEING

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Summary It is important to determine the period of crop growth during which competition from weeds can damage the final crop yield, because this can influence the timing of weed control measures. By using existing hand-weeding methods it is possible to determine the onset and duration of weed competition in a crop. These methods are discussed and adaptations are suggested for use in weed stands germinating over a long period.

INTRODUCTION

Losses in crop yield caused by competition from weeds are widespread and economically very important. Of particular significance is the period during the growth of the crop in which the presence of the weed population is causing damage to final crop yield. This information could be of vital importance in the timing of weed control measures.

Two methods have been described (Nieto, 1960; Nieto et al, 1968) in which the weeds are removed by hoeing at specific times, so that the critical period for weed competition can be evaluated. The purpose of the present paper is to consider the merits and the difficulties of the two methods and to suggest adaptations for use with weeds germinating over a long period.

DISCUSSION OF METHODS

a) The onset of competition

In one of the two approaches (Nieto et al, 1968) they allowed the crop to be weed-infested at first, and hand-weeded different plots after various intervals. The purpose was to determine how long the weeds could remain in the crop before they started competing, and whether there was a later period when the weeds did not cause crop damage.

One of the factors influencing this technique is that different weeds have emergence periods of different lengths. If the length of the period of weed emergence is short, then individual weeds will increase in size with time, but the weed numbers will remain relatively constant. If, however, the weed has a long period of emergence, as with Avena fatua, then at later stages there will be a larger number of weeds as well as an increase in the size of individuals. With prolonged emergence the weed population will be made up of various age groups of plants with different competitive abilities. Each of the groups would presumably commence and cease to compete at different dates. There is then the possibility that weeds emerging all at one time may compete earlier than those with prolonged emergence.

The process of hand-removal, unavoidably disturbs the soil. The treatments where the weeds are removed at an early stage suffer much more crop disturbance due to the continuous reweeding, particularly if the germination period is prolonged, than those treatments where the weeds are removed at a single and later date. However, in the later-weeded treatments, the weeds are large and considerable crop disturbance can occur, the extent depending upon the species of crop and weed. In the earlier-weeded treatments, there is the possibility of crop compensation. Effects that the weeds may have had on yield could be reduced again by harvest (Koch, 1967). However, any crop compensation that will have occurred cannot be distinguished using this technique.

In considering the time at which competition commences and ceases, it is necessary to take into account the numbers of weed and crop plants present per unit area. For if a dense population of weeds is present, they might be expected to start interference with the crop at an earlier date than a sparse population (Harper, 1961).

b) The termination of competition

In the other approach (Nieto et al, 1968) the crop is kept free of weeds at first, but weeds are allowed to grow later on. The purpose is to determine how long a crop must be kept free of weeds if maximum yields are to be obtained. If the technique is used with a weed which has a short period of emergence, the time when the crop needs to be kept free of weeds must be short, for very few weeds will germinate at the later stages. Conversely a weed with a long period of emergence will have a lesser rate of decrease in density with time. Weed density will doubtless influence the duration of competition, for a weed with a high density and a long period of emergence will affect the crop for the longest time, because sufficient weeds will emerge in the later stages to cause damage.

The soil disturbance with this technique is minimal, for there are never any large weeds to remove. However, the treatments which are kept weed-free for the longest times are subjected to more foliage disturbance than those kept weed-free for the shortest periods. Where the soil is frequently disturbed, this may stimulate further germination and result in both a prolonged period of emergence and an increase in total weed emergence. This may even result in an artificially prolonged period of competition.

c) A suggested method for division of a weed population into groups by date of emergence to investigate their relative competitive abilities

In this method, the weeds that emerge within certain periods of time, are allowed to become established and those that emerge before and after each period are removed. The purpose is to find out which fraction of the emerging population is relatively the most competitive. However, it disregards intra-specific competition, which could occur between the emerging groups had they been growing together. This might be particularly important at high weed densities because earlier groups of weeds might have suppressed the later. An estimate of intra-specific competition occurring between groups can be obtained by comparing the yields on plots containing only fractions of the total weed population with plots that have remained weedy or have been kept weed-free throughout. The age composition of the total population can be determined by individual marking of all plants with coloured, plastic-coated wire rings according to emergence date in the continuously weedy plots.

The method is primarily for weeds with a long emergence period and is currently being evaluated at the Weed Research Organization with especial reference to *Avena fatua*. Soil disturbance is minimal, although repeated, for with the frequent reweeding only small plants need to be removed, although foliage disturbance will increase with time.

In a further adaptation treatments can be included that have more and more of the later-emerging groups included with the earlier ones. By combining these two techniques it is possible to obtain further estimates of the intra-specific competition occurring between groups.

A further alternative technique is to remove a group emerging between given dates. The purpose is to determine the effect of the various groups on the crop by subtraction. Only a fraction of the total population is removed so that the lessening of the intra-specific competition will be smaller than in the first alternative method. Soil disturbance is negligible in this method, for no large plants need to be removed; although foliage disturbance increases at the later dates.

In both of these suggested methods, which attempt to evaluate the effect of the different fractions, the density of the weed stand is important, for sparse weed stands, if divided into groups, may be insufficient to affect crop yields. None-the-less density may not be as important as date of emergence relative to the crop.

Throughout the discussion pure stands of weeds with either long or short emergence periods have been assumed. With mixed weed stands, composed of some weeds with long and some with short germination periods, the difficulties mentioned singly, will be combined.

Competition studies are therefore especially difficult in that, no matter which technique is used in investigating it, a number of artifacts are inevitably introduced. The suggested adaptations described above may help to investigate competitiveness of weeds with a prolonged emergence period.

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TECHNIQUES FOR THE ASSESSMENT OF AVENA SPP. IN THE FIELD

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Summary Simple techniques for the assessment of Avena spp. in the field are described and discussed. These include, characterisation of the Avena population at the time of treatment in terms of density and age; 'colour coding' - the labelling of individual plants according to their stage of growth at the time of treatment and the 'sizing' of panicles to increase the precision of measurement of Avena seed production.

INTRODUCTION

The objectives of weed control include both the reduction of the competitive powers of the weed and the prevention of return of viable weed seed to the soil. It is debatable which is the more important when considering annual weeds such as Avena spp. or in fact any weed which is entirely dependent on seed to maintain its population from season to season. However in weed control experiments assessment techniques should obviously be aimed at measuring the effectiveness of any particular treatment in achieving both these objectives. It is a little surprising therefore that many experimenters still rely on simple counts of Avena plants or panicles. This can often seriously underestimate the degree of control which has been obtained (Holroyd, 1960).

In a consideration of assessment techniques it is natural to think of methods of measuring the end situation as exemplified by crop yield and quality, counts of surviving weeds, or seed return, but it is equally important to describe accurately the population of crop and weeds at the time that a treatment is applied.

The growth of a cereal crop, particularly in the early stages is generally relatively uniform and it can be characterised simply, by taking a number of randomly distributed samples of plants from the experimental area and counting the number of leaves on the main shoot. However, one of the characteristics of Avena fatua populations in this country, is the wide range of growth stages which they may contain. For example, in winter cereals during the last two seasons in the southern half of the country, numerous A. fatua germinated during the autumn, overwintered and when well tillered in the spring, were joined by newly emerging plants. Even in spring crops, a cool season can result in A. fatua emerging from March to mid-May. Not only may the inherent susceptibility of these plants to a herbicide vary according to growth stage but also their ability to survive crop competition. Without some characterisation of individual plants according to their stage of growth it is almost impossible to obtain a clear picture of the pattern of response of the Avena spp. to a herbicide except in a very generalised way.

TECHNIQUES

1) Characterisation of the wild oat population Characterisation of an Avena population as a whole at the time of treatment requires measurement of the plant

density and age distribution. This can be done most easily by counting and classifying, according to their age, all the Avena plants either within a 30 cm quadrat or a 30 cm length of inter-row at five randomly selected positions across the experimental area. The number of sampling sites should be increased where the populations are low. In general a total of at least 50 plants should be counted but this is dependent on the range of ages present in the population.

In an even aged population which is newly emerged, 50 plants would be more than adequate but, in a crop of winter cereal with for example two distinct populations of Avena (autumn and spring germinated) 100 plants would be more appropriate. The age of the plants is determined by counting the number of leaves on the main shoot to the nearest half leaf. In an open situation tillering may begin shortly after the third leaf has fully expanded but in a more competitive and shaded situation five or more leaves may develop without tiller formation. When tillering does occur it should be noted together with the number of leaves on the tillers, unless these are excessive.

The counts from the individual sampling areas will also indicate the distribution of the Avena population in space (across the experimental area) as well as in time.

This type of assessment will describe the Avena population as a whole over the experimental area at a specific point in time,but some of the plants in the specific age groups which make up that population must be labelled if differences in their response to a herbicidal treatment are to be detected. 'Colour coding' is a technique for doing this.

2) Colour coding This is a relatively simple way of labelling individual plants according to their stage of growth, so as to study their ultimate fate. The labelling is done with plastic covered single strand copper wire. This is convenient to use and readily available in a variety of colours. The actual labelling operation consists of pushing one end of a 4-5 cm length of suitably coloured wire into the ground adjacent to an Avena plant and wrapping the other end loosely round the base of the plant. The colour of the wire indicates the stage of growth of the particular plant. Initial identification of the plants can be somewhat difficult particularly when they have only ½ to 1 leaf and other graminaceous weeds are present but with experience relatively few mistakes are made. Preferably the density of the Avena population should not be more than 40-50 plants/m^2.

A specific number of plants of each growth stage should be coded e.g. ten on each plot, including controls. Experimenters can vary the detail of the classification according to their own needs and the particular Avena population. Difficulty may be experienced in finding the requisite number of plants at extremes of the classification i.e. the younger or older plants, and if so a note should be made of the number which can be easily found and coded. The growth stage of the crop should also be noted at the time of coding.

Final assessment of coded plants is made just before harvest of the crop. The number recovered is generally in excess of 90% although some plants may be dead and others may have developed into large plants with several panicles.

Colour coding can take an appreciable amount of time depending on how intensively it is carried out but it will provide very precise information which would otherwise be missed. For example data from control plots will indicate how Avena plants at differing growth stages, at one specific point in time, react to subsequent crop competition. This may vary from death for many of those emerging late or otherwise delayed in growth, to the vigorous production of several large panicles by those which emerged early. The susceptibility of A. fatua to competition is well illustrated by the results from an experiment last season in spring barley in which the natural mortality of plants labelled when they had reached the two-leaf stage increased from 3% to 48% over a period of fourteen days. At the start of this period the crop had 2.0 leaves and at the end 4.0-4.5 leaves. The stage at which *Avena* plants are treated with a herbicide can be very important firstly because any check to their growth will be enhanced by crop competition and secondly their inherent susceptibility to the herbicide may vary, as is well illustrated by barban.

'Colour coding' is generally only relevant when post-emergence herbicides are used or patterns of emergence of *Avena* spp. are being studied, but another factor, seldom measured but known to influence the activity of a soil applied herbicide such as tri-allate, is the depth in the soil from which the Avena plant originates. A method of studying this factor was described in an earlier paper (Holroyd, 1964).

All the techniques mentioned so far have been primarily concerned with the *Avena* population at the time of treatment or in the early stages of development. However, as has already been mentioned, the methods used to assess *Avena* spp. at maturity are also often lacking in accuracy, and the simple 'sizing' of panicles at the time of the final assessment can help considerably.

3) *'Sizing' panicles* Just prior to harvest the *Avena* panicles present on each plot of the experiment being assessed, are counted in the usual way, using a number of suitably sized quadrats if the plots are large or the *Avena* population is dense. The maximum number counted per plot is generally 200-300.

As the panicles are counted they are classified into one of three categories according to their size as follows:

1. 'Small' - panicles with 1-10 spikelets
2. 'Medium'- " " 11-30 "
3. 'Large' - " " 31+ "

Occasionally if the plants are particularly vigorous this classification may be slightly modified so that 'medium' covers the range 11-40 and 'large' 40+.

At the time of assessment 100 panicles of each category are collected by the assessors preferably from the control plots but failing this from discard areas or the remainder of the field, always providing that these areas have not been treated with a herbicide for the control of *Avena* spp. The total numbers of spikelets on the panicles are counted and mean figures calculated for each category. The numbers of spikelets produced on the experimental plots are then calculated by simple multiplication of the numbers of panicles in each category. These figures give an estimate of the production of spikelets by the *Avena* plants on the experimental plots and are a more accurate measurement of treatment effects than simple panicle counts. This type of assessment is particularly important when comparing a herbicide such as barban which tends to reduce the size of the panicles produced with a herbicide such as tri-allate which does not. For example, in an experiment reported to the 1968 British Weed Control Conference (Holroyd, 1968), the panicles on the control plots were categorised as follows: 'small' 9.8%, 'medium' 80.7%, and 'large' 9.5% whereas on plots which had been treated with 5 oz a.i./ac of barban they were: 'small' 21.5%, 'medium' 78.5% and 'large' none, indicating a very marked increase in the proportion of 'small' panicles at the expense of the 'large'. Panicle counts alone would have seriously underestimated the effectiveness of the barban treatment. The additional labour involved in 'sizing' panicles in this way is small and well worth while for the consequent increase in accuracy. However there are limitations to the accuracy of this technique which should be mentioned. There is a risk that the mean spikelets/panicle figures calculated from the untreated panicles may be high, particularly for the 'large' category, when applied to the treated panicles. If the mean spikelets/panicle figure for a particular category is obviously high and there are a considerable number of panicles in that category on the treated plots, it would be worthwhile recalculating the figure using 50 of the treated panicles in the appropriate category. Similarly the number of Avena seeds in each spikelet varies between 1 and 3 with a tendency for 'small' panicles to have a greater number of single seeded spikelets. 'Large' panicles have correspondingly more three seeded spikelets. A further refinement therefore is to include a weighting factor for the number of seeds per spikelet in each category. However the quality of seed produced is as important as the quantity and the experimenter should consider, for example, whether the viability and dormancy of the seed should also be tested.

CONCLUSIONS

The accuracy and intensity of assessment of experiments will depend, in the end, on the amount of time and effort which is available, but a large number of experiments are often undertaken to cover a wide range of conditions, and yet, the effects of the range of conditions, admittedly smaller, which exist within anyone experiment are not adequately measured.

Finally, although these techniques are designed specifically for Avena spp., with modification they may be applicable to other weed problems and situations.

Acknowledgements

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AN AUTOMATIC PUNCHING COUNTER AND METERING DISPENSER

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Summary An automatic punching counter is described which allows the recording of counts directly on perforated paper tapes. Auxiliary devices permit the recording of water dispensed to plants and the entry of numerical data. The machine automatically divides the stream of data into lines of suitable length and interposes the correct line termination characters. The instrument consists of a 3-decade electromechanical counter connected by a suitable encoding device to a paper tape punch. Circuitry is provided to enable a range of functions to be performed and to return information on the current state of the machine to the operator. The design of the machine allows remote operation from a considerable distance, and is tolerant of wide variations in supply voltage and frequency. Interruptions of the supply do not cause false operation of the instrument. The equipment has reached a satisfactory level of reliability and shows a saving in time over conventional methods of collecting similar data. Trials indicate that water usage, as recorded on the equipment, may be suitable as an objective indicator of herbicide damage.

INTRODUCTION

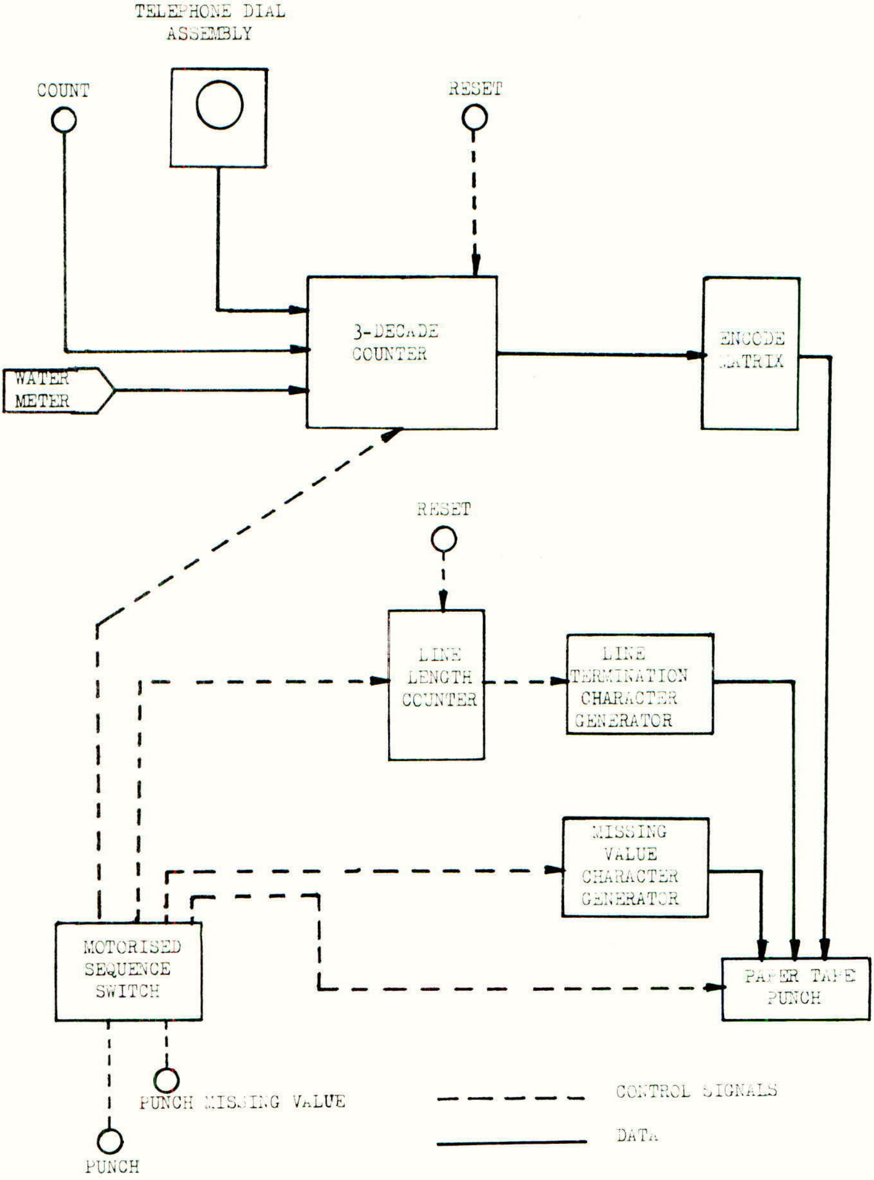
A large proportion of the working time of the staff at WRO, and no doubt other research establishments, is spent collecting, collating and processing data. At WRO objective factors such as shoot number and subjective data such as damage scores following herbicide treatment are usually recorded with pencil and paper, the exception being the use of punch cards for scoring some herbicide evaluation experiments. Small amounts of experimental data can readily be collated and subjected to statistical analysis using desk top electronic calculators. However many of our experiments involve large quantities of data and this is transferred to punched paper tape for processing by the computer at Rothamsted.

The object of the making of the equipment described here was (1) to eliminate pencil and paper recording for subjective and objective data, and to put the information directly onto paper tape in a format compatible with the requirement of computer input. This enables mistakes in recording and copying to be eliminated. Furthermore manpower can be reduced, as the person assessing plant parameters can record them unassisted. (2) in the more specific case of experiments involving herbicide treatments conducted in pots, the water metering dispenser has been used to assess the water throughput of plants with a view to replacing subjective scores as estimates of herbicide damage with objective water-throughput data.

DESIGN

The requirements for paper tape compatible with the computer available to us are that numbers shall be separated by at least one space, and shall be grouped into 'lines' of less than a certain length. Such requirements with minor variations, are usual for many kinds of computing installation. Circuitry therefore has to be

Fig. 1. AUTOMATIC PUNCHING COUNTER. SIMPLIFIED BLOCK DIAGRAM



introduced to count the entries on the tape, and divide them up with the appropriate line termination symbols.

The equipment consists of a 3-decade counter coupled via a diode encoding matrix to an 8-hole paper tape punch. A motorised sequence switch is employed to scan the counter decades in the correct order, and also to provide impulses to the space, tape advance and line length counter mechanisms. A single decade counter is used to count how many values have been punched in the current line; when a preset line length is reached this counter outputs a signal to punch the characters 'carriage return' and 'line feed' onto the tape.

The counting and control circuitry follows telephone practice, employing uniselector switches as the counter elements, and electromechanical relays to perform the control functions. Several advantages occur from this - all the circuit elements are robust and easily replaceable, and as no solid-state or vacuum devices are used, a relatively cheap and unsophisticated power supply can be employed.

Manual reset keys are provided for both counters, and function keys are also provided to enable a special symbol to be punched to indicate a missing value, necessary if a plant has to be omitted from the assessment for some reason. This is effected by causing the sequence switch to scan a preset character code instead of the decade counters.

Circuitry is also provided to reset the decade counter automatically after punching, and to enable runout - blank sprocketed tape - to be produced. The details of the control circuitry will not be dealt with here, but a more detailed account of the equipment, with circuit diagrams, will be available (Simmons, 1972).

USES

The instrument is used for recording water dispensed to plants in pots, and of numerical assessments of plant parameters, such as shoot and leaf count. The water is metered by a device working on the positive-displacement principle - dispensing units of water of fixed volume (normally 10 ml). A count is recorded for each unit of water dispensed.

Counts of plant parameters are recorded by a simple hand or foot operated push-button switch. A small switch can be worn on the hand to allow counting without the need to remove the hands from the plant.

