runners were removed by hand at frequent intervals. Under these conditions a slight reduction in yield after treatment with maleic hydrazide may be more than balanced by the saving in labour for hand or mechanical removal of runners. To be of any practical value, chemical control must be achieved by not more than two spray applications during the summer. As the results of Table IV for runner initiation show this requirement was met except perhaps in the variety Redgauntlet, in which runner control only just reached an acceptable level.

For the two varieties Talisman and Redgauntlet, the crop produced in the following year was reasonably close to that produced by the control plants. In Vigour and especially Favourite the depression in crop yield after treatment suggests that in these varieties maleic hydrazide might cause an unacceptable reduction in yield. It should be noted that the original planting material of the two latter varieties was of rather poor quality and the severe effect of maleic hydrazide on them may have been the result of applying it to plants which were not sufficiently well established at the time of treatment. This explanation seems more likely than to suggest that maleic hydrazide had a direct effect on flower initiation in these two varieties. Papers by Denisen (1953) and Thompson (1961) show that if applied at the time of flower initiation maleic hydrazide may reduce its level. In this experiment however the last spray treatment was applied about a month before initiation is believed to have started, and there was no suggestion, in either variety that treatment had interfered with flower initiation.

These and earlier results (Thompson 1960) suggest that maleic hydrazide may be an effective means of controlling runner production in maiden plantations of strawberries grown on the single row system. In view of the narrowness of the concentration range between runner control and severe depression of growth of the parent plant, more work is needed to give additional information on optimum doses for a number of varieties under as wide a range of conditions as possible.

To make its use a practical proposition it is probably essential that maleic hydrazide should be used in combination with a weedkiller in order to control both weeds and runners. Recent results using simazine (Chappell and Bower 1959; Rahn and Fieldhouse 1960), 2,4-D (Hemphill 1951), or 2,4-DES (British Weed Control Council 1958) as means of controlling weeds in strawberries suggest that this aim may be attainable. In which case it may be possible to dispense entirely with all summer cultivations of maiden strawberry plantations and rely on a combined spray of weedkiller and runner inhibitor, followed in late autumn by a single cultivation to destroy surviving weeds and runners.

Acknowledgements

The author wishes to thank Messrs. Fisons Fertilizers Ltd. who kindly supplied the maleic hydrazide used in these esperiments.

REFERENCES

CARLSON, R. G. (1953). Inhibition of runner plants in the strawberry, Fragaria spp. by chemical treatment. Proc Am Soc. Hort Sci. 61: 201-217.

CHAPPELL, W. E. and BOWER, F. L. (1959). Granular and spray applications of certain herbicides. Proc North Eastern Weed Control Conf, 64-68.

REFERENCES (Cont)

DENISEN, E. L. (1950). Maleic hydrazide on strawberries. North Central Weed Control Conference, 128, Iowa State College.

" (1953). Runner inhibition in strawberries with plant growth regulators. Proc Amer Soc Hort Sci. 62, 246.

" (1955). Chemical inhibition of strawberry runners in the matted row. Amer Soc for Hort Sci Mich. State Univ. 4-5.

" (1956). Inhibiting strawberry runners with maleic hydrazide Market Growers Journal 85 (3), 16.

HEMPHILL, D. D. (1951). New weed control practices in strawberries. Mo. Agric Expt Sta circ. 355.

HITZ, C. W. (1959). Chemical control of plant populations in strawberries. Bull. Delaware Agric Exp. Sta 324, 38.

RAHN, E. M. and FIELDHOUSE, D. J. (1960). Evaluation of several herbicides for strawberries. Proc. North Eastern Weed Cont Conf, 55-59.

THOMPSON, P. A. (1960). The control of runnering in strawberries with maleic hydrazide. J. Hortic Sci. (in press.)

THOMPSON, P. A. (1961). In preparation.

BRITISH WEED CONTROL COUNCIL (1958). Weed Control Handbook. Blackwell Scientific Publications p.99.

Presentation by Mr. D. W. Robinson of preceding eight papers

Dr. van Stallduine's paper may help to explain some of the inconsistences found in trials with simazine on strawberries in the U.K; it is interesting for example that the effect of time of application should be so marked. Doses up to $\frac{3}{4}$ lb/ac applied after harvest caused no injury but applications in the spring with as little as $\frac{1}{4}$ lb were liable to cause damage. It has been shown that root formation and root growth in the variety Royal Sovereign are more active in the summer and autumn than in the spring and Dr. van Stallduine suggests that a possible explanation for the greater susceptibility of the crop in the spring is that closer contact might exist between the root system and the simazine present in the upper layers of the soil. In the Dutch experiments satisfactory weed control was obtained with doses between $\frac{1}{2}$ and 1 lb/ac and the good weed control with these low doses is partly attributed to the normal Dutch practice of growing strawberries on soils rather low in organic matter. The good results with simazine on runner beds are especially interesting, because in this situation weed control is particularly difficult. Mr. Sutherland's paper shows that simazine is also promising on strawberries in Scotland, and that much higher doses than those used in Holland caused no crop injury and, indeed, appeared necessary to give adequate weed control. It is interesting to note that in his main trial the relatively high dose of 2 lb/ac was used successfully in March - the time when strawberries in Holland are most sensitive. Talisman, one of the more tolerant varieties was used in the Scottish trials, but it seems possible that some additional factor, possibly soil organic matter, is also influencing the results.

Six of the eight papers dealt to some extent with the control of weeds in raspberries. Fourteen herbicides have been tested in Scotland and trials have also been conducted in England and Northern Ireland. At these three widely scattered centres, the outstanding herbicide has been simazine. Although good weed control has been obtained consistently with about 2 lb/ac, repeated annual application of much higher doses for 2 or 3 years caused no crop injury on fruiting plantations at all three centres or on cane nurseries in Scotland. The reason for the marked tolerance of raspberries is a problem of considerable interest. Reference has already been made at this conference to the persistence of simazine near the soil surface, and the possibility that part of the tolerance may be due to the retention of the herbicide in the top-most layers of soil is supported by the results of a trial in Northern Ireland in which severe injury occurred on recently planted canes where simazine had been placed in the soil 3 or 6 in. deep, but not when the same dose was sprayed on the soil surface. It is unlikely, however, that the tolerance of raspberries is entirely due to a depth factor, because pot experiments have shown that, even when the entire root system of young plants is in contact with simazine treated soil, the crop was unharmed by doses about 10 times those giving good control of germinating weed seeds.

Sutherland and Stephens have shown that monuron at 2 and 3 lb/ac may be used successfully in cane nurseries in spite of some temporary crop injury. At the same centre, however, damage was caused on a fruiting plantation by $3\frac{1}{2}$ lb/ac and doses of 5 and 10 lb/ac at East Malling caused more extensive injury. Other substituted urea herbicides have been tested by Mr. Sutherland but, at the doses used, fenuron, diuron and neburon either caused crop injury or failed to control weeds, so that in general the substituted ureas do not appear to be as promising as the substituted triazines for weed control in raspberries. Work on blackcurrents has not been as extensive as on raspberries but the results with simazine have been equally promising. Mr. Holloway has applied this chemical at $2\frac{1}{2}$ and 5 lb/ac for two successive seasons without any adverse effect and promising results have also been obtained in Northern Ireland. Blackcurrants may be even more sensitive to monuron than raspberries and at East Malling 10 lb/ac killed a number of the bushes while even 5 lb/ac caused a significant reduction in yield.

In general the results suggest, more strongly than at any previous British Weed Control Conference that the future for the use of herbicides in fruit crops is full of promise. Since soft fruits were first cultivated, we have looked upon hand cultivation as the ideal method of controlling weeds, but in several experiments better results have been obtained where hoeing has been replaced by chemical treatment. Higher yields of better quality raspberry canes, for example, were obtained by Sutherland and Stephens where simazine replaced hand cultivation in a cane nursery bed and in blackcurrants at Loughgall, a higher yield has been obtained where dalapon and other chemicals have been used since 1956 to suppress weeds than on plots kept clean by hoeing. It seems likely that these higher yields are due to the absence of root injury, which is unavoidable when crops with surface roots are cultivated mechanically.

Discussion on preceding papers on Fruit crops.

Mr. P. A. Thompson. I should like to make a few comments which are relevant to the relationship between root growth and sensitivity to simazine in strawberry. There are two main points to consider, first the sensitivity of strawberry plants in the spring and, second, the relatively high resistance of young runner plants. Although the greatest amount of root tissue is formed in late summer and autumn, roots formed at this time are large adventitious roots whose main function is anchorage and the storage of carbohydrates mainly as starch. In the spring, on the other hand, the roots formed are small feeding roots and it is likely that the sensitivity of the plant to simazine at this time is due to the constant production of these small roots which afford much opportunity for uptake of simazine from the upper layers of the soil. The first roots formed by runners are also mainly for anchorage and probably are not very efficient absorptive organs, so that it is not until secondary feeding roots are established in the lower soil levels that the runner becomes self-supporting. This probably explains how the roots of the runners are able to pass through a surface layer of simazine treated soil without the plants being injured by the chemical.

Mr. F. A. Roach. Our observations and trials in the S.E. region support what has been said about the value of simazine for use in fruit crops. We too have found that low doses of simazine show promise for the selective control of weeds in strawberry runner beds.

With regard to the use of dalapon to control grass along rows of apple tres, we find a difference in the control achieved according to the season. In the dry year of 1959 results were very promising but the reverse was the case in the wet season of 1960. For the control of grass round fruit trees simazine appears to work best in wet years and dalapon in dry years.

Mr. W. T. Cowan. I should like to ask why there has been this dismissal of the substituted urea compounds. We have done a considerable amount of work on munuron and although less is known about diuron I think there is much more promise for these compounds than the papers suggest. This year for example, diuron has given very good results in a number of trials on raspberries. Doses of 2 and 4 lb/ac have given very good control of annual weeds without damaging the crop and this compound would appear a promising alternative to simazine.

Mr. D. W. Robinson. I hope I did not give the impression that the substituted ureas should be prematurely rejected. I said that the triazines in general, appeared to hold more premise that the substituted ureas and I think this is a fair comment. I also said, however, that there is a strong case for occasionally varying the herbicide used and it will obviously be necessary to evaluate all the groups of residual herbicides.

Mr. J. Sutherland. In our own experiments we have used monuron on a larger scale than diuron and in 1959, a very dry year, monuron gave better weed control than diuron. The main drawback with both chemicals is that, at low doses, groundsel, Veronica spp. and fumitory are not controlled whereas low doses of simazine have given excellent control of these species. Duiron might, however, have an important part to play in the possible rotation of herbicided in order to combat accumulation in the soil or to prevent the build-up of resistant species of weeds.

Dr. D van Staalduine. We did some experiments comparing the effects of spring application of simazine on Madame Moutot strawberries and found that the plants were more susceptible to diuron than to simazine. On the other hand we think that diuron has possibilities in some other fruit crops.

Mr. A. L. Abel. As a complete layman I should like to ask the horticulturalists whether the planting distances used in practice are determined by the necessity of cultivating for control of weeds. Will the arrival of these newer selective herbicides allow closer planting distances and so increase production per acre?

Mr. David Lowe (Chairman) Answering this question as a grower, my first reaction is that there would not be much difference. Many experiments have been carried out on the spacing of fruit crops and I think that the factors limiting yield have generally been plant nutrients, light or some other such factor rather than the spacings necessary to permit control of weeds.

Mr. F. A. Roach. In aswer to Mr. Abel's question I think that, in the South East, chemical control of weeds in strawberries might enable the row width to be reduced from 3 ft to 2 ft 6 in. with a consequent increase in yield, but this would not necessarily apply to other areas.

Mr. G. A. Toulson. As an agriculturalist I am distrubed to learn of the rather free use of monuron as a herbicide in horticulture, particularly where double and treble cropping systems are employed. In a series of trials in Wales it has been shown that even adose of 1½ lb/ac of monuron applied as a pre-emergence treatment gave a complete kill of swedes and kale as well as controlling the weeds. Yet in horticulture it seems possible to apply 2-3 lb/ac of monuron yearly to some crops without affecting the crops that follow. How is the build up of residues of this most toxic herbicide being avoided in practice?

Mr. D. W. Robinson. There is, of course, a danger of build-up following repeated application of high doses of monuron, but the results presented today are only reports of experiments. No official recommendation is made at present for the use of monuren on fruit crops and no such recommendation would be made for doses likely to result in accumulation from repeated annual application.

Mr. W. T. Cowan. May I confirm that growers have been using monuron on asparagus and there is not the slightest danger from annual application of 2 lb/ac.

Dr. E. K. Woodford. Mr. Brown in his opening remarks emphasised the need for more field experiments in order to provide results on which to base recommendations. I am sure that we are all agreed that there are not enough of us working in this field. In consequence it is very important that all the information obtained by growers, merchants, manufacturers and official workers should be collated. This has happened on the agricultural side with very satisfactory results, but the makers of herbicides for horticultural crops seem to be much more secretive in their methods and there are many products on the market today of unknown composition, unkown except to the manufacturer. This makes it impossible for the N.A.A.S. or growers to relate their field observations on the efficiency of these products to the work undertaken by research stations with pure chemicals. May I appeal to manufacturers of herbicides for the horticultural trade to declare the nature and amount of the active principle in their products and not to change the composition of their product without changing the proprietory name.

THE RESPONSE OF VEGETABLE CROPS TO PRE-EMERGENCE APPLICATIONS OF SOME SUBSTITUTED TRIAZINES

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Summary: The response of twelve vegetable crops to pre-emergence app applications of simazine, propazine, trietazine and atrazine was determined in field trials, and a glasshouse test was conducted in which the crops were grown in soil containing these herbicides. Atrazine proved to be the most generally phytotoxic and trietazine the least, while simazine and propazine occupied intermediate positions. Radish, cabbage, lettuce, spinach, beet and onion were severely damaged by all four compounds when applied at doses necessary for weed control. The most promising treatments were propazine on carrot, propazine and trietazine on parsnip and parsley, trietazine on pea and dwarf French bean, and simazine and trietazine on broad bean.

INTRODUCTION

The general properties of the substituted triazine group of herbicides were described at a previous Conference (Gysin and Knusli, 1956), and since then their possibilities for selective weed control have been examined by many workers. In view of the excellent control of annual weeds which they afford, it seemed desirable to investigate their potential use for pre-emergence treatment of vegetable crops. Field tests with simazine were begun at Wellesbourne in 1956 and these showed that radish, cabbage, lettuce, spinach, beet, onion and carrot were virtually elminated by a pre-emergence spray of 0.5 lb/ac. Parsnip, however, appeared to exhibit some tolerance to simazine, whilst pea showed a variable degree of injury. In 1959 the tests were extended to include propazine, trietazine and atrazine and a test was also carried out in the glasshouse to determine the comparative susceptibility of vegetable crops when grown in soil containing the four herbicides. The results are summarised here and discussed in relation to those from other field trials which have been carried out with particular crops.

MATERIALS AND METHODS

The field tests were conducted on a sandy loam of the Newport series, relatively low in organic matter. Single rows of the different crops were drilled at the normal depths and spray treatments applied across them immediately after sowing. There was no replication, but three similar tests were carried out at different times of the year. The treatments were applied as aqueous suspensions of wettable powder formulations, using a volume rate of 100 gal/ac. Weeds were removed from all plots, including the controls, observations and injury ratings were made at intervals, and stands and fresh weights of whole plants were recorded after an arbitrary period.

The soil for the glasshouse test was obtained by taking samples to a depth of 2 in. from field plots which had been sprayed with 2 lb/ac. After seiving, dilution series were prepared by mixing different proportions of treated soil with soil taken from an adjacent control plot. Concentrations were thus obtained equivalent to 2, 1, 0.5, 0.25, 0.125 and 0.0625 lb/ac mixed uniformly with the surface 2 in. of soil. Two replicate series for each crop were set up in plastic pots, seed sown, the pots sub-irrigated, and after an arbitary period which varied for the different crops, numbers and fresh weights of surviving plants were recorded.

RESULTS

Three field tests were carried out during 1959 with simazine, propazine, trietazine and atrazine applied at rates of 0, 0.25, 0.5 and 1 lb/ac. The details were as follows:

1. Five crops. Begun in March when the soil moisture status was high. Approximately 1 in. rain fell during the first three weeks after spraying.
2. Twelve crops. Begun early July during a very dry period. Approximately 0.5 in. irrigation was given 10 days after spraying, and this was repeated 20 and 25 days after spraying.
3. Twelve crops. Begun at end of July, Although 0.15 in. rain fell immediately after spraying, dry weather followed and 0.5 in. irrigation was given 10 days after spraying.

From the records which were taken, the effect of each chemical on each crop has been summarised by assigning a rating on a scale of 0-10. A rating of 0 indicates absence of any injury from 1 lb per acre, whilst a rating of 10 denotes complete kill at 0.25 lb/ac. These data are shown in Table I.

TABLE I. COMPARATIVE RESPONSE OF VEGETABLE CROPS TO PRE-EMERGENCE APPLICATIONS OF FOUR TRIAZINES

Injury rating

(0 = no effect at 1 lb/ac; 10 = complete kill at 0.25 lb/ac)

Test number	Simazine			Propazine			Trietazine			Atrazine		
	1	2	3	1	2	3	1	2	3	1	2	3
Radish	-	5	6	-	5	6	-	4	4	-	7	9
Cabbage	-	8	9	-	7	8	-	4	5	-	8	10
Lettuce	-	10	10	-	9	10	-	7	8	-	10	10
Spinach	-	6	9	-	8	9	-	4	6	-	8	10
Beet (globe)	-	10	10	-	9	9	-	6	8	-	9	10
Onion	8	6	7	7	6	8	5	1	4	9	8	8
Carrot	9	7	10	4	4	4	6	3	5	9	9	10
Parsley	-	6	6	-	3	0	-	0	0	-	6	6
Parsnip	1	4	5	0	1	0	0	0	0	2	4	6
Pea	3	3	4	3	1	0	1	0	0	6	4	6
Broad bean	4	0	2	3	0	2	0	0	0	5	3	6
Dwarf Fr. bean	-	6	7	-	5	7	-	1	3	-	6	8

The glasshouse test was carried out as already described, and from the dosage-response curves based on fresh weight of surviving plants, estimates were obtained of the amount of herbicide, in lb/ac mixed with 2 in. soil, required to reduce fresh weight to 50 per cent of that of the control. The values obtained for eight crops are shown in Table II.

TABLE II. COMPARATIVE SUSCEPTIBILITY OF VEGETABLE CROPS TO FOUR TRIAZINES INCORPORATED IN THE SOIL

Dose (lb/ac mixed with 2 in. soil) required to reduce fresh weight by 50 per cent.

	Simazine	Propazine	Trietazine	Atrazine
Radish	0.20	0.14	0.61	0.17
Cabbage	0.19	0.17	0.44	0.08
Lettuce	0.08	0.18	0.31	< 0.06
Beet (globe)	0.15	0.12	0.30	0.08
Onion	0.13	0.15	0.56	0.07
Carrot	0.12	1.50	0.62	0.14
Parsley	0.40	> 2.00	> 2.00	0.40
Parsnip	> 2.00	> 2.00	> 2.00	1.18

Pea, broad bean and dwarf French bean were included in the test, but as only small numbers of plants were involved, response curves have not been constructed. It appeared that for pea, a dilution of simazine, propazine or atrazine equivalent to approximately 0.5 lb/ac was required to reduce fresh weight by 50 per cent while for trietazine the value was 1.4 lb. Dwarf French bean was rather more susceptible than pea, while broad bean was more tolerant and required the equivalent of more than 1 lb of each compound per acre. Injury symptoms were very slow to appear in this crop, however, and it is possible that the tolerance was overestimated. Good data were not obtained for spinach, but it appeared that this crop was approximately as susceptible as radish.

DISCUSSION

The data of Tables I and II show that in general, atrazine was the most phytotoxic of the four compounds and trietazine the least, whilst simazine and propazine were intermediate. Information from the field tests and from other experiments indicates that the four compounds can be placed in the same order in respect of kill of annual weeds. The data suggest that atrazine does not have any potential use as a pre-emergence herbicide in the crops tested.

Radish, cabbage, lettuce, spinach, beet and onion were susceptible to all four compounds at doses required for weed control. The results for the other crops listed in Table I, however, suggest that pre-emergence use of particular compounds might be feasible, and these possibilities are considered briefly below.

Carrot. In all the tests, carrot was very susceptible to simazine and atrazine, but showed a much greater degree of tolerance to propazine; it was also the only crop to be injured more by trietazine than by propazine. In a replicated trial, propazine at 0.5 lb/ac caused some stunting and chlorisis without affecting yield, but at 1 lb/ac yield was reduced. Nevertheless, propazine appears to hold some promise if used at doses of no more than 0.5 lb/ac.

Parsley. This crop showed some tolerance to propazine and trietazine, and both would seem to merit further testing. In a replicated trial, propazine at 0.5 lb/ac caused some chlorosis but did not affect yield.

Parsnip. Both field and glasshouse tests confirmed the impression that this crop possesses some tolerance to simazine. In replicated field trials, 0.5 lb/ac caused temporary chlorosis, but at 1 lb/ac reduction in yield sometimes occurred. As suggested by the results in Table I, propazine appears to be more selective than simazine in this crop and in replicated trials, propazine 0.5 lb/ac has given good weed control without crop damage. Trietazine would also appear worthy of further examination.

Pea. The results indicate that the inherent tolerance of this crop to simazine, propazine and atrazine is not very great, but suggest that the possible use of trietazine should be investigated further.

Broad bean.. In replicated trials at Wellesbourne, good weed control without crop damage has been obtained with simazine applied at 0.5-0.75 lb/ac. With 1 lb/ac, extensive marginal necrosis of the leaves has sometimes occurred, whilst with 1.5 lb/ac there were reductions in yield. Considerable variation in degree of injury has been encountered under different rainfall conditions and on plots treated with 1-1.5 lb/ac it has been noticable that of two adjacent plants, one might be killed or severly damaged, whilst the other remained unaffected. These observations suggest that the inherent tolerance to simazine is not very great, and that depth of sowing and rapidity of establishment may be critical. Nevertheless, at doses of 0.5-0.75 lb/ac the use of simazine would seem to be feasible on the particular soil involved. Trietazine has had no observable effect on broad beans even when applied at 2 lb/ac, and the possiblities of this herbicide are being further investigated.

Dwarf French bean. This crop appears to be more susceptible than either pea or broad bean, and only trietazine would seem to be worthy of further testing.