Where it is desired to enter numbers, for example a damage score for a plant, a telephone dial assembly is used to generate a train of pulses of the required length. For convenience a remote dial assembly was made containing the telephone dial and some of the more frequently used function buttons such as 'count', 'punch' and 'enter missing value'. Using this assembly the operator can enter mixed counts and numerical values while remaining remote from the machine. Indicator lamps are provided on the remote unit to indicate when the machine is clear to accept another entry.

The electromechanical components used in the counting stages are intrinsically immune to switch bounce (Atkinson 1951) and will tolerate remote lead lengths in excess of one mile using suitable cable.

Normal mode of operation

The unit will normally be used to record one or two pieces of information about each one of a set of plants in an experiment. Several tapes, identical in format but produced at different dates will be generated during the course of one experiment. After the tape, which may contain, for example, watering figures for 400 plants for one day, is made, it must have a brief heading inserted manually before being sent to be inserted on a magnetic disc file at the computer department. The file has a line format analogous to that created on the paper tape, and the information is held in a set of numbered lines in a storage allocation bearing a name given by the user. The file can be edited, added to, or deleted, and can form the data for a FORTRAN programme. A validation programme (Clarke, 1970) is first run on the data to test for correct format and to locate data figures lying outside bounds of size set by the user. In the case of watering pots in the present research project of the authors, for example, it is unlikely that any entry would exceed 17, since it is impossible to put more than 170 ml of water in the containers used. The range tested can therefore be set as minimum 0 and maximum 17, and figures outside this range will cause a warning to be printed to an output file together with the line containing the suspect data. The data file can then be edited if necessary from a remote teletype terminal and the corrected file stored on magnetic tape. At the end of the experiment the tapes form the data set for a programme to recover routine statistical information from the data and print a summary of the experimental results.

Scope

The basic machine can be adapted to record most factors which can be counted or which can be made to produce a switch closure corresponding to a unit quantity.

The instrument has been tested successfully using power from a portable generator. The voltage and frequency are not critical over wide limits and interruptions of the supply do not cause false operation of the circuitry. The instrument can therefore be vehicle-mounted if desired for use in the field (Fig. 2). A D.C. operated battery powered version can be constructed if desired. The power consumption of the unit could be reduced for this application by the use of non-illuminated switches and digit indicators which were illuminated only on demand. Power consumption would then depend on the type of punch used and the frequency of counting and punching.

EXPERIENCE IN USE

The machine underwent a period of trials before being placed in general service in the laboratory. During this time laboratory staff used the machine and made notes on faults occurring. The machine was also assessed for ease of use, and as a result of this a number of modifications were made to the machine and to its input devices. One target was that the machine should be able to be used by casual staff who water experiments at weekends, and to this end the controls of the instruments were redesigned and a system adopted whereby only a minimum of switch operation, etc was required. Experience has indicated that staff need one or two dummy runs to get used to pressing the punch button after each operation, and to impress upon them the need to record a value for each plant, even zeroes, and to keep strictly to the numerical order of the plants. These were the main errors in the early runs but have occurred with decreasing frequency during later operations. The regular laboratory staff who use the machine both for watering and for assessments of shoot numbers and herbicide damage have become used to the instrument and have been able to take over the task of heading the tapes and despatching them with the correct documents.

The instrument allows a faster rate of work with fewer mistakes and eliminates the need for subsequent repunching of data where a computer analysis is desired. Reliability has been improved during the machine's trial period; one of the problems remaining is the incursion of dirt from the laboratory and greenhouses into the selector mechanisms and contact surfaces. The selection of suitable contact lubricants together with regular routine service periods has mitigated this problem to a large extent.

Fig. 2

Since entering regular service in the laboratory the machine has performed some 34,000 punch operations, and during this period some of the original components have been replaced by heavy duty alternatives as excessive wear or failure occurred. The machine is now considered to have a satisfactory reliability record, though the need remains for regular cleaning of contacts etc, due to operation in humid environments.

Timed tests

To ascertain whether the instrument does in fact save time compared to the methods previously used, a short test was carried out. The time taken to water the plants in a controlled environment cabinet using the water dispenser and automatic counter, was compared with the time taken to water a similar set of plants using the water dispenser but writing the results down by hand. The figures given are the means of two tests, the staff performing the test changing over between tests to eliminate any bias due to innate differences in their ability.

AUTOMATIC RECORDING

Preparing machine for use	6 min
Watering using automatic counter	11 min per block
Total for 2 blocks	28 min

MANUAL RECORDING

Preparation	2 min
Watering using manual recording	23 min per block
Total for 2 blocks	48 min

An experimental example

In a limited preliminary test of various herbicides for effect on Agropyron repens, subjective scores were compared with water usage data to determine whether there was a significant correlation between a subjective assessment of herbicide damage and the record of water usage. In Table 1 the mean values of scores and water usage for various treatments are shown, together with a value obtained from a regression analysis on the data, which indicates the degree of correlation accounted for by the regression.

The low correlation in the case of chlorflurecol may be due to its failure, in this case to cause effective damage to the plants, most of the scores being clustered in the 6–7 region. Where there is little spread of values a high correlation is unlikely to be achieved. Further correlations between data from treated plants and their water usage are under analysis in order to determine to what extent and with which herbicides water usage is a valid indicator of herbicide damage. It seems unlikely that any single objective parameter will completely supplant the visual score because of the wide range of physiological responses which can be provoked by herbicides, but it is possible that measurement of water usage may be useful in many cases, particularly as its recording carries no extra labour penalty beyond that normally involved in watering. In this way it represents an advantage over the many other objective measurements which may be made to record the effects of herbicides on plants, to replace or augment subjective scoring.

Table 1

Herbicide	Mean rate kg/ha	Mean score	Mean water usage	Percent of variation accounted for by regression
Control	0	7	1189	-
Paraquat	0.26	2.6	705	60.4**
Glyphosate	0.35	3.4	801	67.9***
Chlorflurecol	2.30	6.3	1181	23.9*

'Score' is a visual assessment of herbicide damage ranging from 0 - plant dead, to 7 - indistinguishable from control

CONCLUSION

The equipment described has proved useful for the automatic recording of repetitive data associated with herbicide evaluation experiments. The use of electromechanical counting and switching elements provides immunity from electrical noise and supply variations and interruptions, and allows the use of long remote control cables. These factors make the design adaptable for field use. Recording of data directly onto tape reduces the opportunity for error and eliminates some of the effort involved in manual repunching of data.

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"RESEARCH ON WHEELS" - AN AID FOR RESEARCH, DEVELOPMENT AND IMPROVEMENT OF WEED CONTROL PRACTICES IN RHODESIAN CROP PRODUCTION

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Summary Until the recent formation of the "Research on Wheels" unit, weed research in Rhodesia was, of necessity, restricted to research stations, or their close environs. Consequently, the worked covered only a limited range of agro-ecological regions and farming conditions. A mobile, weed research unit has offered a means of applying weed research findings further afield, and of instructing farmers in the use of up-to-date weed control practices. This paper describes the development of the mobile unit, and the adaptation of the "Research on Wheels" technique to suit Rhodesian conditions.

INTRODUCTION

Efficient and economic weed control is essential in crop production, and methods of doing this have become an important discipline of research; a discipline that has been considerably broadened by the introduction of herbicides.

Over the past five years there has been a greater awareness by farmers of all aspects of improved weed control, especially the advantages to be gained from the correct use of herbicides. Commerce has promoted the use of atrazine on maize, especially it's application from the air, and trifluralin and nitralin in cotton, soyabeans and groundnuts. This has enhanced the farmers' awareness of herbicides, and weeds in these crops are now commonly controlled by chemicals.

The Weed Research Unit at Henderson Research Station since its formation six years ago, has encouraged the move to use improved weed control practices. The Unit has screened many herbicides, and investigated cultural practices involving herbicides, and other weed control methods, applicable to local weed problems and farming conditions. As this work progressed it became increasingly evident, that an extension of research findings to a wider range of environmental regions and field conditions found in the country was vital, if farmers were to recognise the benefits of using even more up-to-date weed control practices than hitherto.

The realization that further education of both European and African farmers and extension officers in the correct use of improved weed control practices, in the understanding of the basic principles of chemical weed control, and in weed identification, resulted in the introduction of the idea of forming the mobile unit. The "Research on Wheels" technique was first suggested by Richards (1971), and the Unit was formed soon after the start of the 1971/

72 season, with funds donated by the Rhodesia Grain Producers' Association.

OBJECTIVES

The main objectives of the mobile Unit are:-

1) To test research findings, which of necessity mainly originate from one site, under a wide range of agro-ecological conditions.

2) To report and record problems encountered in the field, especially with herbicide usage, such as resistant weeds, crop phytotoxicity and herbicide residues (carry over) for further research consideration.

3) To disseminate research information on improved weed control practices in a form which is clearly understood and acceptable to farmers.

4) To ensure that farmers interpret results correctly and apply the advocated practices in such a way that they will benefit his farming enterprise.

5) To help farmers recognise their weeds.

EQUIPMENT USED BY THE MOBILE UNIT IN RHODESIA

At present the personnel involved in operating the mobile Unit consists of the writer with two assistants. The Unit runs a light delivery truck and trailer carrying knapsack sprayers, and three single wheeled, manually pushed, gas pressurised sprayers. These sprayers have been made up to simulate tractor-mounted spray operations as closely as possible, and cannot be used on wet soils when conventional tractor application would also be impossible. The knapsack sprayers are used to apply in-row band and directed post-emergence applications.

Although not as sophisticated as its American counterpart, the unit is nevertheless self-contained for herbicide spraying operations, and has been suitably adapted to fit in with local requirements. Reliance on farmers sprayers is kept at a minimum, thus not unduly inconveniencing the farmer during planting operations. All mechanical weed control operations, and large scale incorporation of herbicides must however be undertaken by the farmer.

OPERATION OF UNIT IN THE FIELD DURING THE 1971/72 CROPPING SEASON

Funds were suddenly made available and the research post created in September 1971. This left one month in which to equip and plan the Unit's operations before the main start of the 1971/72 cropping season. The haste with which the project had to be launched in time for the season, led to a consequent lack of detailed planning. The policy adopted therefore, was to do as many small field trials in as many cropping areas as time and season permitted. Sites were selected in areas where results of research at Henderson Research Station were thought to be applicable and where known problems existed.

Thirty-seven trials on twenty farms covering eleven cropping regions were eventually laid down. The areas of the sprayed plots were in most cases small and invariably had to be located in inconspicuous corners of out of the way lands, so as not to inconvenience the farmer. Plot size used was in most cases 1/10th acre or smaller.

The operations served to confirm research results and gave information on the control of troublesome weeds under practical farming conditions, but failed completely as extension teaching aids. Enthusiasm of co-operating farmers or extension officers was not aroused, and therefore, the most important extension objectives of the project were not entirely fulfilled.

FUTURE OPERATIONS AND STRATEGY

As a result of the first season's operations, the objectives have now been carefully reconsidered, and the conduct of the project has been revised. It is planned for the 1972/73 season to co-operate with fewer farmers, and where possible to cover the whole range of crops of particular interest to the Unit on each individual's farm. It is planned to make use of the "result demonstration" technique on these sites.

"Result demonstrations" have been much used by Agricultural Extension Advisory Services in the United States (Wilson et al., 1955) and are recognised by farmers as useful sources of reliable, impartial and factual information. They have proved to be of special value when used in situations involving any major change in traditional methods, in evaluation of new methods, materials or techniques, and in selecting the best technique or materials from a range of similar ones. The primary purpose of the "result demonstration" is to furnish, in a relatively uncomplicated manner, local proof of the desirability of a practice suggested by researchers. They therefore play a logical part in research development, in that they serve as a means of bridging the vital gap between research station trials, and final commercial usage and full-scale adoption of practices advocated by researchers.

In the trials to be conducted by the field unit, it has been accepted that the criterion of success or failure is the efficiency of the herbicides to control weeds. Crop phytoxicity, although not ignored, is considered of minor importance, as previous and concurrent research covers this aspect.

It is the writer's opinion that large plot (minimum size 1/4 acre) "result demonstration" trials, provide a perfectly satisfactory means of evaluating the performance of pre-emergent herbicides on weeds. Large plots, whether replicated or not, will in the majority of cases include a sufficiently representative sample of weeds, whether controlled or more especially uncontrolled, in a field. (Smaller plots, however, are considered satisfactory for post-emergent herbicide trials, as the weeds have germinated and representative areas of specific weeds can usually easily be selected for herbicide treatment). Large plots are more conspicuous, and can more readily involve the farmer in the trial's progress than small plot, complex research trials. Judicious cultivation, when required, can more readily be undertaken by the farmer without complication.

The writer considers that a carefully planned series of impartial "result demonstrations" are vital in the development of herbicides, and should always precede any release of a new herbicide to the farmer. The more widely the demonstrations are distributed throughout the agro-ecological regions, and over different farming conditions, the more practical information on the herbicides is obtained and confidence in weed control performances is gained.

Besides the results obtained from the demonstrations, large plots are more likely to make an impression on farmers than small plots. The strategic siting of the demonstrations on properties of co-operative farmers (preferably informal leaders in the community) would be useful for extension purposes. The plots could be used as visual aids for many types of gatherings, and provide basic information for use by extension and research officers in published articles and circulars.

"Result demonstrations" inspire the confidence of farmers and extension officers in the researchers, while the researcher, and all others concerned with the trial's evaluation, gain first hand knowledge and experience, and thus develop more confidence in the practice advocated.

It is acknowledged here, however, that advantages of a practice must be proved by research before that practice is demonstrated. "Result demonstrations" do not always carry out research, they show to what extent research findings apply in practice, and serve to highlight any specific problem for further attention by researchers.

DISCUSSION

The overall success of the "Research on Wheels" project relies to a great extent on the co-operation between extension and research staff, commercial representatives and farmers. Between them, singly or collectively, they have to select suitable sites; supervise operations; supply labour, equipment and herbicides; and disseminate results.

Before embarking on any future operation full consideration should be given to: the nature of the specific problem under consideration; the most objective siting of the trials; co-operation of farmers; and dependence of treatment application on planting rains and irrigation, which may in turn determine time of planting. The actual number of trials that be undertaken by the one mobile unit will depend on its efficiency, availability of and distance between suitable sites, amount of recording to be done, the number of meetings to be organized, weather and road conditions, and availability of funds.

Acknowledgements

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THE USE OF PRE- AND POST-EMERGENCE HERBICIDES IN DIRECT DRILLED BRUSSELS SPROUTS

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Summary Propachlor, aziprotryne, trifluralin, nitrofen, desmetryne and phenmedipham were used either alone or in various combinations in crops of direct drilled Brussels sprout grown on coarse sandy soil at Stockbridge House EHS in 1969 and 1970. In the 1969 experiment either propachlor at 4 lb a.i./ac or aziprotryne at 2 lb a.i./ac used as pre-emergence treatments followed by a post-emergence application of desmetryne at 6 oz a.i./ac proved to be the best materials where both pre- and post-emergence treatments were necessary. In 1970, when drier conditions reduced the efficiency of residual materials applied to the soil surface, a combined treatment of trifluralin at ½ lb a.i./ac incorporated before drilling followed by propachlor at 4 lb a.i./ac immediately after drilling, gave a good weed control. Chenopodium album which appears to continue germinating in fairly dry soil, was particularly well controlled by this treatment to the extent that follow up treatments were unnecessary.

INTRODUCTION

Over the last few years there has been a move towards the direct drilling of the Brussels sprout crop. Whereas the newly transplanted crop has an initial advantage of size, even in non-herbicide treated soil, over subsequent weed growth, soil for the drilled crop requires the use of residual herbicide in order to gain a similar advantage. Also, the drilled crop occupies the ground for a longer period and therefore a more comprehensive herbicide programme is often necessary if mechanical weed control is to be kept to a minimum. These aspects of herbicide use were examined in two experiments at Stockbridge House EHS in 1969 and 1970 respectively.

METHODS AND MATERIALS

The experiments were conducted on soils of the Stockbridge series which contain approximately 5% silt, 10% clay and only 1 - 2% of organic matter. In the 1969 experiment the range of pre-emergence and follow up treatments listed in Tables 1 and 2 was applied to a crop of Brussels sprout, (cv. Champion) drilled on 12 May in rows 21 in. apart. The seeds were spaced 3 in. apart and the crop was thinned to 21 in. in the row on 17 June. A randomised block layout was used, with three replicates and each plot consisted of an effective area of 147 ft^2. The range of pre-emergence materials was reduced for the 1970 trial; these are shown in Table 3. Because of dry soil conditions there was insufficient weed emergence to justify the use of any follow up treatments in the 1970 experiment and these were omitted. In this trial, seed of the Brussels sprout (cv. Thor) was drilled on 30 April in rows 24 in. apart and the crop was thinned to 18 in. in the row on 3 June. A layout similar to that used in the 1969 experiment was used but the plot size was increased to 216 ft^2. In both trials the materials were applied with a Dorman Wheelaway sprayer in 50 gal water/ac. The main weed species on the sites used are shown in the respective tables along with an assessment of the efficiency of the herbicide.

RESULTS

1969 Experiment

The results of a weed assessment made on 11 June are shown in Table 1. These show that treatment 2) trifluralin + propachlor, and treatment 5) aziprotryne gave a good control of all the main species present. Some of the pre-emergence treatments showed their typical weakness against certain weed species (see Table 1). The usual practice of using nitrofen and chlorpropham together in order to increase the weed spectrum was omitted to avoid the crop damage chlorpropham usually causes on the Stockbridge soils.

Table 1

Assessment of weed control by pre-emergence treatments made on 11 June 0 = No Control 10 = Full Control

Weed Species	Propachlor 3.9 lb a.i./ac	Propachlor + trifluralin 3.9 lb & 0.5 a.i./ac	Trifluralin 1.0 lb a.i./ac	Nitrofen 2.1 lb a.i./ac	Aziprotryne 2.0 lb a.i./ac
Tripleurospermum maritimum ssp. inodorum	8	10	2	4	10
Stellaria media	8	8	7	3	10
Polygonum convolvulus	3	8	7	10	9
Polygonum persicaria	5	7	5	6	9
Poa annua	10	10	6	7	9
Polygonum aviculare	7	9	7	4	8
Average	7	9	6	6	9

Each of the follow up treatments gave a similar measure of weed control, the main feature being their effect on the crop (see Table 2). Several of these materials caused scorching and chlorosis but this is not reflected in the yield figures (see also Table 2). The variations in yield are attributed more to slight variations in soil and the variability within a non hybrid sprout cultivar of which Champion is an example.

Table 2

Crop damage assessment made 2 July to determine effect of follow-up treatment. 0 = No visible symptoms 5 = Severe damage

Marketable yield in t/ac and t/ha

Herbicide	Rate lb a.i. per ac	Yellowing	Leaf Scorch	Total Marketable Yield (t/ac)	Total Marketable Yield (t/ha)
Propachlor followed by aziprotryne	3.9 1.75	0	0	5.9	14.8
Propachlor followed by desmetryne	3.9 0.37	2	1	6.3	15.8
Propachlor followed by phenmedipham	3.9 1.0	2	2	6.4	16.1
Trifluralin + propachlor followed by aziprotryne	0.5 3.9 1.75	0.33	0	7.0	17.6
Trifluralin followed by aziprotryne	1.0 1.75	0	0	6.4	16.1
Nitrofen followed by aziprotryne	2.1 1.75	0	0	5.4	13.6
Nitrofen followed by desmetryne	2.1 0.37	2.33	1.66	5.6	14.1
Aziprotryne followed by aziprotryne	2.0 1.75	0	0	5.8	14.6
Aziprotryne followed by desmetryne	2.0 0.37	1.66	1	6.0	15.1
Hoed	-	-	-	6.2	15.6

1970 Experiment

It was noted on the 25 May that the combined trifluralin/propachlor treatment was giving a good control of weeds and this is confirmed by a weed assessment carried out on 12 June (see Table 3). The trifluralin/propachlor treatment gave the best control of the six main weed species on the site, and was the only treatment which continued to control Chenopodium album, the most prevelant weed, during the dry conditions of June and July. Because of the poor control of this weed on most of the other plots, it was necessary to hoe the trial on 19 June. From then on the crop formed a good canopy of leaves preventing any further weed problems. In terms of yield there was little to choose between any of the treatments, (see also Table 3).

Table 3

Assessment of weed control by pre-emergence treatment made on 12 June - 0 = No Control 10 = Full Control

Yield of marketable sprouts in t/ac and t/ha

	Herbicides			
Weed Species	Propachlor 4 lb a.i./ ac	Trifluralin + Propachlor $\frac{1}{2}$ lb & 4 lb a.i./ac	Aziprotryne $1\frac{3}{4}$ lb a.i./ ac	Hand Weeded
Chenopodium album	7.6	8.0	8.0	-
Stellaria media	8.0	8.6	7.6	-
Urtica urens	7.6	9.6	9.0	-
Capsella bursa-pastoris	10.0	9.0	7.6	-
Tripleurospermum maritimum ssp. inodorum	9.6	9.3	9.0	-
Polygonum aviculare	8.7	9.3	9.0	-
Average	7.4	7.7	7.2	-
T/ac	9.4	9.7	9.4	9.7
T/ha	23.7	24.4	23.6	24.3

DISCUSSION

It appears from the 1969 experiment, that where moist soil conditions are likely to coincide with the application of a pre-emergence herbicide, propachlor or aziprotryne are the best ones to use. Aziprotryne will give a better control of polygonum species if these are a problem. If a further treatment is needed, desmetryne at 6 oz a.i./ac provides a relatively cheap and efficient follow up treatment. The results of the 1970 experiment show that a combined treatment of trifluralin at $\frac{1}{2}$ lb a.i./ac rotovated in before drilling followed by propachlor at 4 lb a.i./ac immediately after drilling is a very useful pre-emergence treatment. This is particularly so in a dry season when residual materials applied to the soil surface are unlikely to be fully effective. The results of this experiment also show that in such a season where a trifluralin/propachlor treatment has been used, a follow up treatment may be unnecessary.

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AN EVALUATION OF R.7465 FOR THE CONTROL OF ANNUAL WEEDS IN BRASSICA CROPS

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Summary Pre-planting soil-incorporated treatments of R.7465 were evaluated in replicated and grower-usage trials for weed control in brassica crops. Weed control with 1.25 lb/ac was generally found to be acceptable, control being more effective in crops planted on flat ground as opposed to crops grown on ridges. Vegetable brassicae and drilled root brassicae showed good tolerance of R.7465, but the tolerance of drilled forage brassicae was variable. Mixtures of R.7465 and cycloate proved superior to R.7465 alone for the control of Galeopsis tetrahit in Scotland.

INTRODUCTION

R.7465 (2-(α-naphthoxy)-N,N-diethylpropionamide) is manufactured by Stauffer Chemical Company, and is formulated as a 50% w.p. Its physical and chemical properties were described by Van den Brink et al (1969). The herbicidal activity of R.7465 was also outlined by Van den Brink et al, and its use in oil seed rape and brassica crops was described by Ludwig (1968) and Holroyd (1968) respectively. The latter indicated that pre-planting soil-incorporation increased the herbicidal activity of R.7465 whilst retaining its selectivity in brassica crops.

Farm Protection Ltd. carried out field trials in 1971 which confirmed the improvement in activity of R.7465 obtained by soil incorporation, particularly in a dry season. Further trials have been carried out in 1972 on a range of brassica crops, and the results are reported herein.

METHOD AND MATERIALS

A total of nine replicated trials and eight one-acre unreplicated grower-usage trials were carried out. The trials programme was divided into three sections: (1) root and forage brassicae in England and Wales (2 replicated and 7 grower trials) (2) root brassicae in Scotland (2 replicated and 1 grower trial) and (3) brassicae grown as vegetables in England (5 replicated trials).

Replicated small-plot trials were of a randomised block design with three replicates and a plot size of 1/80 or 1/160 ac. Application was pre-planting, using a Dorman Wheelaway sprayer with a pressure of 25 p.s.i., giving a spray volume of 40 gal/ac. Treatments were soil-incorporated by rotovating within 30 min of spraying, to a depth of 2 in. for crops grown on flat ground, and 4-6 in. for crops grown on the ridge system. Grower trials were unreplicated one-acre plots, and the chemical was sprayed and incorporated by the grower, using his own machinery.

Weed control and crop tolerance were assessed according to the following scale:-

% Weed Control	Score	% Crop Tolerance
100	10	100
97.5	9	97.5
95	8	95
90	7	90
80	6	80
70	5	70
60	4	60
40	3	40
20	2	20
0	1	0

A score of 7 is taken as a minimum level of commercial acceptability.

Table 1

Replicated Trials - Site Details

Code No	Trial Section	County Of Location	Crop	Cultivar	Date Of Application	Planting
1	(1)	Brecon	a Rape and Kale	-	17/6	25/6
2	(1)	Brecon	a Rape and Kale	-	17/6	23/6
3	(2)	Aberdeen	a Turnip	Wallace	1/6	10/6
4	(2)	Aberdeen	a Turnip	Wallace	1/6	3/6
5	(3)	Bedford	b Cabbage	Autumn Supreme	25/4	2/5
6	(3)	Worcester	a Calabrese	Gem	26/6	6/7
7	(3)	Worcester	b Brussels Sprout	Edwin's	19/5	4/6
8	(3)	Lincoln	b Cauliflower	Barrier Reef	15/6	15/6
9	(3)	Lincoln	b Cauliflower	Lawyna	15/6	20/6

a: drilled crops b: transplanted crops

Table 2

Grower Trials - Site Details

Code No	Trial Section	County Of Location	Crop	Cultivar	Dose a.i. lb/ac	Date Of Application	Planting
10	(1)	Brecon	Swede	Tipperary	1.10	16/6	16/6
11	(1)	Brecon	Swede	Tipperary	0.85	15/6	16/6
12	(1)	Devon	Swede	Acme	1.25	6/7	16/7
13	(1)	Devon	Swede	Acme	1.25	22/6	23/6
14	(1)	Somerset	Swede	Acme	1.25	24/6	25/6
15	(1)	Pembroke	Swede	Wilhelmsburger	1.25	29/6	1/7
16	(1)	Salop	Kale	Marrowstem	1.25	23/5	20/6
17	(2)	Aberdeen	Turnip	Wallace	1.25	11/6	12/6

RESULTS

Control Of Annual Broad-leaved Weeds

1. Root and Forage Brassicae in England and Wales

A. Crops grown on ridges:

Weed control with R.7465 was considered acceptable at only one of the five grower-usage sites, and was inferior to trifluralin at two sites, 14 and 15 (Table 3) where the main weeds were Capsella bursa-pastoris, Veronica spp. and Solanum nigrum. R.7465 proved superior to trifluralin at site 12 where Matricaria spp. were dominant. At site 11, weed control was poor and indicates that dose rates below 1.0 lb/ac are relatively ineffective.

Table 3

Weed Control - Crops Grown On Ridges

Treatment	Dose a.i. lb/ac	Grower Trial Number 11	12	13	14	15	Mean
R.7465	0.85	5	-	-	-	-	5.0
R.7465	1.25	-	8	6	5	6	6.3
Trifluralin	1.0	-	6	6	7	9	7.0
Spraying to assessment (days):		54	33	47	43	36	

In many instances, the degree of weed control on the apex of the ridge was superior to that on the sides and bottom, and suggests that incorporation was inadequate. However, this problem could be overcome by shallower ridging, which would not necessitate deep incorporation and hence dilution of the product in the soil.

B. Crops grown on flat ground:

In general, weed control with R.7465 in both replicated and grower trials was commercially acceptable, and showed little dose response. At sites 1 and 2, R.7465 proved superior to trifluralin, and gave better control of C. bursa-pastoris at site 2.

Table 4

Weed Control - Crops Grown On Flat Ground

Treatment	Dose a.i. lb/ac	Replicated Trial Number 1	2	Grower Trial Number 10	16
R.7465	1.0	7.7	8.3	7	-
R.7465	1.25	8.0	7.7	-	7
R.7465	1.5	8.3	8.0	-	-
R.7465	2.5	8.7	7.3	-	-
Trifluralin	1.0	7.0	6.3	-	-
Spraying to assessment (days):		60	28	51	73

Weed control with R.7465 in crops grown on flat ground was superior to that in ridge-grown crops, and is probably associated with a dilution effect caused by the deeper incorporation which is necessary for ridge-grown crops, and also the possible exposure of "untreated" soil during ridging.

2. Root Brassicae in Scotland (Ridge-grown)

In Scotland, weed control with R.7465 alone proved unacceptable, largely due to the presence in the trials of *Galeopsis tetrahit*, which was indifferently controlled. However, a mixture of R.7465 and cycloate gave satisfactory control of this weed, and also improved the control of *Polygonum persicaria* and *Polygonum aviculare*. Trifluralin gave satisfactory control of *G. tetrahit*, but control of other weed species (*Stellaria media*, *P. persicaria*, *P. aviculare*, *Fumaria officinalis*) was unacceptable, and inferior to the mixtures of R.7465 and cycloate.

Table 5

Weed Control In Scotland - Ridge-grown Crops

Treatment	Dose a.i. lb/ac	Replicated Trial Number 3	4	Grower Trial Number 17
R.7465	1.0	6.0	6.5	-
R.7465 + Cycloate	1.0 + 1.8	7.0	8.0	7
R.7465 + Cycloate	1.0 + 2.7	6.0	8.0	-
Cycloate	2.7	5.0	6.0	-
Trifluralin	1.0	5.5	7.0	-
Spraying to assessment (days):		35	35	25

As in the trials carried out in England and Wales on ridged crops, weeds were more prevalent in the bottoms and on the lower side of the ridges, whereas weed control on the ridge tops was generally acceptable.

3. Vegetable Brassicae in England (Grown On Flat Ground)

Weed control with 1.25 lb/ac R.7465 was satisfactory at three of the four trials, and was superior to trifluralin at site 7, where *Senecio vulgaris* was the dominant weed. R.7465, at site 5, gave poor control of *Urtica urens*, which was better controlled with trifluralin in this trial.

Table 6

Weed Control - Vegetable Brassicae Grown On Flat Ground

Treatment	Dose a.i. lb/ac	Replicated Trial Number 5	7	8	9	Mean
R.7465	1.0	6.7	8.0	8.3	6.7	7.4
R.7465	1.25	5.7	8.0	7.7	7.7	7.3
R.7465	1.5	6.3	7.7	8.0	8.0	7.6
R.7465	2.5	7.0	9.0	7.7	7.7	8.3
Trifluralin	1.0	7.7	5.3	9.0	9.0	7.9
Spraying to assessment (days):		48	38	48	48	

At site 6, poor control of *Solanum nigrum* was common to both R.7465 and trifluralin, and no other weeds were present.

Crop Tolerance

Brassica crops varied in their tolerance to R.7465. Transplanted vegetable brassicae and drilled calabrese showed no signs of phytotoxicity, even at a dose rate of 2.5 lb/ac R.7465. Drilled root brassicae showed complete tolerance of 1.25 lb/ac R.7465, but mixtures of 1.0 lb/ac R.7465 and 2.7 lb/ac cycloate produced marked chlorosis of the leaf margins, cycloate being the probable cause of this phytotoxicity. Drilled forage brassicae varied in their tolerance of R.7465. Kale alone showed good tolerance, but slight damage was detected in rape/kale mixtures at two sites.

DISCUSSION

Weed control with R.7465 at 1.25 lb/ac proved commercially acceptable at most trial sites, and was most effective in crops grown on flat ground. Weed control in ridge grown crops was variable and was probably influenced by the efficiency of incorporation allied to the depth of ridging. The weed spectrum compiled from trial results is shown in Table 7.

Table 7

Weed Spectrum Of R.7465 (1.25 lb/ac)

Anagallis arvensis	Resistant
Capsella bursa-pastoris	Moderately resistant
Chenopodium album	Moderately susceptible
Fumaria officinalis	Susceptible
Galeopsis tetrahit	Moderately resistant
Galium aparine	Moderately susceptible
Lamium purpureum	Moderately susceptible
Matricaria spp.	Susceptible
Poa annua	Susceptible
Polygonum aviculare	Susceptible
Polygonum convolvulus	Moderately susceptible
Polygonum persicaria	Moderately resistant
Senecio vulgaris	Moderately susceptible
Sinapis arvensis	Resistant
Solanum nigrum	Resistant
Spergula arvensis	Susceptible
Stellaria media	Susceptible
Urtica urens	Moderately resistant
Veronica spp.	Resistant

Crop tolerance appeared good on all brassica crops investigated, except forage rape, with no detectable damage occurring at 2.5 lb/ac, but mixtures with cycloate caused damage to turnips when cycloate was included at 2.7 lb/ac.

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WEED CONTROL IN BRASSICA CROPS ON ORGANIC SOILS

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Summary Of a number of herbicides applied pre-emergence, post-emergence and post-planting in cabbage and cauliflower only haloxydine at 0.5 lb and 1.0 lb/ac gave good weed control. This material was safe only in cabbage at the pre-emergence stage. The growth of many broadleaved weeds was retarded by aziprotryne, simazine and prynachlor, therefore reducing competition with the crop to a minimum. Propachlor, sulfallate and chlorpropham controlled only a narrow weed spectrum but are suitable for use in herbicide combinations. The main problem weeds encountered were Stellaria media, Polygonum persicaria, Chenopodium album and Senecio vulgaris.

INTRODUCTION

Brassicae particularly cabbage and cauliflower sown in spring and summer on peat soils produce excellent autumn crops but yield and quality can be seriously reduced by weed competition. A comprehensive weed control programme is necessary to keep the crop weed free until head or curd formation begins. Cauliflower is more slow growing, more sensitive to herbicides and less competitive with weeds than cabbage and needs weed free conditions for a longer period. Although transplanted crops give more rapid ground cover than drilled crops nonetheless the vigorous weed growth which occurs on the peat in the summer months can seriously hinder crop growth. This paper describes the results of trials in cabbage and cauliflower which were conducted at Lullymore in 1969-70.

MATERIALS AND METHODS

Trials were carried out on fen peat in transplanted and drilled cabbage and cauliflower. A randomised block design was used with three replications in 1969 and four replications in 1970 with a standard plot size of 5 yd x 2 yd. Herbicides were applied with a pressure retaining knapsack sprayer in a volume of 40 gal/ac. All doses were applied as lb/ac a.i. Herbicide treatments are given either in the tables or in the text. Assessments of weed growth and crop damage were made at least twice during the growing season. Weed counts were recorded in random six ft^2 quadrats per plot. The trial area in drilled crops in 1969 was previously uncultivated. As a result the weed densities recorded were low, weed distribution was uneven and accurate counts of individual species could not be made.

RESULTS

Transplanted crops 1969-70

Cabbage (c.v. Winningstadt) In the 1969 trial all herbicides were applied three weeks after the crop was transplanted. Applications of haloxydine at 2.0 lb caused severe crop damage and seriously reduced yield. Haloxydine at 1.0 lb and aziprotryne at 2.0 lb reduced crop vigour and caused interveinal chlorosis in the leaf but the crop had fully recovered after two weeks. Propachlor at 5.2 lb and simazine at 3.0 lb caused no crop damage but in 1970 when applied immediately after planting these treatments caused a slight temporary reduction in crop vigour. Slight crop damage was caused by desmetryne at 0.25 lb and prometryne at 0.75 lb applied two weeks after planting. Haloxydine at 0.5 and 1.0 lb caused injury similar to 1969 but yields were not reduced.

The predominant weed species in 1970 were <u>Rumex acetosella</u>, <u>Polygonum persicaria</u>, <u>Stellaria media</u> and <u>Poa annua</u>. Poor weed control resulted from application of trifluralin at 1.0 lb and 2.0 lb incorporated before planting, propachlor at 5.2 lb and simazine at 3.0 lb applied immediately after planting. Aziprotryne at 2.0 lb, prometryne at 0.75 lb and desmetryne at 0.25 lb caused a reduction in weed vigour but weed density was not reduced. Haloxydine at 0.5 lb and 1.0 lb gave excellent control of <u>P. annua</u> and <u>S. media</u>. Although these treatments gave a poor kill of <u>P. persicaria</u> and <u>R. acetosella</u> damage was severe and neither weed recovered sufficiently to cause competition with the crop. The results are given in Table .

Table 1

Effect of treatments in transplanted cabbage (c.v. Winningstadt) 1969 - 70

				Assessments[1]							
		Yield ton/ac		Crop		Weeds		% weed kill 1970			
Treatment	Dose lb/ac	1969	1970	1969	1970	1969	1970	P.a.	P.p.	R.a.	S.m.
Propachlor	5.2	17.3	23.9	10.0	8.8	8.8	2.5	0	33	6	0
Simazine	3.0	18.3	27.5	10.0	8.3	8.8	4.5	0	54	29	20
Aziprotryne	2.0	17.5	27.5	8.8	9.3	9.3	6.3	0	41	0	0
Haloxydine	0.5	N.A.	22.6	N.A.	7.8	N.A.	8.8	90	41	45	89
"	1.0	19.0	23.6	7.3	6.3	9.5	9.3	84	63	69	95
"	2.0	12.5	N.A.	5.0	N.A.	10.0	N.A.	N.A.	N.A.	N.A.	N.A.
Prometryne	0.75	N.A.	26.9	N.A.	8.5	N.A.	7.3	0	14	9	0
Desmetryne	0.375	N.A.	26.1	N.A.	8.5	N.A.	6.5	0	29	0	0
Trifluralin	1.0	N.A.	25.8	N.A.	9.0	N.A.	3.8	0	33	29	23
"	2.0	N.A.	25.4	N.A.	9.3	N.A.	3.5	0	27	4	0
Control (untreated)		18.0	24.4	10.0	9.0	6.3	2.5	0	0	0	0
S.E. of treatment mean		1.28	1.65								
No. of weeds/ft^2 in control plots								2	9	13	7

[1] Rating scale : - Crop : 0 (complete kill) - 10 (no damage)
Weeds : 0 (dense cover of weeds) - 10 (no weeds)

N.A. = not applied

P.a. = <u>Poa annua</u>, P.p. = <u>Polygonum persicaria</u>, R.a. = <u>Rumex acetosella</u>, S.m. = <u>Stellaria media</u>

Cauliflower (c.v. Igloo) Haloxydine at 1.0 lb applied 4 weeks after planting caused a severe reduction in crop vigour and yield. Haloxydine at 0.5 lb and 1.0 lb and aziprotryne at 2.0 lb applied one week after planting and aziprotryne at 2.0 lb and desmetryne at 0.25 lb applied four weeks after planting caused a slight initial reduction in crop vigour.

Table 2

Effect of treatments in transplanted cauliflower (c.v. Igloo) 1970

Treatments	Dose lb/ac	[1]Stage of application	No. of marketable curds/plot 1970	Assessments[2] Crop 8/9/70	Crop 1/10/70	Weeds 8/8/70	Weeds 1/10/70	% weed kill P.p.	% weed kill S.v.
Propachlor	5.2	1	19	9.5	8.5	8.0	6.2	45	56
Simazine	3.0	1	20	8.3	8.0	9.0	8.5	0	67
Aziprotryne	2.0	1	19	7.8	7.0	5.8	4.7	0	0
"	2.0	2	17	7.3	7.0	7.3	5.5	0	0
Haloxydine	0.5	1	18	7.0	7.5	5.0	4.7	0	0
"	0.5	2	19*	8.0	7.7	7.0	5.5	5	0
"	1.0	2	16	5.0	6.2	7.8	5.5	75	37
Desmetryne	0.25	2	17	7.0	7.2	6.8	3.5	0	0
Prometryne	0.75	2	19	8.3	8.2	5.0	5.5	52	0
Control			21	9.3	7.7	2.5	4.5	0	0
S.E. of treatment mean			1.33						
Weeds/ft^2 in control plots								2	42

[1] Stage of application 1 = 1 week after planting. 2 = 2 weeks after planting

[2] Rating scale as in Table 1.

P.p. = Polygonum persicaria. S.v. = Senecio vulgaris.

The dominant weed in the trial, Senecio vulgaris (Table 2) was beginning to emerge one week after planting and was in the 4 - 5 leaf stage four weeks after planting. Of the treatments applied one week after planting simazine at 3.0 lb and propachlor at 5.2 lb provided excellent weed control for nine weeks and six weeks respectively. Aziprotryne at 2.0 lb and haloxydine at 0.5 lb and 1.0 lb provided a good initial weed kill but weeds re-emerged quickly. Of those treatments applied four weeks after planting aziprotryne at 2.0 lb, haloxydine at 0.5 lb and haloxydine at 1.0 lb caused severe injury to Senecio reducing its competitiveness. Desmetryne at 0.25 lb and prometryne at 0.75 lb gave only short lived weed control.

Drilled cabbage

Pre-emergence application 1969 - 70 Haloxydine at 2.0 lb caused severe marginal chlorosis in cabbage seedlings and seriously reduced crop vigour. The remaining treatments showed a high degree of crop selectivity (Table 3). The main weed species in the trial were S. media, P. annua and R. acetosella. None of the herbicides applied gave satisfactory control of R. acetosella. CP 52665 at 1.5 lb and trifluralin at 1.0 lb + propachlor at 5.2 lb gave good control of P. annua, but failed to control S. media. Haloxydine at 0.5 lb gave good control of S. media but a dose of 1.0 lb was needed to control P. annua. Aziprotryne at 2.0 lb and 4.0 lb reduced the vigour of all weeds for 5 weeks but this material caused very little reduction in weed density. Unsatisfactory weed control was given by propachlor at 5.2 lb and trifluralin at 1.0 lb and 2.0 lb.

Table 3

Effect of pre-emergence treatments on crop and weeds - Drilled cabbage 1969-70

Treatment	Dose lb/ac	Yield ton/ac		Plant Stand as % of control	Assessments[1]				% weed kill (1970)		
					Crop		Weeds				
		1969	1970	1969	1969	1970	1969	1970	P.a.	S.m.	R.a.
Propachlor	5.2	20.3	11.2	107	8.3	10.0	9.6	6.0	76	60	0
Aziprotryne	2.0	24.7	12.3	103	9.3	10.0	10.0	6.0	19	0	22
"	4.0	24.3	11.8	116	9.1	10.0	10.0	6.0	0	7	0
Haloxydine	0.5	N.A.	17.0	N.A.	N.A.	9.0	N.A.	9.0	56	86	7
"	1.0	19.0	18.7	126	8.5	9.0	10.0	9.0	95	90	29
"	2.0	22.0	N.A.	96	7.0	N.A.	10.0	N.A.	N.A.	N.A.	N.A.
CP 52665	1.5	N.A.	17.7	N.A.	N.A.	10.0	N.A.	8.0	88	25	11
Trifluralin	1.0	21.7	8.3	112	8.9	10.0	9.3	5.0	44	44	26
"	2.0	26.0	9.2	107	9.1	10.0	10.0	6.0	69	33	21
Trifluralin + Propachlor	1.0 5.2	N.A.	12.8	N.A.	N.A.	10.0	N.A.	7.0	92	11	43
Control		23.3	11.2	100	8.7	10.0	6.3	6.0	0	0	0
S.E. of treatment mean		2.53	1.92	17.3							
No. of weeds ft^2 in control plots									6	8	3

[1] Rating scale as in Table 1.