It is concluded from this work that there are only limited possibilities for the use of the four triazines for weed control in the twelve crops investivated Atrazine did not show sufficient selectivity in any crop. Simazine appears to hold promise only in broad bean. Propazine appears to be worthy of further examination in carrot, parsnip and parsley, whilst trietazine appears to merit testing in parsnip, parsley and the three large-seeded legumes.

Acknowledgements

We are grateful to Fisons Pest Control Limited for making available the herbicides used in this work.

REFERNCE

GYSIN, H. AND KNUSLI, E. (1956). Chemistry and herbicidal properties of triazine derivatives. Proc. 3rd Brit Weed Control Conf., 615-622.

USE OF PRE-EMERGENCE HERBICIDES FOR VEGETABLES IN THE UNITED STATES

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Summary: The use of pre-emergence herbicides on vegetables in the United States has expanded rapidly in the past ten years. Among the materials that are widely applied are dinoseb, chlorpropham, CDAA, CDEC, simazine, atrazine, monuron, NPA and TCA. Some of these are much more important in America than in Europe because of differences in the relative importance of various crops and weeds, especially annual grasses. There are several promising new herbicides which are of special interest to vegetable growers. Two that have received considerable attention are amiben and dimethyl 2,3,5,6-tetrachloroterephthalate.

INTRODUCTION

Chemical weed control in vegetables in the United States received its first real stimulus with the discovery about 1943 of the selective action of certain petroleum oils on carrots and other umbelliferous crops. To be sure, there had been earlier attempts at selective weed control but this was the first use that was widely adopted by growers. During the next few years the major developments were with other post-emergence herbicides including sulphuric acid and potassium cyanate for onions and dinitro compounds for peas. The growth regulators were widely tested for vegetables but very few lasting uses developed.

Starting in the late 1940's and expanding rapidly in the 1950's the idea of pre-emergence treatments evolved and at present by far the majority of the herbicides used on vegetables in the United States are of the pre-emergence type. In the early work (Anon, 1958, 1960) contact materials such as potassium cyanate, oils and PCP received a great deal of attention but with the development of residual types of herbicides the interest in strictly contact pre-emergence treatments has largely disappeared. However, it should be emphasized that an important feature of some presently used residual materials is the contact action obtained on early germinating weeds by 'delayed pre-emergence' or 'at emergence' treatments. It must be pointed out that most of the pre-emergence herbicides have been used in the more humid areas of the country. There have been many difficulties in adapting pre-emergence herbicides to the extensive furrow-irrigated vegetable areas of the south west.

THE WEED PROBLEM

Weeds are as serious a problem in American vegetable crops as they are in British vegetables. High labour costs and actual shortage of hand labour has forced the growers to mechanize production and harvesting. Therefore, effective herbicides are readily accepted by the vegetable grower.

In spite of the general similarity in the need for selective herbicides in Great Britain and America there are tremendous differences in the specific problems. The relative importance of various weeds and crops should be emphasized. There are only a few areas in the United States where the climate is similar to that of the British Isles. Much of the country has a continental climate which is more suitable to the production of warm weather crops. For example, outdoor tomatoes, melons and sweet potatoes are major vegetable crops in the United States, while brussels sprouts and cauliflower are quite minor, In Great Britain the reverse is true. The relative importance of weed species is likewise greatly influenced by climate. The high summer temperatures that are characteristic of much of the United States encourage many annual grasses including Setaria, Digitaria and Echinochloa species. Annual grasses make up the great majority of the weeds in many areas, and thus there has been a great deal of emphasis on the development of new chemicals that are effective for their control. The broadleaved weed problem is also different, Portulaca oleracea and Amaranthus species being especially serious. In contrast, some of your most important weeds such as Urtica urens and Poa annua (Roberts, 1959-60) are unknown to most American vegetable growers and even Stellaria media is a problem in only certain of the dooler climatic areas.

These differences in the problems we face have been pointed out to give a better understanding of the remarks which follow. Having now seen some of the weeds and vegetable crops in Great Britain, I can better appreciate the reasons for the failure of some of our best herbicides under your conditions and likewise the minor importance in America of some of the treatments that have proved effective in Great Britain.

In view of this contrasting situation in the two countries, it is hoped that the information presented here will be used with discretion. An attempt has been made to summarise the important commercial uses of pre-emergence herbicides and mention is made of some of the promising results with new materials. It is hoped that from this information some ideas may be obtained which will be of value in the development of selective herbicides for vegetables grown in Great Britain.

PRE-EMERGENCE HERBICIDES IN COMMERCIAL USE ON VEGETABLES

Dinoseb is generally recommended in the humid regions of the country for pre-emergence treatment of all kinds of beans and in many of these areas it has been widely used. In the north-eastern part of the United States dinoseb is often applied as a pre-emergence treatment on peas and potatoes. It has also been used in mixtures with chlorpropham as described below.

Chlorpropham (CIPC). This herbicide is used extensively for control of weeds in onions grown on organic soils at almost all stages of crop growth, but late season treatments are applied as directed sprays or as granulars. The rates of application are high (4 to 8 lb/ac) because of the tremendous adsorption of this chemical by organic soils. It is especially effective on Polygonum spp. and Portulaca oleracea. However, at the high doses used and by making the early season applications after many weeds have emerged, several other species are killed by contact action. Chlorpropham is often used in combination with CDAA on organic soils to improve the control of annual grasses and Amaranthus spp. On mineral soils chlorpropham is commonly recommended in the north central and north eastern states for use on onions grown from sets or transplants, but it has not proved satisfactory in the winter onion areas of Texas for either field-seeded or transplanted onions.

Extensive areas of peppermint and spearmint grown on organic soils in the mid-west are being treated just before emergence with a mixture of chlorpropham and dinoseb. This same mixture has sometimes been recommended for beans, but has not been widely used.

For several years chlorpropham was in quite general use on the east coast for weed control in several vegetable crops grown for greens and salads. It has now been replaced to a considerable extent by CDEC although mixtures of the two are being suggested in some places. Carrots have shown a high degree of tolerance to pre-emergence treatments of chlorpropham but use on this crop has not been developed due to the excellent results obtained with selective soils.

Propham (IPC). Because of rapid decomposition and vapour loss at high soil temperatures, chlorpropham has largely replaced this herbicide in the United States. The only important use on a vegetable crop is as a pre-planting treatment for control of Avena fatua in peas in the north west.

CDAA. This herbicide is especially effective on annual grasses and thus has been much more widely used in America than in northern Europe. It is one of the main herbicides now applied to onions grown on organic soils. For this purpose it is used either alone or in mixtures with chlorpropham. Treatments may be made before emergence or, at later stages of growth, either as directed sprays or as regular applications.

Where annual grasses are the major problem, CDAA has also been used on sweet corn on all except the sandier soils. A new use that has just been approved is a granular application on tomatoes immediately after transplanting.

CDEC. This herbicide is now used by many vegetable growers especially on the east coast. Annual grasses and certain broadleaved weeds including Lamium spp. are controlled in a number of vegetable crops grown for greens and salads. Results have been good in some areas and poor or unpredictable in others. The reasons for this are not clear but a light sprinkler irrigation after treatment is considered helpful.

EPTC. This is a relatively new herbicide but commercial use is developing on beans (Phaseolus vulgaris only) and on potatoes for control of annual grasses and suppression on Cyperus spp. Because of vapour losses it must be incorporated in the soil immediately after application.

Simazine and atrazine. These materials are generally recommended for sweet corn and have been well accepted by growers. Simazine also has given good results in experimental work on asparagus, but it has not been approved for treatment of this crop.

Monuron and diuron. Monuron is the principal herbicide that is applied to asparagus. Either one or two treatments are made per season at rates varying from 1 to 3 lb/ac depending on the soil type. Results have been good almost everywhere. Diuron is being tried for certain crops because of the greater depth protection afforded by its lower solubility and greater adsorption by the soil. It has been recommended for peppermint in the north west and for a few other crops in limited areas.

TCA. The largest single use of this material on vegetables probably has been for the pre-emergence control of annual grasses in red beets. The crop is highly tolerant and results have been good in areas where grasses are the major weed problem. Another specialised use has developed in the mid-west on field-seeded tomatoes where a mixture of TCA and potassium cyanate have given good results. The potassium cyanate gives contact kill of early germinating weeds, while the TCA is effective as a residual treatment for annual grasses. Potatoes and cabbage have also been treated to a limited extent with TCA.

NPA. (Naphthylphthalamic acid) This herbicide is well tolerated by muskmelons, watermelons and cucumbers both before and after emergence. However, it is only effective when applied before weed emergence so treatments are usually made just after seeding or transplanting in the field. Use of NPA on these crops is not general in the United States, but has developed in some areas.

PROMISING NEW PRE-EMERGENCE HERBICIDES

Amiben and dinoben. These closely related compounds are highly active on a broad spectrum of annual weeds, yet there are certain crops which show excellent tolerance. Carrots, peas, sweet potatoes, most kinds of beans and certain Cucurbita species (C. pepo, C. moschata and C. maxima) have good resistance to amiben. By using the granular formulations additional crop selectivity has been obtained. These formulations of amiben have given promising results on transplanted brassicas and tomatoes on medium to heavy soils. Dinoben is slightly less active than amiben but for lettuce and strawberries there are indications, that it may be safe, whereas amiben may not.

Dimethyl 2,3,5,6-tetrachloroterephthalate (Dacthal). This is a material with very low water solubility (less than 0.5 ppm) that is strongly adsorbed by soil colloids. It is highly selective in its action on both weeds and crops. Stellaria media, Chenopodium album and several annual grasses are especially sensitive, but Polygonum and Brassica species and many other weeds are highly resistant. Excellent selective control of susceptible weeds has been reported on a number of vegetable crops including the brassicas, carrots, beans, potatoes, peas, onions, tomatoes and sweet potatoes. Since it is practically inactive as a foliar spray, it has also given good results on a number of transplanted crops for control of germinating weeds. Performance has been best on the lighter soil types while on organic soils it is so strongly adsorbed that its use is not practical.

Other pre-emergence herbicides. A large number of new chemicals are being investigated in the United States. Among these are the new triazines, EPTC analogues, diphenylacetonitriles and 2,6-dichlorobenzonitrile. Some of these have given encouraging results, but the information is still too limited to draw any conclusions as to their possible place in vegetable weed control.

PROMISING NEW POST-EMERGANCE HERBICIDES

Although this report has been concerned primarily with pre-emergence herbicides, it would be unfortunate if we overlooked a new group of post-emergence materials that are of particular interest to vegetable growers. These are the phenylamides being tested under the names Karsil, Dicryl and Solan. They are active primarily as foliar sprays and are all selective on carrots, celery, parsley and parsnips. Karsil and Dicryl are more active that Solan and have therefore received most attention on these crops. Compared with the selective oils now in use they are more effective on Chenopodium album and less effective on annual grasses. Solan is selective on established tomatoes and has been suggested for trial on potatoes.

CONCLUSIONS

It is hoped that this paper will give some idea of the present use of pre-emergence herbicides in the United States. Our climate, crops and weeds are quite different, but perhaps some of the things we have learned will suggest new lines of research. With the large number of promising new chemicals that appear each year the future is certainly bright.

Acknowledgements

The author is grateful for much unpublished information used in preparing this paper which was kindly supplied by the following individuals: L.L. L. L. Danielson, H. H. Harris, E. S. Haygood, D. D. Hemphill, R. D. Sweet, W. Weber, W. C. McConnell and S. R. McLane.