N.A. = not applied

P.a. = Poa annua. S.m. = Stellaria media. R.a. = Rumex acetosella

Post-emergence application 1969-70 The herbicides were applied at the three-leaf stage of the crop. A reduction in crop yield was caused by haloxydine at 1.0 lb, phenmedipham at 1.0 lb and ioxynil octanoate at 0.5 lb in 1969. Although haloxydine at 0.5 lb caused severe leaf chlorosis and desmetryne and prometryne caused severe scorch the crop recovered rapidly and yields were not reduced. Aziprotryne at 2.0 lb caused slight marginal scorch in the crop, but pronamide at 1.0 and 2.0 lb caused no crop injury. Weeds were in the 2 - 3 leaf stage at the time of herbicide application. S. media and P. persicaria were controlled by haloxydine at 0.5 lb and 1.0 lb. Aziprotryne at 2.0 lb, prometryne at 0.75 lb and desmetryne at 0.75 lb severely retarded weed growth for three weeks. The results are given in Table 4.

Table 4

Effect of post-emergence treatment on crop and weeds - drilled cabbage 1969-70

		Yield ton/ac		Assessments[1] Crop		Assessments[1] Weeds		% weed kill 1970	
Treatment	Dose lb/ac	1969	1970	1969	1970	1969	1970	S.m.	P.p.
Aziprotryne	2.0	30.3	20.5	9.6	8.0	7.7	8.0	38	25
Desmetryne	0.25	31.0	19.4	9.3	7.0	8.0	8.0	43	78
Haloxydine	0.50	32.6	17.4	5.6	4.0	8.3	9.0	84	74
"	1.0	25.0	14.1	4.6	2.0	9.7	10.0	94	88
Phenmedipham	1.0	25.0	18.1	7.6	9.0	9.0	9.0	45	40
Ioxynil	0.5	24.3	N.A.	5.3	N.A.	8.0	N.A.	N.A.	N.A.
Prometryne	0.75	N.A.	20.1	N.A.	5.0	N.A.	9.0	66	85
Pronamide	1.0	N.A.	20.7	N.A.	10.0	N.A.	2.0	0	40
"	2.0	N.A.	19.8	N.A.	10.0	N.A.	3.0	28	71
Control		29.6	15.2	10.0	10.0	8.0	0	0	0
S.E. of treatment mean		2.9	1.5						
No. of weeds/ft^2 in control plots								5	3

[1] Rating scale as in Table 1.

N.A. = not applied

S.m. = Stellaria media. P.p. = Polygonum persicaria

Drilled cauliflower

Pre-emergence application 1970 Although a severe crop check, which was still in evidence four weeks after the crop emerged, was caused by haloxydine at 0.5 lb and 1.0 lb and propachlor at 5.2 lb combined with chlorpropham at 1.0 lb or 2.0 lb yield was not reduced (Table 5). Propachlor at 5.2 lb combined with chlorpropham at 1.0 lb or 2.0 lb gave excellent control of Senecio vulgaris, the dominant weed in the trial, but unsatisfactory control of this weed was given by trifluralin at 2.0 lb + propachlor at 5.2 lb, trifluralin at 1.0 lb and 2.0 lb and haloxydine at 0.5 lb and 1.0 lb.

Post-emergence application 1970 Severe crop damage which persisted for 3 weeks was caused by haloxydine at 0.5 lb and 1.0 lb, aziprotryne at 2.0 lb and simazine at 3.0 lb applied at the 3 - 4 leaf stage of the crop and simazine at 3.0 lb applied at the one leaf stage of the crop. Prynachlor at 2.0 lb applied at the 3 - 4 true leaf stage caused only slight crop injury. Application of propachlor at 5.2 lb either at the one true leaf stage or the 3 - 4 true leaf stage showed high crop selectivity. At the one true leaf stage of the crop when simazine and propachlor were applied S. vulgaris the main weed was in the cotyledon - 2 true leaf stage. At the time of application of the remaining treatments when the crop was in the 3 - 4 true leaf stage this weed was in the four to six leaf stage.

None of the treatments satisfactorily reduced weed numbers but aziprotryne at 2.0 lb and simazine at 3.0 lb applied at the 3 - 4 true leaf stage and simazine at 3.0 lb applied at the first true leaf stage caused a reduction in weed vigour for three weeks.

Table 5

Pre-emergence application of herbicides in drilled cauliflower 1970

Treatment	Dose lb/ac	*Time of application	No. of marketable curds/plot	Assessments[1] Crop	Weeds	% weed kill Senecio vulgaris
Trifluralin	1.0	1	21	8.8	4.5	0
"	2.0	1	20	10.0	6.0	0
Trifluralin + Propachlor	2.0 5.2	1 2	20	9.0	7.5	0
Haloxydine	0.5	2	24	6.0	8.3	38
"	1.0	2	21	7.0	8.5	56
Propachlor + Chlorpropham	5.2 1.0	2 2	19	7.8	9.0	86
Propachlor + Chlorpropham	5.2 2.0	2 2	20	4.0	9.8	93
Control				8.5	5.8	0
S.E. of treatment mean			3.0			
No. of weeds/ft^2 in control plots						2

[1] Rating scale as in Table 1

* 1 = incorporated before drilling. 2 = applied pre-emergence.

DISCUSSION

The pre-emergence, post-emergence and post planting treatments used for weed control in autumn brassicae are applied in the May to July period at a time when the surface $\frac{1}{4}$ in. of the peat is usually dry. Even if rain occurs the dry layer is difficult to rewet and in contrast to spray application in early sown crops the herbicides applied about this time have little residual effect. Because of this a wide range of herbicides tested in brassicae in 1969 and 1970 have not, with the exception of haloxydine, given the desired weed kill. Pre-emergence or post-planting application of haloxydine in cabbage has given promising results, but the main drawbacks of this material is its poor selectivity when applied as a pre- or post-emergence treatment in cauliflower, and its failure to control S. vulgaris. Although the density of all the weed species had not been satisfactorily reduced by any of the other treatments the vigour of the main weeds was in some cases retarded to such an extent that competition with the crop was minimal up to harvest. For example, aziprotryne, simazine and prynachlor caused a severe inhibition in the growth of P. persicaria, S. media and C. ablum. The weed control given by these treatments was much better than weed counts indicate, but their selectivity was marginal when applied post-emergence in cauliflower.

In transplanted cauliflower and in the pre-emergence trials in cabbage and cauliflower, propachlor gave excellent control of S. vulgaris but after 5 - 6 weeks further seedlings emerged. With the exception of haloxydine at 1.0 lb none of the treatments applied gave consistent control of P. annua and R. acetosella. Although difficult to control these weeds are not a serious problem in brassica crops because of their relatively small size.

Of the other materials tested, chlorpropham gave good control of the Polygonacaea and sulfallate gave good control of S. vulgaris. These materials might usefully be included in combinations with other herbicides, but although sulfallate shows excellent crop tolerance in brassicae generally, the selectivity of chlorpropham in cauliflower is suspect. Trifluralin has now been well tested on the peat and has proved to be ineffective on this type of medium. Phenmedipham and ioxynil octanoate applied post-emergence in drilled cabbage have shown insufficient selectivity.

The results of this paper clearly indicate that weed control in brassica crops on peat is still not satisfactory. While it is possible to grow relatively weed free crops on the peat with the materials now available considerable loss of yield can be incurred due to uncontrolled weeds, and for this reason more attention must be given to the use of herbicidal mixtures, or combinations to effect control of as wide a weed spectrum as possible.

Acknowledgements

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WEED CONTROL IN FODDER BRASSICAS AND VEGETABLES USING GRANULAR ALACHLOR AND PROPACHLOR

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Summary Alachlor at 1.5 to 3 lb a.i./ac and propachlor at 4 lb to 8 lb a.i./ac as spray, and granular formulations were applied pre-emergence to 31 trials in the U.K. from 1969 to 1972. A similar control was obtained of a wide spectrum of weeds, the granular formulations producing similar results to the sprays. Although both chemicals showed selectivity in brassicas, alachlor proved to be slightly more phytotoxic. Band applications of propachlor granules gave a good weed control in swedes grown on ridges in north-east Scotland.

INTRODUCTION

Selleck et al (1965) first described the chemistry and properties of propachlor. Evans et al (1968) found alachlor to have similar crop selectivity and weed control to propachlor. Holroyd (1968) found alachlor to be more active and more phytotoxic than propachlor in brassicas. Scragg (1970) showed that both alachlor and propachlor applied as overall sprays could be successfully used in swedes grown on ridges in the north of Scotland.

With the introduction of better granule applicators, a programme commenced in 1969 to investigate the commercial possibilities of granular formulations of alachlor and propachlor for pre-em. weed control.

METHODS AND MATERIALS

Most of the trials were conducted in commercial crops. A randomised block layout with 4 replicates of each treatment was generally used with small plots of 15 to 30 yd^2 and large plots of 1/16 to 1 ac. Some large non-replicated trials were also conducted.

Sprays were applied with a precision knapsack sprayer and a calibrated contractor's sprayer. Granules were first applied by hand and later using Horstine Farmery Microband and Airflow applicators. Normal commercial materials were used, i.e. alachlor (Lasso) as a 48% w/v e.c. and a 10% w/w granule, propachlor (Ramrod) as a 65% w/w w.p. and a 20% w/w granule. Both granules were 24/48 mesh attapulgite clay.

Alachlor was used at 1.5 to 3 lb a.i./ac and propaclor at 4 lb to 8 lb a.i./ac The distribution of granules was checked by means of 4 in. trays placed across the width of the applicator - see Fig. 1. Assessments were made 6 to 8 weeks after application of granules. Crop assessments were made visually for effect on vigour. Weed assessments were made visually and by quadrat counts. In Scotland swede seedling counts were made. Sites and details are shown in Table 1.

RESULTS

Alachlor damaged onion and leek severely, but brassicas were more tolerant (Tables 2 and 3). Alachlor granules were more damaging than the spray. Both formulations of propachlor proved safe on the crops tested. The percentage weed control is given (Tables 4 and 5). Alachlor and propachlor gave a good control of *Capsella bursa-pastoris*, *Matricaria spp*, *Poa annua*, *Senecio vulgaris*, *Stellaria media* *Urtica urens*, *Chenopodium album*. Moderate to poor control was obtained of the *Polygonum spp*. Granules proved as efficient as the spray treatments.

Band application of granules using a 9 in. fishtail outlet fitted to the Microband applicator was made to 22 sites in north-east Scotland in 1971 and 1972, (Tables 6,7 and 8). Crop effects were slight - in the nature of checks to vigour. No reduction in seedling numbers was recorded. In 1971 alachlor granules produced a greater crop check than propachlor granules but the effects were only transient. In 1972 a severe crop check was seen when heavy rain and poor growing conditions followed the application of the propachlor granules (Tables 7 and 8). In both seasons propachlor granules gave a good control of *S media*, *Galeopsis tetrahit*, *Spergula arvensis* and *C album*, with only moderate control of Polygonum spp.

DISCUSSION

Alachlor and propachlor performed differently in the trials from 1969 to 1972. Propachlor proved to be the safer chemical on the crops tested in both a w.p. and a granular formulation. Alachlor was more damaging, but most of the damage to brassicas was only transient. Effects on yield are only recorded when growing conditions were adverse, confirming (Scragg 1970).

Acknowledgements

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TABLE 1

SITE DETAILS

Site	No.	Crop	Planting date	Application date	Weather
Pershore Worcs	1	Various see Table 2	2.7.69.	5.7.69	Dry/soil. Showers then hot and dry.
Lenton	2	Various see Table 2	21.5.69.	22.5.69.	Moist soil Rain after application.
Arnold Notts	3	Cabbage	20.4.69.	25.4.69.	Moist soil Rain after application.
Bishops Castle Shropshire	4	Swedes	19.6.70	19.6.70	Wet soil Rain day after application.
Biggleswade Beds	5	Brussel Sprouts	5-11.5.71	11.5.71.	Soil dry Rain after 2 days than hot and dry
Lilleshall Shropshire	6	Swedes	13.5.71.	16.5.71.	Soil moist. Rain same day.
Whaplode Drove Lincs	7	Onions	15.3.71.	2.4.71.	Dry soil. Showers then hot and dry for 3 weeks.
Clifton Beds	8	Brussel Sprouts	13-15.5.72.	17.5.72.	Showers after planting.
Clifton Beds	9	Cabbage	2.6.72.	5.6.72.	Rain after 3 days

TABLE 2

Crop Selectivity % loss of vigour

	Alachlor 1b a.i./ac						Propachlor 1b a.i./ac				
	E.C.			10G			W.P.			20G	
	1.5	3.0	1.5	1.5	3.0	1.5	4.0	8.0	4.0	4.0	8.0
Onions	0	50	50	0	60	90	0	0	0	0	0
Leeks	0	50		0	60		0	0	0	0	0
Cabbage	0	20	0	0	20	20	0	0	0	0	0
Cauliflower	0	30	0	0	30	40	0	0	0	0	0
Brussel Sprouts	0	20	0	0	20	40	0	0	0	0	0
Oil Seed Rape	0	20	20	0	20	30	0	0	0	0	0
Turnip	0	30	40	0	30	50	0	0	0	0	0
Swedes	0	20	40	0	20	20	0	0	0	0	0
Site No.	1	1	2	1	1	2	1	1	2	1	1

TABLE 3

Crop Selectivity % Loss of Vigour

	Alachlor 1.5 1b a.i./ac									Propachlor 4.0 1b a.i./ac							
	E.C.				10G					W.P.			20G				
Onions												0			0		
Cabbage	0			0	0				0	0							0
Brussel Sprouts							0				0		0			0	
Swedes		16	20			10		10						7			
Site No.	3	4	6	9	3	4	5	6	9	3	5	7	5	6	7	8	9

TABLE 4

% Control of Individual Species

ALACHLOR 1.5 lb/a.i./ac

	E.C.						10G						
Site No.	1	2	3	4	6	7	1	2	3	4	5	6	7
Capsella bursa-pastoris	8	80	70	80			18	100		80	80		
Mayweed spp	50	100	80	90	85		0	100	60	85		85	
Poa annua	97	100		100	90		100	100		100	90	95	
Senecio vulgaris	30	100	80		100		31	100	80		80	100	
Solanum nigrum	28	-					45	-					
Sonchus arvensis	73	-					66	-					
Stellaria media	80	80	60	90	100		0	90	60	90	80	100	
Urtica urens	75	100	80			85	93	90	80				85
Chenopodium album	47	90		90	77	80	58	100	60	90	80	85	80
Veronica persica	75	-					25	-					
Polygonum aviculare	-	-	60	60	70		-	-	70	60		70	
Polygonum convolvulus	-	-		70			-	-		70	60		
Polygonum persicaria				70	85		-	50		70		85	

TABLE 5

% Control of Individual Species

PROPACHLOR 4.0 lb a.i./ac

	W.P.						20G					
Site No.	1	2	3	5	7	8	1	5	6	7	8	9
Capsella bursa-pastoris	60	80		90	100		70	90		100		
Mayweed spp	30	60	60		100		50		93	100		
Poa annua	100	70		100	100		100	100	100	100		
Senecio vulgaris	70	70	80	95			85	90	100			
Solanum nigrum	60						70					
Sonchus arvensis	40						50					
Stellaria media	80	70	70	95	100		10	90	100	100	90	
Urtica urens	90	60	70				95				95	100
Chenopodium album	90			95			90	90	93		95	
Veronica persica	50						50					
Polygonum aviculare			40						75			
Polygonum convolvulus				60				60				
Polygonum persicaria		50							85			

TABLE 6

SITE DETAILS - SCOTLAND

1971 Site	Applied	Rainfall	1972 Site	Applied	Rainfall
1. Alva	1/6	20/6	1. Northwaterbridge	2/5	23/5
2. Forres	10/5	17/5	2. Inverbervie	3/5	3/5
3. Drumlithie (1)	7/5	6/5	3. Pitmedden	4/5	5/5
4. Drumlithie (2)	10/5	6/5	4. South Buredales	5/5	5/5
5. Mintlaw	10/5	26/5	4. Fordafourie	10/5	10/5
6. Crimond (1)	17/5	21-26/5	6. Culbeuchley	10/5	20/5
7. Crimond (2)	17/5	21-26/5	7. Forres (1)	10/5	31/5
8. Fordyce	6/5	26/5	8. Forres (2)	10/5	31/5
9. Adziel	10/5	26/5	9. Hatton	11/5	11/5
			10. Insch	11/5	11/5
			11. Drumlithie (1)	11/5	11/5
			12. Drumlithie (2)	11/5	11/5
			13. Kennethmont	14/5	

TABLE 7

THE PERFORMANCE OF GRANULAR ALACHLOR AND PROPACHLOR IN SCOTLAND 1971

	ALACHLOR 16 lb/ac 10G					PROPACHLOR 21 lb/ac 20G							
% Weed Control													
Stellaria media	94	-	66	77	80	99	100	-	66	80	95	90	
Galeopsis tetrahit	80	-	85	83	80	80	-	68	86	85	100	85	95
Spergula arvensis	99	90	-	95	80	100	100	90		96	100	100	
Chenopodium album	-	99	-	-	-		99	-			95	-	90
Polygonum persicaria	-		75	62			85	100	86	71	85	70	70
Polygonum aviculare	70	-	-	66		75	-	-				-	70
Chrysanthemum segetum	-	-	-	-	-							95	-
% Loss of Crop Vigour	0	10	20	0	0	0	0	0	10	0	0	0	0
SITE No.	1	2	3	5	9	1	2	3	4	5	6	7	8

TABLE 8

THE PERFORMANCE OF PROPACHLOR GRANULES IN SCOTLAND 1972

% Weed control at 21 lb/ac													
Stellaria media	70	100	87	95	90	90	95	99	90	90	90	95	80
Spergula arvensis	100	100	99	100	99	-	99	99	99	-	99	99	100
Chenopodium album	85	-	-	90	90	-	90	90	-	-	-	-	-
Polygonum persicaria	<50	70	50	-	-	-	-	60	-	-	-	90	60
Polygonum convolvulus	0	70	-	-	-	-	-	-	-	60	-	-	-
Polygonum aviculare	55	-	<50	-	-	-	-	-	70	60	-	-	60
Galeopsis tetrahit	99	100	99	95	99	-	-	-	95	85	75	70	95
Poa annua	100	-	-	-	-	-	-	-	90	100	99	100	-
Matricaria spp	99	100	99	-	-	-	-	-	90	-	-	-	-
Veronica spp	99	100	-	95	99	-	-	-	-	-	-	-	-
Capsella bursa-pastoris	-	-	-	-	99	-	-	99	-	-	-	-	-
Lycopsis arvensis	-	-	-	-	90	95	99	99	-	-	-	-	-
Fumaria officinalis	-	<50	-	<50	-	-	-	-	-	<50	-	-	-
Ranunculus spp	99	100	80	-	-	-	-	-	-	-	70	<50	60
Myosotis	99	-	-	-	-	-	-	-	-	-	99	95	-
Chrysanthemum segetum	-	-	-	-	90	-	-	-	-	-	-	-	-
Galium aparine	-	-	-	-	-	-	-	-	-	-	99	-	-
% Loss in Vigour													
21 lbs	50	10	10	0	0	0	0	0	0	0	30	15	0
42 lbs	(70)	(40)	(10)	(0)	(0)	(0)	(0)	(0)	(0)	(0)	(30)		
Site No.	1	2	3	4	5	6	7	8	9	10	11	12	13

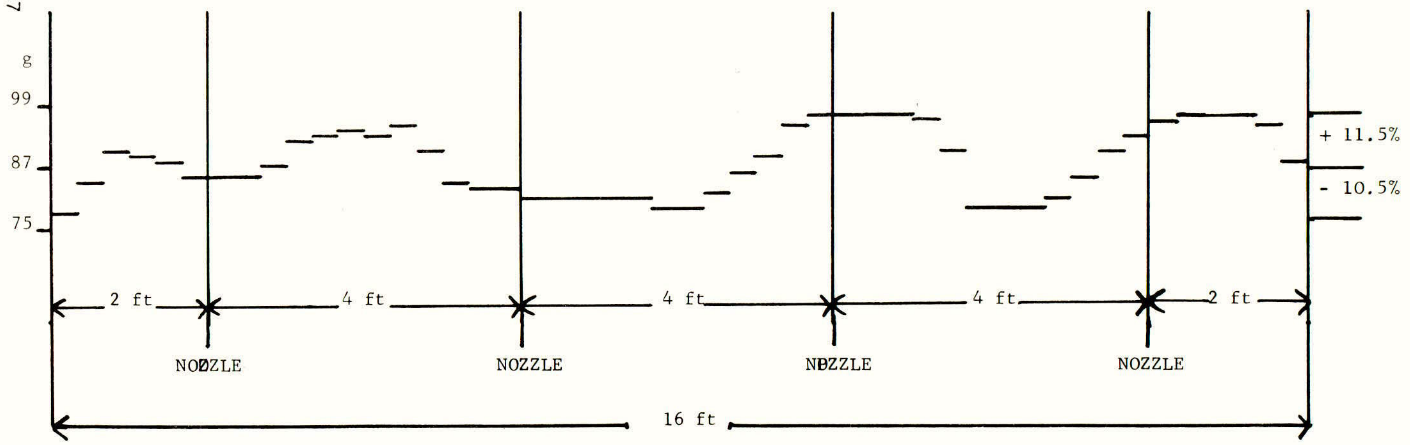
Fig. 1

THE DISTRIBUTION PATTERN FOR 20% PROPACHLOR GRANULES USING HORSTINE FARMERY TMA 2 AIRFLOW APPLICATOR OVER A 16 FT SPREAD AND USING 4 IN. TRAYS

Fan Speed 4,000 rev/min Ground Clearance 18 in.

4 Impact Nozzles each spreading 4 ft and fitted with 13° plates and ¾ in. gap

Average weight 87 g Variation + 11.5%
- 10.5%



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THE INFLUENCE OF ACTIVATED CHARCOAL ON THE TOLERANCE OF VEGETABLE CROPS TO SOIL-ACTING HERBICIDES

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Summary A root dip of powdered steam activate charcoal increased the tolerance of lettuce to simazine, atrazine and linuron and of cauliflower and tomato to simazine in bioassay experiments. In a field experiment the root dip increased the tolerance of cauliflower to pre-planting applications of simazine and linuron but was ineffective against post-planting treatments. Charcoal did not protect cauliflower against terbacil. It is concluded that a root dip of activated charcoal can provide a significant protection of some vegetables against herbicide soil residues but not against overhead applications.

INTRODUCTION

The evident value of persistent soil-acting herbicides for selective weed control in various crops has led to their increasing use in recent years. The sensitivity of some crops, however, limits their use when they might otherwise be advantageous. Their soil persistency could also be detrimental if susceptible crops are sown or planted too soon after their application to a previous crop. Gast (1962) showed that simazine was adsorbed by charcoal and Robinson (1965) demonstrated the practical value of this when he showed that newly planted strawberry runners could be protected from simazine injury, by dipping their roots in activate charcoal before planting.

During experiments at the Horticultural Centre, Loughgall, which were designed to evaluate improved weed control methods for brassica crops, the normal susceptibility of which render them difficult subjects for selective weed control, it was decided to examine the increase in crop tolerance that could be achieved in some vegetables by root dips of activated charcoal and to determine whether this technique might be used on a field scale.

METHOD AND MATERIALS

Powdered steam activated charcoal was used as a root dip in bioassays in which lettuce (cv Delta), cauliflower (cv All the Year Round) and tomato (cv Ware Cross) were planted as test plants into herbicide treated soil. The charcoal had an iodine index of 80.5. This represents the weight of iodine (gm)absorbed by 100 gm of dry activated powder. Herbicides were intimately incorporated into soil after which a series of herbicide/soil dilutions were formed to give concentrations in the range of 0.4 to 8.0 ppm in experiment

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1 and 0.2 to 4.0 ppm in experiment 2. A concise account of this bio-assay technique has been given by Allott (1970). Test seedlings were planted at the 2-3 true leaf stage. Their roots were dipped in activated charcoal according to treatment immediately before planting. Dipping ensured that the roots were uniformly covered by charcoal whilst the foliage was not affected. The root treatment was applied to bundles of twelve plants simultaneously.

Experiment 1 examined the tolerance of lettuce to simazine, atrazine, lenacil and linuron and Experiment 2 examined the tolerance of lettuce. cauliflower and tomato to simazine. In both experiments crop responses to be analysed were expressed as ratios of the appropriate unsprayed controls. The fresh weight above soil level of each crop plant was recorded. Lettuce was recorded when the unsprayed control plants reached the 8 true leaf stage and tomato and cauliflower the 7 true leaf stage.

The value of steam activated charcoal as a root dip was also examined in a field experiment (Experiment 3) in which simazine, linuron and terbacil were applied to cauliflower (cv All the Year Round) the roots of which were either dipped or undipped in charcoal. Herbicides were applied before or after planting. Each herbicide was applied at 2.0 lb/ac a.i. This relatively high herbicide dose was deliberately chosen to increase the severity of the test of the efficiency of the charcoal root dip.

RESULTS

Experiment 1

The soil that was used as both test soil and diluent had the following physical analysis:

% Coarse Sand	Fine Sand	Silt	Clay	Loss on Ignition
56.0	21.7	5.1	8.2	10.0

The mean leaf number ratios 7 and 14 days after planting, the mean fresh weight ratios and potency estimates are presented in Table 1. There were no consistent differences in leaf number 7 days after planting but 14 days after planting dipped plants all had a higher leaf number ratio than undipped plants. An examination of the mean fresh weight ratios shows that plants were more developed when charcoal dipping was practised with the exception of the lenacil treatment where there was no difference between dipped and undipped plants. The benefits of the charcoal treatment are emphasised by the potency estimates in Table 1 which show that the root dip increased the tolerance to simazine by 75%, to linuron by 60% and to atrazine by 50% but that it only had a marginal effect against lenacil.

Experiment 2

The test and diluent soils in this experiment had the following physical analysis:

% Coarse Sand	Fine Sand	Silt	Clay	Loss on Ignition
21.1	34.6	9.9	23.1	13.7

Fresh weight ratios and potency estimates are presented for each crop in Table 2. Regression coefficients for lettuce dipped and undipped were similar and therefore comparable. Similarly for cauliflower and tomato. Potency estimates should, therefore, be compared in groups of two each crop being treated separately. Estimates are not comparable between crops. The potency estimates suggest that to produce the same effect on dipped as on undipped plants dipped lettuce would need twice the simazine dose, dipped cauliflower four times and dipped tomato five times. The undipped fresh weight ratios show that cauliflower is the most sensitive crop to simazine. It is evident from the yields that charcoal root dipping significantly increased the yield of each crop. ($P < 0.05$).

Experiment 3

This experiment was conducted in the field where the physical soil analysis was:

% Coarse Sand	Fine Sand	Silt	Clay	Loss on Ignition
29.9	41.2	8.8	11.3	6.2

The use of simazine and linuron provided a link with the glasshouse bio-assays whilst terbacil was included as a persistent herbicide with increasing potential use which could cause residue problems. Table 3 shows that an activated charcoal root dip significantly increased crop tolerance to pre-planting applications of simazine and linuron ($P < 0.05$) but it had no effect when the herbicides were applied after planting. Charcoal was ineffective against terbacil.

As Table 4 emphasises even when the relatively high dose of simazine of 2.0 lb/ac was used as in this experiment cauliflower was surprisingly tolerant to post-planting treatment although it suffered a significant yield reduction ($P < 0.05$). Pre-planting treatment with linuron was less damaging than post-planting whilst terbacil caused severe damage irrespective of the time of application. Table 4 also shows that the charcoal root dip significantly increased crop tolerance ($P < 0.05$).

DISCUSSION

Where crop tolerance to soil applied herbicides such as simazine is inadequate such as in newly planted strawberries or in transplanted brassicae it has been shown by Ahrens (1965), Robinson (1965), Allott (1968) and others that it can be improved by dipping the roots of plants into activated charcoal immediately before planting. Whilst this technique has been mainly used for protection against simazine the experiments that are reported in this paper show that it could haveuses against other herbicides such as atrazine and linuron.

Cauliflower was chosen as a test plant because of its know susceptibility to applied herbicides. Under glasshouse conditions in which simazine was intimately mixed with the soil the soil potency to cauliflower was reduced by over 70% by charcoal root dipping. Similarly the potency to lettuce and tomato, which are also susceptible plants, was reduced by 50% and 80% respectively. In another experiment in which lettuce was used as the indicator plant the potency of simazine was reduced by 75%, atrazine 50%

and linuron by 60%. This discrepancy in the protection of lettuce can probably be partly explained by differences in the physical composition of the soils in the two experiments where the clay percentages were 23.1 and 8.2 respectively. As could have been anticipated the simazine was less potent to lettuce in the former soil. From the results it is evident that this technique can be effective against a number of herbicides. It is also of value for the protection of different plants under particularly severe conditions in which the plant roots are completely surrounded by herbicide treated soil there being no physical soil barrier between the herbicide and the roots as could be expected to apply under field conditions.

Experiments on a field scale have been described by Gast (1962) in which a layer of activated charcoal 1 mm thick was applied to the soil. He concluded, however, that 50-100 parts of charcoal are needed to inactivate 1 part of simazine to the point at which it is no longer biologically detectable. It would, thus, appear that when charcoal is applied to the soil instead of as a root dip the effective dose may be so high that economically this would not be a practical proposition. In addition to increasing the cost of herbicide treatments the presence of charcoal in the soil would probably reduce the level of weed control due to herbicide inactivation. The root dip technique would, therefore, appear to be preferable as this in effect only involves the placement of charcoal where it is required. Experiment 3 demonstrates the value of this technique under field conditions. It is interesting to note, however, that it was only effective following pre-planting herbicide treatments. It is, thus, evident that charcoal root dipping could provide an effective means of plant protection when herbicide soil residues are suspected - a conclusion that is supported by the bio-assay results. Whilst it might have a use in limited situation such as this it is unlikely to provide a method of protection for normal herbicide treatment as it could only be used effectively after pre-planting herbicide applications. Soil disturbance during planting would limit the efficiency of soil-applied herbicides and, therefore, necessitate their post-planting application.

Charcoal root dipping, therefore, provides a useful technique in minimising crop damage from herbicide soil residues of simazine and linuron and to a lesser extent of atrazine. It's use, however, would appear to be limited to transplanted crops and to situations where the herbicides are present in the soil before planting.

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Table 1

Preparation means (ratio of treatment response to unsprayed control response) and potency estimates* following herbicide treatments to lettuce (cv Delta) with and without charcoal root treatment

Herbicides	Root Treatment	Mean leaf number ratio 7 days after planting	Mean leaf number ratio 14 days after planting	Mean fresh wt ratio	Potency estimate
Simazine	dipped	1.80	0.85	0.53	0.25
"	undipped	0.90	0.50	0.22	1.00
Atrazine	dipped	0.87	0.87	0.58	0.51
"	undipped	0.93	0.65	0.43	1.00
Lenacil	dipped	0.85	0.93	0.55	0.94
"	undipped	1.00	0.86	0.54	1.00
Linuron	dipped	1.02	1.02	0.97	0.41
"	undipped	1.04	0.90	0.78	1.00
S.E. of a difference between two means		0.033	0.038	0.048	-
Error d.f. 117					

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*Potency estimates are compared in pairs, ie comparisons are made between root treatments for each herbicide individually.

Table 2

Preparation means (ratio of treatment response to unsprayed control response) and potency estimates* of dipped relative to undipped plants for each crop following simazine treatment with and without charcoal root treatment

Crop plant	Root treatment	Preparation mean (fresh wt ratio)	Potency estimate
Lettuce	dipped	1.98	0.49
"	undipped	1.31	1.00
Cauliflower	dipped	1.51	0.27
"	undipped	0.29	1.00
Tomato	dipped	2.82	0.20
"	undipped	1.29	1.00
S.E. of a difference between two means		0.157	-
Error d.f. 105			

* Potency estimates are compaired in pairs ie comparisons are made between root treatments for each crop individually.

Table 3

Total plant wt (lb/plot) following herbicides applications to transplanted cauliflower (cv All the Year Round) the roots of which had either been dipped or not dipped in activated charcoal

Herbicide	Root treatment	
	dipped	undipped
No herbicide	21.04	20.75
Simazine pre-planting	14.09	0.83
" post-planting	14.17	16.63
Linuron pre-planting	21.67	3.84
" post-planting	0.17	0.00
Terbacil pre-planting	0.21	0.00
" post-planting	0.83	0.00
S.E. of a difference between two means	2.957	
Error d.f. 26		

Table 4

Mean plant wt. (lb/plot) following herbicide applications to transplanted cauliflower (cv All the Year Round) the roots of which had either been dipped or not dipped in activated charcoal

Herbicide	Total plant wt.
No herbicide	20.90
Simazine pre-planting	7.46
" post-planting	15.40
Linuron pre-planting	12.75
" post-planting	0.08
Terbacil pre-planting	0.10
" post-planting	0.42
S.E. of a difference between two means	2.091
Root treatment	
Dipped	10.31
Undipped	6.01
S.E. of a difference between two means	1.298
Error df 26	

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FIELD TRIALS WITH 2-(4-CHLORO-6-ETHYLAMINO -S-TRIAZIN-2-YLAMINO)-2-METHYL-PROPIONITRILE (CYANAZINE)* FOR WEED CONTROL IN BRASSICAS

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Summary. Cyanazine, 2-(4-chloro-6-ethylamino-S-triazin-2-ylamino)-2 methyl-propionitrile, was evaluated as a herbicide for use in a range of emerged and transplanted brassicas in a series of trials during 1971 and 1972. At 1.40 kg a.i./ha cyanazine gave good control of a wide range of annual weeds frequently better than the standard treatments and was well tolerated by established transplants of cabbage and Brussels sprouts. It was not sufficiently selective on cauliflower, calabrese or the 4-5 leaf stage of drilled crops generally. Crop symptoms on transplants were temporary and the crop recovered to give yield increases of between 15 and 24% over standard treatments on transplanted cabbage. The optimum rate was the same for the range of soil types covered by the trials with the exception of sandy loam soils.

INTRODUCTION

Cyanazine was introduced by Chapman et al at the 9th British Weed Control Conference in 1968 as a herbicide showing promise on a range of crops. Preliminary work carried out in the U.K. and Europe confirmed the effective weed control and demonstrated a useful degree of selectivity on emerged and transplanted brassica crops.

Further trials were accordingly undertaken on these crops during 1971 and 1972 to determine the effective selective dose.

METHODS AND MATERIALS

Cyanazine was used as a 50% wettable powder and a 50% suspension concentrate in 1971 and 1972 respectively. Rates of use are expressed as kg a.i./ha. Sites were located in the main brassica growing areas of England and Scotland and covered a representative range of conditions, growing techniques and varieties. Rainfall data and soil analyses were obtained for each site. The layout used was a randomised block with 3 or 4 replicates and a plot size of 1.8 m x 11.0 m. Treatments were applied in 281-562 l./ha at a pressure of 2.1 kg/cm^2 using a precision sprayer. In the farmer user trials, strips of 0.25 hectare were treated at 1.40 kg in 280-560 l./ha.

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* Provisional chemical name. Known also in the U.K. as WL 19805 and DW 3418, in the U.S.A. as SD 15418 and in Europe and N. America as Bladex.

The following trials were laid down at sites in Scotland and England.

	Cabbage		Brussels Sprouts		Cauliflower		Calabrese	
	T	D	T	D	T	D	T	D
Replicated								
1971	1	3	2	1	1	1	-	-
1972	3	2	2	0	1	2	-	2
Farmer User								
1971	-	3	-	-	-	-	-	-
1972	1	2	3	-	-	-	-	1

(T - Transplanted; D - Drilled)

In 1971 the rates applied were 1.12, 1.40, 1.68 and 2.24 kg, but in 1972 rates of 1.05, 1.40, 2.10 and 2.80 kg were used and at two sites on light soil a rate of 0.70 kg was included. Treatments were applied to drilled crops when the plants were at least 15 cm high with 4-5 true leaves. Those weeds present were at a range of stages. Applications to transplants were made when the plants became fully established, 2-4 weeks after planting, pre-emergence or early post-emergence of the weeds. An appropriate commercial herbicide at the recommended rate was used as a standard at each site.

Following treatments, weeds were assessed using either EWRC scores, quadrat counts or percentage cover at 14 days, and 4-6 weeks. With crops of longer duration a third assessment was made when plants were approaching maturity. EWRC scores were used throughout to record crop effect.

RESULTS

Weed Control

General weed control results and individual weed responses are set out in Tables 1 and 2. In general, treatments of cyanazine gave a performance superior to that of the standards, the 1.40 kg rate giving a mean weed control of 90% at 4-6 weeks after treatment.

Good control of most annual weeds was obtained whether the treatments were applied before weed emergence (transplant sites) or after weed emergence (drilled sites) but the stage of growth of certain weeds was important. 1.40 kg gave an outstanding control of Spergula arvensis and Senecio vulgaris (Table 2) and at those sites where applications were made to emerged young weeds it gave a markedly better control of Capsella bursa-pastoris and Matricaria spp. than the standard.

An excellent control of Polygonum persicaria was obtained up to the young plant stage and both Matricaria spp. and Chenopodium album were well controlled at the seedling stage. However, treatment was not so successful in those farmer user trials where applications had been made in an attempt to control larger weeds of these three species established within rows that had been inter-row cultivated. Poa annua and other annual grasses were well controlled in those trials where applications were made before weed emergence. Perennial weeds suffered only a slight check.

Table 1

General Weed Control at 4-6 weeks (percentage control)

Crop	Cauliflower					Calabrese		Cabbage									Brussels sprouts					
Trial No.	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18	19	20	21	
Treatments kg a.i./ha	T	T	D	D	D	D	D	D	D	D	D	D	T	T	T	T	T	T	T	T	D	Mean
Cyanazine @ 0.70	-	-	-	-	-	-	-	-	-	-	61	-	-	-	-	81	-	-	-	-	-	71
" 1.05) 1.12)	85	84	91	-	-	80	79	91	96	83	67	72	93	52	-	87	64	87	86	98	98	83
" 1.40	88	86	95	-	-	-	-	91	96	-	78	82	97	-	-	91	77	91	88	100	96	90
" 1.68	89	-	95	52	87	88	75	-	94	86	-	86	-	69	71	-	79	90	-	-	91	82
" 2.10) 2.24)	91	89	95	58	75	94	88	95	93	94	86	83	97	74	50	-	78	91	90	98	100	86
" 2.80	-	86	-	-	-	-	-	92	-	-	-	-	98	-	-	-	-	-	96	100	-	94
Desmetryne @ 0.42	-	-	-	73	46	66	50	76	96	49	47	88	-	73	72	99	-	-	-	57	57	68
Propachlor @ 4.50	79	58	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	68
Aziprotryne @ 2.24	-	-	-	-	-	-	-	-	97	60	-	-	74	-	-	-	40	58	80	100	73	73

T = Transplanted

D = Drilled

Table 2

Summary of the control of individual weed species with cyanazine at 1.40 kg.

Weed Species	No. of sites	Mean Control	Range of Control
Capsella bursa-pastoris	3	82	60-100
Chenopodium album	(3	91 pre-em.	83-96
	(4	70 post-em.	45-91
Diplotaxis muralis	1	97	-
Fumaria officinalis	1	86	-
Lamium purpureum	1	97	-
Matricaria spp.	6	81	40-100
Polygonum aviculare	(3	41 pre-em.	38-42
	(1	28 post-em.	-
Polygonum convolvulus	2	89	86-92
Polygonum persicaria	3	93	90-97
Poa annua	2	75	60-90
Spergula arvensis	1	100	-
Stellaria media	8	96	80-100
Solanum nigrum	2	88	81-95
Senecio vulgaris	5	100	99-100
Urtica urens	6	96	90-100
Veronica persica	3	88	64-100

Crop effect and yields

Crop effect scores are shown in Table 3 and yields in Table 4. In most of the trials there was an increasing crop effect with increase in rate. At 1.40 kg cabbage and Brussels sprouts were treated successfully on all sites except those on light sandy loams, (Trials 10, 11 and 19, with 80, 82 and 63% sand respectively). There was an adequate selectivity margin in transplants, but rates higher than 1.40 kg proved unacceptable on drilled sites (Fig 1) unless the crops were well beyond the 4-5 leaf stage on application (Trial 12). Except in one trial where treatments caused a slight check, crop effects from farmer-user applications were minimal, regardless of whether the crop was direct drilled or transplanted. In these instances drilled crops were well beyond the 4-5 leaf stage at application. Symptoms which took the form of chlorosis were consistently unacceptable at all rates on cauliflower, and resulted in a delay in maturity. Applications to calabrese (Trials 6 and 7) also proved unacceptable.