REFERENCES

ANON (1958). Research Summaries. North Central Weed Control Conf, 15, 66-68

ANON (1958). Report of the Research Committee. Southern Weed Conf, 13, 336-344.

ROBERTS H. A. (1959-60). The Use of Herbicides in Horticulture. Sci. Hort, 14, 55-62.

OBSERVATION STUDIES ON THE USE OF RESIDUAL HERBICIDES ON ANEMONES DURING 1958-59 AND 1959-60

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Summary: Trials using residual herbicides in controlling weeds in anemones were carried out in the 1958-59 and 1959-60 seasons. Weather conditions were vastly different in these two seasons, the summer of 1958 being wet and that of 1959 very dry. This served to show the inconsistency of simazine which gave good control of weeds in the first year at 2 lb/ac, but checked growth of the anemones, and comparatively poor weed control in the second year. Monuron was more consistent but less efficient than simazine and at 2 lb/ac some check to the anemones also occurred. Chlorpropham at rates above 1 lb/ac also caused considerable damage, but when applied at ½ lb/ac mixed with fenuron at 1 lb/ac weed control appeared fairly good with little damage to the anemones. PCP at 4½ lb/ac was included for comparison in the second year and showed good initial weed control, but the effect was not so lasting as with the residual herbicides.

INTRODUCTION

The first of the trials using residual herbicides was carried out in 1958-59 and repeated with some modifications the following year. Both trials are reported on separately as the climatic conditions in the two seasons were vastly different giving contrasting results.

Anemone corms are planted at a depth of 2-3 in. and the emergence period is about 14 days, conditions which are well suited to weed control by the residual type of herbicide. Fairly extensive trials have already been done using contact herbicides and these have been described in the 2nd, 3rd and 4th Annual Reports of work at Rosewarne Experimental Horticulture Station.

I. TREATMENTS IN THE 1958-59 SEASON

METHODS AND MATERIALS

The materials used were chlorpropham at 1, 2 and 4 lb/ac, fenuron at ½, 1 and 2 lb/ac, simazine at ½, 1 and 2 lb/ac, chlorpropham at 2 lb and fenuron at ½ lb/ac, and hand weeding as control. There were 4 replications of each treatment. The sprays were applied on 15th July during hot dry conditions, the 2/3 cm grade corms having been planted 6 days previously on 9th July. The plot size was 20 ft x 6 ft containing a 4 row bed of anemones at 12 in. apart with a bordering footpath also included in the sprayed area. The dry weather at the time of application did not last and the succeeding weeks were extremely wet.

RESULTS

Weed counts were made at intervals taking a random sq ft sample on each plot. Table I shows the average numbers at each count for the 4 replications of each treatment.

TABLE I. WEED COUNTS

Treatments	Number of days after spraying - 1959 season							
	15	17	21	23	27	30	35	41
CIPC at 1 lb	14	14	15	15	18	18	14	18
CIPC at 2 lb	22	33	17	24	23	26	17	20
CIPC at 4 lb	12	12	11	10	13	12	13	11
Fenuron at ½ lb	30	29	29	36	37	34	39	35
Fenuron at 1 lb	14	10	8	22	17	21	26	23
Fenuron at 2 lb	12	14	11	9	9	11	19	15
Monuron at ½ lb	10	13	9	8	15	11	13	15
Monuron at 1 lb	9	7	6	7	5	6	8	6
Monuron at 2 lb	13	10	3	4	4	4	3	4
Simazine at ½ lb	12	10	6	4	7	8	6	7
Simazine at 1 lb	11	4	3	2	3	4	3	3
Simazine at 2 lb	12	7	2	2	2	2	1	<1
CIPC + Fenuron	12	9	10	13	19	15	15	16
Control	26	31	36	41	40	39	38	Not Counted

In this wet season simazine and monuron had the greatest effect on weed growth, the population growing progressively less at each count except in the case of monuron at ½ lb/ac. Where the applications were at 2 lb/ac no hand weeding was found necessary throughout the whole of the season. Simazine was more effective than monuron. Chlorpropham was somewhat disappointing giving only fair control at the higher dose and poor control at the lower doses. Fenuron appeared to have little effect at all.

As soon as crop emergence commenced on 24th July it was evident that chlorpropham at 4 lb/ac had caused damage. The anemone leaves appeared stunted, curled and yellow and the vigour of the plants was well behind that of other plots. Damage was also apparent but not so severe with chlorpropham at 2 lb/ac and also with the chlorpropham/fenuron mixture. Growth with all other treatments appeared normal until mid-October when plants on the simazine 2 lb/ac plot began to show signs of a check in growth. There were no unhealthy symptoms other than this slowing of growth in comparison with other healthy plants, and later in February and March normal and more vigorous growth was resumed. There was a similar but very slight check with monuron at 2 lb/ac. None of the other treatments apart from chlorpropham had any adverse effect.

The yields of blooms are set out in Table II as marketable flowers cropped in successive 4 week periods with the totals or marketable flowers and the totals of all flowers cropped.

TABLE II. YIELDS OF MARKETABLE FLOWERS FOR EACH MONTH

(Totals of the 4 replicates)

Month ending:	4/10/ 1958	1/11/ 1958	29/11 1958	27/12/ 1958	24/1/ 1959	21/2/ 1959	21/3/ 1959	Total	Total of all flowers cropped
CIPC at 1 lb	-	11	23	7	26	21	115	203	1276
CIPC at 2 lb	-	11	21	9	25	22	192	280	1365
CIPC at 4 lb	1	8	13	2	19	32	103	178	913
Fenuron at ½ lb	-	12	19	4	27	32	123	217	1369
Fenuron at 1 lb	2	24	31	8	41	44	164	314	1476
Fenuron at 2 lb	-	4	34	6	40	43	162	289	1470
Monuron at ½ lb	-	18	33	14	32	26	107	230	1428
Monuron at 1 lb	2	18	40	21	58	62	172	373	1662
Monuron at 2 lb	-	9	27	9	39	46	216	346	1471
Simazine at ½ lb	3	26	46	7	66	57	214	419	1602
Simazine at 1 lb	1	13	23	13	38	17	115	220	1375
Simazine at 2 lb	-	7	8	6	33	26	145	225	946
CIPC at 2 lb) Fenuron at ½ lb)	-	12	27	8	16	13	79	155	1354
Control	1	14	28	6	27	27	101	204	1428

The highest yield of marketable blooms came from the ½ lb/ac simazine plots followed by the 1 lb/ac monuron plots although the latter gave the highest total yield. Where damage at commencement of growth had occurred with chlorpropham yields were correspondingly low. Relatively low yields were also obtained on the hand weeded plot. In this case the first weeding had been left to a late date and removal of the large weeds had disturbed the anemones. Where growth was checked by simazine and monuron cropping was reduced during the latter months of 1958 but increased again with the improvement of growth in the following spring.

II. TREATMENTS IN THE 1959-60 SEASON

METHODS AND MATERIALS

Following the results of the previous season the treatments were modified omitting those obviously detrimental and of little value. The treatments were chlorpropham at ½ lb plus fenuron at 1 lb/ac, monuron at 1 lb/ac and ½ lb/ac, simazine at 1 lb and ½ lb/ac, PCP at 4½ lb/ac, and two controls (i) minimum hand-weeding removing larger weeds only and (ii) frequent careful hand-weeding keeping plots as clean as possible.

PCP although not a residual herbicide was included as being standard commercial practice and the two types of hand-weeding were an attempt to study the degree to which anemones are damaged by soil disturbance. The corms were planted on 22nd June and the chemical treatments applied on 2nd July - 10 days later in very dry conditions which persisted throughout the summer.

RESULTS

The performance of the residual chemicals in this dry season was disappointing. This was particularly so in the case of simazine which showed less control than monuron thus giving the opposite result to last season. Larger weeds and those just germinated at the time of treatment survived to grow except in the case of PCP which gave good initial weed control. The table of weed counts per square foot (Table III) gives an indication of the slow development of weeds due to the dry soil conditions, the number on the plot receiving a minimum amount of attention reaching only 13 in 27 days compared to 40 for the similar plot of the previous year.

The most persistent control was given by the chlopropham ½ lb/fenuron 1 lb/ac mixture and by monuron at 1 lb/ac, these plots having been weeded once only on 14th August. The remaining plots were all weeded twice except for the carefully weeded plot which received attention 5 times in all.

TABLE III. NUMBERS OF WEEDS PER SQUARE FOOT

(Average of the 4 replications of each treatment)

Treatments	Number of days after spraying - 1960 season								
	8	11	13	16	18	20	25	27	31
CIPC at ½ lb) Fenuron at 1 lb)	1	1	-	3	2	2	2	2	2
Monuron at 1 lb	1	2	1	3	3	2	4	3	3
Monuron at ½ lb	1	2	1	3	3	2	3	3	3
Simazine at 1 lb	5	5	2	4	6	4	5	5	5
Simazine at ½ lb	4	5	3	5	4	4	7	9	6
PCP at 4½ lb	1	1	1	2	4	2	10	10	8
Minimum weeding	6	6	4	10	11	8	13	13	11
Careful weeding	6	2	4	7	6	5	W	-	-

W - Hand weeded by this date

In spite of the low number of weeds per square foot the plots soon become untidy and in no case was control sufficient to make hand weeding unnecessary.

In this year the growth rate of the anemone plants was not visibly affected by any of the treatments. By mid-September, however, a small amount of marginal chlorosis had appeared on the older leaves of some plants on the chlorpropham/fenuron plot and also with monuron at 1 lb/ac. This was not lasting and by the end of October the symptoms had disappeared.

TABLE IV. YIELDS OF MARKETABLE FLOWERS FOR EACH MONTH

(Total of 4 replications)

Month ending:	26/9/ 1959	24/10/ 1959	21/11/ 1959	19/12/ 1959	16/1/ 1960	13/2/ 1960	Total	Total of all flowers cropped
CIPC at ½ lb) Fenuron at 1 lb)	35	90	45	35	15	1	221	1422
Monuron at 1 lb	35	79	64	38	22	-	238	1635
Monuron at ½ lb	26	66	44	43	32	1	212	1460
Simazine at 1 lb	26	64	62	38	10	-	200	1418
Simazine at ½ lb	42	50	39	38	10	-	179	1477
PCP at 4½ lb	35	53	54	45	18	3	208	1739
Minimum weeding	26	48	50	28	26	-	178	1441
Careful weeding	35	57	50	27	16	1	186	1531

Table IV shows that the highest total yield of blooms was given by PCP but the highest marketable yield was given by monuron at 1 lb followed by the chlorpropham/fenuron mixture then monuron at ½ lb/ac. Of the hand-weeded plots the carefully weeded ones gave a slightly better yield in marketable flowers than those weeded a minimum number of times, in total flowers however the former were considerably better.

DISCUSSION

In these two seasons there was ample opportunity of studying the relationship and behaviour of anemones and residual herbicides under vastly differing weather conditions. For 1958 the rainfall for the critical three months from July to September inclusive was 12.9 in. compared to 6.18 in. for the same period the following year. This difference had a considerable bearing on the action of the residuals particularly in the case of simazine. In the wet season this material afforded excellent weed control but in doing so checked the growth of anemones, the reverse being the case in the dry season. This inconsistency would rule out simazine as a reliable herbicide for general use. Monuron appears more consistent than simazine but at the dose where weed control is efficient, damage to the anemones can occur.