Table 4

Crop Yield as percentage Standard Control

Trial Number	(1.05 (1.12	1.40	1.68	(2.10 (2.24	2.80	Standard yield 000's kg/ha	L.S.D. at p = 0.05
			Cabbage (drilled)				
9	110	106	118	103	-	48	46
			Cabbage (transplanted)				
13	115	120	-	124	120	46.7	24
			Cauliflowers (transplanted)				
1	80	90	88	76	-	64.4	26
2	106	91	-	103	101	49.3	20

Table 3

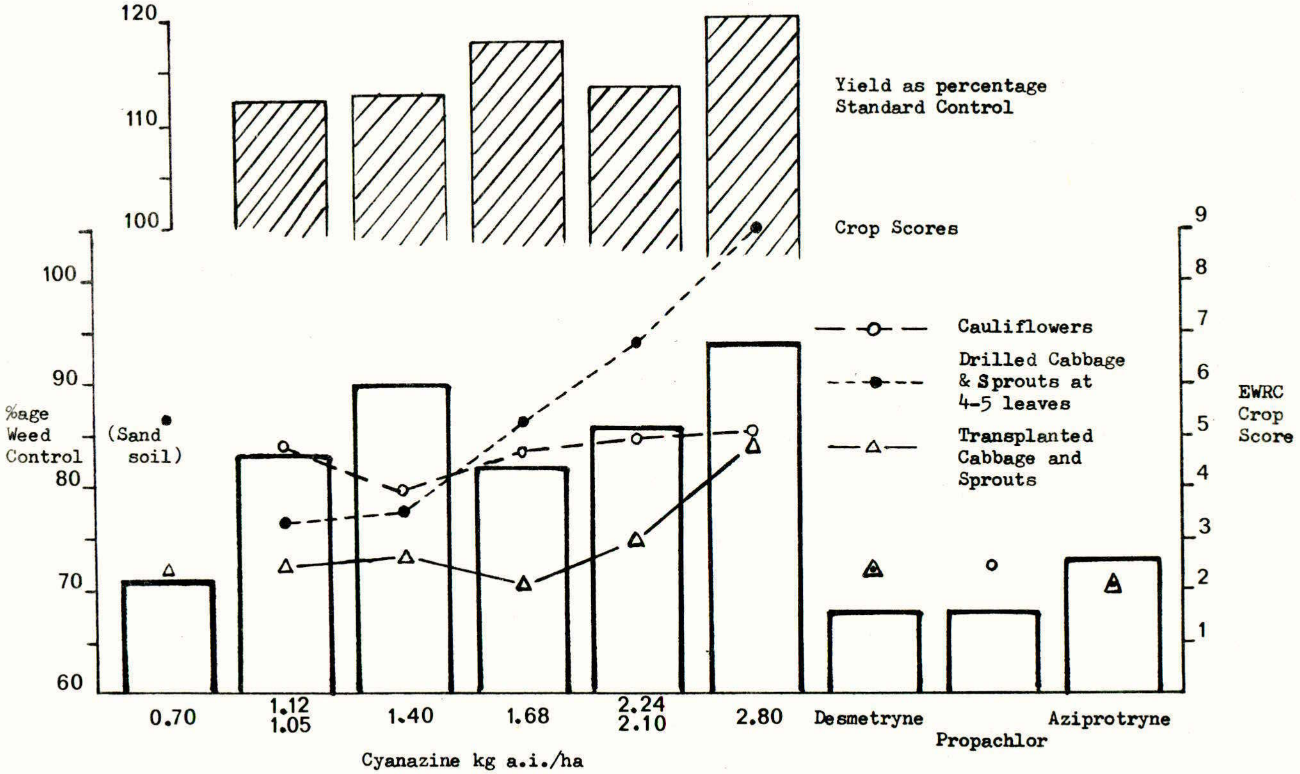
CROP EFFECT

EWRC Scale 1.0 = no damage 9.0 = complete crop kill

Crop	Cauliflower						Calabrese			Cabbage											Brussels sprouts					
Trial No.	1	2	3	4	5	M*	6	7	M*	8	9	10	11	12	M*	13	14	15	16	M*	17	18	19	20	M*	21
Treatments kg a.i./ha	T	T	D	D	D		D	D		D	D	D	D	D		T	T	T	T		T	T	T	T	D	
Cyanazine @ 0.70													5.3						2.3							
" 1.05) 1.12)	5.2	4.0	3.0			4.7	4.8	3.5	4.2	2.4	2.7	5.3	4.8	2.0	3.4	4.0	2.0		2.8	2.9	1.6	1.5	3.8	1.3	2.0	2.7
" 1.40	4.1	4.5	3.0			3.9				2.0	4.0		7.0	2.5	3.9	4.0			2.0	3.0	2.1	2.2	4.0	1.3	2.2	4.8
" 1.68	4.7		3.0	5.0	5.8	4.6	5.3	3.0	4.2		3.0	7.0		3.3	4.4		2.0	2.0		2.0	2.1	2.5			2.3	5.7
" 2.10) 2.24)	5.9	4.2	3.3	4.5	6.8	4.9	7.3	4.3	5.8	7.3	4.7	8.0	7.0	3.8	6.2	5.0	2.0	1.3	2.0	2.6	2.4	2.9	5.3	2.3	3.2	6.8
" 2.80		5.1								9.0						5.0							6.3	3.5	4.9	
Desmetryne @ 0.42				1.3	5.8	3.5	4.8	3.0	3.9	1.7	4.3	2.7	1.0	1.5	2.2		2.0	1.8	2.5	2.1						4.0
Propachlor @ 4.50	3.9	2.7	1.0			2.5																				
Aziprotryne @ 2.24											2.3	2.5			2.4	3.3					3.0	1.2	1.5	1.0	1.7	2.0
Soil Type (Bouyoucos)	SiL	SiL	L	-	SaCL		SaL	SaL		L	L	SaL	LSa	L		L	SaL	L	SaL		CL	SiCL	SaL	SiL		C

L = Loam	LSa = Loamy sand	SiL = Silty Loam	SaCL = Sandy clay loam
C = Clay	SaL = Sandy loam	SiCL = Silty clay loam	CL = Clay loam
M* = Mean	T = Transplanted	D = Drilled	

Figure 1 Cyanazine on Brassicas



DISCUSSION

Work during 1971 and 1972 showed that cyanazine provided a highly effective weed control together with a useful degree of selectivity in well established transplants (8 leaves) of cabbage and Brussels sprouts, where it compared very favourably with commercial standards, (Fig 1). Except on light sandy loams the optimum rate for good weed control consistent with crop safety was 1.4 kg. Any crop reaction was quickly outgrown with no effect on yields, which were equivalent or superior to those of the commercial comparisons. However, this rate was not well tolerated by cauliflowers.

At 1.4 kg there was an insufficient selectivity margin on drilled crops treated at the 4-5 leaf stage. However treatments applied at the 8 leaf stage of drilled cabbage at site 12, for the control of weeds within the row following tractor hoeing, indicated a greater selectivity margin and similar results were obtained in two farmer user trials. This suggests that selectivity to the crop is dependent on plant size as well as soil type and soil moisture content. Advantage could well be taken of this improvement of selectivity by employing cyanazine as a follow-up treatment after the breakdown of short persistence pre-emergence herbicides.

Applications made to young weeds show that herbicidal activity occurred in two main stages; contact action resulting in leaf scorch, followed by root uptake and subsequent death. The second stage depended on soil moisture and could be delayed by drought or cold conditions following application. Because of this contact action it was found necessary for the protective covering of the leaf in the crop to be well developed at spraying.

Spray volume between 280 and 560 l./ha had no noticeable influence on crop effect.

Acknowledgements

Thanks are due to those farmers who co-operated in providing trials facilities and to Shell Research Ltd., Sittingbourne, for the statistical analysis.

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PRE- AND POST-EMERGENCE WEED CONTROL IN DRILLED ONIONS

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Summary The results of trials carried out from 1969 - 72 show that pre-emergence application of paraquat at 0.5 lb + propachlor at 4.0 lb + chlorpropham at 1.0 lb gave good weed control until mid-July on fen soil. The substitution of prynachlor at 4.0 lb for propachlor at 4.0 lb in this programme resulted in improved weed control. Application of paraquat at 0.5 lb pre-emergence and prynachlor at 4.0 lb + chlorpropham at 6.0 lb at the loop stage of the crop gave good control of broadleaved weeds and potato volunteers until the end of July. Pre-emergence and loop-stage application of chlorpropham at doses up to 12.0 lb caused no crop damage. The use of synthetic oil as a carrier caused marked reduction in the selectivity of herbicides.

INTRODUCTION

Peat is regarded as an ideal medium for the growing of main crop onions but one of the major limiting production factors is the control of weeds. Onion seedlings emerge early in the season and make slow progress from spring to mid summer. The heavy weed flushes which occur on peat from April onwards can cause a serious reduction in the vigour of the crop and a programme for early weed control is essential. The onion crop with its upright growth habit provides poor ground cover even when the foliage is fully developed and the weeds which grow rapidly under the ideal growing conditions of late summer can cause a reduction in bulb yield, an increase in the incidence of botrytis and difficulty with harvesting. A comprehensive pre- and post-emergence programme is therefore necessary for the full control of weeds from crop emergence to harvest. This paper describes the results of a number of pre- and post-emergence trials conducted at Lullymore in 1969-72.

MATERIALS AND METHODS

All experiments were carried out at the Peatland Experimental Station, Lullymore on fen peat. A randomised block design with 4 - 6 replications and a standard plot size 5 yd x 2 yd was used. Herbicides were applied with a pressure retaining sprayer. In all trials, a volume of 40 - 50 gal/ac of water carrier was used. With some of the treatments in 1971 and 1972 a volume of 8 gal/ac TVO or 8 gal/ac of the more crop tolerant synthetic oil (No. 3408) was used as a carrier. All herbicide doses are given as lb/ac a.i. Assessment of weed and crop growth was made at least twice during the growing season. In 1969 - 71 weed kill was assessed by counting survivors in a number of random quadrats on each plot.

RESULTS

Pre-emergence application - 1969 At the time of herbicide application 1 - 2 onions per ft^2 had emerged in the crop rows. Paraquat at 0.5 lb was applied pre-emergence on all plots except controls. All treatments (Table 1) reduced crop stand and vigour. Aziprotryne at 2.0 lb caused the most severe crop injury. After eleven weeks onion plants had regained full vigour in all treatments. *Stellaria media* and *Rumex acetosella* were in the cotyledon - 2 true leaf stage and *Poa annua* was in the cotyledon stage at the time of herbicide application. *Polygonum persicaria* did not emerge until mid May, 10 days after weed density was recorded. Plots treated with aziprotryne at 2.0 lb were completely weed free two weeks after application but dense weed growth was present three weeks later. *P. persicaria*, *P. annua* and *R. acetosella* were growing vigorously in plots sprayed with propachlor at 5.2 lb ten weeks after application, but although some *S. media* had emerged its growth was severely suppressed. Propachlor at 5.2 lb + chlorpropham at 1.0 lb gave excellent weed control for 11 weeks.

Table 1

Effect of pre-emergence herbicides on crop and weeds 1969

Treatment	Dose lb/ac	Plant Stand % control	Assessments[1] Crop	27/5/69 Weeds	% weed kill 5/5/69 S.m.	R.a.	C.a.	Weed weight (all spp.) 8/7/69 (ton/ac)
* Aziprotryne	2.0	79	7.7	7.9	100	100	100	9.6
* Propachlor	5.2	76	8.2	9.4	100	100	100	3.4
* Propachlor + Chlorpropham	5.2	79	8.6	10.0	100	100	100	1.3
Control (handweeded)		100	10.0	0.0	0	0	0	-
S.E. of treatment mean		8.8						5.68
No. of weeds/ft^2 in control plots					22	15	5	

[1] Rating scales : Crop : 10 (no damage) - 0 (complete kill)
Weeds : 10 (no weeds) - 0 (dense cover of weeds)

* Paraquat 0.5 lb applied prior to emergence

S.m. = *Stellaria media*. R.a. = *Rumex acetosella*. C.a. = *Chenopodium album*

Pre-emergence application - 1970 The first of the two trials was conducted to determine the optimum doses of chlorpropham and propachlor for use in onions. Paraquat at 0.5 lb was sprayed on the trial area immediately before the treatments were applied. Normally propachlor is applied to peat soil at 5.2 lb and chlorpropham is applied at 1.0 lb. Pre-emergence application of propachlor at 4.0 lb + chlorpropham at 1.0 lb and 2.0 lb, and propachlor at 5.2 lb + chlorpropham at 1.0 and 2.0 lb were selective and gave equally good weed control.

In the second trial ioxynil octanoate was compared with paraquat as a contact pre-emergence spray treatment in onions. Barley in the 1 - 2 leaf stage provides very good wind protection for the onion crop at emergence but is suspectible to paraquat. The results of this trial shows that ioxynil octanoate used as a substitute for paraquat gives equally effective results without damage to the barley.

Pre-emergence application - 1971 Prynachlor, pronamide, high doses of chlorpropham and TVO as a carrier for propachlor and chlorpropham were compared with the standard treatment of paraquat at 0.5 lb + propachlor at 5.2 lb + chlorpropham at 1.0 lb. None of the herbicides applied caused crop damage (Table 2).

The weeds, mainly *Polygonum lapathifolium* and *Chenopodium ablum* were in the early cotyledon stage at the time of application. *Polygonum lapathifolium* was susceptible to all doses of chlorpropham, prynachlor and pronamide. Any remaining in plots treated with these herbicides were severely stunted and never made a full recovery, but this species shows a resistance to propachlor. The activity of pronamide at 2.0 lb and 6.0 lb was slow and many *P. lapathifolium* survived up to the 4th true leaf. Prynachlor at 5.2 lb and 10.4 lb and chlorpropham at 12.0 lb gave good control of *C. album.* Although the numbers of this weed were not greatly reduced by paraquat at 0.5 lb + propachlor at 5.2 lb + chlorpropham at 1.0 lb, propachlor at 5.2 lb + chlorpropham at 6.0 lb in TVO 8 gal and chlorpropham at 6.0 lb those surviving were severely stunted and did not cause a serious problem in the crop before harvest.

Table 2

The effect of pre-emergence herbicides on crop and weeds 1971

Treatment	Dose lb/ac	Plant Stand % control	Yield ton/ac	Assessments[1]		% weed kill		Wt. of potato shoots lb/plot
				Crop	Weeds	P.l.	C.a.	
Paraquat	0.5							
+								
Chlorpropham	1.0							
+								
Propachlor	5.2	103	37.4	10	9.3	93	67	5.6
Chlorpropham	6.0	97	33.2	10	9.5	86	67	4.5
"	12.0	101	39.7	10	9.3	100	86	2.0
Propachlor	5.2	93	27.3	10	6.3	36	42	8.8
Prynachlor	5.2	112	37.0	10	8.8	85	81	2.5
"	10.4	102	35.3	10	9.8	85	90	1.6
Propachlor	5.2							
+								
Chlorpropham	6.0	118	36.5	10	10.0	99	69	3.6
+								
TVO 8 gal								
Pronamide	2.0	109	35.7	10	6.5	87	0	10.6
"	6.0	97	N.R.	10	8.3	100	32	7.9
Control		100	23.0	10	3.3	0	0	11.6
S.E. of treatment mean		4.7	9.84					1.99
Weeds/ft^2 in control plots						6	2	

[1] Rating scale as in Table 1

N.R. = not recorded

P.l. = *P. lapathifolium*. C.a. = *Chenopodium album*

Pronamide at 2.0 lb and 6.0 lb gave poor control of *C. album* and propachlor at 5.2 lb gave poor control of both weed species. Potato volunteers are a serious weed problem in peat soil even following a severe winter. In 1970 potatoes were grown on the trial site. The herbicides were applied ten days before the potato shoots emerged. Prynachlor at 5.2 lb and 10.4 lb and chlorpropham at 12.0 lb severely inhibited shoot growth for eight weeks. Results are given in Table 2.

Pre-emergence application - 1972 The crop showed a high degree of tolerance to all herbicides. In 1972 the surface layer of the peat was removed during grading of the experimental site. Few weeds occurred and with the exception of *P. annua* were erratically distributed. As a result meaningful counts could not be recorded. Nevertheless, where control was poor those that did occur were vigorous enough to cause severe competition to the crop as bulbs were beginning to develop. Prynachlor at 4.0 lb + chlorpropham at 6.0 lb, prynachlor at 6.0 lb, propachlor at 4.0 lb + chlorpropham at 6.0 lb and dinitramine at 2.0 lb gave good weed control. These treatments caused severe stunting of *S. media*, *R. acetosella* and *P. persicaria*. Propachlor at 6.0 lb, prynachlor at 4.0 lb and pronamide at 2.0 lb were slightly less effective. Chlorpropham at 3.0 lb, 6.0 lb and 12.0 lb gave excellent control of *P. annua*, *P. persicaria* and *R. acetosella*. Although only a few *S. media* occurred these were large and vigorous in all plots treated with this material. Propachlor at 4.0 lb, and dinitramine at 1.0 lb gave poor weed control. The shoots of volunteer potatoes were beginning to emerge when the spraying was done. Prynachlor at 4.0 lb + chlorpropham at 6.0 lb, chlorpropham at 3.0 lb, 6.0 lb and 12.0 lb caused severe inhibition of potato shoot growth for seven weeks. Results are given in Table 3.

Table 3

The effect of pre-emergence herbicides on crop and weeds 1972

Treatment	Dose lb/ac	Plant Stand % control	Assessment[1] Weed	% weed kill P.a.	% weed kill Other spp.	% weed kill Potato
*Propachlor	4.0	100	8	76	40	14
"	6.0	111	6	79	39	16
*Prynachlor	4.0	89	6	71	58	48
"	6.0	111	5	67	78	36
*Prynachlor	4.0					
+						
Chlorpropham	6.0	77	4	78	74	89
*Propachlor	4.0					
+						
Chlorpropham	6.0	100	5	87	61	44
*Chlorpropham	3.0	89	8	79	35	82
"	6.0	111	7	92	21	74
"	12.0	89	6	53	61	55
*Pronamide	2.0	100	4	58	61	25
*Dinitramine	1.0	89	8	0	34	1
"	2.0	122	5		54	
Control		100	9	0	0	0
S.E. of treatment mean		14.6				
No. of weeds/ft^2 in control plots				2	3	20.5 lb

[1] Rating scale : - Crop : 1 (no damage) - 9 (complete kill)
Weeds : 1 (no weeds) - 9 (dense cover of weeds)

* paraquat applied pre-emergence

P.a. = *Poa annua*

Application at the loop stage 1971 - 72 In 1971, simazine at 2.0 lb and methazole (VCS 438) at 2.0 lb caused a severe reduction in crop stand and vigour. Simazine caused no crop damage in the 1972 trial. All other treatments showed high crop selectivity (Table 4). In 1972 weed density in the trial area was low. Weed distribution was very erratic and accurate recordings of weed species in the various treatments could not be obtained. Nevertheless, those weeds that did occur were vigorous enough to cause severe crop competition on plots with poor weed control.

Paraquat at 0.5 lb was applied pre-emergence and weeds had not emerged when the herbicides were applied at the loop stage. In 1971 chlorpropham at 6.0 lb and 12.0 lb, pronamide at 2.0 lb and 4.0 lb and propachlor 5.2 lb + chlorpropham at 6.0 lb gave excellent control of P. lapathifolium.

Table 4

Effect of application at the loop stage on weeds and crop - 1971-72

Treatment	Dose lb/ac	Plant Stand % control 1971	1972	Assessments[1] Crop 1971	Weed 1971	1972	% weed kill P.l.	C.a.	All species 1972
Propachlor	5.9	92	92	10.0	6.0	7.6	56	67	37
Prynachlor	4.4	N.A.	92	N.A.	N.A.	8.7	N.A.	N.A.	22
Chlorpropham	6.0	85	92	10.0	8.5	9.3	100	22	33
"	12.0	92	83	10.0	9.8	9.3	100	70	50
Simazine	2.0	68	83	10.0	8.0	8.3	76	89	47
Pronamide	2.0	111	100	10.0	7.5	8.5	93	20	47
"	4.0	90	72	10.0	8.5	9.5	99	42	50
Methazole	1.0	86	N.A.	10.0	7.3	N.A.	78	75	N.A.
"	2.0	63	N.A.	7.5	8.5	N.A.	82	64	N.A.
Prynachlor + Chlorpropham	4.4 6.0	N.A.	83	N.A.	N.A.	9.7	N.A.	N.A.	75
Propachlor + Chlorpropham	5.2 6.0	86	110	10.0	9.5	10.0	56	67	34
Control		100	100	10.0	5.3	2.9	0	0	0
S.E. of treatment mean		10.7	8.3						
No. of weeds/ft^2 in control plots							20	6	4

[1] Rating scale as in Table 1

P.l. = P.lapathifolium. C.a. = Chenopodium album

Simazine at 3.0 lb and methozole at 1.0 lb and 2.0 lb caused a severe inhibition in the growth of P. lapathifolium and C. album which was still evident ten weeks after application. Chlorpropham at 6.0 lb and 12.0 lb, pronamide at 4.0 lb and propachlor at 5.2 lb + chlorpropham at 6.0 lb caused a similar inhibition in C. album. Propachlor at 5.9 lb gave poor weed control. In a trial comparing the use of a pure synthetic oil carrier with water, chlorpropham at 3.0 lb and 6.0 lb, chlorpropham at 6.0 lb + propachlor at 5.2 lb and nitrofen at 0.5 and 1.0 lb were applied in 8 gal of the oil. All treatments caused severe crop damage. In 1972 all treatments except propachlor at 5.9 lb gave good weed control.

Application at 2 - 3 leaf stage 1972 Ioxynil octanoate at 0.63 lb, bentazon at 3.5 lb, cyanazine at 1.0 lb, propachlor at 4.0 lb + chlorpropham at 3.0 lb in oil, aziprotryne at 2.0 lb in oil and linuron at 0.5 lb + ioxynil at 0.5 lb caused severe crop injury but the crop had fully recovered after 6 weeks in all cases. Methazole at 2.0 lb, aziprotryne at 2.0 lb + simazine at 2.0 lb, dinitramine at 1.0 lb and 2.0 lb were highly selective. The trial area was sprayed with the standard propachlor/chlorpropham programme and few weeds were present when the treatments were applied. All treatments except aziprotryne at 2.0 lb in water gave good weed control. Results are given in Table 5.

Table 5

Effect of application on crop and weeds at the 2 leaf stage - 1972

			Assessment[1]			
Treatment	Dose lb/ac	Plant Stand % control	Crop 4/7	Crop 28/7	Weeds	% weed kill all species
Ioxynil octanoate	0.63	90	8	5	2	38
Methazole	2.0	110	3	2	2	38
Aziprotryne	2.0	100	2	2	7	10
Bentazon	3.5	90	8	7	3	44
Cyanazine	1.0	100	6	5	2	78
Aziprotryne	2.0	100	2	3	2	62
+						
Simazine						
Propachlor	4.0	100	8	6	1	80
+						
*Chlorpropham	3.0					
*Aziprotryne	2.0	100	6	5	5	34
Linuron	0.5					
+						
Ioxynil octanoate	0.5	90	8	4	2	62
Dinitramine	1.0	100	1	3	3	44
"	2.0	100	2	3	2	48
Control		100	2	1	8	0
S.E. of treatment mean		6.9				
No. of weeds/ft^2 in control plots						2

[1] Rating scale as in Table 3

* 3408 oil

DISCUSSION

The results of many trials carried out from 1969-72 have shown that with pre-emergence spraying, good weed control can be obtained until mid July. Application is made in April when the peat surface is usually moist and the residual activity of the propachlor/chlorpropham mixture is at a maximum. Weed emergence takes place well in advance of crop emergence and the inclusion of a contact herbicide is necessary to allow for flexibility in the time of application. The results indicate that the more selective ioxynil octanoate may be substituted for paraquat where barley is used for shelter in emerging onions. It was also shown that no increased benefit was gained from using propachlor at doses in excess of 4.0 lb.

Further weed seedlings begin to emerge in mid July as bulb formation is beginning. These weeds, in particular P. lapathifolium, P. persicaria, R. acetosella and P. annua are especially hazardous to the crop and create problems with harvesting. In 1971 the use of alternative materials to propachlor and the standard propachlor/chlorpropham mixture were investigated. Prynachlor at 5.2 lb applied pre-emergence showed excellent selectivity and gave better control than propachlor of all species except P. annua. An important factor adding to its overall usefulness is the ability of this material used alone or in combination with chlorpropham to inhibit the emergence of potato 'volunteers' thus allowing onions to be used in a cropping rotation immediately following potatoes.

One of the highlights of these trials is the remarkable tolerance of onions to high doses of chlorpropham applied pre-emergence or at the loop stage. These treatments gave excellent control of the Polygonaceae and Poa but their failure to arrest the vigour of some S. media which escaped control is a major drawback. Loop stage application of herbicides had the advantage of prolonging the period of control in 1971 and 1972 and pre-emergence application of paraquat followed by loop stage application of a prynachlor/chlorpropham mixture may be the answer to more lasting weed control. The use of synthetic oil as a carrier enhanced the herbicidal properties of the materials tested but severely reduced crop selectivity.

Of a number of herbicides tested, only methazole at 2.0 lb, aziprotryne at 2.0 lb + simazine at 2.0 lb and dinitramine at 2.0 lb provided the required standards of selectivity and weed control for application at the 2 true leaf stage.

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POST-EMERGENCE CONTROL OF WEEDS IN ONIONS WITH METHAZOLE

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Summary Methazole was tested in 1968 - 71 in both small plot and grower trials, and became commercially available in 1972, for the selective control of weeds post emergence in onions.

To prevent early weed competition a residual weedkiller, usually propachlor, was applied pre-emergence followed by methazole post emergence.

Results using rates of 2.0 to 2.2 kg/ha at or after the 2 true leaf stage of the onions, have been consistently satisfactory, giving no more than slight temporary yellowing of the crop and killing a wide range of weeds, in some species up to an advanced stage of growth. Control of Polygonum spp. Stellaria media and Chenopodium album has been good, and Veronica spp. (susceptible to propachlor) has been the only important resistant species.

The residual action of methazole has usually maintained good weed control until harvest. Winter wheat was grown satisfactorily on several sites after the onions were harvested.

INTRODUCTION

Methazole (VCS 438, 2- (3.4- dichlorophenyl) - 4-methyl- 1,2,4 - oxadiazolidine - 3,5, - dione) a product of the Velsicol Chemical Corporation, first showed promise for selective weed control in onions post emergence in a field screening experiment by Fisons Agrochemicals in 1968. Further field tests were carried out in 1969 and 1970, and grower trials in 1971 led to commercial marketing in 1972.

This report covers the above work.

MATERIALS AND METHODS

In field screening in 1968, 3 dosage rates of methazole were used on two replicates of plots 2 x 1.5 m (2 x 20 m for weeds) sprayed at 220 l/ha.

In three experiments on commercial crops in 1969 methazole was applied post-emergence at 2.2 kg/ha on plots of 15 m^2, using four replicates following the farmer's pre-emergence herbicide. Desmetryne was used as a standard.

In one experiment in 1970 methazole was applied at three dosage rates and at 3 growth stages, on 2 replicates of plots of 4 m^2 following propachlor. Ioxynil was used as a standard.

In 18 grower trials in 1971 plots of one acre were sprayed post-emergence by farmers with methazole at 2.1 kg/ha following pre-emergence treatment with propachlor, pyrazon/chlorbufam, chlorpropham or paraquat. The standard post-emergence treatments were propachlor, pyrazon/chlorbufam, ioxynil or ioxynil/linuron.

Methazole was used as a wettable powder in most experiments (Flocon suspension in 1969). Ioxynil was used as an ester in emulsifiable oil. Desmetryne was used as a wettable powder.

RESULTS

I. 1968 Field Screening Experiment

Onions: Variety Bedfordshire Champion, 2 true leaves, 12.5 cm.

Weeds: Up to 10 cm.

Table 1

Effect of Methazole on Onions and Weeds, 1968.

Methazole kg/ha	% crop reduction after 1 wk.	after 8 wks.	% Weed Control (after 8 weeks) Polygonum aviculare	Stellaria media	Chenopodium album	Veronica persica	All Species
4.5	30	0	100	100	100	20	90
2.2	10	0	90	90	95	0	75
1.1	0	0	75	75	85	0	50

II. 1969 Experiments on Farm Crops

Onions: Variety Produrijn. Sprayed at early post crook stage.

Table 2

Effect of Methazole (2.2 kg/ha) and Desmetryne (1.7 kg/ha) on Onions and Weeds, 1969.

Site	% Weed Cover after 5 - 8 wks.			% Crop Chlorosis (initial)		Onion Yield (% of Hand-Hoed)	
	Meth.	Des.	Hand.	Meth.	Des.	Meth.	Des.
A	41	32	67	18	4	-	-
B	-	-	-	11	9	95	82
C	10	17	22	7	6	270	183

At site A, the pre-emergence treatment with chlorpropham, on organic soil, was not very effective and failed to control Avena fatua, Polygonum convolvulus and P.persicaria, Chenopodium album, Tripleurospermum maritimum and Senecio vulgaris. On this site with Avena fatua, no post emergence treatment gave acceptable control and yields were not taken.

At site B, the pre-emergence treatment with propachlor, was effective, and in addition the crop was kept clean mechanically so that no results for weed control could be obtained.

At site C, the pre-emergence treatment was chlorbufam + pyrazon and species surviving this treatment were *Chenopodium album*, *Tripleurospermum maritimum*, *Polygonum aviculare* and *Senecio vulgaris*. It proved impossible to keep the hand-hoed plots clean.

In all experiments the level of initial crop chlorosis was commercially acceptable.

III. 1970 Growth Stage Experiment

Onions: Variety Bedfordshire Champion.

Pre-emergence treatment: Propachlor 4.5 kg/ha over the whole experiment.

Weeds: *Polygonum aviculare* dominant. Also *P. convolvulus*, *Chenopodium album*, *Tripleurospermum maritimum*, *Senecio vulgaris*, *Viola tricolor*, *Aethusa cynapium*.

Table 3

Effect of Methazole and Ioxynil on Onions and Weeds, Applied at 3 Growth Stages. Assessed Visually at Harvest.

	On Onions (% Reduction)						On Weeds (% Reduction)				
Stage	Methazole (kg/ha)			Ioxynil (kg/ha)		Stage	Methazole (kg/ha)			Ioxynil (kg/ha)	
	4.5	2.2	1.1	0.8	0.4	(P.aviculare)	4.5	2.2	1.1	0.8	0.4
Early crook	45	10	10	+	+	2.5 cm	100	100	87	+	+
2 lvs. 7.5 cm	25	0	0	+	0	7.5 cm	97	100	77	+	15
2½lvs. 18 cm	-	-	-	-	-	20-30 cm	90	82	70	25	0

+ = material not used
- = not assessable - damaged by weed competition before spraying.

IV. 1971 Grower Trials

a) Weed Control

Methazole has both contact and residual action. Excellent control was obtained on a wide range of annual broad leaved weeds. In some instances good control of large weeds was obtained within about 7 days after spraying e.g. fat hen up to 30 cm, chickweed up to 38 cm and annual nettle up to 30 cm. The effect was thought to be due mainly to the contact effect of the chemical perhaps accentuated by the warm weather experienced shortly after spraying.

The following table gives categories of weed control obtained.

Table 4

Weeds Controlled by Methazole

Susceptible

Anagallis arvensis
Atriplex patula
Capsella bursa-pastoris
Chenopodium album
Galeopsis tetrahit
Poa Annua
Polygonum aviculare
Polygonum convolvulus
Polygonum lapathifolium
Polygonum persicaria
Senecio vulgaris
Sinapis arvensis
Solanum nigrum
Sonchus oleraceus
Stellaria media
Urtica urens
Viola tricolor

Intermediate

Daucus carota
Silene alba
Plantago major
Tripleurospermum maritimum spp.
Inodorum

Resistant

Alopecurus myosuroides
Fumaria officinalis
Lamium purpureum
Veronica spp

The weed control by methazole was better and lasted longer than any of the standards used in these trials.

b) Effect on the Crop

In several trials the onions were damaged especially when they had only one true leaf. The young plants were either scorched or occasionally killed especially where they were growing on loamy sands or lighter soils. When the onions had 2 or more true leaves any scorch or check to the plants was much less severe and recovery took place within a few weeks.

c) Soil Persistance

As weeds were controlled in some trials for up to 14 weeks it was desirable to ascertain whether normal crops could be grown safely after an onion crop treated with methazole has been harvested. Soil samples were therefore taken from 6 trial sites in October after a May application of methazole. In the glasshouse there was no effect on the germination and growth of the test species - Amaranthus, clover, poppy, lettuce, ryegrass, mustard, wheat and sugar beet.

DISCUSSION

Effect on Onions

In the experiments reported, and in other trials, lasting crop toxicity has not occurred at a rate of 2.2 kg/ha so long as spraying was delayed until the crop had two true leaves. Table 3 shows that onions were affected even at 1.1 kg/ha when sprayed at an earlier stage.

When sprayed at the two true leaf stage visual and yield assessments (Tables 1 and 2 respectively) have shown that any temporary check is quickly outgrown.

Effect on weeds

The degree of weed control obtained both in these and in other experiments, in grower trials and in commercial use has been consistently good at a rate of 2.0 - 2.2 kg/ha in favourable conditions. Susceptible species, in some species up to 38 cm high have been controlled at these rates and the range of susceptible species is wide. Veronica spp, the most important species resistant to methazole (Table 1) are susceptible to propachlor applied pre-emergence.

Nevertheless the delay in spraying until the two true leaf stage of the onions, required for crop safety, together with the susceptibility of onions to weed competition in the early stages make the use of a pre-emergence chemical treatment necessary before post emergence treatment with methazole. The two spray programme adopted in most of these experiments has given good results in commercial practice in 1972.

Persistence

Tables 1 and 3 show that a high level of weed control was maintained until harvest. While the post emergence activity of methazole is partly based upon uptake through the foliage it is also active and persistent as a residual herbicide, thus preventing weed germination. Experiments and commercial practice have shown that on mineral soils weed control is reliably maintained for approximately 3 months after spraying.

Bioassays on treated soil after harvest showed that several crops could be safely grown. In practice the most likely crop after onions is winter wheat and this crop was grown without adverse effect on several of the grower trial sites.

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EXPERIMENTS WITH METHAZOLE ON ONIONS AND LEEKS

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Summary In 1970-71, methazole was examined in seven experiments with bulb onions, salad onions and drilled leeks as a post-emergence spray following pre-emergence treatment with propachlor + paraquat/diquat. Bulb onions and leeks were severely injured at early growth stages, but application of doses up to 2 lb/ac a.i. at the 2-leaf stage had no significant adverse effect. At this stage salad onions for over-wintering were injured, but slightly later application caused only transient injury. Control of most weed species was very good, and because of the considerable residual action, was more long-lasting than that given by ioxynil or ioxynil + linuron with which methazole was compared.

INTRODUCTION

It was shown by Griffiths & Baker (1970) that methazole (VCS-438) could provide selective control of weeds in bulb onions provided that application was delayed until the crop had reached the 2-leaf stage. This finding was substantiated in further experiments described by Edwards (1971) and Lake & Griffiths (1971). Methazole was included in seven experiments at Wellesbourne in 1970-71 with bulb onions, salad onions and drilled leeks as a follow-up to routine pre-emergence treatment, and the results obtained are summarised in this report.

METHODS AND MATERIALS

The experiments were of randomised block design, with plots of 5-10 yd^2 and three replicates. The soil was a sandy loam (2% o.m.), the treatments were applied as HV sprays, and doses are given as lb/ac a.i. The formulation of methazole used was a 75% wettable powder, and for comparison ioxynil octanoate (Totril) and ioxynil + linuron (Certrol-Lin) were included. In all experiments a uniform spray of propachlor 3.9 lb/ac, with or without paraquat/diquat 0.5 lb/ac was applied shortly before crop emergence and the post-emergence sprays applied as follow-up treatments at appropriate growth stages. Relative estimates of weed control and crop injury were made by visual scoring on a scale of 0 (no different from that with the pre-emergence treatment alone) to 10 (complete kill). Crop stands and total yields were recorded and are expressed as percentages of the values for hand-weeded controls. Those significantly less than the control values are indicated by single ($P = 0.05$) and double ($P = 0.01$) asterisks.

RESULTS

In 1970, methazole at 1.0 and 2.0 lb/ac was compared with other post-emergence treatments on bulb onions at the 2-3-leaf stage; in this experiment pyrazone 0.75 + chlorbufam 0.60 lb/ac had been applied post-crook, in addition to the standard pre-emergence spray.

Table 1

Effect of methazole on bulb onions and leeks in 1970

		Onions				Leeks			
Herbicide	lb/ac	Leaf No.	Weed control 0-10 at harvest	Stand %	Yield %	Leaf No.	Weed control 0-10 24 Jun	Stand %	Yield %
Methazole	1.0	2-3	8.8	98	108	2	9.3	96	93
"	2.0	2-3	9.5	91	103	2	9.5	97	106
Ioxynil	0.63	2-3	7.7	96	100	2	8.9	91	100
Ioxynil + linuron	0.25 + 0.25	2-3	7.7	95	95	2	9.2	100	100

The weed control was very good except for some plants of Fumaria officinalis, and at harvest the plots treated with methazole were cleaner than those of any other treatment. There was no visible crop injury, other than transient scorch with ioxynil, and the stands and yields of dry bulbs were not significantly different from those of the weeded control (Table 1).

The same treatments were also compared on drilled leeks, applied at the 2-leaf stage. Again, weed control was very good and the only weeds present on the methazole-treated plots by the end of June were occasional Fumaria officinalis and Polygonum aviculare. There was little visible crop injury, and stands and yields did not differ significantly from those of the weeded control (Table 1).

In an experiment on overwintered salad onions drilled in August, 1970, methazole was applied at the early 1-leaf and 2-3-leaf stages and compared with ioxynil and ioxynil + linuron at the 2-3-leaf stage. When applied early, methazole caused severe crop damage and both doses significantly reduced the stand (Table 2).

When applied at the later stage, none of the treatments caused other than slight damage, and neither stand nor yield was reduced. The main survivors of the pre-emergence treatment were Stellaria media and Thlaspi arvense, with some Capsella bursa-pastoris, and these were killed by all the post-emergence treatments. Further emergence of seedlings occurred during autumn; these were killed on the methazole-treated plots, so that by the following April the plots were still clean except for a few Poa annua, Matricaria spp. and Fumaria officinalis. The control of weeds withioxynil + linuron was initially good, but less persistent than that with methazole, while on the ioxynil plots there was extensive development of Stellaria media during winter.

In 1971, methazole at a single dose of 1.87 lb/ac was included in four experiments with the main object of determining the effect on the crop when applied at different growth stages.

Table 2

Effect of methazole on overwintered salad onions in 1970

Herbicide	lb/ac	Leaf number	Weed control 0-10		Crop injury 0-10	Stand %	Yield %
			25 Nov	13 Apr	25 Nov		
Methazole	1.0	1	9.7	9.3	4.3	64**	86
"	2.0	1	10	9.8	6.7	22**	27**
Methazole	1.0	2-3	8.0	8.3	1.7	107	123
"	2.0	2-3	9.5	9.2	2.0	114	127
Ioxynil	0.63	2-3	6.7	4.3	1.3	102	106
Ioxynil + linuron	0.25 + 0.25	2-3	8.7	6.3	1.7	108	109

In two experiments with bulb onions, methazole caused some visible injury when applied at the 1-leaf stage, and in one of them significantly reduced both stand and yield (Table 3).

Table 3

Effect of methazole on bulb onions, leeks and overwintered salad onions in 1971

Herbicide	lb/ac	Leaf number	Bulb onions Exp. 1		Bulb onions Exp. 2		Leeks		Salad Onions	
			Stand %	Yield %	Stand %	Yield %	Stand %	Yield %	Stand %	Yield %
Methazole	1.87	1	91	90	77**	82*	63**	82	79*	91
"	1.87	2	98	109	102	100	103	109	58**	74*
"	1.87	2½	92	110	99	91	90	87	107	111
"	1.87	3	98	110	108	101	99	88	114	108
Ioxynil	0.63	3	106	109	97	95	107	106	96	86
Ioxynil + linuron	0.25 + 0.25	2½	108	104	101	96	96	108	81*	91

At the later stages, the damage was only slight, comparable with that produced by ioxynil and ioxynil + linuron, and there was no significant reduction in either stand or yield. In both experiments, the pre-emergence treatment of propachlor + paraquat/diquat was very effective, but emergence of Fumaria officinalis occurred with that of the crop a few days after application. Methazole did not control this species, and the plants were later removed by hand from these plots. Otherwise, the control of weeds was excellent.

Duplicate samples of bulbs from plots which had been treated with methazole at the 2-leaf stage and from the control plots of each experiment were placed in nets and kept in a bulk store until February, when their condition was assessed. There was no significant difference in the mean numbers of sound, unsprouted bulbs, the values being 73% for the methazole treatment and 79% for the control.

The results obtained with drilled leeks were similar to those for onions (Table 3). When applied at the 1-leaf stage, methazole caused a significant reduction in stand, but at later stages there was only transient injury, with no significant effect on stand or yield.

In an experiment on salad onions drilled in August for overwintering, methazole significantly reduced crop stand when applied either at the 1-leaf or 2-leaf stages, and the injury was greater at the 2-leaf stage, leading to significant yield depression. Treatment at the 2½-leaf stage, however, caused only slight injury and did not affect stand or yield.

DISCUSSION

The results obtained with bulb onions support the findings of Griffiths & Baker (1970) in showing that provided the crop had reached the 2-leaf stage methazole applied at doses up to 2 lb/ac caused no significant injury. In the single test which was made, there appeared to be no adverse effect of treatment on the behaviour of the bulbs in storage. The two experiments with leeks (Tables 1 and 3) indicated a degree of tolerance similar to that with onions, and again when applied at the 2-leaf stage or later, methazole had no permanently injurious effects.

The results with salad onions drilled in late summer for overwintering were rather less clear-cut. When applied at the early 1-leaf stage in 1970, there was severe crop injury, but no effect on stand or yield when application was delayed until the 2-3-leaf stage (Table 2). In 1971, application at the 1-leaf stage significantly reduced the stand, whereas at the 2½-leaf stage there was again no injury (Table 3). Plants sprayed at the 2-leaf stage, however, were damaged more than those treated earlier, and it seems that this was associated with a rainy period which occurred at this time.

In respect of weed control, methazole consistently performed as well or better than the other herbicides included in the experiments. As pointed out by Griffiths & Baker (1970), methazole is effective by foliar uptake and can kill quite large plants of a wide range of weed species, including some like Polygonum aviculare and Poa annua which can be a problem in onions and leeks. In the present experiments the ability to kill plants of P. aviculare which had escaped the pre-emergence propachlor treatment was outstanding; such control cannot be achieved with any other post-emergence herbicide currently available for use on onions. Fumaria officinalis, however, which is also tolerant to propachlor, was not killed by methazole in these experiments.

Besides foliar action, methazole is persistent in the soil so that on mineral soils there is an extensive period of residual weed control, sometimes up to 14 weeks (Edwards, 1971). This long-lasting control was apparent in the present experiments. It is possible, however, that in some circumstances the soil residues could prove a problem in relation to following crops. Preliminary tests have shown that when applied to bulb onions at the 2-leaf stage, up to 40% of the amount applied could still be detected by bioassay at onion harvest (Roberts & Bond, 1972); these tests are being continued.

Acknowledgments

We are grateful to Velsicol Chemical Corporation for samples of methazole and to Miss M.E. Ricketts for assistance.

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PROPERTIES OF METHAZOLE (VCS-438) FOR DEVELOPMENT AS A SELECTIVE HERBICIDE IN AGRICULTURE

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Summary Methazole and bioxone are the approved common names for 2-(3',4' - dichlorophenyl)-4-methyl-1,2,4-oxadiazolidine -3,5-dione, known also as VCS-438.

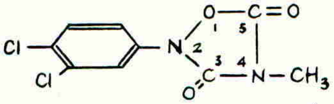
Methazole exhibits residual activity as a soil applied herbicide and contact activity upon the foliage of certain plants.

On medium loam soil, when applied pre-emergence at 2 kg a.i./ha, methazole provides good control over Capsella bursa-pastoris, Chenopodium album, Matricaria spp, Polygonum spp, Solanum nigrum, Thlaspi arvense, Urtica urens and many other annual weeds: at slightly increased rates, applied post-emergence at the 4-6 leaf stage, a similar range of weeds is susceptible. Poa annua and Veronica spp. beyond the seedling stage are not readily controlled.