Most promising is the chlorpropham ½ lb/fenuron 1 lb mixture which is also giving the same indications in the current seasons (1960-61) trials.

It must be remembered that the treatments in the dry season were applied 10 days after planting, this was in order that a suitable comparison with PCP should be made. Ideally the residuals should have been applied immediately after planting in which case weed control might have been more effective. Arising from this point there would seem to be some argument in favour of using PCP in conjunction with a suitable residual herbicide. The latter, if applied immediately after planting and failing to control an early germination of weeds, could be supplemented by the application of PCP at an estimated time of 4 days before the emergence of the anemones. This could be particularly beneficial in a dry season when the action of the residual is likely to be slow.

More work is necessary in the case of anemones to find the most suitable residual herbicide and to establish the critical dose where maximum weed control and minimum damage to the anemones occurs. This can be made more complicated by differing climatic conditions, to which anemones may react in any case. However these plants will soon indicate if there is any substance within reach of leaves or roots that is disagreeable to them.

TRIALS OF HERBICIDES ON NARCISSUS AND TULIP BEDS, 1958-60

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Summary: In field trials with herbicides on narcissus and tulip crops chlorpropham was used alone, in mixtures with fenuron or diuron, and following application of contact herbicides at the pre-emergence period of bulb growth. Post-emergence applications of chlorpropham were also tested at different developmental stages of the crops. The effectiveness of comparative treatments varied within the limits of weed cover and doses in relation to times of application, and under different weather conditions in two consecutive years. No programme gave completely satisfactory results. Herbicidal effects diminished in late April, or early May, and weed growth generally became vigorous before July. Difficulties increased when narcissus bulbs were not lifted annually. On observation plots diquat gave promise for pre-emergence use, while for post-emergence use neither diuron nor simazine gave adequate control of weeds at dosage levels of crop tolerance.

INTRODUCTION

Though the control of weeds in bulb crops by herbicides has become commercial practice, much remains to be done to obtain the essential information about the tolerance of weeds and crops to those herbicides which have seemed promising in preliminary tests. For the major bulb crops this is especially true of chlorpropham which, despite its limitations, seems likely for some time to occupy an important place in the bulb growers' weed control programme.

Since chlorpropham became available for bulb crops in Britain in 1957, its limitations have had a marked influence upon the role assigned to it in alternative herbicide programmes, particularly as a result of its failure to control Senecio vulgaris (groundsel) and Matricaria maritima ssp. inodora (mayweed). To overcome this difficulty three methods have been advocated; (a) early pre-emergence application on a clean tilth, (b) mixture with a residual additive to which groundsel and mayweed are not resistant, and (c) following or mixed with a pre-emergence contact herbicide.

Used either alone or as a mixture with fenuron, another residual herbicide, chlorpropham has given good results in post-emergence applications, though Wood and Howick (1958) observed crop injury, and Dutch workers (1958) drew attention to some factors influencing bulb crop susceptibility.

In continuing field trials at the two N.A.A.S. experimental centres responsible for investigating bulb growing problems - Kirton E. H. F., Lincs. and Rosewarne E. H. S. Cornwall - an attempt has been made to collect data having a bearing on existing controversial issues, with a view to making the best use of available herbicides while conducting preliminary tests with new materials.

The recent voluntary exclusion of sodium arsenite for herbicidal use has made specific reference to that material in some respects irrelevant, except as a standard for comparison.

METHODS AND MATERIALS

All bulbs used were produced on the farm at Kirton where the stocks are grown as an annual crop in a six-course rotation in which bulbs follow early peas, but never receive manurial dressings. They are finely graded to facilitate equalisation of plot weights for planting. Narcissus bulbs are subjected to standard hot water treatment - 110°F/3 hours. Care is taken to exclude tulip bulbs carrying sclerotia of Botrytis tulipae, but any bulbs showing symptoms of primary infection at shoot emergence are removed.

Treatment plots of two sizes were used. The smaller plots consisted of 50 bulbs planted in Dutch beds, spacing being 6 in. apart in 10 rows 9 in. apart. The larger plots consisted of 300 bulbs planted 3 in. apart in 5 long rows 9 in. apart, by the commercial method termed 'ploughing in'. Replicated treatment plots were arranged in randomised blocks or Latin Squares. All herbicides were applied as sprays by Oxford Precision Sprayer at a rate of 100 gal/ac, and drift was prevented by using screens. The herbicides were in most instances materials formulated for commercial use.

Assessment of herbicidal effect was by visual methods, identification of weeds present, and scoring for total density. Crop tolerance was judged by visual inspection of the growing crop, inspection of the dry bulbs, and the recording of plot yields at harvest.

RESULTS

One-year trial of pre-emergence and post-emergence herbicides 1958-59

On beds of narcissus, cultivar King Alfred, the following treatments were applied as sprays at a rate of 100 gal/ac.

- Control, unweeded
- Kept clean by cultivation only
- Simazine 0.5 lb/ac, - pre-emergence only
- Chlorpropham 4 lb/ac, pre-emergence only
- Sodium arsenite (As_2O_3 98 per cent) 1 gal/ac, pre-emergence + Chlorpropham 4 lb/ac, pre-emergence
- Sodium arsenite (As_2O_3 98 per cent) 1 gal/ac, pre-emergence + Chlorpropham 2 lb/ac, pre-emergence
- Chlorpropham 2 lb/ac, pre-emergence, repeated post-emergence
- Chlorpropham 2 lb/fenuron 0.5 lb/ac mixture, pre-emergence, repeated post-emergence
- Sodium arsenite (As_2O_3 98 per cent) 1 gal/ac, pre-emergence + Chlorpropham 4 lb/ac, post-emergence
- Sodium arsenite (As_2O_3 98 per cent) 1 gal/ac, pre-emergence + Chlorpropham 2 lb/ac, post-emergence
- PCP 7.5 lb/ac, pre-emergence + Chlorpropham 2 lb/ac, post-emergence
- PCP 7.5 lb/ac, pre-emergence + cultivation + Chlorpropham 2 lb/ac, post-emergence

The earliest pre-emergence sprays were applied on the 8th December, seedlings of Stellaria media were present but sparse. Pre-emergence applications of chlorpropham following sodium arsenite treatments were given on the 15th December. All post-emergence treatments were applied on the 2nd March when the narcissus leaves were approximately 3 in. high.

The weed seedlings present were small when the earliest treatments were applied, and the contact herbicides were soon effective, but by the end of January 1959, all the treated plots were clean, and remained so until the beginning of April when slight differences became visible. There were no signs of crop injury by chlorpropham applied post-emergence, even at 4 lb/ac, nor where the chlorpropham/fenuron mixture had been applied. At a dose of 2 lb/ac chlorpropham had a better residual effect when applied in early March. Simazine at a low dose was not sufficiently effective, but in a year remarkable for drought some of the results obtained were exceptional. Over the whole experiment the mean increase in bulb yield over the weight planted was 100 per cent and the differences between treatment mean yields were not statistically significant.

Two-year trial of herbicides on narcissus 1958-60

The aim of the trial was to compare herbicide programmes under conditions of management closely approximating to commercial practice. Results are given in Table I.

1958-59

Narcissus cultivar King Alfred, 300 bulbs/plot was planted on 30th September. Chlorpropham and the chlorpropham/fenuron mixture were applied as early pre-emergence treatments on 28th October. The contact herbicides were applied as late pre-emergence treatments on 24th November. Post-emergence applications of chlorpropham, where included, were made on 2nd March 1959 when the crop foliage was approximately 4 in. high.

When the first sprays were applied the weeds present comprised Stellaria media, Poa annua, Veronica sp. and Matricaria maritima ssp. inodora in the seedling stage. They were at a more advanced stage when the contact herbicides were applied and the weather during the interval was showery with some fog and little sunshine. In early February all the treated plots were free from weeds other than Poa annua, the untreated plots being lightly covered. Where chlorpropham was applied as a supplementary post-emergence treatment no injury occurred. Early applications were the least effective except where the chlorpropham/fenuron mixture had been used. Subsequently the dry weather limited weed growth and the difference remained slight.

Owing to drought the operations of plot cleaning were rendered difficult at the end of the season in July. After rain in late August weeds began to appear and the plots were shallowly cultivated as it was feared that failure to obtain a fine tilth would reduce the efficiency of the herbicides to be applied subsequently. A satisfactory tilth was obtained.

1959-60

Following the summer cultivations weeds appeared earlier than on adjoining newly planted plots, and the dates of herbicide application were adjusted accordingly. The residual herbicide treatments were applied on 22nd October. There were then slight differences in the amount of weed present on the different plots, but Stellaria media was generally dominant. On the plots untreated in 1958-59, additional weed species present were Capsella bursa-pastoris, Urtica urens, Veronica sp. Senecio vulgaris and Poa annua. The contact herbicides were applied on 11th November, and the post-emergence applications of chlorpropham on 25th January 1960.

TABLE I. TREATMENT MEAN YIELDS AND PER CENT INCREASES FROM 300 BULB/PLOTS

Narcissus 'King Alfred', 12 cm offsets. Wt/plot planted 28 lb
Layout: 8 treatments: 3 randomised blocks
Spray volume: All sprays applied at 100 gal/ac

Dates of spray applications	1958-59	1959-60
(a) Early pre-emergence	28 October	22 October
(b) Late pre-emergence	24 November	11 November
(c) Post-emergence	2 March	25 January

Treatment (lb/ac)			Mean yield	Per cent
Pre-emergence		Post-emergence	lb/plot	increase
(a) Chlorpropham/fenuron	2.5	-	70.3	151
(a) Chlorpropham	4	-	66.0	136
(a) Chlorpropham	2	+ Chlorpropham 2	67.6	141
(b) Sodium arsenite	9.8	+ Chlorpropham 2	70.6	152
(b) PCP	10.5	+ Chlorpropham 2	67.0	140
Handweeded			66.3	137
Kept clean by cultivation			66.0	136
Unweeded			60.2	115
		General mean	66.75	138

S.E. 1.95 (14 d.f.) = 2.92 per cent of general mean
sig. diff. between mean yields 4.76 lb at P = 0.01, 3.43 lb at P = 0.05

The yields from treated plots were all significantly higher than those from unweeded plots. Judged visually, on all the plots receiving an early application of chlorpropham groundsel was plentiful, and the plots receiving a contact herbicide + chlorpropham were the cleanest. There was no indication that fenuron had caused injury to the crop.

Trials of post-emergence applications of chlorpropham on narcissus and tulip 1959-60

With the aim of studying the conditions under which crop injury occurs, chlorporpham at 2 lb/ac was applied at four stages of crop growth and the weather conditions prevailing before and after treatment were recorded. The results are given in Table II.