Onion is one of several crops tolerant to methazole at rates up to 4 kg a.i./ha applied pre-emergence or, especially, post-emergence after the 2-leaf stage. Other crops on which methazole may be used selectively include garlic, leek, potato, cereals, maize, sorghum, cotton, deciduous fruits, citrus, lucerne, vines.

INTRODUCTION

During the period 1964-1966 many substituted oxadiazolidines were synthesised and screened in respect of herbicidal activity. One of those which seemed highly selective on many desirable crops was 2-(3',4'-dichlorophenyl)-4-methyl - 1,2,4-oxadiazolidine-3,5-dione.



Under the slightly different nomenclature 2-(3',4'-dichlorophenyl)-4-methyl-3,5-diketo-1,2,4-oxadiazole this same compound was described by one of us (Furness, 1970) with the purpose of introducing its characteristics for development as a herbicide in various crops. Second and third papers (Furness,1971; a,b) described in detail the researches which have brought methazole into commercial use for selective weed control in onion, and a fourth paper (Furness,1972) outlining recent investigations on many crops has since been published.

In this report the technical grade 2-(3',4'-dichlorophenyl)-4-methyl-1,2,4-oxadiazolidine-3,5-dione is conveniently designated by Velsicol code VCS-438. The American National Standards Institute has recently approved the common name methazole to designate this compound in its pure state. The approved WSSA common name is bioxone. Trade marks include Probe (Velsicol Chemical Corporation), and Paxilon (Fisons) for the 75% wettable powder. Methazole can be prepared, for example, from 1-methyl-3-(3',4'-dichlorophenyl)-3-hydroxyurea by cyclisation with an alkyl chloroformate or with methyl isocyanate (Velsicol, 1966).

The pure compound is crystalline and of melting point 124°C. Its solubility in water is believed to be between 1 and 2 ppm, and the solution is basic. Accordingly, it is adsorbed by soil, the capacity for and tenacity of adsorption being much greater upon soils of high organic content than upon medium loam or sandy soils. From experiments by Dr. E. Bosch (1970) there is evidence that its partial vapour pressure at 25°C is too small to enable methazole to exert any appreciable herbicidal activity through the vapour phase even upon such sensitive plants as lettuce. Other researches show that the activity of methazole is manifest in two distinct ways:

(a) by desorption from soil particles and so by diffusion through the aqueous phase of the soil towards plant roots,

(b) by direct contact with foliage.

In connection with (a) it follows that availability of methazole and its degradation products for herbicidal activity in the soil cannot ever be directly proportional to the applied dosage, and that much greater dosages will be required on organic soils than on light soils to achieve comparable instantaneous residual activity. It also follows that activity is greater in a moist soil than in the same soil when dry, that plants whose roots are near the surface will be more susceptible than plants even of the same species having deeper roots. Accordingly, in testing the selectivity of methazole as between plants of different species we have to bear in mind not only dosage and soil type, but also rainfall and irrigation, depth of root formation, precision of drilling. In connection with (b), possibilities for control of deep rooted perennial weeds will be dependent much more upon contact of methazole with foliage than upon residual activity in the soil.

For a compound of such slight aqueous solubility whose performance is so dependent upon its adsorption and desorption from particles of soil, it follows also that its most reliable performance in terms of selectivity will be realised when it can be adsorbed most uniformly upon the uppermost layers of soil. Two factors which contribute directly towards this ideal are:

(i) application of methazole in the most finely-divided state, preferably as emulsifiable concentrate

(ii) application of methazole to a soil surface which is already uniformly moist.

However, as we shall show, there are significant differences between the ideal and the practicable performance.

The toxicology of methazole is currently under study, and the following data are now available:

Acute oral toxicity LD_{50} of technical methazole (94% purity)

To albino rats	1350 ±194 mg/kg

Acute toxicology of methazole 75% wettable powder

Acute oral LD_{50} to albino rats	1769 ±377 mg/kg
Acute dermal LD_{50} to albino rabbits	greater than 10200 mg/kg
Acute aerosol inhalation LC_{50} (4 hours exposure)	greater than 0.053 mg/litre

Chronic toxicology

Ninety-day feeding studies with diets containing up to 500 ppm methazole have been completed in the rat and dog; there were no significant gross nor histopathologic changes.

When it is used in agriculture, methazole seems to be completely metabolised in plants, the principal plant metabolites being N-dichlorophenyl urea and N-dichlorophenyl-N'-methyl urea. Now in progress are many other metabolic studies which are essential to the continuing toxicological research.

METHOD AND MATERIALS

The low solubilities of methazole in those cheap solvents which are commonly available for the formulation of herbicides limit the concentration in emulsifiable and dispersible solutions to about 120 grams per litre. An emulsifiable formulation is technically ideal for enabling such an active ingredient to become uniformly adsorbed upon the surface of seed beds of finely-divided even tilth and, in fact, emulsifiable concentrates of methazole served well in early screening and field trials; however, the maximum concentration of methazole was too small for economic commercial use. A granular formulation containing 5% of methazole is available for tests; but there is evidence that the granular formulation does not facilitate a distribution of methazole which is sufficiently uniform even in the most carefully prepared seed bed.

For these reasons the greater part of our effort has been devoted to the technical and field development of a wettable powder containing 75% of methazole. The preparation of this formulation in a very finely divided state and the incorporation of carefully chosen surfactants enables the active ingredient to be well dispersed in the water of the spraying tank, hence distributed evenly over the surface of a seed bed. If that seed bed has been previously moistened by rainfall or by irrigation, the methazole dissolves and quickly becomes adsorbed uniformly upon the soil. Thereafter, so long as the soil surface is not disturbed, this technique provides in the uppermost layer of soil a reservoir of methazole which is available for residual herbicidal action whenever the soil is moistened naturally by rain and dew or at will by irrigation.

RESULTS

On moist medium loam soil the following species of weeds are susceptible to pre-emergence applications of methazole at 2 kg active per ha.

Aethusa cynapium
Alchemilla arvensis
Alopercurus myosuroides
Amaranthus spp
Anagallis arvensis
Atriplex patula
Capsella bursa-pastoris
Centaurea cyanus
Chenopodium album
Chrozophora plicata
Convolvulus arvensis
Daucus carota
Fumaria officinalis
Galeopsis tetrahit
Galinsoga parviflora
*_Galium aparine_
Lamium purpureum
Malva spp
Matricaria spp
Medicago hispida
Melilotus indicus
Mercurialis annua
Phytolacca spp
Plantago major
*_Poa annua_
Polygonum aviculare
Polygonum convolvulus
Polygonum persicaria
Portulaca spp
Raphanus raphanistrum
Senecio vulgaris
Silene alba
Sinapis arvensis
Solanum nigrum
Sonchus oleraceus
Spergula arvensis
Stachys spp
Stellaria media
Thlaspi arvense
Tripleurospermum maritimum
spp _inodorum_
Urtica urens
*_Veronica arvensis_
Viola spp

* susceptible only in young seedling stage

Post-emergence also, at the stage 4-6 leaves, most of the foregoing species (excepting those marked *) are susceptible to methazole when applied at 2-3 kg a.i./ha. Phytotoxic effects are then due to a combination of contact action on emerged leaves and of residual action through the soil; however, for effective control of perennial weeds (especially those having deep or extensive rhizomes) contact action is of much the greater importance.

Among the crops on which methazole can provide selective weed control, by application either pre- or post-emergence of the crop, are onion, garlic, leek, potato, cereals, maize, sorghum, cotton, deciduous fruits, citrus, lucerne, and vines. Details are presented in the Proceedings of the Sixth International Velsicol Symposium (1972); whereas in this paper we are to confine our attention to the onion crop.

DISCUSSION

When bulb onion is grown from seed in organic loam soil methazole e.c. can be used as a pre-emergence herbicide. In this case it is essential that the seed bed shall be carefully prepared so as to be uniform in composition and evenly of fine moist tilth. The seed, for example of Rijnsburger type, is drilled at depth 1.5 cm, the soil is lightly compressed over the seed and within 4 or 5 days, while the soil is still thoroughly moist, methazole formulated as emulsifiable concentrate is sprayed at 2-5 kg a.i./ha. In England the seeding and spraying of methazole are usually in the second half of April; after 3 months the degree of control over broad leaf weeds may be expected to be 75% when the dosage rate is 2 kg a.i./ha or 95% if the higher rate 5 kg a.i./ha has been employed. In England and in Europe the onion crop offers little competition to annual weeds, and so the vigour of the crop is always greatly improved by the action of the methazole, although at 5 kg a.i./ha the crop may suffer slight phytotoxicity and the plants might be reduced in number for example by 10%.

It is important to notice that methazole in its formulation as 75% wettable powder may not always be safely and effectively substituted for the emulsifiable concentrate in the foregoing pre-emergence application.

At the moment of its emergence through the soil, and through the stages of growth known as the crook stage up to the first true leaf, onion is highly susceptible to fresh applications of methazole; the crop might suffer between 50% and 100% of damage if methazole were applied, for example at 2-4 kg a.i./ha, at these stages. However, from the stage of two true leaves, most varieties of bulb onion suffer no significant damage by the application of methazole as 75% wettable powder within the range 2-4 kg a.i./ha. This discovery can be traced back through the work of Griffiths and Baker (1970) to Baker and Pfeiffer (1969).

In many countries, it is highly desirable to protect the onion crop as from the date of seeding. Pre-emergence treatment with chlorpropham, propachlor, or chlorbufam with pyrazon, already in commercial use for several years, can provide weed control which is effective up to or just later than the moment of emergence. From this moment onwards, it is desirable to make use of a post-emergence technique for weed control; accordingly, the treatment with methazole as from the two-leaf stage of the onion can follow the aforementioned pre-emergence herbicides.

During the 1972 season, for commercial use in England and some European countries on the varieties Rijnsburger, Primadora, Produrijn, Bedfordshire Champion and others, the recommended post-emergence dosage on mineral soils of low organic content is 2 kg a.i./ha. In experimental work in Italy a similar procedure has been found safe on the varieties Dorata di Bologna and Dorata di Parma; but the varieties Precocissima and Americana were susceptible to damage by post-emergence applications of methazole, whereas pre-emergence treatments with methazole at 2 kg a.i./ha were found safe (Kovàcs 1972).

Methazole may be used for the protection of onion seedlings which are transplanted as in the practices of Upper Egypt and of Sudan. Seedlings at the two-to three-leaf stage can be transplanted directly into a bed whose surface has been sprayed just previously with methazole at 2-4 kg a.i./ha; alternatively, the transplants already in their new bed can be sprayed after the two-leaf stage at 2-4 kg a.i./ha.

Zahran et al. (1971) showed how methazole may be used in association with chlorthal, fluorodifen, noruron, nitrofen, between 4 and 18 days after the date of transplanting. In an extended series of tests, they showed that the greatest yield of onion bulbs followed the use of a methazole/chlorthal combination.

Recommendations for the use of methazole for weed control in onion, with descriptions of the supporting experimental work have been collected in a series of five papers by Edwards, by Lake and Griffiths, by Kovàcs et al., by Zahran et al., and by Furness. All these papers were presented to the Fifth International Velsicol Symposium (1971). There is also a later paper by Furness (1971; b) of which the text is in French.

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CONTROL OF COMPOSITAE WEED SPECIES IN TRANSPLANTED LETTUCE

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Summary Results are presented which indicated good tolerance by transplanted lettuce (cv Suzan) to pre-planting applications of pronamide 1.0 lb/ac, chloroxuron 5.0 lb/ac and prometryne 1.0 lb/ a.i./ac. The weed spectrum of chloroxuron and prometryne can effectively be widened by addition of 0.5 lb/ac pronamide, while crop tolerance remains good for the mixtures. Trifluralin at 1.0 and 2.0 lb/ac also appears to be safe in transplanted lettuce.

High residual herbicide soil activity (31 - 43%) at harvest indicates that extreme caution is necessary in the selection of a crop to follow lettuce which were treated with the herbicides mentioned.

INTRODUCTION

The introduction of pronamide for weed control in lettuce represented a significant improvement over earlier methods. Pronamide possesses a wider weed spectrum than the previously used chlorpropham and was seen to be particularly suitable for the control of grass weeds. Crop tolerance is also good. However in spite of its many advantages, pronamide has disadvantages in that it fails to control certain weed species such as Senecio vulgaris and Capsella bursa-pastoris (Uprichard and Allott, 1970). Roberts and Hewson (1970) found that pronamide did not control Anagallis arvensis and, that under warm dry summer conditions its effectiveness was seriously reduced.

Uprichard and Allott (1970) reported good tolerance of chloroxuron and prometryne by transplanted lettuce. Both these herbicides control the resistant weeds just mentioned and they are also less likely to be influenced by soil temperature.

Experiments were designed to study the effectiveness and safety with which chloroxuron and prometryne could be used in transplanted lettuce. The use of trifluralin in lettuce was also thought to merit investigation, it being effective under dry soil conditions.

MATERIALS AND METHODS

Experiments were conducted on a medium loam soil using transplanted lettuce (cv. Suzan). Experiment 1 was designed as a split plot with 4 replicates of the main plot treatments. Herbicide treatments formed the main plots and these were divided into 2 sub-plots to accommodate the pre and post-planting applications. Experiment 2 was unreplicated with 9 treatments in a simple randomised design. Herbicides were applied either pre-planting or 9 days later (post-planting) using an Oxford precision sprayer and a spray volume of 50 gal/ac. All herbicide doses refer to active ingredient. The lettuce were planted on a 9 in. spacing with 7 rows on a 72 in. wide bed. Standard fertilizer, pest and disease control recommendations were used throughout. At harvest total number of plants and their weight in lb was recorded from the 5 centre rows of each sub-plot. A double row of lettuce was left as guard plants between adjacent sub-plots. Weed and crop vigour scores were made on a 0 - 5 scale; for weeds 0 = no weeds, 5 = weeds dominant and for crop vigour 0 = complete death of all plants, 5 = no visible crop injury with healthy vigorous growth.

Soil samples were taken at 0 - 2 in. depth from Experiment 1 at harvest and after air drying residual herbicide potency was measured using the bioassay technique of Allott and O'Neill (1970). These authors suggested lettuce seedlings as the most reliable test species, but for obvious reasons lettuce could not be used in this case. Pre-germinated oats (cv. Stormont Zephyr) were used to measure residual potency.

RESULTS

Experiment 1

This experiment was planted on 19 April 1972 and the post-planting treatments applied overhead on 3 May. Trifluralin was applied at 2 rates pre-planting and incorporated according to the manufacturer's recommendation. The crop was harvested on 20 June and yield results (lb/plant) along with weed and crop vigour scores are presented in Table 1.

From Table 1 it can be seen that no significant differences occurred between pre-planting treatments. Prometryne, pronamide + prometryne and pronamide + chloroxuron (1.0 + 5.0 lb/ac) caused significant yield reductions ($P < 0.01$) when used post-planting. Post-planting applications of chloroxuron alone and the mixture of pronamide + chloroxuron (0.5 + 2.5 lb/ac), did not significantly affect crop yield when compared with pronamide alone. Neither rate of trifluralin had any adverse effect on crop yield.

Pronamide alone, chloroxuron alone and mixtures of these herbicides, gave the most satisfactory overall weed control. The main weeds on the site were Senecio vulgaris, Capsella bursa-pastoris, Veronica persica and Poa annua.

Table 1

Effect on weeds, crop vigour and yield at harvest of herbicides applied to transplanted lettuce

Herbicide applied	Total weed score 21.6.72		Crop vigour score 30.5.72		Crop yield lb/plant 20.6.72	
	Pre-planting	Post-planting	Pre-planting	Post-planting	Pre-planting	Post-planting
1. Pronamide (1.0 lb/ac)	1.33	1.33	5.00	5.00	0.56	0.67
2. Chloroxuron (5.0 lb/ac)	1.00	1.00	5.00	3.33	0.68	0.60
3. Prometryne (1.0 lb/ac)	2.00	1.67	5.00	1.00	0.66	0.16
4. Pronamide + chloroxuron (0.5 + 2.5 lb/ac)	1.00	1.00	5.00	4.00	0.69	0.58
5. Pronamide + chloroxuron (1.0 + 5.0 lb/ac)	0.67	1.00	4.67	3.33	0.61	0.47
6. Pronamide + prometryne (0.5 + 0.5 lb/ac)	1.67	2.33	4.67	1.00	0.66	0.18
7. Pronamide + prometryne (1.0 + 1.0 lb/ac)	1.33	1.67	4.33	0.67	0.63	0.08
S.E. of a difference	-	-	-	-	0.093	
Variance within treatment means	-	-	-	-	**	
Additional (pre-planting)						
Trifluralin (1.0 lb/ac)	1.67		4.67		0.55	
Trifluralin (2.0 lb/ac)	2.00		4.67		0.55	

Experiment 2

This experiment was planted on 19 April 1972 and the post-planting treatments applied overhead on 3 May. The crop was harvested on 20 June and yield results (lb/plant) along with crop vigour scores are presented in Table 2.

Table 2

Tolerance of transplanted lettuce (cv. Suzan) to a range of herbicide doses

			Crop vigour score 30.5.72		Crop yield lb/plant 20.6.72	
Herbicide applied			Pre-planting	Post-planting	Pre-planting	Post-planting
1.	Pronamide	1.0 lb/ac	5.00	5.00	0.52	0.46
2.	Chloroxuron	5.0 lb/ac	5.00	4.00	0.49	0.44
3.	Chloroxuron	7.5 lb/ac	5.00	3.00	0.47	0.31
4.	Chloroxuron	10.0 lb/ac	4.00	3.00	0.35	0.38
5.	Chloroxuron	15.0 lb/ac	5.00	2.00	0.38	0.26
6.	Prometryne	1.0 lb/ac	5.00	2.00	0.49	0.09
7.	Prometryne	1.5 lb/ac	5.00	2.00	0.37	0.10
8.	Prometryne	2.0 lb/ac	4.00	1.00	0.35	0.00
9.	Prometryne	3.0 lb/ac	3.00	0.00	0.40	0.00

Yield results in Table 2 indicate that transplanted lettuce will tolerate up to 7.5 lb/ac of chloroxuron applied pre-planting, without any significant yield reduction. However a similar rate applied post-planting would cause crop damage. Tolerance of lettuce to pre-planting prometryne applications is very limited - rates above 1.0 lb/ac caused a reduction in yield.

Experiment 3

Soil samples from Experiment 1 were taken (0 - 2 in.) immediately after harvest and these were air dried for bioassay measurement of residual herbicide potency. Bioassay results were calculated using statistical analysis of the parallel line assay type and estimates of herbicide residual potency obtained by computing the relative responses of test and standard soils until a concentration was found which gave a similar response in both. The percentage residual potency indicating the amount of herbicide activity present in the soil at harvest, is given in Table 3.

The results in Table 3 represent the amount of herbicide activity in soil 9 weeks after application to a lettuce crop. Except for Treatment 4, all herbicides showed a residual activity in the range 31 - 43%. Unfortunately no estimate for pronamide alone is available. However it is interesting to note that Roberts and Hewson (1970) reported a 40% residual potency for pronamide following a lettuce crop.

Table 3

% Residual potency at harvest for herbicides used in Experiment 1

	Herbicide	Rate lb/ac	% Residual potency 20.6.72
1.	Pronamide	1.0	*
2.	Chloroxuron	5.0	36.9
3.	Prometryne	1.0	43.3
4.	Pronamide + chloroxuron	0.5 2.5	21.3
5.	Pronamide + chloroxuron	1.0 5.0	40.7
6.	Pronamide + prometryne	0.5 0.5	41.4
7.	Pronamide + prometryne	1.0 1.0	42.1
8.	Trifluralin	1.0	31.6

*The figure for pronamide is not available.

DISCUSSION

These experiments clearly demonstrate a definite tolerance by transplanted lettuce to normal rates of chloroxuron and prometryne. However, Experiment 2 would suggest that lettuce are more tolerant of chloroxuron than of prometryne. Due to its contact action prometryne caused severe damage when used post-planting. Chloroxuron on the other hand can safely be applied post-planting, although from Tables 1 and 2 there is a noticeable tendency for the pre-planting applications to result in a higher weight per plant at harvest. Previous work (Watkinson, 1969) suggested that when applied post-planting, chloroxuron might cause a slight but acceptable amount of initial crop damage in lettuce. However, the results presented in this paper indicate that pre-planting applications of both chloroxuron and prometryne are perfectly safe and that no crop damage will result.

The use of either chloroxuron or prometryne in lettuce would enable troublesome weeds such as _Capsella bursa-pastoris_, _Senecio vulgaris_ or _Anagallis arvensis_, to be easily controlled. While chloroxuron will not control _Poa annua_, addition of pronamide at 0.5 lb/ac, would give supression of this weed. In addition to controlling the compositae weed species mentioned above, prometryne will also control _Veronica_ and mayweed spp., while addition of pronamide 0.5 lb/ac would give improved control of grass weeds. While the tolerance of transplanted lettuce to trifluralin seems good, this herbicide's inability to control compositae species would seem to limit its use in this crop to situations where dry soil conditions are encountered and where irrigation is not practiced.

High residual herbicide potency values experienced after harvesting lettuce is not a new phenomenon (Roberts and Hewson, 1970). However this undoubtedly results not from the particularly persistent nature of the chemical used, but from the short term nature of the crop (9 weeks from planting to harvest). Growers who are aware of this situation and who follow lettuce with a tolerant crop, can avoid the unnecessary loss of income that might otherwise result.

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