TABLE II. DATES OF TREATMENT, GROWTH STAGES, AND CROP YIELDS

Narcissus 'King Alfred' 14 cm 55 bulbs/plot. Wt planted 126 oz
Tulip 'Rose Copland' 10 cm 50 bulbs/plot. Wt planted 35 oz
Layout: 5 x 5 Latin squares
Spray volume: All sprays applied at 100 gal/ac
Herbicide: Chlorpropham 2 lb/ac

Date of application	Growth stage	Mean yield oz	Per cent increase
Narcissus			
25 January	Leaves 2 in. high	236	87
23 February	Leaves 5 in. high	234	86
23 March	Immediately pre-flowering	234	86
20 April	After flowering	236	87
Control Untreated	-	222	76
S.E. 5.12 (12 d.f.) = 2.20 per cent General mean Sig.diff. 9.8 oz at P = 0.01		232.4	84.4
Tulip			
2 February	Folded leaf	98	179
10 March	Cupped leaf	81	131
20 April	Full leaf	87	150
18 May	After flowering	92	163
Control Untreated	-	76	119
S.E. 9.84 (12 d.f.) = 11.33 per cent General mean Sig.diff. 13.5 oz at P = 0.05		86.8	148.5

At the commencement of the trial the plots were cultivated so that the herbicide could be applied on a clean tilth. There was no visible injury to narcissus, but the untreated plots became weedy. With tulip, however, slight differences in vigour were evident. Dwarfing of flower stems did not occur, but differences in growth followed the sequence ultimately shown by yields. The critical stage for tulip injury appeared to be during the period of rapid growth commencing at the cupped leaf stage, before elongation of the flower stem commenced; but it was not possible to interpret differences in accordance with temperatures, or humidity, and the soil was moist at all times.

Observation plots 1959-60

In 1959 a number of herbicides were applied as post-emergence treatments on tulip beds on 23rd March when weather conditions were favourable and monuron 0.5 lb/ac, simazine 0.5 lb/ac, chlorpropham 2 lb/ac and a chlorpropham 2 lb/ fenuron 0.5 lb/ac mixture all caused crop injury. It was observed however that fenuron at 0.5 lb/ac had the least injurious effect and only caused a slight difference in the colour of the crop foliage, while chlorpropham inhibited the growth of the flower stems.

The following however, seemed promising for further trial on narcissus and tulip.

Diquat 2 lb/ac. Late pre-emergence application gave favourable results.
Chlorpropham 2 lb/diuron 0.5 lb/ac mixture, for early pre-emergence use.
Simazine 0.5 lb/ac early pre-emergence, followed by chlorpropham 2 lb/ac applied late pre-emergence.
PCP 5 lb/ac late pre-emergence followed by chlorpropham 2 lb/ac early post-emergence.

DISCUSSION

Chlorpropham appears to be a very useful herbicide for controlling weeds in the major bulb crops. Its merits are ease of handling, and effectiveness at winter temperatures, but its limitations should not be overlooked. It is clear that on narcissus and tulip crops, both fenuron and diuron are useful as additives to chlorpropham. The use of an efficient contact herbicide is generally more impressive through speedier visual effect. All herbicides however have limitations, and the aim in using a contact herbicide first must surely be to obtain a weed-free bed, failing which chlorpropham will not give good results. PCP has maintained its position for this purpose, and diquat also promises to be useful. For pre-emergence use chlorpropham mixtures appear to be more efficient than chlorpropham alone, where certain weeds are present; to advocate the use of chlorpropham alone is perhaps no longer tenable.

Concerning crop tolerance, no injury to tulips by chlorpropham at 2 lb/ac has yet occurred in trials if the spray has been applied before the leaves unfurled, nor to narcissus before the leaves separated at a height of approximately 2 in.

Though herbicide programmes for bulb crops are now generally used, the period of weed control is not sufficiently extended. During approximately two months before crops are harvested the grower is unable to find a remedy other than hoeing, or hand weeding. On established bulb beds of narcissus the difficulty continues through summer and early autumn. It is desirable that such a problem should not be overlooked.

Acknowledgments

We desire to express our thanks to the A.R.C. Unit of Experimental Agronomy, Oxford, to manufacturers who have supplied materials and given information about their products, and especially to Miss B. Upsall, our recorder.

FIGURE 1. CHLORPROPHAM AT 4 LB/AC APPLIED PRE-EMERGENCE IN TULIPS. PHOTOGRAPH TAKEN IN MAY.

FIGURE 2. THE SIMILAR EFFECT ON NARCISSUS FLOWERS OF DALAPON AT 10 LB/AC AND TCA AT 20 LB/AC APPLIED IN SEPT 1958. PHOTOGRAPH TAKEN IN APRIL 1960.

At doses needed to control Agropyron repens neither chemical is considered safe.

REFERENCES

VERENIGING PROEFSTATION voor de BLOEMBOLLENCULTUUR te LISSE (1958) Proeven betreffende Chemische Onkruidbestrijding in de bloembollenteelt Mededeling No. 19. 1958. p.5 - 35.

WOOD, J., & HOWICK, S. J., (1958) Experiments with herbicides on beds of narcissus and tulip 1955-58 Proc Brit Weed Control Conf 1958, 112-115.

(78178)

THE USE OF TRIAZINE HERBICIDES IN HORTICULTURE, ESPECIALLY ON FLOWERS AND ORNAMENTALS

A. Gast
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Summary: Some possibilities of practical use of triazine herbicides in horticulture are described. In nurseries and established ornamental shrubs, as well as in roses, simazine may be used very safely. Propazine is advised for further experimentation, especially in conifers. Among bulbs, gladiolus may be treated with simazine but not with propazine. Tulips, narcissus and crocus are more sensitive and there are contradictory results. A method is described to keep fallow land weed-free with simazine before Chrysanthemums are planted. Because of their short residual effects methyl-mercapto triazines may offer better possibilities for horticultural use than for instance simazine or propazine.

INTRODUCTION

The practical use of triazine herbicides, particularly of simazine and atrazine in agriculture (e.g. maize), viticulture and in nurseries of woody plants has become more and more common during recent years and is now very widespread in the above mentioned crops. In numerous publications the properties of the triazines and the results of experiments have been described, so that a basic knowledge about the possibilities of application may be supposed to be known.

In field crops and viticulture the world-wide practical use has brought a lot of experience, so that the possibilities of application can be defined today very accurately. In horticulture we find a more complicated situation, only for a limited number of ornamentals do we dispose of sufficient experience to recommend a general use of triazines. For quite a number of horticultural crops we are still in the phase of experimentation. According to the experience gained so far there are two main reasons which are limiting the practical use of triazines in these crops. Most of the horticulturally cultivated plants possess only a weak physiological resistance to triazines, and the long residual effect of triazines in the soil is in some cases a disadvantage, because a following sensitive crop may be damaged. In order to reduce this danger only small amounts of the herbicide can be used, but in that way also the limits of sufficient weed control are reached.

ORNAMENTAL SHRUBS, ROSES

The treatment of ornamental shrubs and roses with simazine normally presents no difficulties, because simazine is kept back in the surface layers of the soil and there is no phytotoxic effect on the deeper roots.

In nurseries and established plantations of ornamental shrubs simazine has a wide field of practical use. The results of numerous experiments in different countries have shown that among the various species of woody ornamentals there are only few which are very sensitive and may show phytotoxic symptoms or damage. Among the more sensitive ones we find representatives of the following families:

Saxifragaceae: Deutzia gracilis, some Ribes species
Oleaceae: Syringa, Ligustrum, Fraxinus and among the
Rosaceae: Spiraea bumalda.
Larix decidua seems to be more sensitive than other conifers.

An experiment with simazine, propazine and trietazine in a new plantation of conifers and broad leaved trees, which was started in 1958 and is still going on, showed an interesting difference of sensitivity to the triazines used. Propazine in comparison with simazine has a higher degree of safety in conifers but a poorer one in the broad leaved trees. Trietazine was very safe in both categories but the herbicidal effect was distinctly lower compared with the corresponding amounts of simazine and propazine, so that trietazine may be dropped in further experimental work. Further work with propazine in conifers, however, is strongly recommended.

Roses present a very advantageous field of application for simazine and a treatment with the above mentioned herbicide normally presents no risk. In an experiment which was started in 1957 (in the first spring after plantation) and where treatments have been repeated every year until now, only one variety Mme. Pierre S. du Pont has shown injury, whereas New York, Friedrich Schwarz, Comtesse Vandal have remained without any damage. During the first summer after the application Mme. du Pont showed chlorosis and a growth depression. Now, after four treatments with 3 lb/ac simazine, the plants are stunted but not chlorotic.

Another experiment was carried out on young plants which were grafted the previous year. In 1956 the varieties Puricelli, New York, Comtesse Vandal, Spek's Yellow, Friedrich Schwarz, Marakesch, Mme. Pierre S. du Pont, Ville de Saverne were grafted on the rootstock Rosa laxa. During the following winter the young plants were covered with soil and in spring 1957, after the removal of the protecting soil layer, the herbicidal treatment was carried out on bare ground at 5, 3 and 1 lb/ac simazine. In applying the treatment no precautions were taken to avoid a contact of the herbicide with the plants, which already showed the first leaves. The development of the young grafts in the next growing season was quite normal and they showed no phytotoxic effects. Mme. du Pont also remained uninjured in this experiment. The herbicidal effect of simazine at all doses was good to excellent.

Chemical weed control in one year old grafts is of great practical value, because the mechanical removal of the weeds must be executed very carefully to avoid damage to the young shoots.

In an experiment with the variety Spek's Yellow simazine was applied to the regions of the roots with a soil sterilant injector. The injected amount of simazine corresponded to a surface treatment at 3 lb/ac, in another plot the same amount was applied as a surface treatment for comparison. Neither treatment produced any sign of phytotoxicity and it may be concluded that roses possess a certain natural resistance to simazine so that the good results obtained with this chemical are not only based on a "positional selectivity".

A special experiment with three varieties of rootstocks showed obvious differences in resistance to simazine. The rootstocks tested, Rosa canina Bröghs, Rosa laxa, and Rosa multiflora, were planted on April 15, 1958, and treated a month later with 15, 7.5, 5 and 2.5 lb/ac simazine. The results are summarized in Table I.

TABLE I. RESISTANCE OF ROSE ROOTSTOCKS TO SIMAZINE

0 = no damage
\+ = slight chlorosis on all plants
++ = slight chlorosis and/or necrosis on all plants
+++ = heavy chlorosis and/or necrosis on all plants

Inspection date	Variety	Simazine, lb/ac			
		15	7.5	5	2.5
30. 6.1958	R. can Bröghs	0	0	0	0
22. 8.1958		0	0	0	0
13.10.1958		0	0	0	0
30. 6.1958	R. laxa	++	+	0	0
22. 8.1958		++ (stunting)	0	0	0
13.10.1958		0	0	0	0
30. 6.1958	R. multiflora	++ - +++	++	+	+
22. 8.1958		++ (3 plants dead)	0	0	0
13.10.1958		stunting	0	0	0

It is interesting to note that with R. Bröghs and R. laxa at all doses and with R. multiflora from 7.5 lb/ac downwards, some plants were distinctly better developed at the end of the season than untreated plants. The disappearance of the phytotoxic symptoms during the growing season indicates that roses are able to metabolize the absorbed simazine into innocuous compounds. Among the three tested varieties R. multiflora is obviously more sensitive than R. laxa and R. Bröghs, while R. Bröghs is the most resistant.

BULBS

Much experimental work has been done on this subject especially in England and the Netherlands. It has been found that Tulips, Narcissus and Crocus are rather sensitive to simazine and this chemical can only be used at low doses. At doses above 100 g/ac damage is likely to occur but even at this low dose simazine can give a useful degree of weed control especially when used in combination with chlorpropham.

Gladiolus appears to be more resistant and in a number of experiments these plants have been treated with up to 5 lb/ac simazine. In rainy summers this dose has caused some damage, but never sufficient to kill the plants. These experiments showed also that among the diverse varieties of Gladiolus there are considerable differences in sensitivity, and it may be that this is the reason for some of the cases of damage which have occurred in the practical use of simazine. In a special experiment to evaluate differences in sensitivity the following varieties were tested: Alfred Nobel, Sans Souci, Aranjuez, Harry Grant, Johann Strauss, Joe Wagenar, Atlantic, Picardy, Paul Rubens, Neu Europa, Han van Megeren, Poppy Day, General Eisenhower, Mansoer.

The most sensitive of these were Aranjuez and Mansoer, which showed obvious damage at 2 lb/ac and light symptoms of phytotoxicity even at 1 lb/ac.

Neu Europa, Atlantic and Poppy Day were injured only at 3 lb/ac, Joe Wagenar was very resistant, showing practically no symptoms even at 5 lb/ac while the rest of the above-mentioned varieties showed distinct damage at 5 lb/ac, but not at 3 lb.

These results indicate that simazine may be used for Gladiolus, but for the most sensitive varieties it is advisable to use relatively low rates of application.

FLOWERS AND PERENNIAL ORNAMENTALS

Whereas the treatment of annual flowers with simazine is practically impossible, there are some positive results in established perennials.

In 1958 the following species were treated:

with simazine 2 lb/ac: Solidago, Iberis, Papaver, Kniphofia, Delphinium, Helenium, Sedum, Paeonia

with simazine 1 lb/ac: Hemerocallis, Sedum, Iris

All the treated plants behaved like the untreated ones until the end of the growing season.

In an established Delphinium plantation some plots were treated at 5, 3, 2 and 1 lb/ac simazine (first treatment May 7, 1958) and the plants developed quite normally. After flowering they were cut down completely at the end of July in order to stimulate new growth and the second shoots also showed no differences in comparison with the plants in the check plot. After repetition of the same treatments in 1959 there were still no signs of damages.

There is a special problem connected with the culture of Chrysanthemums which are only brought into the open during summer. From spring until the moment the Chrysanthemums are planted out the soil cannot be used for other crops but it should remain free of weeds. On May 19, 1958, various plots were treated with 1 and 2 lb/ac simazine. In one part of the area Chrysanthemums were planted out immediately after the treatment without pots, in the other part they remained in pots. All the plants were damaged to some extent but good results were obtained when the pots with the plants were not brought into the treated area until July. None of the tested varieties Etoile de Valence, Louvrier, Jean Cot, Calypso, Gerbes d'Or showed any injury and the weed control was excellent.

RESIDUAL PROBLEMS

As already mentioned one of the limiting factors for the use of triazines in horticulture is their long lasting effect and the possibility of residues effecting following crops. Simazine and propazine, which can be used as selective herbicides in carrots and celery, are particularly liable to cause damage to following sensitive crops.

We therefore tested the possibilities of planting flowers in plots previously treated with these chemicals.

Experiment 1

May 29, 1957: Treatment with simazine and propazine at 4 and 2 lb/ac

Autumn 1957: Ploughing

Spring 1958: Planting of Zinnia (var. Scarlet Flame, Golden Dawn) and Aster (Herz von Frankreich, Chinaaster)

Result: Normal development of all plants.

Experiment 2

May 7, 1958: Treatment with simazine and propazine at 5, 3, 2, 1 lb/ac (experiment on Gladiolus)

Sept. 1958: Planting of Viola tricolor, Myosotis and Cheiranthus

Results in April 1959:

Simazine at all doses:	Test plants normal	
Propazine 5 lb/ac	Viola	normal
	Cheiranthus	normal
	Myosotis	15 per cent kill; remaining plants stunted
Propazine 3 lb/ac	Viola	normal
	Cheiranthus	normal
	Myosotis	stunted
Propazine 2 and 1 lb/ac	All plants normal	

The experiments show that Viola tricolor and Cheiranthus are particularly suitable for planting after a crop which was treated with simazine or propazine.

FUTURE DEVELOPMENT

In the course of the last few months we have tested various methyl-mercapto triazines which have a very rapid herbicidal action and a short residual effect. They show too, a distinct selectivity in carrots. Though there are as yet no results available on the effects of these compounds on flowers there is hope that some horticultural problems will find a better solution using these new chemicals, owing to their short residual action.

Discussion of preceding five papers

Mr. G. D. Lockie. I should like to make a comment on diquat, which has been mentioned several times. We have had very satisfactory practical experience with this chemical at Fernhurst when applied as a pre-emergence or pre-planting treatment. It gives a quick kill of weeds, is broken down rapidly in the soil and can be of great value in speeding up recropping, especially when conditions are too wet for cultivation. It also shows promise as a 'chemical hoe' for a wide range of vegetables, flowers and shrubs.

Dr. R. Pfeiffer. Can simazine be used at low doses in a perennial flower border in winter?

Dr. G. W. Ivens. Experiments with simazine suggest that doses up to about 1 lb/ac can be used safely on established plants of a number of perennial flowers such as Chrysanthemum maximum, Delphinium, Peony and Scabious but a great deal more experimental work is needed before any general recommendation can be made.

Mr. Paul Bracey. In the last year or so we have been concentrating on improving the safety margin of residual herbicides by developing special formulations which tend to keep the chemicals in the upper layers of the soil. The danger of building up toxic residues of such compounds as chlorpropham, fenuron and 2,4-DES does not appear to be very great as large areas have now been treated with these chemicals and up to 5 treatments have been applied without causing any damage to subsequent crops.

Mr. R. W. Sidwell. Dr. Gast's work shows variation in susceptibility of rose rootstocks to simazine but I am not clear as to the effect of rootstocks on the susceptibility of the scion varieties. In fact, in the studies on scion varieties no mention of rootstock is made. Would Dr. Gast please clarify the position?

Dr. A. Gast. In the rose experiments all roses were grafted on Rosa canina.

Mr. J. D. Whitwell. Have full investigations of the possibility of adverse side effects from the use of simazine been made? For example, in South Devon an asparagus crop treated with 2 lb/ac of simazine become smothered with Solanum nigrum. I realise that an alternative chemical can be used but these side effects often appear suddenly. I should also like to comment on the ineffectiveness of simazine in a dry year. When this chemical was applied under fruit trees in autumn 1959 at Pershore Horticultural Institute better control of grass was obtained with a volume rate of 1000 gal/ac than with 100 gal/ac.

With reference to roses, simazine applied at 2 lb/ac at a site in Devon has caused damage to the Floribunda variety Fashion.

Mr. H. A. Roberts. It is quite true that, if the same herbicide is used year after year on the same land, the tolerant species tend to increase. We have shown this in asparagus beds in the instance of Veronica persica and monuron. The answer, I think, is rotation of herbicides as advocated by Mr. A. L. Abel at a previous conference.

Dr. F. H. Feekes. I should like to point out that the chlorpropham treatments shown in Mr. Wood's slides were applied too late in the season. The leaves of the tulips should still be closed when chlorpropham is applied so that no chemical gets into the tube formed by the leaf blade. In Holland we consider diuron and other substituted ureas too dangerous to be used in bulbs, especially in tulips.

Mr. J. Wood. I am pleased to learn that Dr. Feekes agrees that chlorpropham can injure bulb crops when applied at the wrong time. We have stressed that point repeatedly.

Concerning the value of diuron as an additive, we have not had sufficient experience of using chlorpropham/diuron mixtures. A single pre-emergence application was promising but two pre-emergence applications appear to be near the margin of crop tolerance, especially with tulips, and we shall await the results of further experiments before making any recommendation.

SESSION 8

Chairman: Professor A. H. Bunting.

NEW HERBICIDES FOR THE CONTROL OF WILD OATS

FACTORS AFFECTING THE SELECTIVITY OF BARBAN FOR THE CONTROL OF AVENA FATUA IN WHEAT & BARLEY

R. K. Pfeiffer, C. Baker and H. M. Holmes

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Summary: Timing of barban application proved the most critical factor. The best results were obtained when the main flush of wild oats were sprayed at the 1-2½ leaf stage. In practice the period during which spraying gave a good control lasted, on average, 10-14 days. Some experimental results are presented showing how crop competition appears to assist barban in reducing a wild oat infestation. Differences in the tolerance of barley varieties to barban are described.

If applied in one spray, 2,3,6-TBA and 2,4-D markedly reduce the activity of barban on cereal crops and wild oats. MCPB does not produce this effect; MCPA and mecoprop gave intermediate antagonistic activity to barban. 2,3,6-TBA and 2,4-D also antagonise barban if applied up to 4 days before but not if applied several days after barban.

At the tentatively recommended barban rates, optimum performance was obtained at spray volumes between 10 and 30 gallons per acre. Comparisons between spraying vertically and at an angle of 45° showed no differences in wild oat control or crop safety. The same was found when comparing a single application with split applications of barban.

INTRODUCTION

Following the first publications by Hopkins and Hoffman (1959) on specific selective properties of 4-chloro-2-butynyl-N-(3-chlorophenyl) carbamate (barban) against *Avena fatua* in cereals, investigations by the authors started in 1959 to assess the value of this new herbicide under British conditions. A substantial part of the investigations was directed towards a study of the factors found or suspected to influence reliability and selectivity of barban. This paper presents the results so far obtained in a very condensed form, because of the strict limitation of space. As the different aspects are not necessarily related to each other the results are briefly discussed under the separate headings.

METHODS AND MATERIALS

Chemical: Barban formulated by Spencer Chemical Company (1.18 lb per Imperial gallon emulsifiable concentrate)*

Design of experiments: All greenhouse and field experiments were replicated. On most factors under investigation several field trials on different fields were carried out using basically the same design.

Assessment and presentation: Wherever possible assessments were made either by counting wild oats, or by measuring the grain yield or fresh weights of plants. The method of "Blind Scoring" of effects was used in some experiments, all of which were replicated and included the herbicide in a range of treatments.

RESULTS

Time of Application and Susceptible Growth Stages of Wild Oats

Previous work by Hopkins and Hoffman (1959) had shown wild oats to be most susceptible at the $1\frac{1}{4}$ to $2\frac{1}{2}$ leaf stage. This observation was confirmed by the authors in 1959.

Following this finding two questions of practical importance arose and the authors directed their work towards throwing some light on these problems. Considering the fairly long period over which wild oats can germinate in certain seasons, what is the relative importance of wild oats emerging after the first flush have been sprayed with barban, and over what period can barban be successfully sprayed in practice?

On the first aspect two experiments were carried out in which assessments were made of the proportion of seed contributed by wild oat plants emerging at increasing intervals after sowing the crop. The results are presented in the following two tables, which show (a) that 75-79 per cent of the wild oats emerged during a fairly short period - this first flush of plants contributed 95 per cent of the wild oat seed formed by all plants and (b) a marked reduction in the number of spikelets per plant emerging at later dates - this effect can be ascribed to the influence of crop competition.

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* As "Carbyne"

TABLE I. NUMBER OF SPIKELETS PRODUCED BY WILD OATS IN RELATION TO TIME OF EMERGENCE

Site 1 - Spring wheat

Sowing date - March 7th, 1960.

Date of Emergence	No. of plants	Total no. of spikelets	No. of spikelets/ plant
Before 3rd April	38	1434	37.7
April 3rd - 12th	104	1746	16.8
April 13th - 19th	20	100	5.0
April 20th - 26th	16	42	2.6
April 27th - May 4th	8	2	0.2
May 5th - 11th	1	10	10.0

Site 2 - Spring barley

Sowing date - March 3rd, 1960.

Date of emergence			
Before April 1st	42	950	22.6
April 1st - 7th	126	1072	8.5
April 8th - 14th	16	87	5.4
April 15th - 21st	9	5	0.6
April 22nd - 28th	2	1	0.5

These results were obtained in 1960 when the weather was very dry during the germination period. The authors are well aware that the emergence pattern and subsequent growth are likely to be influenced by variation in weather conditions.

On the second aspect - the period during which successful control can be obtained - ten field experiments (5 on spring barley, and 5 on spring wheat) were carried out in which barban at 4 oz/ac on wheat and 6 oz/ac on barley was sprayed at intervals of 3 days. The spraying period which covered about a month started when the wild oats were mainly at the ½-1 leaf stage and continued until the 4-4½ leaf stage was reached.

The final **result** averaging all experiments is shown in Figure 1.

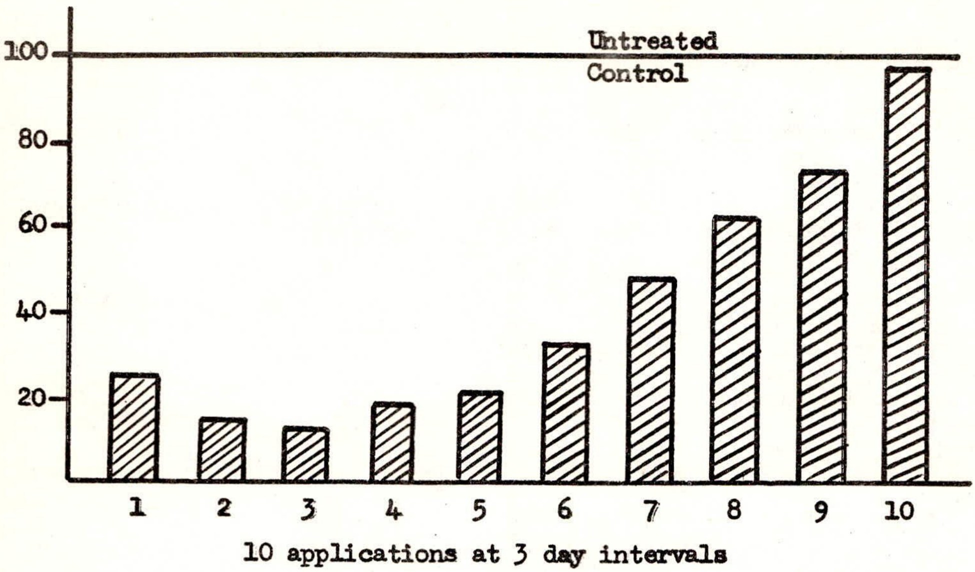

FIG. 1. PERCENTAGE OF WILD OATS REMAINING AFTER SPRAYING AT DIFFERENT TIMES. MEAN OF 10 EXPERIMENTS

The results showed that spraying should be done when the main flush of wild oats had emerged but before many had passed the 2½ leaf stage. The detailed results show over what period spraying gave acceptable results (at least 80 per cent control) at each site. This is summarised as follows:-

Number of experiments	Spraying period giving 80 per cent control
2	20 days and over
2	15-19 days
4	10-14 days
2	less than 10 days

Crop Competition and Dose

The degree of competition offered by the crop was found to be of considerable importance. The authors originally thought that a highly competitive crop directly assists and increases the activity of barban on wild oats by reducing the light intensity around the weed and thus slowing down breakdown of the herbicide.

A complex field experiment was carried out in which the degree of crop competition was varied by using different seed rates of barley cross-drilled with cultivated oats (var. Victory). This experiment showed a) that increasing the seed rate of barley (without spraying barban) itself led to a significant reduction in weight of oat plants per unit area, and b) that barban spraying superimposed over each seed rate of barley gave a constant relative reduction of weight of oats of the order of 80 per cent. (see Figure 2).

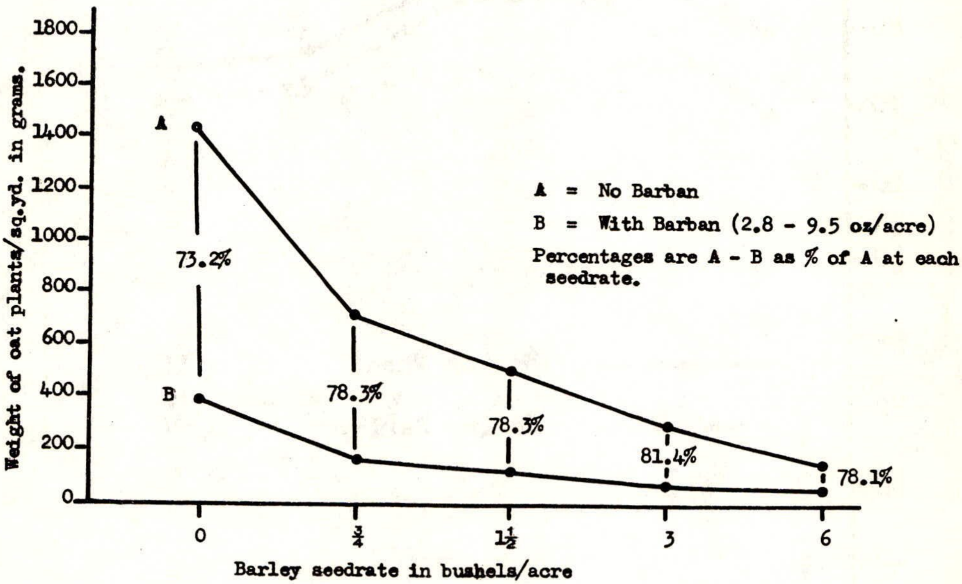

FIG. 2. EFFECT OF BARLEY SEED-RATE ALONE AND BARLEY SEED-RATE PLUS BARBAN ON TOTAL WEIGHTS OF OAT PLANTS/SQ YD.

Weights taken end of July. Oat seed in milk stage.

This result, if reproduceable under more practical conditions, implies a) that on an evenly infested wild oat field a highly competitive crop has, even without barban, less wild oats per unit area at harvest time as compared with a poor crop on the same field, b) that a certain dose of barban on both these crops will control more or less the same percentage of wild oats which the crop allows to develop, and c) that crop competition and barban effect are independent and simply additive.

The choice of an optimum dose is accordingly closely linked with crop competition. The authors found consistently that a dose leading to some crop damage, even if only temporary, will result in a heavier infestation at harvest time than a somewhat lower, but completely safe dose (Figure 3). Such crop damage appears to reduce crop competition with an obviously poorer result.

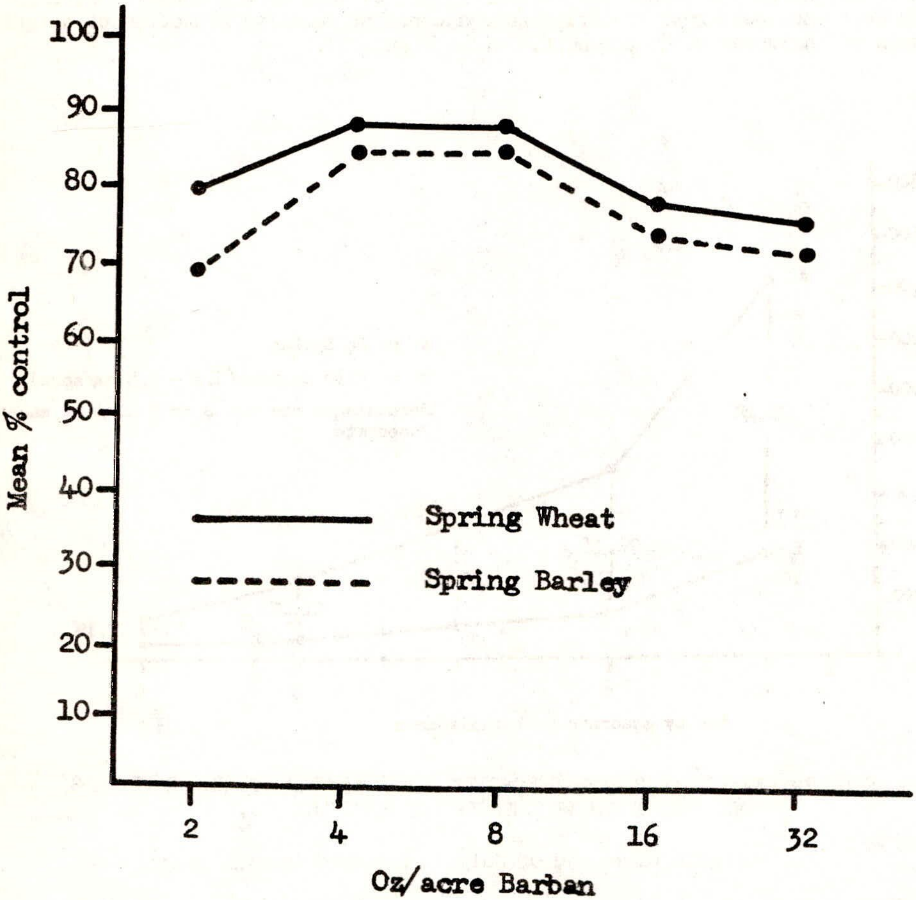

FIG. 3. MEAN PER CENT WILD OAT CONTROL IN 12 SPRING WHEAT AND 12 SPRING BARLEY EXPERIMENTS - 1959

(Based on estimates of size and number of wild oat panicles by three independent observers for each experiment.)

Tolerance of Cereal Varieties to Barban

An analysis of 48 "logarithmic" barley experiments (42 in the U.K., 3 in Sweden and 3 in Denmark) in 1959 indicated marked differences in the tolerance of different barley varieties to barban. The variety Proctor showed considerably lower tolerance than the varieties Carlsberg, Rika, Herta, Ymer and certain Swedish 6-row barleys.

This observation was followed up by field and greenhouse investigations in 1960. 9 barley varieties were included in all 4 main experiments, the results of which are presented in Table II.

TABLE II: PER CENT GROWTH REDUCTION OF 9 BARLEY VARIETIES AFTER BARBAN TREATMENT

Degree of tolerance	Variety	Field expt 1960 16 oz	G/house expt 1960 8-32 oz	G/house expt 1960 8-32 oz	Field expt 1960 32 oz
(Group A)	Provost	93	55	41	100
	Proctor	90	64	50	100
low	Freja	94	53	53	80
	Plumage-Archer	92	48	31	80
(Group B)	Earl	67	41	13	20
	Rika	66	15	24	20
medium	Spratt-Archer	64	19	18	20
	Maythorpe	7	46	31	80
(Group C) high	Carlsberg II	22	19	18	0

These results confirm the observations made in 1959. The 9 barley varieties can accordingly be placed in 3 categories of tolerance. Varieties in category A are unlikely to tolerate the proposed practical barban doses (4-6 oz/ac), while the varieties in categories B and C are likely to be safe at these doses.

A number of other barley varieties were included in one or two of the experiments only. Subject to confirmation from further trials, these varieties can be tentatively placed in the 3 tolerance groups as follows:-

Group A (low tolerance) - Domen

Group B (medium tolerance) - Ingrid, Pallas, Nordgarden, Hillmarsh, Delta, Hafnia, Arva Kenia, Haisa II, Gateway Kenia, Gazelle, Volla, Herta, Vada, Ymer.